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These are the Proceedings of the Eighteenth Annual university-wide seminar WORKSHOP 2009 which took place at the Czech Technical University in Prague from 16th to 20th February, 2009.

The aim of the seminar is to present and discuss the latest results obtained by researchers especially at the Czech Technical University in Prague and at collaborating institutions.

The organizing committee has selected a total of 221 contributions divided into 15 different areas of interest:

• Part A:

- mathematics
- physics
- informatics and automation engineering
- electrical engineering and instrumentation
- materials engineering

• Part B:

- mechanics and thermodynamics
- mechanical engineering
- production systems, technology and technological processes automatisation
- energetics and power engineering
- nuclear engineering
- chemistry
- biomedical engineering
- civil engineering
- architecture, town planning, geodesy and cartography
- transportation, logistics, economy and management

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Section 1

MATHEMATICS

On Bol Algebras

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A vector space V equipped with a bilinear operation [a,b] and a trilinear operation [a,b,c] is called a left Bol algebra if it satisfies the following identities:

 $\begin{bmatrix} [a,a,b] = 0, \\ [a,b,c] + [b,c,a] + [c,a,b] = 0, \\ [x,y,[a,b,c]] = [[x, y,a], b, c] + [a, [x, y,b], c] + [a, b, [x, y, c]], \\ [a,b] = - [b,a], \\ [a,b,[c,d]] = [[a,b,c],d] + [c,[a,b,d]] + [c,d,[a,b]] + [[a,b],[c,d]],$ (5) for all a,b,c,d,xy in V.

The first three equations (1), (2), and (3) define the so called Lie triple system. From the Lie triple system one may construct a left Bol algebra by defining a bilinear operation [a,b]=0.

An alternative way of defining a Bol algebra is by usage of a derivation on a ternary operation and a pseudo-derivation on a binary operation. The derivations and the pseudo-derivations are linear maps on V and it holds for a derivation D:

$$D([x,y,z]) = [D(x),y,z] + [x,D(y),z] + [x,y,D(z)]$$

and for a pseudo-derivation P, there exists z in V (the companion of P) such that:

$$P([x,y]) = [P(x),y] + [x,P(y)] + [x,y,z] + [z,[x,y]].$$
(6)

Hence a left Bol algebra may be defined as a Lie triple system with a skew-symmetric bilinear operation [x,y], such that the derivation $D_{a,b}(x) = [a,b,x]$ is a pseudo-derivation on the bilinear operation [x,y] with the companion [a,b].

Before giving other example of constructing a Bol algebra, recall a definition of alternative and left alternative algebras. We say that a vector space equipped with bilinear operation – usually marked just by a juxtaposition xy – is an alternative algebra if the associator (x,y,z) = x(yz)-(xy)z vanishes for (x,x,y) and (x,y,y). For a left alternative algebra we require just the first condition (x,x,y)=0.

By defining a bilinear operation [x,y]=xy-yx on an alternative algebra, one obtains a Malcev algebra. Recall that the Malcev algebra is defined as an anticommutative algebra such that it holds J(x,y,[x,z])=[J(x,y,z),x], where J(x,y,z)=[[x,y],z]+[[y,z],x]+[[z,x],y] is so called Jacobian. The Malcev algebras constructed in this manner are called special.

By defining a bilinear operation [x,y]=xy-yx and a trilinear operation [x,y,z]=x(yz) - y(xz) - z[x,y] on a left alternative algebra, one obtains a left Bol algebra, see [1]. In this sense, Bol algebras generalize the notion of Malcev algebras.

It is still an open question if every Malcev algebra can be constructed in the way presented above. This problem has been investigated in [2] for free algebras, where the question has been reformulated to the question whether the kernel of the natural homomorphism of the free Malcev algebra of countable range into the special Malcev algebra of the corresponding free alternative algebra is nonzero. As for the moment the bases are not known for both free Malcev and alternative algebras, the question is hard to be answered. In [2] the base for the free Malcev superalgebra on one odd generator was constructed. Due to [3] and [4] this enabled to obtain a base of the space of skew-symmetric elements in the free Malcev algebra.

As Bol agebras generalize Malcev algebras, it is a challenging question to try to find a base of a free Bol algebra. One can begin as well by the free Bol superalgebra on one odd generator. The first step consists in defining a Bol superalgebra by multilinear identities. In general, the construction of a base contains two steps; first, one has to find a generating set, and second, one has to prove that the elements of the generating set are linearly independent. In fact, there are not many classes of non-associative algebras where the bases are known; free non-associative, free (anti)commutative and free Lie algebras are examples of them. In the case of associative algebras the problem is pretty simpler.

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Mathematical models of multiphase flow in porous media including dynamic effect in models of capillary pressure

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In order to understand and predict flow of immiscible and incompressible fluids in porous medium, it is crucial to develop a reliable model of capillarity. Capillary forces acting on the fluids are commonly described by the capillary pressure, defined as the difference between the non-wetting (air) and the wetting (water) fluid pressures.

In the past decades, various capillary pressure - saturation models were correlated from laboratory experiments in equilibrium conditions. These static capillary pressure - saturation relationships such as the Brooks and Corey or the van Genuchten model, have been used in almost all mathematical studies on modelling of multiphase flow in porous medium. However, soil physicists have found that the laboratory measured static capillary pressure - saturation relationship does not correspond to the effects of capillarity in the large scale dynamic systems and holds only in the state of thermodynamic equilibrium. Consequently, the static capillary pressure - saturation relationship cannot be used in the modelling of capillarity when the fluid content is in motion. Thus, a new model of the capillary pressure - saturation relationship is proposed in [3] and referred to as the dynamic capillary pressure model. The thermodynamic definition of macroscale fluid pressures enables for expressing the dynamic capillary pressure in the form

$$p_c = p_c^{eq} - \tau \frac{\partial S_w}{\partial t},$$

where p_c^{eq} [Pa] is the static capillary pressure model already known from the literature, τ [ML⁻¹T⁻²] is the material property of the system, and S_w [-] is the saturation of the wetting phase (water).

The inclusion of the dynamic capillary pressure in the existing mathematical models has been a subject of investigation of various researchers for the simplified flow situations as for instance for the case of the Richard's problem. However, the relevance of using the dynamic capillary pressure in the full two-phase flow system of equations has not been answered yet. Therefore, a fully implicit numerical scheme has been developed by the authors that can be used for such a detailed investigation of the saturation and capillary pressure behavior when dynamic capillary pressure is used instead of the static capillary pressure in the full system of two-phase flow equations. Moreover, the numerical scheme enables for solving the two-phase flow equations for the case of a heterogeneous porous medium, where the continuity of the capillary pressure across the material heterogeneities requires solving an additional equation at each such material discontinuity.

Altogether, the fully implicit numerical scheme for the one-dimensional incompressible and immiscible two-phase flow enables simulation with the non static capillary pressure models in both homogeneous and heterogeneous porous media. The numerical scheme is validated and its order of convergence is estimated using the analytical and semi-analytical solutions for the static capillary pressure - saturation relationships. The semi-analytical solutions can be derived for both homogeneous and heterogeneous porous medium, see [1] and [2]. Once the numerical scheme is validated and found to be convergent for the static capillary pressure - saturation relationship, the model of the dynamic capillary pressure is employed in the system of equations and tested for different models of the dynamic capillary pressure parameter τ . Laboratory measured parameters were used in such numerical simulations including three main functional models of the dynamic effect coefficient τ - as a constant, a linear, and a loglinear function of the wetting phase saturation S_w . The laboratory experiments were held in the Center for Experimental Study of Subsurface Environmental Processes, Department of Environmental Science and Engineering, Colorado School of Mines, Golden, Colorado. The laboratory experiment consists of multiple drainages cycles in a vertically placed column filled with water.

The numerical solutions for the dynamic capillary pressure show that the dynamic effect has a significant impact on the magnitude of the capillary pressure while the change in the saturation profiles may be considered negligible in some cases. The constant model of τ showed rather unrealistic profile of the numerical approximation of the capillary pressure because the spatial monotonicity was different with respect to the results obtained with the static capillary pressure model, see [4].

Results of the numerical simulation indicate that the dynamic effect may not be so important in drainage problems in a homogeneous porous medium, but, on the other hand, it is of a great importance in highly heterogeneous media where the capillarity governs flow through material interfaces. Hence, a detailed numerical study of flow of air in porous medium with a single material discontinuity revealed that the linear and loglinear model of τ accelerates flow of air across the interface for both directions of the flow from coarse to fine sand and vice versa. The constant model of τ however did not seem to influence much the speed of flow of air across the material interface compared to the results obtained using the static capillary pressure model.

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Multi-Agent Approaches in Problems of Operational Research and Applied Mathematics

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Distributed artificial intelligence stands for relatively well established fields. There are two typical directions in this: distributed problem solving and multi-agent systems. The present grant attempted to put these two directions together: utilize the multi-agent techniques and concepts for improved distributed problem solving. Following areas were examined: the eHealth application, distribution problems, and operation in the environment with renewable resources.

First area that was examined in more detail within this grant, were the renewable resources and their exploration by a multi-agent system. First of all, simple model with a finite amount of renewable resources was designed and implemented. Afterwards, the agent actions were examined as well as their decision making procedures. The decision making decided to continue loading from particular resource or to move to another one. This procedure reflected the number of successful visits of particular resource, whether the last visit has satisfied the requirements and how the agent is curious to visit resource that was not visited for a longer time. These agents operate in the environment and strive to exploit the material. The function of the multi-agent system is evaluated from different point of views, namely total exploration, number of agents survived, number of resources not desolated. The system is optimized, but only from the decision point of view, i.e. things like number of agents, resources, their physical properties and capabilities are fixed. The first point where the system can be optimized is the conflict resolution. If more than one agent meets at the same resource, they the question arises which one will load the material in given time instant first, whether the stronger one, the weaker one or whether the order is random. This conflict resolution has been parameterized. Other parameter expresses the optimal satisfaction of the agent when the agent is at strongest. Next parameter states the implicit preference to travel in comparison to the preference to stay and load. Final parameter was the hastiness. These four parameters of the system were optimized with respect to above mentioned objective criteria. The optimization (search of nondominated solutions) was performed with a modification of a genetic algorithm. It has been shown that the travelling appetite has a strong influence on total exploation and

Another area examined were eHealth applications of multi-agent systems. Preparing a book chapter, a systematic research has been done and the integrative role of multi-agent systems in the e-Health was mentioned. This work does not relate to the topic of the grant directly, nevertheless, it was very useful for explicit definitions and theoretical background necessary for other work and esp. for the thesis.

The examined third area is the specific distribution problems. There are some heuristics for solving distribution problems. Nevertheless, such heuristics suppose the linearity of the objective function. A very particular problem was examinated in detail: how to divide people into discussion groups with respect to their interpersonal relationships. If the average satisfaction with such distribution would be used, we would face just an instance of usual 16

distribution problem that can be solved by linear programming methods. Nevertheless if we deal with the satisfaction of the at least satisfied group member, we the complexity of the problem increases. The problem has been generalized and it covers much more specific and real problems. The complexity of this problem was examined and through reduction of the maximal independent subset it has been shown that the problem is NP complete. Consequently, there designed three different methods for the solution of this problem. The first one has used well established differential evolution algorithm and applied it on the ranking of group members. The individuals are divided into subgroups with respect to the ranking. Another method stems from principles of genetic algorithms. This method uses the representation of individuals division into subgroups and defines operators like crossover and mutation. The third method is based on some implicit principles that can occur if autonomous individuals attempt to divide themselves into subgroups. These methods were compared and it has been shown that the first two are better than the third one.

Other work is performed in the direction of global optimization. However, this work will be published in 2009 therefore it is not reported here as the result of the grant.

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Mathematical Model of Dislocation Dynamics

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In the field of material science, the dislocations are defined as irregularities or errors in crystal structure of the material. The presence of dislocations strongly influences many of material properties. This justifies the importance of developing suitable physical and mathematical models. From the mathematical point of view, the dislocations are defined as smooth closed or open plane curves which evolve in time. They are located in a plain called slip plane. Their motion therefore is two-dimensional.

Our work deals with the numerical simulation of dislocation dynamics. Dislocations are described by means of the evolution of a family of closed or open smooth curves $\Gamma(t): S \to R^2, t > 0$. The curves are driven by the normal velocity v which is the function of curvature κ and the position vector $x \in \Gamma(t)$. In this case the equation is defined as $v = -\kappa + F$. The evolving curves can be mathematically described in several ways. One possibility is to use the level-set method, where the curve is defined by the zero level of some surface function. One can also use the phase-field method. Finally, it is possible to use the direct (parametric) method where the curve is parametrized in usual way. In our case, the motion law is treated using direct approach solved by two numerical schemes, i.e., backward Euler semi-implicit and semi-discrete method of lines.

For long time computations with time and space variable external force F(u,t), the algorithm for curvature adjusted tangential velocity is used. This algorithm moves points along the curve according to the curvature, i.e., areas with higher curvature contain more points than areas with lower curvature. This improves numerical stability and also accuracy of computation. Unlike the case with no tangential force, the equation is not given by a simple formula but it is based on the relative local length between points.

The equation we solve has the following form:

$$\partial_{t}X = \frac{\partial_{uu}X}{\left|\partial_{u}X\right|^{2}} - \alpha \frac{\partial_{u}X}{\left|\partial_{u}X\right|} + F(u,t)\frac{\partial_{u}X^{\perp}}{\left|\partial_{u}X\right|^{2}},$$

where X is the parameterized curve, u is the parameter, α is the redistribution parameter, and F(u,t) is the external force.

In the curve dynamics in general, and in the dislocation dynamics in particular, topological changes may occur (e.g., connecting or splitting, closing of open curves, etc.). The parametric approach does not handle them intrinsically, and we therefore need an additional algorithm allowing for such changes of discretized curves. The algorithm which we developed for this problem is not supposed to be universal for every situation and possibility. Main purpose is to simulate topological changes that can happen during dislocation dynamics. We assume that curves can touch only in one point but the there can be more connections or divisions in one timestep. Details are described in [2].

Schemes were tested on open or closed curves with or without tangential redistribution of points. At first, we simulated evolution of a circle and compared with analytical solution. Experimental order of convergence and absolute error were measured. Then, we simulated more complex shapes. See [1].

Our method is now applied to the real physical problems, such as Frank-Read source, dislocation evolution in the channel, evolution through grains in material, etc. For example, the simulation of the Frank-Read mechanism which describes how new dislocation loops are created, makes use of parts of our method. At the beginning, we have a line dislocation (i.e., open curve with fixed ends). An external force is applied to the dislocation line. The curve keeps expanding until it touches itself. At this moment, the curve splits into two parts - dipolar loop and dislocation line. The loop continues in expansion. The dislocation line will again undergo the same process.

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Scalability of Domain Decomposition Method

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Behavior of civil engineering structures described by large scale models are in the focus of the engineering community. Numerical models based on the system of partial differential equations are usually obtained with the help of some numerical method. The finite element method is the most used method in numerical analysis. It transforms the original problem described by the system of partial differential equations or by the minimization of suitable functional to the solution of a system of algebraic equations. The number of equations depends on applied mesh of finite elements. The number of equations grows with the number of nodes and elements in the applied mesh. The finer mesh is used, the more equations are generated. There are basically two kinds of methods for solving of the system of algebraic equations. Direct methods are the first group of these methods. Direct methods are based on Gaussian elimination. Iterative methods are the second group of methods for solving of the system of equations. Iterative methods are often based on minimization of the quadratic form connected with the system of equations. Booth groups have advantages and disadvantages. Disadvantage of the direct methods is large demands on memory capacity of computers in the case of the large scale systems of equations. Disadvantage of the iterative methods is large demands on elapsed time of computers. Parallel computers offer significantly greater memory and computational power than single-processor computers. Parallelisation of sequential algorithms of solvers of the system of equations can be very difficult. Domain decomposition methods are used for solution of the large scale systems of equations on parallel computers. There are many variants of domain decomposition methods.

The FETI (Finite Element Tearing and Interconnecting) method is a nonoverlapping domain decomposition method, which was introduced by Farhat and Roux in 1991 in article [1]. The FETI method is based on decomposition of the general domain into smaller subdomains, where the continuity condition on boundaries is enforced by Lagrange multipliers. This method divides unknown displacements into two types - internal displacements and boundary displacements, which belong to boundary among subdomains. Lagrange multipliers are defined to connect appropriate boundary unknowns. The original system of equations is reduced to a coarse problem, where Lagrange multipliers and coefficients of the linear combination of base vectors of the null space of the stiffness matrix are unknown. The coarse problem is solved by the modified conjugate gradient method. The classical method of the conjugate gradient can be used for symmetric positive-definite matrices. Modification of the conjugate gradient method is needed because stiffness matrices of subdomains are only positive semi-definite. Unknown displacements are computed from Lagrange multipliers and from coefficients of the linear combination of base vectors of null space of the stiffness matrix after solving of the modified conjugate gradient method. More information about FETI method can be found in articles [1, 2] and in the book [3]. In the articles [1, 2], there are two basic preconditioners for the FETI method. The optimal preconditioner which is called Dirichlet preconditioner and the economical preconditioner which is called lumped preconditioner. The economical preconditioner is simpler than the Dirichlet one because it is based on matrix-vector multiplication. Submatrix defined by interface unknowns is selected and interface parts of subdomain vectors are multiplied by this matrix. The Dirichlet preconditioner is more complicated because it is based on the Schur complements. Preliminary step therefore contains computation of the Schur complements which may be time and memory consuming. Ordering of nodes and unknowns is not arbitrary and is similar to the ordering used in the substructuring method. During the final phase of the FETI method, interface parts of vectors are multiplied by the Schur complements in each iteration.

In order to achieve parallel scalability, the preconditioners are necessary. A domain decomposition method is said to be scalable, if its rate of the convergence does not deteriorate when the number of subdomains grows [3]. Scalability is tested on suitable benchmarks. Principle of scalability testing:

- · choice of mesh size on each subdomain,
- · choice of direction in which the number of subdomains is growing,
- gradual growth of the number of subdomains.

Supercomputer HPCx and cluster Ness at the EPCC (Edinburgh Parallel Computing Centre) of the University of Edinburgh and heterogeneous cluster Perun at the Department of mechanics of the Faculty of Civil Engineering of the Czech Technical University in Prague were used for scalability testing.

The FETI method has been implemented into the code SIFEL earlier but without preconditioners. The SIFEL code [4] is developed at the Department of Mechanics of the Faculty of Civil Engineering of the Czech Technical University in Prague. It is an open source code for mechanical, transport and coupled problem written in C language. The code works on a single-processor as well as multiprocessor computer. The parallel version of the code is based on the MPI library [5] and distributed memory architecture is considered.

In case of the preconditioned FETI method, the rate of convergence is independent on the number of subdomains. Results in non-preconditioned FETI method shows slow increase of the number of iterations with respect to increase of the number of subdomains. Our implementation of FETI method has nearly the same results for supercomputer HPCx, cluster Ness and cluster Perun.

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Generalization of Bell's inequalities

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One of the most famous thought experiments concerning quantum theory is Einstein-Podolsky-Rosen paradox which was published in 1935. This paradox was designed to demonstrate that quantum theory is incomplete and therefore the results of quantum theory could be described by classical theory if one imposes hidden variables.

An important milestone in discussion on incompleteness of quantum theory was the proof of Bell's inequality in 1964. Bell showed [1] that the correlations between two systems (which are no longer interacting but have interacted in the past) have to satisfy certain inequality if the global system can be described by classical physics. However, this inequality is violated by some expectations of quantum theory. The violation is caused by different description of observables in quantum and classical physics. Bell's inequalities have provided a possibility to decide a conflict between quantum theory and "local hidden-variable theory" by performing an experiment. The derivation of Bell's inequalities is based on the locality principle which means that for noninteracting systems the measurement on one system cannot disturb the other system. Bell's inequality was the first one from the set of inequalities which are called Bell-type inequalities (or simply Bell's inequalities). It is interesting to note that Bell-type inequalities can be used to test not only the predictions of classical theory but also that of quantum theory. In particular, the family of Bell-type inequalities includes the Cirel'son's inequality which provides a quantitative bound on a correlation experiment in quantum theory.

The mathematical description of both classical and quantum theory can be unified to a general C*-algebraic framework. In this approach it is assumed that observables of the physical system correspond to self-adjoint elements of a C*-algebra. A state of the system is then described by a positive normalized linear functional on given C*-algebra. A result of measurement (i.e. expectation value) is given by the value of a given state at the corresponding observable. A difference between classical and quantum theory in this framework lies in the fact that in the case of classical theory the underlying C*-algebra is commutative whereas in the case of quantum theory it is non-commutative. This algebraic point of view is powerful in many branches of physics research and can be applied to study of Bell's inequalities and their algebraic structure (see [2-3]). (For introduction to elementary notions of a C*-algebra see [4]).

The work deals with the generalization of the Cirel'son's inequality to all complex linear spaces. We are also interested in the circumstances under which the bound in the inequality is attained. Let X be a complex linear space equipped with a positive sesquilinear form Q. The sesquilinear form defines the quantity

$$\chi = \frac{1}{2} |Q(a_1, b_1 + b_2) + Q(a_2, b_1 - b_2)|,$$

where a_1, a_2, b_1, b_2 are elements of X whose seminorms induced by Q is less or equal to one. We have proved that χ have to be less or equal to $\sqrt{2}$, which generalizes considerably hitherto known estimations. Moreover, our arguments are based only an appropriate application of the Schwartz inequality and do not require advanced operator algebraic techniques used in [2, 3].

Suppose further that X is a complex *-algebra and φ is a positive normalized functional (called state) on X. Then φ induces naturally positive sesquilinear form Q on X by $Q(x, y) = \varphi(y * x)$. If this form is definite, then φ is said to be faithful. Let us note that Q is a far reaching generalization of correlation dualities arising in the quantum field theory. Our main result shows that the bound $\sqrt{2}$ is attained in this situation if and only if the elements a_1 and a_2 are realization of the Pauli spin matrices. From mathematical point of view this generalizes considerably results in [2, 3], especially for mutually noncommuting subalgebras. In physical interpretation it shows that Einsten-Podolsky-Rosen experiment is the only possibility how to demonstrate that Bell's inequalities are maximally violated.

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The Construction of the Base of the Alternative Superalgebra of Index 3

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The construction of effective bases of free algebras is one of most important and difficult problems in the theory of non-associative algebras. There are not many classes of algebras where such bases are known: free non-associative, free (anti)commutative and free Lie algebras are the most known examples besides polynomials and free associative algebras. A. I. Shirshov formulated the problem of the construction of a base of the free alternative (respectively left alternative, Jordan, Malcev, binary-Lie) algebra on *n*-generators. Note that, contrary for example to the Lie algebras, the free alternative algebra contains non-trivial nilpotent elements and zero divisors; moreover, the free alternative ring has elements of finite additive order. This makes the problem of the base more complicated, and it seems natural to consider first some special cases.

Subject of our interest are relatively free alternative algebras of nil index *n* (or alternative nil_n algebras). Recall that, nil_n algebra consists of nilpotent elements satisfying $x^n = 0$. Suppose that the ground field has characteristic zero. Then the variety of alternative nil_n algebras can be defined by multilinear identities.

It is known that for every multilinear variety of algebras V, one can consider the corresponding V-Grassmann algebra, which is isomorphic as a vector space to the subspace of all skew-symmetric elements of the free V-algebra. Thus, it seems interesting to construct a base for this subspace. Due to works [3, 4] that formalized the method of construction the superalgebra from the algebra, the problem is reduced to the free V-superalgebra on one odd generator, which is easier to deal with.

We will consider alternative superalgebras. In general, a superalgebra means a Z_2 graded algebra, that is an algebra A which may be written as a direct sum of subspaces $A = A_0 + A_1$ subject to the fact that the subspace A_iA_j is the subspace of $A_{i+j \pmod{2}}$. The subspaces A_0 and A_1 are called the even and the odd parts of the superalgebra A and so are called the elements from A_0 and from A_1 , respectively. Below all the elements are assumed to be homogeneous, that is, either even or odd. A superalgebra $A = A_0 + A_1$ is called an alternative nil₃-superalgebra if it satisfies the super-alternativity (see [2]) ad super-idetity W(u, v, w) = 0, where

$$W(u, v, w) = (uv)w + (-1)^{u(v+w)}(vw)u + (-1)^{w(u+v)}(wu)v + (-1)^{w(u+v)}(wu)v + (-1)^{w(v+w)}(wv)u + (-1)^{w(v+w)}(wv)u$$

and the symbol $\underline{x} = i$ means the parity of the homogenous element x in A_i . We denote by *Alt-Nil₃[0;x]* the free alternative nil₃-superalgebra on one odd generator x. Now let us construct a base of it.

In general, the construction of the base consists of two steps. First one must construct a prebase, that is a set of elements which span the superalgebra, and next prove the linear independence of the pre-base elements. We essentially used the base of the free alternative superalgebra on one odd generator x Alt[0;x], which base was constructed in [2]. We examine the super-identity W(u,v,w) = 0 to construct a pre-base of the alternative nil₃ superalgebra on one odd generator $x Alt-Nil_3[0;x]$ (see [1]) and next proved the linear independence of these elements.

The linear independence may be proved by induction on degree of homogeneous basic elements or by defining formally a multiplication on the basic elements and then proving that the obtained algebra satisfies the desired axioms. We have shown the linear independence of the pre-base of the alternative nil₃ superalgebra on one odd generator Alt- $Nil_3[0;x]$ using the second method.

We defined a new superalgebra *C* generated by the element *a* by giving its base and multiplication table. After that, we verified that *C* satisfies the super-alternativity rules and W(u,v,w) = 0. That means this superalgebra *C* is alternative and nil₃. Than we considered the surjective homomorphism of superalgebras *f*: *Alt-Nil*₃[0;x] \rightarrow *C*, defined by the condition f(x) = a. It happened that *f* maps our pre-base of *Alt-Nil*₃[0;x] to the base of *C*. Since the elements of the base of the superalgebra *C* are linearly independent, so are their pre-images in *Alt-Nil*₃[0;x] and this superalgebra consists of the base which we have proofed.

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Section 2

PHYSICS

The Surface and Liquids Decontamination Using the Point-to-plane and Point-to-point Corona Discharge

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The action of electric discharges and the plasma generated by them is one of the possible methods of decontamination or sterilization, mediated by bactericidal action of UV light and reactive particles. The method is not yet frequently used in practice, but it is potentially important, especially for the decontamination or sterilization of heat labile or otherwise sensitive materials. Its various experimental arrangements, advantages and status of research in this field were reviewed in details in, e.g., [1], [2], [3] and [4].

We studied the decontamination or sterilization of surfaces and liquids by low temperature plasma generated in corona discharge. The simple apparatus of an open-air type enabling the point-to-plane or point-to-point arrangement was used.

For the surface sterilization, the negative point-to-plane corona discharge was generated on the point electrode represented by the tip of a hypodermic needle. The plane anode was realized by the surface of an agar cultivation medium. The microorganisms under study were "wild" strains of the following species isolated at the Institute of Immunology and Microbiology: a yeast *Candida albicans*, bacteria *Escherichia coli* and *Staphylococcus epidermidis*. The suspensions of microorganisms were inoculated onto the surface of culture medium and exposed to the corona discharge. The samples were exposed to the discharge for the times for 1 to 6 minutes. After exposition, the samples were cultivated and the inhibition zones were measured. In the case of liquid sterilization, a drop of appropriate bacterial suspension was placed on the hydrophobic surface of a sterile silicone disc and exposed to the discharge. The disc was then washed into physiological saline, inoculated on cultivating medium and the number of colonies was counted after incubation.

The bipolar point-to-point corona discharge was generated on a pair of hypodermic needles arranged in an angle of 30° with tips approx. 4-6 mm apart. The exposition, zone measurement or bacterial counting was performed in the same arrangement mentioned for the point-to-plane discharge.

From described experiments we obtained following results. In the case of sterilization of the liquid by the point-to-plane discharge we have found that the drop of bacterial suspension becomes sterile after 2 and more minutes of exposition to the discharge. In the case of point-to-point discharge we have found that the drop of suspension becomes sterile after 2 minutes for the bacteria *Staphylococcus epidermidis*, 2.5 minutes for bacteria *Escherichia coli* and 4 minutes for the yeast *Candida albicans*.

More interesting results were obtained for surface sterilization. While in the case of point-to-plane discharge we obtained circle and well bordered inhibition zones with diameters of 1 to 4 mm depending on the exposition times for 1 to 16 minutes, in the case of point-to-point discharge applicated on surface, we obtained asymmetric punkable inhibition zones of two types. In the case of yeast *Candida albicans* and gram-negative bacterium *Escherichia coli* the inhibition zones were well bordered and clear of any surviving colonies,

but for the gram-positive bacterium *Staphylococcus epidermidis* we have obtained punkable inhibition zones with the reduction of survival colonies only and without or only with very small zone of total inhibition.

We found, that after the same exposition, the inhibition zones are larger and the number of surviving bacteria is lower in the case of point-to-point discharge as compared with the point-to-plane discharge. Fact, that two types on inhibition zones have been observed holds the conclusion, that in the case of point-to-point discharge the sterilization agens has different efficiency and probably other mechanisms of the disturbing of microorganism's structures.

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The Possibility of Self Organisation of Discrete Systems with Diffusion and External Force

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In this paper we introduce the possibilities of spontaneous self-structuralization of auto-reproducing biological systems with discrete diffusion and partially describe its behaviour. Those possibilities are studied by the mathematical apparatus using the autocatalysis and the diffusion process as a long- and short-distance force respectively. The autocatalysis is fitted by the Verhulst's logistic equation and the diffusion process is fitted by the transport of elementary subjects (bio molecules, viruses, bacteria ...) between discrete locations based on the Fick's law in non continuous space. Potential effect of an external force is included into the system as the diffusion symmetry violation. This system was analyzed in one- and two-dimensional space for various input conditions: speed of reproduction, intensity of diffusion and external influence on the system. It is exposed that for proper control parameters and initial conditions the system exhibits spontaneous self-structuralization, what may be used for the description and prediction of the behaviour of real inorganic, organic or biological systems concretely e.g. microelectronics (viral nano-electronics) or biosensors.

It is generally known that inorganic, biochemical, biological or social systems for some levels of evolution enter the non-stable state and the creation of several time-space structures may arise. These processes are discussed in wide synergetic literature. Due to known mathematic analysis two necessary system conditions must be fulfilled: existence of long-distance force (physical field, auto-catalyze) and short-distance force (diffusion), which may be realized for biological systems also: the auto-catalysis and the diffusion (migration) as long- and short-distance force respectively.

The basic logistic equations, which determinate the spontaneous discrete replication systems, are described by the Verhulst's equation. Although it is only partially applicable, it was demonstrated that acquired results are in good correlation with the general characteristics of evolution of nearly all realistic and complicated systems. Consequently we prefer this simplified technique. The process of the discrete growing system is formulated by the Verhulst's logistic equation.

First satisfying results were observed in 1-D system in the case of chaotic distribution of initial states. It was shown that the structuralization is objectively present, but it is not ordered sufficiently and it is changing with dependence on various initial states. On the other hand in the same system with only one non-zero initial cell the sequential step by step creation of homogenous periodic structure is apparent. Next results have been obtained in the case of non-symmetric diffusion. We observed that in 1D model the linear diffusion violation does not generate qualitative structure changing. The attendance of the violation causes the moving of the structures in positive or negative direction only and due to the periodic boundary conditions, no new structure was observed.

Consequently the numerical analyzes for 2-D system was done. The analyzed system consists of square lattice of $N \times N$ cells where N = 128. In the first case, initial cells states were set chaotically as was described above. The numerical simulations show that the probability of structure formation depends on the control parameters and initial state and that this dependence is similar like in 1-D model. Nevertheless very interesting results were observed for cases where the initial values distribution was set to zero except one or several cells. The advantage of this case is that the formed structure is predicable and does not depend on chaotic influence like in previous case. Contrary to the 1-D model where the external force does not act the creation of qualitatively new structure, in 2-D model attends the creation of interesting structures. This asymmetric diffusion disturbs the symmetric aspect of the structures, which appear as if they were waft by the wind.

Finally we take into account the potential of arising of ordered structure in the chaotic regime. Despite of our expectance the structure was apparent. From this result it can be concluded that the system transition to the chaotic regime does not suppress the ability of the system to create the structures and that the external force has similar influence on the system as in the non-chaotic state.

The evolution of simple discrete biological systems (viruses, bacteria or macro specimen) was demonstrated using the numerical gap analyses of appropriate logistic equation. It was demonstrated that with the participation of diffusion and proper parameters the systems are able to self-organize themselves. Although it may seem strange, similar inorganic phenomena are known from the real life experience. For example the order of snowdrifts, sand dunes and clouds in the sky or gigantic self-organization processes like were (and are) the creations of galaxies or stars from homogenous matter. It was shown, that described discrete systems based on Verhulst's equation with diffusion are able to self-organization in the modes with two and more stable states and despite the experience in regime of deterministic chaos also. This knowledge has noetic, that means cognitive, aspect, but it is possible that reached results may have the practical application in the field of "bioelectronics", particularly "viral nanoelectronics".

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Processing of the neutron signals and interferograms from the plasma focus device

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The processing of the neutron and deuteron characteristics and processing of the interferograms is one of several themes of my PhD studium. The source of processing signals is the device PF 1000 situated in Institute of Plasma Physics and Laser Microfusion, in Warsaw, Poland. This device is the biggest discharge source of neutron in European Union with neutron yield up to 6×10^{11} per shot. The experiments were processed on this device by the students and workers of CTU Prague since 1994. As a neutron and high X-ray detectors we have plastic scintillation probes of 5 cm thick, equipped with fast photomultipliers,

The probes were situated downstream (at distances of 7.0 m, 16.3 m and 58.3 m), upstream (at distances of 7.0 m, 17.0 m, 30.3 m, 44.2 m and 58.3 m) and side on (at distance of 7.0 m).

For the neutron yield measurement, indium and silver activation counters were used.

The interferometer used in system is the Mach-Zehender type with 16 beams delayed 10-20ns and the NdYAG laser with the parameters energy of the pulse 1J and the length of the pulse 1 ns. Mach-Zehender interferometer is used for precise measurements of refracting of transparent objects, although it is not as sensitive as Michelson interferometer for which the laser beam passes objective volume measured object twice.

The neutron signals are filtrated with using the wavelet transform [1, 2] and neutron energy distribution [3] is calculated for each shot.

From the energy distribution of the neutrons in axial direction and the set of the several shots (7 in our example) we can obtain some others characteristics. We processed the spectral distribution of axial component of deuteron produced neutrons energy as a function of the deuteron energy axial component [4], the distribution of the axial component of deuteron energy multiplying with the quadrate of the deuteron energy as a function of the axial component of the deuteron energy. Futher from that characteristics we calculated the dependence of the energy distribution maximum on the neutron gain, which is approximately linear function. The dependence of the energy distribution maximum on the time between maxims of the signals registered in the distance 7 m in the directions downstream and upstream is approximately quadratic function.

The next step is to obtain the deuteron energy distribution in all directions from the neutron distribution. The basic idea is calculation of deuteron energy distribution with using isotropic distribution for lower neutron energy and distribution with the main component in the axial direction for higher neutron energy.

The resulting dependence was calculated according to the formula (1):

$$n_d(E_d) = \begin{cases} n(E_{dz}), E_{dz} \le E_{dk} \\ n(E_d) - \left(n(E_d) - n(E_{dz}) \frac{\Delta E}{E_{\max} - E_{\min}} \right) (1) \end{cases}$$

The last part of my work for today is concerned on the processing of the interferograms, which a reached from the Mach-Zedenher interferometer. From the reference picture we can calculate the width of the active zone in plasma focus, which is about 2cm. After that we can calculate the density of the deuterons and total number of deuterons in the plasma across the active zone.

The mean density of deuterons, which is the same to the mean density of the electrons, was calculated as

$$n_d = n_e = \frac{N}{A\lambda d}(2),$$

where N is a number of the streaks in definite small area (2cm is choosed), d is the diameter of plasma focus and $A \approx 4.4 \cdot 10{-}16$ is constant, which is obtain the benefit of one electron to the streak displacement.

The results were calculated for 7 interferograms, which were produced in different times of discharge and were brought up to the 3-D graphs

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X-ray Structure Analysis of bio-Macromolecules Active at Extreme Conditions and Their Complexes with Ligands

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Key words: β-galactosidase, cold-active enzyme, X-ray structure, active site

The three-dimensional structures of enzyme β -galactosidase from an Antarctic bacterium *Arthrobacter* sp. C2-2 with bound ligands have been determined at resolutions of 2.2, 2.5 and 3.3 Å. Three complexes with bound D-galactose, D-galactonolactone and IPTG (Isopropyl β -D-1-thiogalactopyranoside) were determined. IPTG is an inhibitor for this enzyme, diffraction data were collected on an in-house source of X-ray radiation using rotating anode. The resolution limit is 3.3 Å. The data for complexes with D-galactonolactone and D-galactose were collected in ESRF in Grenoble using synchrotron radiation. D-galactonolactone is an inhibitor for this enzyme and the D-galactose is a product of the catalyzed reaction.

The enzyme β -galactosidase (EC 3.2.1.23) belongs to the enzyme class called glycosylases which catalyze hydrolysis of the terminal β -D-galactosyl of β -D-galactosides. It is attractive for research and industry because of its wide range of biotechnological applications (to reduce the energy costs, to treat lactose intolerance, to prevent crystallization in sweet products, to increase its sweetening power, to simplify fermentation during production of sourced milk products, to modify the freezing point of ice creams, etc.).

Arthrobacter sp. C2-2 is an Antartic bacterium which is able to exist at low temperature. This enzyme from *Arthrobacter* sp. C2-2 is adapted to low temperature and beres several distiret structural features. The biggest one is that this enzyme forms hexamer with molecular weight of 660 kDa. These hexamers were indicated in solution and in asymetric unit of crysta in contrast to β -galactosidase from *E. coli* which forms homotetramers.

Each monomer consists of five domains and contains 1023 residues. The active site is localized in the TIM barrel domain in the center of each monomer and contains the pair of catalytic residues Glu442 and Glu521. There are two distinct binding modes for the galactosyl group of substrate - shallow and deep. Each binding mode has specific hydrogen bonds between enzyme and ligands. In the cold adapted enzyme, the residue Trp552 is responsible for binding in the deep binding mode and the residue Cys999 for binding in the shallow binding mode. One of the most important differences between the mesophilic and the psychrotropic counterpart is residue 999. In the mesophilic enzyme there is a tryptophane which is replaced by cystein in the psychrotropic enzyme. In previous research it was 34

determined that the necessary condition for binding in the shallow binding mode is presence of trpyptophane on the top of the active site. But in this case, trpyptophane is replaced by cystein. In spite of this, one molecule of ligand was found in the shallow binding mode in the active site of enzyme β -galactosidase from *Arthrobacter* sp. C2-2 in this study.

IPTG is bound in the shallow binding mode. IPTG is located on the top of the active site and in contact with Cys999. IPTG is bound in the very similar position as IPTG in the structure of the mesophilic β -galactosidase. It is an evidence that tryptophane is not necessary condition for binding in the shallow binding mode.

The molecules of D-galactonolactone and D-galactose were found in the deep binding mode. In comparison with the shallow binding mode, the galactosyl moiety is rotated by about 90° and shifted deeper into the active site to rest on Trp552.

The molecule of D-galactose was found in a chair conformation in each monomer. Its oxygen atom 1 is in β -anomer configuration. The galactose 6-hydroxyl binds directly to the sodium ion. The binding is not accompained by any conformational change of the enzyme as opposed to the complex with D-galactonolactone. There is only a small difference between the molecule of D-galactose and D-galactonolactone: D-galactonolactone has the double bond between carbon C1 and oxygen O1 atoms. This small difference causes a large structural change in the case of the complex with D-galactonolactone.

The molecule of D-galactonolactone was found in the active site of each monomer. The 6-hydroxyl binds directly to the sodium ion in all three structures. The binding is accompained by an enzyme conformational change - Phe585 is rotated and the side chain of His335 moved up closer to the active site.

Unit cell parameters are very similar in all three complexes but as far as the complex with IPTG the packing of the hexamers differs.

As a part of the supported research, the crystallization conditions for anhydrolases from different sources were found and optimized. Several obtained crystals were tested using synchrotron radiation in BESSY in Berlin.

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Analysing Software for Complex Interferograms of Laser-Produced Plasma

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Classical interferometry belongs to the key methods in plasma diagnostics. Its far more sophisticated version, allowing reconstruction of up to *three* sets of independent data from just *one* interferogram - the *phase shift*, the *amplitude*, and the *phase shift time derivative* - was developed in the past and became known as *complex interferometry* (CI) [1]. For analysis of recorded data objects (complex interferograms) the fast Fourier transform (FFT) needs to be employed. Hence, for practical applications of CI, special computer software is required. Moreover, to obtain appropriate physical quantities from the reconstructed phase shift, amplitude, and phase shift time derivative, the *Abel inversion* algorithm needs to be used. One such algorithm, extremely fast and potentially very accurate, which is also based on FFT, has been developed in the past [2] and became part of the analyzing software. Many versions of such software for various operating systems have been developed over the last twenty years and they are being routinely used in several laser laboratories all around the world [3].

Due to its *potential* as well as *complexity*, fine tuning of this software is still an ongoing process. In our last major upgrade of this software a new algorithm for the *phase shift reconstruction* was first developed and tested separately in MATLAB. Subsequently it was included as an option in the main software package. This option can be used in cases where besides the usual data a completely signal free complementary interferogram is also recorded. This approach allows omit a rather sensitive side lobe shifting procedure in the Fourier space. And as an important byproduct it also takes care about any rather frequently encountered systematic errors caused by the interferometer setup - either due to imperfect optical components employed or their insufficient alignment.

Another, much more important research activity supported by this grant was connected with *experiments* performed in two laboratories abroad (Hungary – University of Szeged and Republic of Korea – Korea Atomic Energy Research Institute). At both places we were invited to design, assemble, and put into operation the Fresnel bi-prism based Nomarski type interferometers. Subsequently, these interferometers were employed for diagnostics of *laser produced plasmas*. With our software used for analysis of recorded interferograms.

In Szeged the interferometer design was made to allow for complex interferometry in order to measure *spontaneously generated magnetic fields* (SGMF). During two measurement campaigns (4+2 weeks) a successful application of such interferometer was first verified in diagnostics of *sparks* produced by their femtosecond laser in the air. This was followed by laser matter interaction studies performed as a necessary prerequisite for much more complicated SGMF studies. Unfortunately, due to laser related problems which gradually developed and were beyond our control, these SGMF related measurements could not be accomplished during the second campaign. However, the overall success could be demonstrated by the fact that based on our *first* experimental campaign we were invited to perform similarly at KAERI. Moreover, our colleagues from the University of Milan decided to send for the second campaign one of their students to Szeged to learn about these diagnostics.
Our somewhat unexpected one week only visit to KAERI could be regarded as a complete success. The inerferometer itself was designed in advance through mutual consultations. As a result of that we succeeded to make it operational already during the very first day. The remaining part of the week thus became available for experimenting. In this particular case the *cryogenically* cooled D_2 gas (kept under a very high pressure - up to 100 atm) was subsequently released through the *nozzle* into the vacuum chamber creating *clusters* as a result of further cooling caused by the gas expansion. This clusterized gas was then irradiated by a high intensity femtosecond laser. Very fast *ionization* of these clusters with electrons quickly escaping left these clusters *positively* charged causing their subsequent *coulombic explosion*. Velocities which some of these nuclei could gain during these explosions were sufficiently high for D-D fusion to take place in case they would come on a collision course. Existence of such collisions was monitored by measurement of generated *neutrons*.

Dozens of interferograms for various gas backing pressures had been recorded both *with* and *without* the laser action taking place. In the latter case rather *unique* interferograms were obtained containing simultaneously the *plasma channel* (with index of refraction *smaller* than unity) and *neutral gas* regions (with index of refraction *larger* than unity). From the point of the analyzing software application the most important fact was its capability to reconstruct the *phase shift* of both of these distinctly opposite regions simultaneously as well. Naturally, for calculation of corresponding *plasma density* or *neutral gas* profiles it was then necessary to deal with both regions *separately*. Also, it should be mentioned, that in order to fit on the CCD chip both of these regions while keeping maximum possible spatial resolution a very *sophisticated* original optical setup was invented and applied.

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Atmospheric Pressure PE-CVD of Titanium Dioxide Films from Titanium Isopropoxide

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One of the great challenges for thin film deposition methods is to find new technologies which could be clean, easy-to-use for non-stop process and at the same time economically viable. Many low pressure plasma techniques have been developed in the recent years and their efficiency have been largely demonstrated [1], but these low pressure techniques require a large amount of expensive vacuum equipments. Thus the development of a new plasma technology operating at atmospheric pressure which could be more cost-effective for on-line thin film deposition over large surfaces, is a real industrial problem. Among the different discharges already developed to produce plasmas at atmospheric pressure, the dielectric barrier discharges (DBD) are particularly attractive because of their simplicity, cheapness, great flexibility in terms of geometric shape, working gas mixture composition and operating parameters. Thus DBDs are commonly used to produce non thermal plasma usable for many applications such as UV emission, ozone generation, surface modification and flux gas treatment. Under special conditions a diffuse mode of the DBD, so-called atmospheric pressure glow discharge (APGD), exists. It is obviously performed in rare gases, but DBDs are mostly operated in a filamentary mode at atmospheric pressure.

There are many materials which need to improve or change their surface properties without changing bulk properties, e.g. by deposition of thin layers on the material. There is a vast number of thin film deposition methods available and in use today [2, 3]. All methods have their specific limitations and involve compromises with respect to process specifics, substrate material limitations, expected film properties and cost. Among prospective methods can be filed plasma enhanced chemical vapour deposition (PE-CVD). PE-CVD is mostly operated at low pressures, but, recently, some papers already mentioned first attempts of thin layers deposition with atmospheric DBD (ADBD) [4]. The main benefits of PE-CVD ADBD technology would be high speed non-stop processing of large-size products, including thermally sensitive materials, i.e. on-line thin film deposition on different large substrates in a low-priced working gas (nitrogen, argon or air). Atmospheric PE-CVD thin film deposition method would be most certainly attractive for many branches of industry.

In atmospheric pressure conditions the existence of DBD filamentary discharge mode with inhomogeneous character of the discharge is highly probable. Thus there is necessary to find such deposition conditions that would make possible homogeneous treatment of surfaces (and homogeneous thin film production) in the ADBD.

Among metal oxide thin layers TiO_2 layers have found widespread applications due to their electrical and optical properties. These thin layers are widely used e.g. for the photo-oxidation of water, photo catalysis, electrochromic devices, as antibacterial coatings, etc.

Our research deals with a study of an atmospheric pressure PE-CVD process in ADBD. We have investigated the influence of some deposition parameters on properties of TiO_2 layers grown from a TTIP/O₂/Ar gas mixture.

ADBD PE-CVD system consists of plexiglass reactor [(90x79x41) mm], gas input and AC power supply (supply voltage (12.5÷14) kV/50 Hz). The dimensions of electrodes were (45x8x18) mm and (40x17x18) mm, respectively. The greater, grounded, electrode was covered by the glass plate ((70x46x1) mm). Experiments were carried out in air atmosphere (relative humidity of 35–40% and room temperature $20\div22^{\circ}$ C) with inlet gases. Metal organic compound titanium tetraisopropoxide (TTIP) (97%) was used as a precursor. It was heated, evaporated and mixed with argon and then transported into the discharge region. The temperature of the precursor was maintained at approximately 30°C. Gas flow rate was adjusted by means of the mass flow controller. For all experiments 10 minutes deposition time duration was chosen due to results of preliminary tests. Surface morphology of the TiO₂ layers deposited on glass substrates was studied by the atomic force microscopy (AFM) and water contact angle (CA) test (with distilled water drops' size about 0.5 μ l, 60 s duration).

CA measurement results were used for detection of TiO_2 layers wettability in dependence on oxygen or argon concentration in the processing atmosphere. Our TiO_2 layers have very high hydrophilicity (contact angle 5°-10° corresponding to the Ar flow rate 1 l/min and O_2 flow rate 1 l/min and 5 l/min, respectively). Ar flow rate increase to 2 l/min led to rapid hydrophilicity decrease (CA changed to 50°).

The hardness of our layers was qualitatively assessed by a scratch test and adhesion was checked by a simple adhesive tape test. For deposited layers thickness measurement an elipsometer was used. The roughness thickness was about 40 nm. AFM topography (scan size 10x10 μ m) has shown that the best homogeneity thin layers were prepared at precursor evaporation temperature 30°C, Ar flow rate 1 l/min and O₂ flow rate 1 l/min and 5 l/min, respectively. The images of samples prepared with increased Ar flow rate (2 l/min) have shown layers characterozed with a smoother surface but also containing peaks up to 140 nm. Existence of peaks significantly affected results of CA tests.

In conclusion we can report that our results have verified the possibility of TiO_2 layers deposition by ADBD PE-CVD. It seems that the ADBD power is one of critical parameters determining the growth rate velocity and characteristics of the deposited layers. Further studies into morphology and process optimisation are underway.

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Differential Radiography and Tomography Using the Methods of Filters

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In this research project, the differential radiography and tomography as a method of dual energy applicable to filters was being solved. The objective of this study was to suggest such a system that would not only improve the quality of image (better contrast), but as well in case of differential radiography, would determine the thickness of the two-component materials, and in case of differential tomography, would classify the individual components of an object that being tested in a way that the images based on atomic number and density could be achieved. However, the required aim consisted of working out a numerous partial tasks, which was necessary to solve subsequently.

Firstly, the appropriate filters had to be calculated for relevant energies. The use of filters with appropriate thickness of different elements produces a method to quasimonochromatize X-ray beams. In order to conduct calculation, the spectrum outgoing from an X-ray tube had to be known. The simulation of the spectrum by Monte Carlo Code GEANT 4 provides sufficient and necessary data. Computation of transmission through filters uses the supporting table of absorption coefficients as well as the equation for transmittance. Two kinds of filters were considered. So called, pre-filters employ the combination of filters mainly with atomic number higher than 60. The second group, designated as K-edge filters, has a dominant effect at the energy of the K-edge of filters. Therefore, the element type and thickness was suggested and transmission through filters simulated. This study showed that the following types of filters met the best criteria for quasi-monochromatic radiation with respect to the energy in range from 40 keV to 80 keV: 0.25 mm Yb, 0.2 mm Gd, 0.1 mm Sb.

Further, the suggested filters were applied to the experimental measurement of differential radiography. Herein, the differential radiography yields the better contrasted image. Radiography measured at two different energies tuned simultaneously by X-ray tube voltage and current, and applied filters enables us to establish the system of equations for setting thicknesses of the tested multi-components materials. However, the system was incomplete since more than two unknown independent variables occurred. For that reasons the estimation of that unknown input variables was necessary. The obtained results were not enough accurate. The measured thicknesses differ more than required and could be use for the first approximation. Taking into account the knowledge of detector response (efficiency), the measured thicknesses would reach more precise results. The next study following this project will be continuing to achieve the more accurate data.

The area of differential tomography constitutes a phenomenon that could be solved in a few different approaches. Except improving the quality of the image, the two approaches were considered.

The qualitative method is based on the peak photon energy above of the K-edge of the element. When using Gd filter, the method is effective for material with atomic number in range from 55 to 60 (Cs – Nd). When using Yb filter, the method is effective for material with atomic number in range from 58 to 65 (Ce – Tb). The principle of this method is that the above mentioned elements increase their attenuation coefficient while others elements

decrease, and therefore, these elements can be delineated. The application of this approach is limited only to a specific type of elements.

The second applied method deals with a quantitative differential tomography. Since the image acquired from computed tomography represents a matrix of attenuation coefficients determined by the composition and density of each volume element (voxel) the image interpretation for samples with multicomponents is considerably complicated. Measurements made with X-rays in a dual energy system can give enough information to differentiate between density and composition contributions to the image. This system could be solved [1] while regarding monochromatic radiation. For two discrete photon energy peaks, the modeling of the total cross-section at these two energies for all elements which are intended to occur in a sample could be determined. The total cross section is composed of two parts: photoelectric absorption and Compton scattering. The photoelectric interaction is strongly dependent on the atomic number and density of the absorbing medium (the probability approximately depends on $Z^3 - Z^5$); the Compton scattering is predominantly a function of the electron density of the material (the probability approximately depends on Z). Photoelectric attenuation dominates at lower energies and becomes more important with higher atomic number, while Compton scattering dominates at higher energies and becomes more important at lower atomic number... The new parameter k given by the ration of theoretical cross sections for low and high energy measures was calculated. For the range of k for a subgroup of a few elements, the energy dependent coefficients for a defined subgroup were set by fitting.

The parameter k given by the ratio of the linear attenuation coefficients from the two tomograms was assigned to above defined range of k. The energy dependent coefficients deposited into the equation of the total cross section make possible to determine the effective atomic number and consequently the density.

However, this approach performs well when only the monochromatic radiation is applied. In our tomography system, the pertinent arrangements must be carried out to decompose two tomograms into the effective atomic number and density images. To create such a robust system, the other study followed to this project has been just started.

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Numerical Simulation of the Field Tension Infiltration Experiment on Soil with Preferential Pathways

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Transformation of extreme rain events in the watersheds depends largely on infiltration into soil. Infiltration during extreme rain represents the near saturated water flow in the upper soil layer. It was shown in the literature that such flow may be affected by many effects, which are not conventionally considered by models nowadays. This includes slow infiltration into dry soil caused by soil repellency, the preferential flow, temporal changes of hydraulic properties due to various physical reasons (e.g. changes in volume of the entrapped air) or caused by biological processes. Relatively simple methods of measurements of effective infiltration properties of soil, accounting for the above mentioned effects, are disc tension and ring ponded infiltration experiments [3].

Current study is focused on measurements of near-saturated hydraulic properties of soils exhibiting the preferential flow and temporal changes of the hydraulic properties. The field tension and ponded infiltration experiments were conducted to estimate the soil hydraulic properties of the soils with preferential pathways (Dystric Cambisol, Korkusova Hut, Šumava, Czech Republic). The soil under study exhibits preferential flow, as well as dependence of saturated hydraulic conductivity on the water content at the beginning of the infiltration event [2]. Zones of preferential flow were in previous studies shown through analyses of photographs taken during laboratory dye tracer infiltration experiments performed on undisturbed soil samples.

The field infiltration experiment was carried out in a shallow pit for a period of one day. The upper boundary condition was controlled by the tension disk infiltrometer (Soil Measurement Systems, Tuscon, Arisona, USA), the propagation of a water front was monitored by two tensiometers (Irrometer Co.) equipped with electronic transducers (Omega PX 202, Omega Engineering, Inc., USA) installed in the depths of 20 and 40 cm below the infiltration disc.

Infiltration was started with tension - 4 cm and the same pressure head was maintained overnight for 24.5 hours. Then PVC barrier was built around the disc and pressure head was raised to + 2 cm creating ponded conditions. After both tensiometers placed below the area of infiltration reached the positive pressure readings, the infiltration disc was removed (in time 25.5 h) and redistribution started.

Cumulative infiltration fluxes and continuous pressure head data from depths of 20 and 40 cm below the infiltration disc were the direct outputs of the experiment. Additional information about the wetting front propagation in x-y plane was obtained from photographs of the disc surroundings; the wetted area was significantly darker then soil at the initial soil moisture [2].

Soil hydraulic properties were evaluated by inverse modeling of the infiltration experiment. Two dimensional axisymetric numerical simulations were conducted to evaluate the results of the experiment. We used dual-permeability approach based on two interacting water flow domains (matrix and preferential flow domains), each governed by one Richards' equation [1]. The parameter estimator PEST coupled with the simulation code S2D_DUAL [4] were used.

The reference parameters (derived from retention curves which were obtained by standard pressure extractor method) were taken as the hydraulic parameters of the soil matrix. The input hydraulic parameters were subsequently inversely optimized. The saturated hydraulic conductivity of the preferential flow domain and the transfer term were optimized to fit rapid response of the tensiometers after the start of ponded infiltration. Objective function for optimization was defined by means of differences between measured and simulated cumulative infiltration fluxes and suction pressure heads from two depths.

Results from experiments on Cambisols have shown that the dual permeability approach produces significantly better fit to the observed pressure and flow data than the single porosity model. We successfully simulated the rapid increase of water front velocity after the change of upper boundary pressure to ponded conditions. The simulated propagation of the wetting front at the surface around the infiltration ring is in very good agreement with the observation.

The method based on tension and ponded infiltration combined with the simultaneous monitoring of pressure heads seems to be a promising method for estimating the near saturated hydraulic properties of Cambisols. The mathematical model based on dual-permeability approach is a good tool for numerical simulations.

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Aberration properties of deformed mirror

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The shape of the wave-front that is transformed by an optical element is changed depending on its properties. This fact can be used in many areas of science and technology e.g. in the field of adaptive optics that deals with the problem of the wave-front correction. Nowadays, a great attention is paid to the design and development of special optical elements that enable to change continuously some of its properties. Such optical elements can be used for defined shaping of the transformed wave-front. These elements are based on the use of some basic optical phenomena (mostly the reflection and refraction of light, diffraction and polarization). Our work deals with the aberration properties of the deformed mirror that enables to transform the shape of the incident wave-front in relatively wide range and with sufficient speed. Depending on the construction of the mirror it is possible to design deformable mirrors that can partially or rather fully compensate the aberration of the incident wave-front. The wavefront reflected from such mirror will have the desired shape (e.g. plane or spherical wavefront) or the residual aberrations of this wave-front will be reduced to acceptable value. Our work presents a detailed analysis of the properties of a simple planar deformable mirror from both the aspect of the analysis of the shape of the reflecting surface of the mirror and the mechanisms that enable us to reach this desired shape. Finally, a simple experimental device for practical realization of the optical system for wave-front correction is proposed.

Imaging by optical system

The point spread function (PSF) that gives us the distribution of intensity of light in the image of a point source is the basic characteristic of imaging properties of optical system [1]. Many factors can influence the PSF e.g. wavelength of light, aberrations of optical system, the shape of the pupil and the transmittance of the optical system. The PSF can be further influenced by the properties of the object or image space medium e.g. its inhomogenity i.e. the dependence of the refractive index on the coordinates n = f(x,y,z) etc.. Spherical wave-front Σ is transformed by this optical system to wave-front Σ' the shape of which is different from the ideal spherical wave-front Σ_0 ' that would be formed by the ideal optical system. Assuming the geometrical optics theory an ideal image of point *A* would be imaged as point A_0 '. The optical path difference *W* between the real wave-front Σ' and the ideal wave-front Σ_0 ' is called the wave aberration. Point spread function is given by the function I(x',y') representing the intensity of light in the image plane (when imaging a point source *A*).

In case of diffraction limited optical system i.e. optical system that is affected only by the diffraction of light the normalized PSF is given by [1, 2]

$$I(x',y') = \left[\frac{2J_1(\alpha)}{\alpha}\right]^2, \ \alpha = \frac{2\pi}{\lambda}\sqrt{x'^2 + y'^2}\sin u'_{\max}$$
(1)

where λ is the wavelength of light in the image space and u'_{max} is the maximum value of aperture angle in image space of given optical system. Due to the fact that the PSF of the real optical system can be very different from the PSF of the diffraction limited optical system there is a need of some methods that enable us to correct (minimize) the influences that result in such difference. This can be achieved in many different ways. We will show a simple method for the wave-front correction that is based on the deformation of a planar mirror.

Deformation of a plate

Assume a planar plate of circular shape that is fixed at its edge and exposed to a uniformly distributed load. Let's have a round plate with radius R and thickness h. Furthermore r is the distance of the investigated point from the center of the plate and p is the pressure that acts on the plate. When we assume a plate with a finite value of thickness the relation for a flexure w is given by [3]

$$w = w_4 r^4 + w_2 r^2 + w_0, \ w_4 = \frac{p}{64D}, \ w_2 = -\frac{p}{64D} \left(2R^2 + \frac{4h^2}{1-\mu} \right), \ w_0 = \frac{p}{64D} \left(R^2 + \frac{4h^2}{1-\mu} \right) R^2$$
(2)

where μ is the Poisson ratio and E is the Young's modulus of elasticity of the plate material.

Correction of the wave aberration by the deformation of a mirror

Assume that the shape of the reflecting surface of a deformed mirror is given by the previous relation and the incident wave-front is given by

$$W = W_{20}r^2 + W_{40}r^4 \tag{3}$$

After the reflection from the deformed mirror the wavefront W_r will be given by

$$W_r = 2w - W - 2w_0 = A_2r^2 + A_4r^4, \ A_2 = 2w_2 - W_{20}, \ A_4 = 2w_4 - W_{40}$$
(4)

The Strehl definition (SD) is then given by

$$SD = 1 - \left(\frac{2\pi}{\lambda}\right)^2 E_0, \ E_0 = \overline{W_{ref}^2} - \overline{W}_{ref}^2 = \frac{1}{12}A_2^2R^4 + \frac{4}{45}A_4^2R^8 + \frac{1}{6}A_2A_4R^6$$
(5)

where

$$\overline{W_r^2} = \frac{2}{R^2} \int_0^R W_r^2 r dr, \ \overline{W_r} = \frac{2}{R^2} \int_0^R W_r r dr$$
(6)

By the deformation of a mirror due to the change of the pressure p one can maximize the Strehl definition SD.

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The Crystal and Magnetic Structure of Double Perovskites La2-xSrxCoRuO6 (x=0.6 and 1.4)

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The crystal and magnetic structures of the $La_{2-x}Sr_xCoRuO_6$ samples x=0.6 and 1.4 were investigated using the neutron diffractometer KSN-2 in Rez near Prague using the neutron wavelength λ =1.365. The results show that both compounds retain a high ordering (95(3)%) and 84(4)%, respectively) of Co and Ru ions in the alternating sites of the double perovskite. This ordering, combined with important octahedral tilts, is described within the structure of monoclinic P2₁/n symmetry and enlarged $\sqrt{2a_p} \ge \sqrt{2a_p} \ge 2a_p$ unit cell with respect to simple cubic perovskite. The cell parameters refined at RT are a=5.5865(8) Å, b=5.5802(5) Å, c=7.886(1) Å, V=245.84(4) Å³ for x=0.6 and a=5.5810(3) Å, b=5.5410(3) Å, c=7.8364(6) Å, V=242.34(4) Å³ for x=1.4. The extent of the octahedral tilt is 11.5° and 7.5° for x=0.6 and 1.4, respectively (average Co-O-Ru angle 157° and 165°). The bond lengths in the CoO₆ and RuO₆ octahedra are <Co-O>=2.057(7) Å, <Ru-O>=1.962(7) Å for x=0.6 and <Co-O>=2.014(9) Å, <Ru-O>=1.944(9) Å for x=1.4. These values are consistent, when compared with distances reported for the Co^{2+}/Ru^{5+} compound x=1 (LaSrCoRuO₆) [1,2], with assumption that Co ions in x=0.6 remain divalent and the average Ru valence is decreased to 4.6. In x=1.4, the Ru ions remain pentavalent and the average Co valence is increased to 2.4. The same trends has been derived from our preliminary LDA+U band structure calculations for x=0, 1 and 2 – increase of the number of 4d electrons in the Ru atomic sphere on adding of electron and decrease of the number of 3d electrons in the Co atomic sphere on removal of electron. The calculations show, however, that mentioned valence assignment is only of formal validity since the extra charge are partly attracted by the La and Sr sites and the rest is distributed mostly out of the Co and Ru atomic spheres due to strong hybridisation of 3d and 4d levels with oxygen 2p states.

The determination of magnetic structure was performed based on the neutron diffraction diagrams taken at 8K. Rather weak extra reflections due to AFM ordering were observed in the positions given by propagation vector along the pseudocubic 111 direction, in particular $k=\frac{1}{2}$ 0 $\frac{1}{2}$ with respect to the crystallographic P2₁/n cell. The magnetic arrangement is thus the same as determined for x=0 and 1 by Bos and Attfield [1]. To illustrate the kind of magnetic ordering, it is useful to view metallic sites in the double perovskite as two interpenetrating f.c.c. sublattices consisting of Co and Ru, respectively. The observation of the lines with $k=\frac{1}{2}$ 0 $\frac{1}{2}$ defines that AFM arrangement in each sublattice is of type II, consisting of ferromagnetic 111 planes. Such type is observed commonly in cobalt double perovskites with second non-magnetic metal like LaACoNbO₆ (A=Ba, Sr, Ca; T_N=10-17 K) or La₂CoTiO₆ (T_N=20 K) while the AFM arrangement of type I consisting of ferromagnetic planes 001 is reported for ruthenium compound Sr₂YRuO₆ (T_N=26 K) [3]. In the present case, the coexistence of two AFM arrangements of type II means that the spins in 111 planes in succession Co-Ru-Co-Ru alternate as +/+/-/-, but it cannot be distinguished from the powder neutron diffraction data what are the relative moments and orientation of spin axes in the Co

and Ru subsystems. Our LDA+U calculations show that spins are non-zero for both subsystems and their magnitudes are comparable. Under this assumption the refinement for x=0.6 and 1.4 gives the magnitudes of long-range ordered moments $\mu(Co) \sim \mu(Ru) \sim 1.0-1.1 \ \mu_B$. It can be noted that the long-range ordered moments reported for LaSrCoRuO₆ [1] are larger, $\mu(Co) \sim \mu(Ru) \sim 2 \ \mu_B$, but also reduced compared to the full theoretical value $\sim 3 \ \mu_B$.

In summary, the La_{2-x}Sr_xCoRuO₆ double perovskites with x=0.6 and 1.4 are mixedvalency oxides with hoping conduction of the n and p type, respectively. The neutron diffraction combined with the magnetic susceptibility measurements show that the samples are magnetically ordered with T_N determined to 60 K for x=0.6 and estimated to 60-80 K for x=1.4 . The observed AFM arrangement of type II in both the Co and Ru sublattices demonstrates that the nearest-neighbour interactions Co-O-Ru are marginal and ordering is governed by the 180° Co-O-Ru-O-Co AFM exchange paths [4]. The existence of competing 90° Co-O-Co AFM exchange paths results, however, in magnetic frustration that might be responsible for rather low values of long range ordered moments detected by neutron diffraction. Another source of frustration is the coupling of the Co and Ru AFM type II configurations, which is forbidden by symmetry if respective spin axes were collinear but Dzyaloshinskii-Moriya interaction becomes effective for perpendicular orientation .

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Study of Fusion D-D Reaction at CTU in Prague

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The plasma focuses are simple and effective sources of neutrons produced from deuterium-deuterium (D-D) reaction [1], [2]. Neutrons can be used as a convenient tool for the diagnostics of the fast deuterons with energies above 10-20 keV. The summery of possible acceleration mechanisms responsible for the generation of ions is presented in [3]. These mechanisms are probably composed from different kinds of the high electric field generation, e.g., anomalous resistivity, fast movements of the plasma column, transformation of internal magnetic field and decay of plasma microstructures.

In this paper we present the results obtained on the PF device which have so-called anti-anode of different shapes and configurations. We compare the influence of various electrode configuration on the hard X-ray (HXR) and neutron production.

We use the Mather type of electrode configuration. The diameter and the length of the copper anode are 2.7 cm and 11 cm, respectively. The cathode is formed from 12 steel rods, each of 6 mm in diameter and 19 cm in length. The diameter of the cathode cylindrical configuration is 6 cm. The copper cylindrical anti-anode has the diameter of 2.7 cm and the distance between the anode and anti-anode is 1-2 cm. We use a configuration with the anti-anode to study an influence of the length of the pinching plasma column on the neutron production.

Total energy of the capacitor bank of 3 kJ is obtained at the charging voltage of 15 kV. The maximum of the current of 200 kA is reached within 2 μ s. The initial pressure of deuterium in the discharge chamber was 700-900 Pa.

We used the following set-up of diagnostics. A calibrated Rogowski coil registered the discharge current, a high voltage probe detected the discharge voltage and a loop probe registered the current derivative. For detection of soft X-rays we used the silicon PIN detector filtered with an Al 1.5 μ m foil, a microchannel-plate detector split into 4 quadrants in the photon energy range above 10 eV without any filter with 2 ns exposure time and delay between exposures 10 ns, and a time integrated XUV spectrometer. Fast plastic scintillation detectors of 5 cm thickness equipped with fast photomultipliers Hamamatsu R1828-01 enabled a detailed time-resolved measurement of neutron emission and hard X-rays above 100 keV (such X-rays penetrated steel and lead shielding).

The time delay between the current onset and the pinch phase, when X-rays and neutrons were generated, varied in the range of $1.5 - 1.7 \,\mu$ s. The pinch phase was characterized by the deep of the current derivative. The minimum of the deep of the current derivative was chosen as the time zero 0. In the following paragraph we present the results of neutron, hard X-ray (HXR) and XUV frame diagnostics.

The number of neutrons detected end-on Nz is in average higher than that detected side-on Nr (anisotropy Nz/Nr is above 1). While the number and energy of produced neutrons depends on the angle between fast deuteron and produced neutron and while the number of neutrons produced at the angle 0^0 and 180^0 (to the z-axis) is higher than the number produced at the angle 90^0 , then the fast deuterons producing neutrons move dominantly along the axial direction toward target deuterons.

The neutron yield and FWHM of neutron signals decrease with the decrease of the distance between the anode and anti-anode, whereas the amplitude of the neutron signal is

independent on this distance. Decrease of both neutron yield and FWHM in the shots with anti-anode can be caused by a smaller region for acceleration of fast particles and for collisions of fast deuterons with target deuterons.

Face-shape of the anode influences the direction of deuterons producing neutrons. Deuterons at the plane anode move dominantly in end-on direction. In shots with half-spheres anode face, the important part of fast deuterons producing neutrons moves upstream and/or side-on in the first 10-15 ns.

The presence of anti-anode enabled a detail study of characteristics and common correlations of short pulses of HXR and neutrons in duration up to 10 ns. Two observed pulses could be generated from two pinches formed early near the anode and later near the anti-anode. Short pulses confirm the conclusion, that neutrons are emitted in the same time as HXRs.

A wide energy range up to 2.7-3.1 MeV and high anisotropy of registered neutrons confirm a dominance of a beam-target mechanism of neutron production from D-D fusion reactions.

Information about evolution of the plasma column pictures during neutron emission was obtained from XUV frames. Intensity of XUV-ray emission was near the boundary of the sensitivity of detector, therefore we could not use any filter. The radiation observed in pictures was emitted both from the evaporated copper near of electrodes and from the densest part of the deuterium pinch in form of bremsstrahlung. Second difficulty of XUV registration was caused with variation of the time of the pinch of 100-200 ns.

The minimal energy of photons detected by MCP 10 eV registered in frames is below the threshold registered with PIN detector (200 eV) and considerably below the energy of HXRs (above 30 keV). The structures imaged in the frames are observed in better temporal correlation with PIN detector signals than with HXRs. Interesting frame structures are registered in the shots with low neutron yield at the time of the pinch, whiles only poor emission between electrodes is observed at the time of HXR and neutron emission. During the high HXR and neutron emission, we observe usually emission of the near-electrodes areas.

The dip of current derivative correlates with the pinch of current sheath imaged in XUV frames. In the shots with high neutron yield, the increase of the HXR and neutron signals start at the time of the deep minimum. The pinches and instabilities are observed mainly in the shots with lower neutron yield.

The interelectrode structures emitting XUV were registered usually at the time of onset of the HXRs.

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Growth of CNT by capacitively coupled CVD reactor

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Carbon nanotubes (CNTs) have attracted much attention in the past several years because of their unique and potentially useful structural, electrical and mechanical properties.

In the presented work we report on role of the growth temperature and the effect of the catalyst layer thickness in determining the nanotubes structure.

For this purpose, thin films with thickness from 0.9 to 12.5 nm of Ni catalyst were deposited onto Si/SiO₂ substrates using thermal evaporation method. After Ni deposition the films were thermally treated (~ 800°C) in hydrogen (H₂) atmosphere to provide formation of separate catalyst nanoislands using an ellipsoid microwave plasma reactor (AIXTRON P6). After the annealing process, CNTs were grown by radio frequency plasma enhanced CVD process. Gas mixture of methane and hydrogen was used as the source gas and the flow rates were 20 and 60 sccm, respectively. The substrate temperatures ranged from $250 \div 610^{\circ}$ C. After stabilizing the substrate temperature, the depositions were carried out for 15 min in stable discharge at power of 450 W.

The morphology and the structure of grown nanotubes are investigated by Scanning electron microscopy (SEM), Energy dispersive X-ray analysis (EDX) and Raman spectroscopy.

Influence of the deposition temperature on CNT growth

Influence of the deposition temperature on the growth of CNT was studied for three different temperatures.

The sample deposited at the lowest temperature, i.e. 250°C, exhibits non-homogenous features. The surface looks like an amorphous carbon layer with isolated Ni particles which are partially embedded in the layer bulk. The sample was grown at medium temperature. A development of 3D-like structures is observed. However, poor density of CNTs is observed which indicates that this temperature range is still too low to obtain a CNT growth. When the deposition temperature increased up to 560°C, a clear evidence of CNTs presence is observed. The nanotubes have been grown at relatively high density and they are partially ordered in vertical direction. The outside diameter of grown CNTs is in the range between 20 and 35 nm.

The EDX measurements demonstrate that the intensity of Ni coverage increased with the temperature increasing from 250°C to 560°C. This observation indirectly indicates that bright Ni particles should be preferably situated on the top of the formed tubes. Based on this observation we assumed that the CNT growth was controlled by the tip-growth mechanism [1].

Raman measurements of the deposited samples show no significant differences among the spectra of the observed samples. The peaks at 180 and 200 cm⁻¹ are characteristic for all samples. These peaks are usually assigned to the radial breathing mode (RBM) of single-walled nanotubes [2]. The Raman spectra collected at higher wavenumbers reveal three broad bands for all temperatures studied. One of them is located at 1320 cm⁻¹ known as D-band. The 50

second one lies at around 1580 cm⁻¹ known as G-band. D-band arises from amorphous carbon or defects in the nanotube walls, while G-band corresponds to the graphitic sheets of the CNTs. Similar spectra were observed by Antunes et al., whereas D-band was positioned at $1320 \div 1324$ cm⁻¹ and G-band was centered at $1555 \div 1572$ cm⁻¹ [3]. The third broad band which is centered at 970 cm⁻¹ is assigned to the second order vibration mode of the silicon substrate.

Influence of the catalyst layer thickness on CNT growth

The influence of the catalyst layer thickness on the growth of nanotubes was studied for different Ni thicknesses varied in the range from 0.9 to 12.5 nm. The deposition temperature for nanotubes growth was 610°C. Other deposition parameters like total gas mixture, total power, etc. were constant for all samples deposited.

For catalyst thickness of 0.9 nm, the very thin tubes with low density are observed. The diameter of grown nanotubes was from 30 nm to 60 nm. For Ni thicknesses of 3.2 nm and 6.2 nm, the tubes are partially ordered in vertical direction with diameters in order from 30 nm to 80nm. When the Ni layer thickness was increased to 8.7 nm, the nanotubes with rectangular-like shapes were observed. The diameter of grown nanotubes was from 30 nm to 200 nm. This result indicates that the nickel layer is too thick. For Ni thickness of 12.5 nm, the bunching of Ni structures was observed.

Based on these observations we conclude that appropriate thickness of catalytic layer for forming Ni nanoparticles lies in the range up to 6.2 nm.

Raman spectra of nanotubes grown at different Ni thicknesses were again observed RBM peaks at 180 and 200 cm⁻¹ for all the samples. The two most prominent peaks at ~ 1320 cm⁻¹ (D) and ~ 1590 cm⁻¹ (G) were detected at wavenumbers lower than 2000 cm⁻¹. The intensity of the D and G bands for all Ni thicknesses were relatively similar, with the exception of the sample grown on 8.7 nm Ni layer show weak intensity of D and G peaks. Similar results were obtained by Chhowalla et al..

In summary, CNTs have been synthesized and their morphology showed a dependence of CNT growth on the substrate temperature. For our experimental setup, the minimum substrate temperature required for an effective growth of CNTs was 560°C. The relation between the nickel thickness and morphology of formed structures was investigated. It was found that the increasing the Ni thickness resulted in change of formed particles from island-like to rectangular one. The appropriate Ni thickness, which results in formation of island particles, was found 6.2 nm. Raman measurements indicated presence of CNTs in the whole investigated temperature range.

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Commissioning Experimental Setup for TOTEM Roman Pot

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Introduction:

The Department of Physics at the Faculty of Mechanical Engineering continues its collaboration with the International Laboratory for Nuclear Research, CERN. Since 2006 we performed testing measurements of the vapor cooling circuit for the TOTEM Experiment [1]. The preparation stage has ended during summer 2008 and it is followed by the final stage of commissioning and an actual installation of Roman Pot detectors in the LHC tunnel.

The main goal of the TOTEM Experiment is to measure the total cross section, elastic scattering and diffractive processes at both sides of the CMS detector at the Large Hadron Collider (LHC) at CERN.

The TOTEM Experiment consists of two pairs of tracking telescopes and 4 Roman Pot (RP) stations containing up to 24 Roman Pots. The RP is a vacuum vessel separated from the primary vacuum of the LHC beam pipes by a thin steel envelope. Ten thin silicon edgeless detectors in each RP measure events in the halo of the beam very close to its center. The silicon detectors require operating temperature below -15 °C. The dissipated heat from the detectors' electronics reaches up to 30 W. Each Roman Pot is therefore equipped with two evaporators and two capillaries and a fluorinert based cooling circuit with its central compressor unit located in one of the supporting cavern of the CMS detector supplies refrigerant to the structures to evacuate dissipated heat.

The Roman Pot detectors are installed one at a time during planned LHC shutdown. Each Roman Pot has to undergo a thorough commissioning measurement testing all its systems, thermodynamic properties and vacuum tightness. This measurement takes place in building 887 in Prévessin at the H8 beam line facility providing low energy muons from the Super Proton Synchrotron (SPS). The experimental set up is equipped with a versatile cooling circuit prepared by the Department of Physics of the FME of the CTU in Prague.

The running parameters are monitored by a large number of sensors around the cooling circuit and by sensors installed inside the Roman Pot itself. There are two Pt100 sensors located near the silicon detectors and four Pt1000 sensors on both ends of the evaporators. The DAQ system is based on the ELMB technology and it is used for monitoring of the commissioning runs.

Each RP, after its assembly, passes a test for leak-tightness and then it is installed in to the test stand in Prévessin and connected to the cooling circuit and DAQ systems. If the SPS is out of operation, the RP is installed in horizontal position and the detectors are tested using cosmic rays. All RP connections are pressurized with nitrogen and monitored for several hours to assure a leak-tightness. As soon as the RP is evacuated and ready to be cooled down, the cooling system is turned on. It takes about half an hour to stabilize the system before the liquid line to the RP detector unit is opened. The active electrical systems of the RP detector unit are switched on as soon as the RP reaches stabilized conditions. During measurement all functions and operation modes are tested and two inner vacuum pressure sensors are calibrated.

After the measurement the RP has to stay evacuated in order to prevent any condensation on vulnerable inner detector silicon surfaces. Once the RP is warmed above the dew point, it is disconnected from the circuit and prepared for transport and installation at its final destination in the Pit.

Results:

There were two successfully commissioned Roman Pots so far. Both have already been installed at one side of the CMS detector, 220 m from its interaction point. There is the third Roman Pot connected and it undergoes the process of commissioning. Temperatures inside the Roman Pots are reaching required limits, i.e. well below - 20°C on the silicon surface. Very complex structure of the detector and geometrical limitations required thin evaporators which show considerable pressure drop. The cooling system has therefore a slightly lowered efficiency. For the next generation of Roman Pots new ways of cooling of the detectors are being currently developed.

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Program Neutrons for Reconstruction Time-Resolved Neutron Energy Spectra: Possibilities and Limitations

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Program Neutrons is used for reconstruction of the time-resolved neutron energy spectra of fusion neutrons released from $D(d,n)^3$ He reaction in Z-pinch experiments. The reconstruction is based on the type of the time-of-flight (TOF) methods which determine the energy spectrum from several time-resolved neutron signals. The experiment consists of a recording of signals in a chain of neutron detectors placed at various distances from the neutron source [1]. There are several types of neutron detectors relevant for TOF measurements. We use scintillation detectors which consist of a fast plastic scintillator (Bicron BC-408, 45 mm thickness and 50 mm or 120 mm in diameter) and a fast photomultiplier (Hamamatsu, head-on R1828-01). The temporal resolution of our detectors was determined below 5 ns in FWHM for neutrons with energy 2.45 MeV.

The reconstruction of the energy spectra is based on the Monte Carlo (MC) method [1] which has been improved by simultaneous usage of neutron detectors placed on two opposite directions from the neutron source. The anisotropy of neutron energies and the anisotropy of differential cross-section (by extension, anisotropy of neutron fluxes) [2] were calculated on the basis of the kinematics of the binary fusion system applied specifically to the $D(d,n)^{3}$ He fusion reaction.

Program Neutrons has been developed in FORTRAN language since November 2005. During last year (2008), many numerical tests were performed to demonstrate the efficiency of the reconstruction and to study the influence of the some parameters on the reconstruction of the energy spectra. During these tests the number of events, number of reconstruction rounds during the reconstruction with neutron signals from both detection direction, number of detectors, the energy resolution, comparison between reconstruction with neutron signals from one and two direction of the detection, reconstruction with small number of detectors, and influence of the scattered neutrons were examined. The whole processing chain was considered in these numerical tests: i) simulation of signal acquisition, ii) preparation of data as input for the reconstruction program, iii) reconstruction process, and iv) the analysis of its output. The simulation of neutron signal acquisition at different distances were performed with the assistance of the another program. Besides the qualitative evaluation, two statistics were used to assessment of the reconstructed time-resolved spectra and TOF signals. The first is the Pearson's correlation coefficient, and the second is the chi-square coefficient.

Some possibilities, recommendation, and limitations of the reconstruction program followed from accomplished above mentioned numerical tests:

• Recommended number of neutron detectors used in the experimental setup is 6 (3 in one direction and 3 in the other direction). Minimum number of neutron detectors is 4 (2 in each direction).

- Number of neutrons (i.e. events in MC simulation) depends on the resolution of the reconstructed spectrum. Recommended number of events is in range from 2 to 8 per one pixel of the spectrum.
- Recommended number of reconstruction rounds is no more than 5.
- Energy resolution of this method must be estimated numerically for each experimental setup (for different number and positions of detectors, for different times of neutron production). Energy resolution could be only a few tens of keV.
- Estimation of the time evolution of neutrons is not recommended from reconstructed spectrum (by integrating the time-resolved energy spectra in energy). Better estimation is from the nearest detector.
- The component of the deuterons which produced neutrons could be estimated only in the direction of the neutron detection.
- Special procedure for data processing from small number of detectors is already done and used in the processing of data from experiments in the S 300.
- Scattered neutrons play an important role in the reconstruction. We find out that the influence of scattered neutrons can be eliminated by using neutron signals from both directions. When we reconstruct time-resolved neutron energy spectra from signals in one direction, scattered neutrons shift the energy spectra towards the lower energy. When we use neutron signals from both directions, scattered neutrons do not shift the energy spectra but shift the time of neutron production. This disadvantage is not so important because we do not determine the time of neutron production from reconstructed time-resolved neutron energy spectrum but from the nearest neutron detector.

Presented reconstruction program Neutrons has been used in the processing of data from experiments in the PF-1000 facility (placed at IPPLM in Warsaw) and S 300 facility (placed at KI in Moscow). The last papers where the program Neutrons is used for reconstruction of the time-resolved neutron energy spectra can be found in ref. [3, 4].

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A partial Upgrade of the ATLAS Innner Detector Cooling System

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Introduction:

The fundamental design of the ID evaporative cooling [2], based on a standard industrial direct expansion cooling system, is finished. The system is designed to be as simple and robust as possible to minimize maintenance while being as low mass as possible to reduce material in the tracker volume and in front of the calorimeters. All of the components of the system have been prototyped, tested on an evaporative system in the laboratory with a subset tested in the ATLAS ID. As far as possible, they have been shown to work for the full range of operating conditions expected during the lifetime of the ATLAS experiment. Some of the pressure drops, most notably in the vapor lines of the SCT barrel, are higher than the design requirements due to the limited space and the geometrical constraints. However, this should not affect the operation of the tracker until significant radiation damage has occurred after several years of operation. Nevertheless some "room"for a partial improvements of the system has been observed during the commissioning runs [3].

The main goal of the additional tests in 2008 was aimed to improve the heater control system both for the SCT and Pixel part of the cooling system [1]. Some new sensors were also tested, namely for the backpressure (BPR) control and Soclair converting boxes were examined for the use of NTC sensors as the input signals to the PLC heaters control.

The team of the Department of Applied Physics at the Faculty of Mechanical Engineering of the CTU Prague performed the following measurements during last year, mostly at CERN:

- Measurements performed with SCT barrel and forward sector heaters were prepared to find the optimized PID parameters for the PLC control system. Main purpose of the test was to find most convenient parameters of the PID controller of the heater. The parameters should assure stable behavior of the heater at conditions of either different high subcooled liquid pressure varying from 11.0 bar to 13.5 bar or various evaporative pressure, i.e. the nominal one equal to 2.0 bar ('cold mode') or 4.0 bar, which corresponds to a so called 'warm run'. Average values of the efficient parameters were found in the range of 5-10-2 and 6-7-2, respectively.
- 2. Similar measurements were executed for the Pixel type of the heaters and more detailed study was devoted to the heater orientation, i.e. its position with refrigerant flow along and against gravity. Several PID parameters were also tested for shock power dissipation in the range 0 220 0 W on bistave. This was done for nominal parameters $p_{BFC} \sim 13.5$ bara, $p_{evap} \sim 2$ bara (~ 4.2 g/s) and following PID parameters 5 25 12, 60 20 10, 80 20 10, 100 20 10 were investigated. The best response seemed to be for 80 20 10.

- 3. Two Soclair Electronics boxes characteristics and conversion features between Ohms and mA signal; respectively between T and mA signal were studied. The boxes exhibit reasonable linearity. Their use for the heater control might be preferential if the span of the Ohm scale between 0 and 100 kOhm would transform signal to the range between 4 mA and 20 mA. Reasonable accuracy in temperature monitoring will be difficult to achieve with existing boxes taken "out of shelf" since we are limited by PLC resolution in mA. The use of the Sinclair Electronics boxes was not recommended for the intended application.
- 4. The last experimental study was devoted to the verification of the AST pressure sensors. Investigated type AST 4100 compact pressure sensors with output signal in mV exhibited reasonable linearity and repeatability and have shown a resistance to the strong magnetic field as well. These sensors were recommended for the upgrade purposes.

Results:

Optimized PID parameters have been found for the heater control by PLC both for the SCT and Pixel heaters. The Soclair conversion boxes were investigated in details and their use was not recommended for the application. Several pressure transducers of the type AST 4100 were tested and they have met all requirements for the upgrade of the cooling circuit control system of the ID ATLAS.

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Two-Rods Sensor Installation Method and Its Effect on Applicability of TDR Method for Moisture and Salt Concentration Measurement

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For the experimental assessment of moisture content in porous building materials, several different types of methods and approaches were developed and tested till now. Among them, indirect methods based on measurement of another physical quantity having clear relation to moisture changes are very often used in materials research as well as in building practice. The time domain reflectometry (TDR) method is dielectric method, based on an analysis of the behavior of dielectrics in a time-varying electric field, and consists in the measurement of permittivity of moist porous media.

The current state of the TDR measuring technology can be characterized as very advanced but its development is still far for completed. The experimental setups used in various scientific laboratories are being continuously improved and refined to achieve higher accuracy and to get more information from the measured data. Also, investigation of new materials leads to further adjustments of the technology. It can be anticipated that the development of the TDR method will continue rapidly in the near future and its application will spread to other fields of research and other materials.

The TDR method was originally developed for measurement of liquids and loose or soft solid materials [1], [2]. The originally designed sensors and measuring technology were developed with regard to these materials. On this account, when we would like to apply the TDR technology for measurement of solid building materials, the measuring procedure has to be adjusted.

In this paper we have focused on one of the most serious problems of TDR method application, which represents sensors installation into the measured material. Therefore, three different experimental approaches of TDR sensors installation are studied in this work. In the experimental part of the paper, moisture content changes in ceramic brick samples were monitored for specific methods of sensors placing. A two-rod miniprobe LP/ms, manufactured by company Easy Test and designed by Malicki et al. [3], was used for the measurement of complex relative permittivity in three different approaches for sensor installation. The sensor is made of two 53 mm long parallel stainless steel rods, having 0.8 mm in diameter and separated by 5 mm. The sphere of influence of the applied sensor creates the cylinder having diameter about 7 mm and height about 60 mm, circumference around the rods of sensor.

The first studied method of sensor installation consists in boring of two parallel holes having the same dimensions as the sensor rod. For good contact of sensor with material, the bored powder of the studied material was partially placed back into the bored holes.

The second method is based on application of electrical conducting gel that is placed into the bored holes and ensures the ideal contact of rods and wet material.

In the third method, the samples of studied materials are cut into two parts and the slots having similar thickness as sensor rods are recessed on one of the sample parts.

All the measured samples were after the sensors placing partially saturated by water and insulated to prevent water evaporation. The complex relative permittivity of wet samples was then continuously monitored until the measured values reached the constant value. Then, the experiment was interrupted, sensors removed from the samples and moisture content in the samples was determined using gravimetric method. Finally, the measured values of permittivity were assigned to the gravimetric moisture content. In this way, the empirical calibration curves for specific method of sensor installation were assessed.

From the obtained results we can conclude, all the investigated methods of sensor installation are applicable for moisture content measurement by TDR method in solid materials. However, their empirical calibration by reference method is necessary for any particular method of sensor installation and any measured material. On the basis of measured results we can assume that the tested methods of sensor installation will find use also in measurement of moisture content in materials containing higher amount of water soluble salts and also for determination of concentration of these salts.

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Structure Analysis of Chemisorbed Faujasite Aluminosilicates by Powder Neutron Diffraction

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The research activities at the Laboratory of Neutron Diffraction (Faculty of Nuclear Sciences and Physical Engineering CTU Prague) are focused on neutron scattering for solid state physics and materials science investigations. Results of the zeolite (types: NaY, NaX, NaLSX with chemisorbed species) studies obtained on the KSN-2 diffractometer by powder neutron diffraction method in the frame of MŠMT grant No. MSM 6840770021 during last fourth years are summarized.

Chemisorbed methyl groups in the zeolitic lattice belong to the most important problems of surface chemistry. Knowledge of structures has been quite important for developing new materials, as well as for tailoring properties of existing materials. To understand the properties of zeolites it is necessary to determine the structure arrangement of these microporous compounds.

Theoretical investigations [1] demonstrated that chemical properties of protons are controlled by actual basicity of the lattice oxygen atoms and by the character of bonds where protons are attached. It is well known that chemisorbed carbenium ions on zeolites and other alumosilicates are bonded to basic lattice oxygen atoms, forming thus surface alkoxy species [2]. Experimental support was obtained also from the results of diffraction methods, where namely neutron diffraction provided direct evidence on the location of protons in faujasites with various H+/Na+ ratio [1,2].

Well-developed crystals of NaY, NaX and NaLSX with high content of sodium cations and with low content of defects and decationation were used in our studies. Chemical composition of investigated dehydrated zeolites of NaX and NaY was

 $Na_{80.0}Ca_{1.2}[(AlO_2)_{82.4}(SiO_2)_{109.6}]$ and $Na_{48.9}Ca_{1.6}[(AlO_2)_{52.1}(SiO_2)_{139.9}]$

respectively. Preparation of samples for neutron diffraction and MAS NMR experiments was described in [3,4]. A valuable information on the conversion of methyl iodide to methoxy species was obtained by this NMR method.

The neutron diffractometer KSN-2 is placed at the second horizontal beam tube of the research reactor LVR-15 in the Nuclear Research Institute near Prague. The KSN-2 is equipped with the auxiliary devices, e.g. programmed temperature control for cryostats and furnaces (closed cycle refrigenerator system mod. CP-62-ST/1, heater furnace up 1000 K), texture goniometer TG-1, magnets. This diffractometer offers good intensity with wavelengths in the range 0.095 to 0.141 nm and the best resolution value of $\Delta d/d = 0.001$ was reached in the region d ~ 1.0 ÷ 0.1 nm (d is interplanar spacing). The diffraction patterns recorded are treated by Rietveld analysis method (code RIET-N, GSAS package, FULLPROF).

If we take into consideration our results than we can do following remarks:

- The complete structure parameters of NaY (a= 2.4851(7) nm) [4], NaX (a= 2.4895(6) nm) [3,4] and NaLSX (a= 2.4975(4) nm) type of zeolitic catalysts in initial form and after 60

chemisorption were determined in the frame of the Fd3 space group from our powder neutron diffraction measurements. Structure parameters of methyl groups were determined by means of a difference Fourier maps.

-Chemisorption of methylium ions at nucleophilic lattice oxygen sites has a remarkable effect on the distribution of cations in the lattice. Typical example was found for NaX in the cases without and with chemisorbed species. Our experimental data allow to compare the changes in the occupation of positions of the lattice atoms in original evacuated NaX and in the same sample after chemisorption of methyl iodide. These changes were detected not only with occupation factors of cationic sites but sometimes also in coordinates of Na⁺ cations where a splitting (at 7 K) is demonstrated of the position SI² into two sites Na2 and Na3, which are separated at helium temperature but merged at room temperature. Cations are distributed over six possible sites in the frame of the Fd3 space group. The distribution of Na⁺ cations in faujasites was also tested by high resolution ²³Na MAS NMR. The NMR results altogether confirm the results from diffraction methods. Cations in SII positions are represented after chemisorption only with the fully occupied Na4 site (32 per unit cell). It demonstrates that long-range forces and variations of electrostatic field gradients significantly change the cations distribution.

-Methylium ions are located in X faujasite at O_4 and O_1 lattice oxygen and in Y faujasite at the O_1 lattice oxygen. The location of the center groups (CD₃ or CH₃) was found in the position 96g (0.387, 0.387, 0.119).

- We observed fact that the distances from the oxygen atoms O1or O2 to the center of the CH₃-group (or CD₃-group) are spread in the interval from 0.15 to 0.17 nm. It has been shown that in NaLSX the same distances from the CH₃-groups (or CD₃-groups) exhibit a shorter lengths to O4 than to O1, although in NaX structure the situation is opposite. It is assumed that this effect is associated with the amount of particles in supercages.

Neutron powder diffraction is very valuable for this work since single crystals are rarely available and because understanding the sitting of light atoms is paramount.

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Study of SrTiO₃ Nanocrystalline Powder by Luminescent Impurity Probe Method

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The study of small size and confine geometry effect on properties of ferroelectrics and related materials is presently an important trend in solid-state physics. Research is performed mainly on nanolayers, fine-grained ceramics, thin crystals, and nanoparticles embedded in host material. Study of nanopowders seems very attractive in this context since very small nanoparticles can be obtained and their properties are not influenced by substrate, surrounding host environment or neighboring grains as in the case of thin films, nanoparticles embedded in host material or ceramics. However, application of conventional electrophysical methods for investigation of ferroelectric phase transitions such as dielectric spectroscopy is in the case of nanopowders obviously connected with a whole range of inconveniences. In this situation luminescent impurity probe method can be very useful because it enables to obtain information about structure and phase transitions in dielectric materials without regard to the form of given material.

Quantum paraelectrics SrTiO₃ is the most popular and widely investigated model material from the perspective of highly polarizable ABO₃ oxides with perovskite-like structure and phase transition physics. SrTiO₃ possesses an antiferrodistorsive structural phase transition between the cubic O_h^{1} and tetragonal D_{4h}^{18} phase at ~ 105 K. Dielectric constant increases at cooling with extrapolated Curie-Weiss temperature $T_c \sim 35$ K due to the TO₁ phonon mode softening. However, polar ordering is prevented by quantum fluctuations and dielectric constant and TO₁ soft phonon mode saturate at the lowest temperatures. Nevertheless SrTiO₃ practically losses stability to polar distortions and due to this inherent instability even low levels of appropriate impurities or perturbations can induce in SrTiO₃ ferroelectric phase transitions. These features result in very interesting and unusual optical properties of SrTiO₃. Very large temperature shift of the zero-phonon R-line of photoluminescence of octahedral Cr³⁺ impurity centers to lower energies was discovered at cooling in SrTiO₃:Cr crystals in contrast to conventional dielectric oxides where the R-line corresponding to ${}^{2}E \rightarrow {}^{4}A_{2}$ zero-phonon transition of Cr³⁺ ion shifts to higher energies with decreasing temperature [1]. The R-line splitting to the doublet (12594.3 and 12597.2 cm⁻¹ at 20 K) observed at the tetragonal D_{4h}^{18} phase originates from the splitting of the ²E excited state of Cr³⁺ ion in the tetragonal crystal field. Moreover temperature behavior of the shift of the average position of the R-lines was found in the tetragonal phase proportional to the reciprocal dielectric constant $1/\epsilon'$ of SrTiO₃ and to the square ω_0^2 of TO₁ soft phonon mode frequency. Such temperature behavior of the zero-phonon R-lines of photoluminescence octahedral Cr³⁺ centers in SrTiO₃ was explained as a manifestation of local configurational instability of the 3d³ impurity ions in the degenerate ²E state towards quadratic Jahn-Teller effect on a soft polarization TO mode [2].

This unusual "dielectric-related" temperature behavior of the zero-phonon R-lines of photoluminescence of octahedral Cr^{3+} centers controlled by their interaction with the TO₁ soft phonon mode that depends on the character of phase transition enables use Cr^{3+} ions as a

luminescent probe in the studies of phase transitions in perovskite-type oxides with TO soft phonon modes as was successively proved on the series of chromium doped materials such as $Sr_{1-x}Ca_xTiO_3$ crystals [3] or $SrTiO_3$:Cr sol-gel ceramics with the average grain size of about 24 µm [4]. The local minimum in the temperature dependence of the average position of the R-lines can be observed in the vicinity of ferroelectric phase transition because TO_1 phonon mode softens at cooling above ferroelectric phase transition and stiffens below it. At present we used analysis of the temperature behavior of the zero-phonon R-line of photoluminescence of Cr^{3+} impurity ions for the study of low-temperature phase of $SrTiO_3$:Cr(0.1%) nanocrystalline powders with an average size of the particles between 13 and 100 nm. The powders prepared by the Pechini-type polymeric sol-gel method contained single phase with O_h¹ cubic perovskite structure.

All studied SrTiO₃:Cr nanocrystalline powders revealed in the near infrared spectral region photoluminescence characteristic for octahedral coordinated Cr³⁺ ions substituted in Ti⁴⁺ sites in SrTiO₃. The emission spectra consisting of the zero-phonon R-line and vibronic sidebands were very similar as in the case of bulk SrTiO3:Cr crystals. Nevertheless the zerophonon R-line and vibronic sidebands were slightly shifted to higher energies and substantially inhomogeneously broadened so the splitting of the R-line in the tetragonal phase was hidden too. The R-line half-width observed on the powder with average particle size of 100 nm was about 20 cm⁻¹ at 12 K in contrast to about 1 cm⁻¹ in the case of bulk SrTiO₃:Cr crystals [1]. The R-line broadening increased with a decreasing size of the nanoparticles evidencing increasing inhomogeneity of the particle structure. The observed slight shift of the R-line to higher energies with a decreasing size of the nanoparticles can be connected to changes of lattice parameter of crystal neighborhood of Cr³⁺ ions that probably occur with a decreasing nanoparticle size due to increasing influence of surface effects on nanoparticle crystal structure. The R-line position continuously shifted to lower energies at cooling. This temperature shift observed on the studied SrTiO₃:Cr nanocrystalline powders appeared both in character and magnitude very similar as in the case of bulk SrTiO₃:Cr crystals. Such temperature behavior of the R-line position indicates that the nanocrystalline particles maintain properties inherent to quantum paraelectric SrTiO₃ crystals even at the particle size of about 10 nm.

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Deuterium Gas-Puff on S-300 Z-pinch at Kurchatov Institute in Moscow

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Nowadays Z-pinches belong to the most powerful laboratory sources of radiation. On the one hand, this naturally leads to detailed studies of EUV and soft X-ray radiation. On the other hand, however, there is a need for more experimental data about fast ions and we hope that fusion neutron measurements could help in that sense. For that purpose we have performed experiments on the S-300 generator with various deuterated loads and we observed whether some fusion neutrons were produced.

In order to describe Z-pinch dynamics, an optical streak camera, X-ray pinhole cameras, 5-frame laser shadowgraphy, high-voltage and dI/dt probes were employed. The neutron yield was measured with an In-activation counter and TLD detectors. As regards the most recent neutron diagnostics, the time-of-flight analysis was enabled by 12 scintillators and photomultiplier tubes -4 in each of three mutually perpendicular axes. Because the neutron signals at different distances depended on the energy of neutrons, it was possible to estimate the neutron energy spectrum. In our case, the neutron spectra were reconstructed by the Monte Carlo simulation. The neutron energy spectrum carries important information about the energy of colliding deuterons. If the deuteron energy is much smaller than the fusion energy, the neutron energy is given mainly by the component of deuteron kinetic energy in the direction of neutron detection. On the basis of this fact, it was possible to transform neutron spectra into the energy distribution function of deuterons which produced fusion neutrons.

The experiments were performed on the S-300 generator (4 MA peak current, 700 kV voltage, 100 ns rise time, 0.15 Ω impedance) at the Kurchatov Institute in Moscow. We carried out Z-pinch experiments with (i) deuterated fibres [1,2], (ii) various types of wire arrays imploding onto a deuterated fibre [2,3], and (iii) deuterium gas puffs [4] as Z-pinch loads. In this paper we particularly focus on experiments with deuterium gas-puffs.

The gas puff hardware was designed according to the gas valve used on the Angara-5 device. The separation between the cathode and the anode was 10 mm. The anode was formed by a stainless steel mesh. The gas puff was triggered by an electrical spark which ignited gunpowder. A teflon piston driven by the burning gunpowder then compressed the deuterium gas in a closed volume below the nozzle. The deuterium gas entered the nozzle when the gas pressure broke through a 0.2 mm thick stainless steel foil. The delay between the detection of the deuterium gas in the nozzle and the current generator start-up was set up between 10 and 40 μ s. The outer diameter of the conical solid deuterium gas puff was 10 mm and about 15 mm at the cathode and at the anode, respectively. At the time of the current onset, we

expected the line deuterium gas density of $5\pm50~\mu$ g/cm. The gas density profile has not been characterized so far since our primary intention was to implement and to test extended.

The peak neutron yield above 10^{10} was achieved with a deuterium gas-puff on the current level of 2 MA. The fusion neutrons were generated at about 150 ns after the current onset, i.e. during the stagnation and at the beginning of the expansion of a plasma column. The neutron emission lasted on average 25 ns. The neutron energy distribution function was reconstructed from 12 neutron time-of-flight signals by the Monte Carlo simulation. The side-on neutron energy spectra peaked at 2.42 ± 0.04 MeV with about 450 keV FWHM. In the downstream direction (i.e. the direction of the current flow from the anode towards the cathode), the peak neutron energy and the width of a neutron spectrum were 2.6 ± 0.1 MeV and 400 keV, respectively. The average kinetic energy of fast deuterons, which produced fusion neutrons, was about 100 keV. The generalized beam-target model probably fits best to the obtained experimental data.

In future experimental campaigns we shall pay special attention to the reduction of a deuterium gas spread in the energy concentrator and to the optimization of a deuterium gas puff. We would like to increase the neutron yield and to measure the gas puff density profile. This, we believe, is necessary for further experimental data processing and for the subsequent discussion of deuteron acceleration mechanisms.

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Single- and Several-Photon Detection Avalanche Photodiode Study

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Silicon is a natural first choice for the design and construction of a solid state photon counter. The avalanche photodiodes acting as photon counting devices has been pioneered by S. Cova and co-workers [1]. This detector, called Single Photon Avalanche Diode (SPAD), is an avalanche photodiode structure prepared using a conventional planar technology on silicon reported by Haitz [2]. Research and development of the SPADs based on silicon were started in our labs at the CTU in Prague in 1984. The primary goal of the work was to develop a solid state option to the micro-channel plate photomultiplier based photon detector for laser ranging applications. The anticipated application required the minimal active area size of 100 µm in diameter and a timing resolution lower than 40 picoseconds [3]. In our design we focused on the diode structure design and the chip manufacturing technology. The chip manufacturing technology tuning resulted in a process, internally called K14, which permits the creation of SPAD structures with a diameter 20 to 200 µm, timing resolution better than 50 picoseconds and an acceptable dark count rate. A noteworthy feature of the K14 manufacturing process of silicon SPADs is its capability to provide relatively large active area detectors without compromising the timing properties. This feature is in contrast to measurements performed using different construction SPAD chips.

The existing solid state photon counting detectors have been dedicated for picosecond resolution and timing stability of single photon events. However, the high timing stability is maintained for individual single photons detection, only. If more than one photon is absorbed within the detector time resolution, the detection delay will be significantly affected. This fact is restricting the application of the solid state photon counters to cases where single photons may be guaranteed, only. For laser ranging purposes it is highly desirable to have a detector, which detects both single photon and multi-photon signals with picoseconds stability. The SPAD based photon counter works in a purely digital mode: a uniform output signal is generated once the photon is detected. If the input signal consists of several photons, the first absorbed one triggers the avalanche. Obviously, for multiple photon signals, the detection delay will be shorter in comparison to the single photon events. The detection delay dependence on the optical input signal strength is called the" detector time walk". To enable the detector operation in both the single and multi-photon signal regime with a minimal time walk, a time walk compensation technique has been developed in nineties. The procedure is based on the fact that the avalanche rise-time of the K14 SPAD chip depends on the input optical signal strength. The observed rise-time changes were 30 ps over the dynamical range of 1 to 3000 photons per pulse. The circuit is using this information to compensate the time walk of the detector in this dynamical range.

The critical limitation of the technique described above is very small measured difference in an avalanche build up rise-time in the range of tens of picoseconds only. That is why new effort has been directed to the avalanche build up studies.

The picosecond laser diode Hamamatsu C4725 providing 42 ps wide pulses at 778 nm was used as a signal source. The laser output was attenuated by means of a stack of calibrated

neutral density filers and focused on the detector active area. The X-Y-Z stage enabled us to test the focusing and position sensitive effects of the detection process. The optical signal intensity was measured using the detection chip in a linear mode with unity gain and monitoring its reverse current by the electrometer Keithley 610C and operating the power stabilized laser source at a high repetition rate of 1 MHz. The timing chain of the experiment consisted of an ORTEC Time to Amplitude Converter 566, feeding data to a multi-channel analyzer card in a personal computer. The timing resolution of this chain was 50 picoseconds Full Width at Half Maximum (FWHM). The detector was operated in an active gated and passive quenched circuit, its output was monitored on the oscilloscope Tektronix DPO7254. The individual current rise-time waveforms were recorded with a resolution of 40 Gsamples per second and processed off-line using a dedicated software package.

In the first experiment the detection uniformity was investigated. The optical signal was attenuated down to single photon level and was focussed to a spot $\sim 10 \ \mu m$ in diameter, the detector active area was scanned with $10 \ \mu m$ step, the relative sensitivity was recorded. In the next experiment, the optical pulses of ~ 3000 photons were focussed on the detector, the area was scanned and the recorded waveforms were processed. The detection delay corresponding to various trigger levels has been recorded, as well. The resulting detection delay dependence is flat within the diode sensitive area. These experiments verified the detection area delay uniformity. In all the next experiments, the optical signal was de-focussed is such a way, that it just illuminated (more or less uniformly) the entire detector active area.

The dependence of the avalanche rise-time on the input photon number has been recorded together with the relative detection delay. The K14 SPAD chip, 200 μ m in diameter was biased 5 Volts above its breakdown voltage in this experiment. The precision of the individual values is about 90 ps in rise-time and 40 ps in detection delay for all the photon numbers. Note the dependence of the rise-time on the optical signal strength, which can be simply fitted by a simple curve.

Several key conclusions may be stated on the basis of the experiments. The avalanche rise-time of the K14 SPAD chip depends on the detected photon number in the photon number range 1 to 10000 photons, this dependence is about 150 picoseconds per factor of $10\times$ in photon number and the precision of the individual measurement is about 90 picoseconds r.m.s. These facts enable us to estimate the photon number on the basis of output pulse rise-time measurements. Averaging 50 detection events and more, the photon number detected may be estimated with the uncertainty $3\times$. On an shot-to-shot basis, the photon number may be estimated with the uncertainty of $20\times$. The detection delay might be compensated in a dynamical range 1: 10^4 .

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DC Corona Ozone Production from Contaminated Air Enhanced by Photocatalyst

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Electrical discharges in air at atmospheric pressure are sources of ozone and other oxygen based reactive species. Ozone can cause the health risks but on the other hand its oxidative properties have been harnessed for many beneficial purposes such as sanitizing the air, elimination of odors and destroying bacteria and mildew. These properties can be used among others for the transportation of food, fruits and vegetables with the aim to extend their storage life.

Up to now the main technique used for this purpose in these commodities transportation e.g. by trucks was cooling. At present because of the strong bactericidal effect of ozone its supply into containers with these commodities simultaneously with cooling is intensively studied.

Due to the short lifetime of ozone, it must be produced at place of its usage, e.g. in trucks. Ozone mobile sources must operate in wide range of conditions – temperature, humidity, pressure, presence of different contaminants etc. The effect of temperature and humidity on ozone production by electrical discharges is relatively well known. As for other contaminants ozone production can also be affected by traces of volatile organic compounds (VOCs) present in automotive fuels. The frequent part of automotive as well as aviation fuels is *n*-heptane. As far as the most frequently as a feed gas for these sources of ozone production. Because the detailed knowledge of the influence of *n*-heptane contamination on ozone production by electrical discharge in air is still missing we studied the effect of trace *n*-heptane contamination in air on ozone production.

We studied ozone production by DC the hollow needle to mesh corona discharge in air or in air contaminated by small concentrations of *n*-heptane [1]. We found that for both polarities of the needle electrode addition of small amount of 9.4, 43 and 106 ppm of *n*-heptane to air: a) decreases discharge ozone production; b) causes the discharge poisoning to occur at lower current than for the discharge in air and c) does not substantially influence the current for which the ozone production reaches maximum. Finally maximum ozone production for the discharge in air occurs for the same current as the maximum ozone production for the discharge contaminated by *n*-heptane.

We also found that as well as ozone production from air decreases with increased humidity the same is truth for ozone production from air contaminated by *n*-heptane. This result was obtained for both polarities of the coronating needle electrode though this dependence is stronger for the discharge with the needle biased positively.

We showed that contamination of air with *n*-heptane strongly influences plasmachemical processes leading to ozone production and thus consideration of this contamination found in the feed gas must be noted to assure proper operation and durability of electrical discharge sources of ozone.

Corona discharge ozone production can be enhanced by the usage of photocatalysts. This type of discharge from air is apart of the source of ozone, charged, and excited species and acoustic noise also the source of electromagnetic radiation of different wavelengths. The important component of this radiation from the standpoint of photocatalyst activation is the ultraviolet radiation. We studied the role of UV radiation on corona discharge ozone production by placing the titanium dioxide photocatalyst into the discharge region [2,3]. We used hollow needle to mesh DC corona discharge at atmospheric pressure with TiO_2 globules on the mesh. The discharge was enhanced by the flow of air through the needle.

We found that that for the needle biased negatively addition of TiO_2 photocatalyst globules on the mesh:

- strongly influences electrical parameters of the discharge,
- shifts the transition from the glow into the streamer regime of the discharge into higher currents,
- stabilizes the discharge,
- drastically increases discharge ozone production,
- increases discharge ozone production yield.

It was also found that discharge ozone production depends on the mass of the photocatalyst and its location in the discharge chamber.

Though our experiments were performed with hollow-needle to mesh electrode configuration, it is reasonable to expect that qualitatively similar results concerning the TiO_2 photocatalyst effect on ozone production could be obtained also with other discharge electrode systems e.g. wire to cylinder.

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Section 3

INFORMATICS

&

AUTOMATION ENGINEERING

Innovation in the Course - Communication in Data Networks

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For a graduate in our profession it is important to gain not only theoretical foundation through education, but also an adequate practical proficiency. The main aim of the project was

to innovate educational process in course "Communication in Data networks" in practical courses as well as in theoretical level.

Innovation of practical courses

Main work has been done in innovation of practical courses. Refreshed practical courses syllabus contains six practical tasks.

- Task 1 Frame Relay basic configuration and analysis
- Task 2 Configuration of virtual LANs and port security on switch
- Task 3 Basic router configuration static routing and RIP
- Task 4 Application layer protocols analysis DHCP, HTTP, SMTP
- Task 5 Secure authentication using 802.1x mechanism
- Task 6 Remote configuration and administration of network devices using SNMP

Innovation of theoretical workshops

Three theoretical workshops consist of segment of theory and segment of simulation presentation. Simulation should enrich educational process with demonstration of behavior theoretically known methods and principles.

Simulations are mainly in a manner of

- Principle of dynamic routing protocols.
- Authentication in LANs using 802.1x.
- Virtual LANs principle IEEE 802.1q
- FrameRelay operations.

All simulations are done by multimedia presentation.

Innovation of practical tasks

All input study materials for practical tasks have been innovated and transformed into Internet—ready form and then published to server that belongs to our department (www.comtel.cz \rightarrow Předměty \rightarrow X32KDS \rightarrow Materiály pro výuku) and therefore are anytime easily accessible by students.
Innovation of theoretical lectures

The revised basic of telco knowledge that has been deeply studied has extended a spectrum of lectures. The lectures were extended on actual topics from the area of network security – secure authentication using IEEE 802.1x mechanisms, encryption on link layer - IEEE 802.1AE, mechanisms for secure key exchange - IEEE 802.1AF and secure device identification IEEE 802.1.AR. Mainly English written literature has been translated into new lecture base that is in form of MS PowerPoint presentation. This chosen format is able to show new concepts with animated explanation. This is more didactical. An electronic form of new lectures has been placed on Internet (www.comtel.cz \rightarrow Předměty \rightarrow X32KDS \rightarrow Materiály pro výuku) and therefore is easily accessible by students.

Conclusion

Main goals of subject innovation are:

- New simulation implementation in theoretical workshops.
- Workplace innovation for practical tasks.
- Practical tasks optimization and material, tools and device complementation.
- New study material creation for theoretical parts of course.
- All study material is now in electronic form of presentation.
- Motivation of students to study modern telco technologies.

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SVET - New World for Digital Evolution

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The evolution theory presents new controversy in whole society. Many people accept some vision of the evolution, nevertheless there is significant group of people that reject this theory. This people, e.g. creationists, believe that space, people and Earth were created by the act of Providence. They reject the evolution due to the religious reasons. But the evolution is the well-established, chief and no non-confirmed theory. However there are some specific parts of the evolution which may be disputable, its principles are well verified. Now, when the genetic algorithms and similar evolution methods are practically used in several areas, the entire evolution may be impeached only very hardly [1].

However the evolution was discovered by Darwin in the area of biology, it may be realized not only by the real organisms like bacteria and others, but in the area of digital organisms as well. These systems enable the study of basic evolution principles on the computers. This evo-technology and artificial life may be used not only for the simulation of organic evolution but also for the fundamentals of evolution itself. The knowledge may be applied in the biology in the study of altruism and complex features. On the other side, the evolution principles help to find novel technical solutions e.g. new types of computer chips, antennas, and also in the concurrent area of high-tech [2,1].

There are two most significant artificial life systems: Tierra and Avida. Avida is inspired by Tierra and is two-dimensional system. These systems are based on an array cells which can interact. Organisms are machine-language instructions which are running on the computer. The organisms can obtain bonus energy when it discovers something useful. The tasks learned by organisms are exactly defined. The task may be for example the addition of two numbers and its writing to the output. For each completed task get the organisms some extra processor time which may use to create more copies of its genotype in comparison with the concurrence. The process is able to learn due to mutations, which obtain by the copying or reading and writing to the memory. The most of the mutations are mortal, but sometimes some positive mutations may occur and the organisms may profit.

We are developing new system for digital evolution called SVET which has several enhancements. The principles of this new system are similar to the previous systems Avida and Tierra, but with the difference definition of the organism. The organisms are defined like a virtual pointer to the system memory only and without any reservation or memory protection for the organisms. The organisms are not defined by the memory allocation but only with the memory position of actual instruction. Instruction set is of CISC type and inspired by the Intel 80x86 type. Some special instructions were included. The instruction for replication, which create new process with separated registers. Next instruction for generating random value and other instructions for the solution of several tasks by the programs. No all possible combinations of machine code are real instruction. In case the process performs undefined instruction, it is killed. The mutation may obtain in the case of reading or writing to the memory. This system is in the beginning state and first results show that the anticipated results are consistent with the results of Tierra or Avida. In the future we plan to. We have observed the mutation of the programs and their modification for better surviving. In future we plan long time evolution.

In digital organisms proceed the some life determining processes like reproduction, mutation and challenge for the power which enable the presence of evolution and natural selection in the organic life. Those processes were observed in digital organisms too and e.g. the presence of altruisms has been confirmed. Digital life, in the form like Avida or Tierra, may be read as an instance of evolution and not only like the simulation of evolution. Computer systems are real experimental systems and shouldn't be read like the pure simulations, but the obtained results should be interpreted like equivalents to the nature [2].

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Dynamic information system

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The goal of our project is creating database storage, administrative and public interface including web pages. The project is developing for a factual production company which is conversant in production and recording advertisements.

The main idea of this project is developing a software product which is strictly divided into number of modules which could be combined for creating another new information system that could be offered another company whit different needs. We want to be able to do this without large changes in our source code. The essential modules of this project are persons, subjects, possessions these modules are supplemented by modules projects, controlling, building and places. These ones are designed directly for needs of production company. For others potential clients will be designed and developed different modules according to client's specifics.

The project is intended for small and middle company for large company will be the project capable of competing earliest after few years of successful operation. The project is platform independent and is able to use any of main relational databases.

Nowadays in the market there are a lot of information systems which are available in a broad price range but each client has its own elevation on its business problems and its own workflow. The client wants to use an information system which is able to solve client's specific problems and work with its specific workflow. So there is long chance to find two or more clients which would be willing to use the same information system without any customization of system data storage or business logic. Our policy for this marked is: be able to customize an existing information system easily and at earliest possible time. We have few ideas how to carry our point and hold this project viable.

The first way for fast developing and customizing is in project strict fission modules. We would developed a couple version of each modules and

in sort time put modules together to construct a new prototype of information system which in our view is the best solution for a potential client.

The second way is using specific data materialization and dematerialization data between application server and database. We do this in special way almost like creating persistent framework. We use metadata from database engine to get description and structure of database table. Then we dynamically know all variables which have to be in object on application server and we are able to create it. For creating SQL query and display data in a grid there are not enough data in database engine so we had to create few special tables for this special metadata. These tables contain information about grids, user settings and access privileges. After a user selects a section of module the application server get request for a grid of data. Then server asks database about structure of grid - name of tables, join type between tables in grid and attribute relationship. After that we are able to construct a SQL query which returns data structure and data from relational database. That means if we add a new attribute into a table from grid, the application server will be able to construct SQL query with the new attribute by itself. Before executing a query and displaying data the application server check user's settings and access rights - number of column, column sequence, number of raw and content filters. Then the application server is able to run a SQL query which returns data structure and data which user wants to see.

The technology used for this project Java platform for server site of application and Google Web Toolkit (GWT) framework with Ext library for client site. Java platform is noted for its operation system independency and GWT conception is able to compile source code for a concrete version of web browser. That means GWT has different code for each version of browser. So the project isn't confined to specific platform and version of operation system and other software on server site nor client site.

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Digital Signal Processing in Telecommunication Engineering

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Abstract

This paper deals with the innovation of the subject Digital Signal Processing in Telecommunication Engineering. The changes were introduced into the education starting the winter period 2008. The improvement of the subject is based on a novel laboratory setup for the digital image and video processing. The knowledge of signal processor algorithm design is fundamental for students. The main goal of the project is to establish new workplaces for students, where it is possible to study digital image and video processing tasks. These workplaces are based on the TMS320C6455 starter kits completed by video daughter boards. The workplace is also completed by video camera. Further, these laboratory activities were designed, tested and established.

Introduction

The education in the subject Digital Signal processing in Telecommunication Engineering is focused at on magister students. The knowledge of digital image and video processing is essential for them. The benefit lies in the creation of fundamental prerequisites for their further educational and publication activities. Another advantage consists in the opportunity to use a top technology to solve the tasks joined with their diploma thesis.

New Laboratory Setup

An apparent development of digital signal processors architecture, product differentiation and specialization is recently proceeded. The very long instruction word (VLIW) architecture [1] is more popular in Telecommunication Engineering. It is usually completed by peripheries for typical telecommunication solutions. The digital signal processors (DSP) TMS320C6455 [2] belong to the VLIW architecture. They are aimed to the real time processing of audio, voice, image and video signals. The video daughter board [3] device is a compact module which allows capture of both the NTSC and the PAL video signals. The grabbed data can be transferred via the External Memory Interface (EMIF) to the on-chip RAM memory. User can define external or internal triggers used to control the start of grabbing process. The selection of image data format and cropping can be made using the ASCII commands. The video back end is represented by a video controller for image and video visualization. The video acquisition, video processing and video visualization are processed in parallel. We have established three equivalent hardware setups for laboratory activities. These hardware setups were further completed by tough material with regard to periodic usage. A metal base was mounted to the bottom of the hardware setup and Plexiglas on the top. Laboratory activities are completed by video camera N-90, which enables scan a real scene. It serves for all hardware setups. The video camera enables scanning of static pictures and video sequences. For the effective training, we have proposed and tested three projects.

Video Filtering

In this project, students design their 2-D FIR filters regarding individual specifications. They learn to know the importance of the phase signal in the image processing. Based on this, they learn different design methods for 2-D FIR filters, e.g. the McClellan approach, frequency sampling, the 2-D window functions, Remez approach, contour approximation, etc. They exercise the design of 2-D low-pass, 2-D high-pass, 2-D half-band and 2-D nail filters. They implement the 2-D filters using linear discrete convolution and using FFT. The programming occurs in C language.

Edge Detection

In this project, students implement the edge detection using the Sobel edge operator and using the Canny approach. They combine the filtering approach with morphologic operation in order to get continuous edges. On top of this, they exercise the edge-based local orientation pyramidal approach for basic recognition tasks. The programming occurs in C language combined with intrinsics.

Motion Detection

In this project, students implement the motion detection procedures using a full search and selective search procedures in the searching area, processing in the transformed domains like 3-D space, Fourier contour approach etc. The aim is to separate the changes in shadow levels caused by the true motion from that caused by other phenomena like changing illumination, occlusion, noise etc. The programming occurs in C language combined with linear assembler. Our best students make their first steps in the assembler here.

Conclusions

In this paper, we have introduced our latest results in the innovation of the subject Digital Signal Processing in Telecommunication Engineering. The laboratory setup was innovated. New laboratory projects were established. New digital signal processors, video daughter board device and video camera were used for this innovation.

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Accounting of Private Calls for Organizations -OpenPhoneIS

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OpenPhoneIS is information system, which facilitates accounting of private calls for organizations with little to middle amount of telephone stations (cell phones). Settlement or taxation (as subsidiary income) of private call cost is mandatory by law. System enables automatic calculation of private call cost for each number/user based on detailed statement of phone calls and marking of private calls by corresponding user. On the basis of electronic bank statement (which system acquires through email or from file) system fetches incoming payments and matches them with system generated charging orders.

Another useful feature of the system is possibility of enrolling family members or friends to employer's phone network. The system generates charging orders for these persons based on their total call cost. This feature brings savings in two forms:

- 1. Higher total cost discount.
- 2. Lower price of calls to family members and friends made by employees.

How to start using OpenPhoneIS? It is easy indeed. In near future, testing version of OpenPhoneIS will be started. You can try this version before making any decision. In this internet service you will be able to register your company and enter the system right away. Whole process is simple. You will register phone numbers and users, service allows you to pair them together. After your phone service provider sends you detailed telephone bill, you will insert it in the system. Users you registered sign in to mark private calls. You then can tell service to generate charging orders. Later on, bank account statement arrives in mail, system fetches this email and automatically process payments made to you by registered users. If you don't trust email service or you fear of forged emails you can use our control mechanism. You can insert electronic bank statement you trust in form of file into the system. OpenPhoneIS cross-checks payments from email and trusted statement. You can setup time after which unconfirmed payments automatically becomes forgery, in that case forged payment amount is subtracted from last paid payment of given person.

Application is programmed in JAVA language, concretely on J2EE (Java 2 Enterprise Edition) platform [1]. Application is structured to several independent modules. Graphical user interface was programmed with help of Apache MyFaces Trinidad framework integrated into JSF (Java Server Faces) framework [2]. We already think about new user interface based on facelets framework, which will allow better pages styling and ease their modification. Core and modules of application use EJB (Enterprise Java Bean). Database connection is based on JPA (Java Persistence API) and object-relational mapping tool OracleTopLink.

Then there is business logic code in core and application's modules. Module PhoneParser provides parsing of detailed telephone bills. This module is able to process data from major cell phone operators in Czech republic (T-Mobile, Telefonica O2, Vodafone). Data are acquired

from .csv or .xls files, which can be packed in one .zip file. Module BankParser provides parsing of bank statements. Currently it is able to parse statements from Komerční banka (.txt) and mBank (.csv). Emphasis was placed on plug-in modularity to ease creating of plug-ins for new banks. Getting statement from mail storage is made through another module, Mailer. It fetches mails using POP3 protocol. Mailer also provides interface for sending emails (e.g. charging orders).

Why we used JAVA and J2EE? Java is modern, robust object oriented programming language. It enables easy logical and physical structuring on systems and subsystems, which can interact in many different ways. For example we can switch our web based interface for Swing to make OpenPhoneIS single desktop application.

What are the requirements? Hardware requirements depends on number of user, but it must handle our software requirements, which are:

- 1. GlassFish application server
- 2. any relational database (for testing currently using Derby database)

There is no need for administration of application after deployment. You just use it as you please.

Application is based on open source software and is therefore open source itself. That means no purchase cost. Source code is fully open and your company can adapt it to complement with company's internal systems.

Last but not least advantage is OpenPhoneIS continuous development, which promises new features and innovations. Any organization can join our effort and submit new ideas for further improvements.

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Opinion Formation Models and Optimization

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Generally, there is increasingly popular trend of connecting different fields of science. An example of this is the interaction between social and natural sciences that mostly lays in the use of natural sciences in a formal description of social phenomena. A particular case is the use of physical and mathematical models of society and social interaction, whose historical roots date back to 17th century. One of characteristics shared by these models is the presence of many, more or less simple, individuals representing the participants of the social processes. These individuals, sometimes called agents, form an artificial society. They are very often situated in an environment which could be defined as a medium separate from the agents, on which the agents operate and with which they interact. There is wide variety of such models differing in their purpose or structure of agents and environment. Very simple models of social interactions are opinion formation (OF) models, where each individual holds an opinion represented by continuous, discrete or binary number. For example, one can take a view on a continuous altitude at which a plane is flying, on a discrete number of traffic accidents that will happen at particular day or on a binary political decision that a country should do. Beyond the representation of opinions, the OF models include also a definition of rules that describe the dynamics of opinion change. These local rules usually describe the change of particular opinion on the basis of opinions of other individuals in the modeled society. Because of simplicity, the majority of OF models assume binary opinions and for such case, the models are more or less similar to spin models intensively examined in physics. Finally, one can not ignore the fact that some OF models are cellular automata known from artificial life area.

This paper sketches the potential use of the OF models for binary optimization. The optimization problem to be solved is to find argument of a fitness function that maximizes its function value. The argument can be any binary vector of predefined dimension. Although one can use effectively local search methods that improve one candidate solution at each step, the existence of multimodal function with many local optima urges us to overcome the local optima problem using population based techniques. One example of such techniques is genetic algorithm that is inspired by Darwinian evolution and models evolutionary operators like selection, crossover and mutation. The main driving force of evolutionary techniques is "survival of the fittest". However, back to the OF models.

The main idea of using the models for optimization can be described as "the fitter the individual, the higher its influence on the others". Each individual holds binary opinions on a certain number of issues. Each issue represents one character (-1/1 alphabet is used for practical reasons) of the whole binary string that encodes particular candidate solution just as the chromosome in genetic algorithms. The relative impact of an individual can be represented by individual's strength that is a number from <0,1> and can be computed from the fitness value using a non-decreasing function that ensures that fitter individuals will have higher strength (influence on the others). The second component is update rule that describes a condition for changing a particular opinion of a particular individual. Very simple case is the use of weighted sum of opinions of adjacent individuals. Consider an individual *i* that holds opinions represented by vector $\vec{x}_i = (x_1^1, ..., x_n^D)$, where *D* is the dimensionality of the

search space (the vector encodes *i* th candidate solution of the optimization problem) and $x_{-}^{d} = \{-1,1\}$. The update rule can be defined as

$$x_{i}^{d}(t+1) = sign[\sum_{j \in N_{i}} s_{j} x_{j}^{d}(t)],$$
(1)

where (t) denotes discrete time, s_j is the strength of individual j and N_i is the set of all neighbors of individual i. The update rule (1) is applied at each time step on each opinion and each individual and this leads to something what can be called "social evolution". The notion of neighborhood ensures locality of the update rule, the individuals can be located in a topological structure (graph) that defines neighborhood of each individual. Finally, to empower the explorative behavior and prevent loss of diversity, one must add a random component to the algorithm. A simplest way of stochasticity introduction is random mutation of each "opinion" after applying update (1).

The model described above is only one simplest particular case of update rule. The rule can include distances between individuals i, j, nonlinear components and other modifications. The first OF model based optimization metaheuristic was Social Impact Theory based Optimizer (SITO). Although in early experiments with SITO ([1]-[4]) the rectangular lattice topology and much more complex update strategy are assumed, recent work shows that the simpler random or ring topology can perform comparably. All experiments showed great importance of addition of random component that can improve the explorative capability and prevent loss of diversity [1]. The other experiments focused on parameter settings are described in [2] and [3].

As it is mentioned above, the recent work leads to simplifications of the original SITO optimizer and its generalization to wide framework encapsulating the optimization algorithm inspired by OF models. The experimental comparability with genetic algorithms and particle swarm optimization as well as practical applicability in area of pattern recognition [3] give us main motivations for the further work on optimization based on OF models.

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TeXonWeb - Writing TeX Documents Online and Converting Them to PDF

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TeX is an increasingly popular typesetting system used for creating professionally looking documents and presentations. Besides the many pros it has one big drawback installing TeX on every computer where you need to convert a TeX document to PDF or PostScript can be difficult and time consuming. To generate a result with correct diacritic and encoding you need to install a lots of separate software packages too.

So called cloud computing and moving desktop applications to the web is great help not only for people than need mobility and accessibility, but also offer huge possibilities for collaboration and communication. For every team project the way distributing and reviewing changes is one of most crucial decisions. It needs to be easy, fast, accessible and reliable.

Main goals of our project is not only to make it possible to convert TeX documents to PDF online, but also to help in the writing process. We offer comfortable syntax highlighting and document formatting reporting. Also we allow our users to maintain versions of their documents, annotate changes, and track their history, which is especially valuable for team projects.

The system also allows fast anonymous publishing of TeX based documents. This feature is supposed to help anybody who needs to communicate using advanced math symbols or any other advantages of TeX documents. Equivalent tool called pastebin targeted at programming languages is great communicating aid for many computer programmers and is deployed on numerous sites across the internet.

Although there is trend to shift the application from web server to the browser, many people either lack resources or are not willing to run JavaScript and other client-side languages. Therefore we tried to make the interface as accessible as possible. Text browsers, legacy systems and even blind people with text-to-speech environment should be able to use it.

Alternative markup language, restructured text, is supported both for managed documents and quick publishing. This language was especially designed to be as simple to read in source form as possible, while maintaining text formatting capability. It is very simple to learn and use. In contrast to similar wiki syntax it not only produces web pages, but can also be transformed to TeX, thus creating great looking printed documents.

The system itself is designed with different computer platforms in mind. It is written in multiplatform programming language Python and is currently developed on GNU/Linux and Microsoft Windows. The versioning backend called Bazaar-ng is standard tool used by big projects like Ubuntu or MySQL. In future it should be possible to interface directly with bazaar through WebDAV, so documents can be edited offline with full support of versioning. It's necessary for user rights management that SQL database is running, but thanks to the

Django web framework you can use PostgreSQL, MySQL, SQLite or Oracle. The choice is yours.

Software is licensed under GNU Affero general public license. You can use the software on your own server, avoiding privacy and IP issues with using third-party service, such as Google documents. Also you are sure to have access to all improvements and additions to the software, due to the nature of license. You can get copy of the software and file bugs on launchpad at https://launchpad.net/onlinetex.

Future wok will be mainly aimed at improving team collaboration on projects. So far only one project per user is supported. Repository branching and merging for more distributed development process is also possible. Everyone will be able to have several independent modification of documents. Also there is a good basis for localization. The web framework itself uses standard gettext tools for translations, so it's easy to create new ones and to maintain them when software changes. Adding more languages should also be quite trivial task, though it may be difficult to write syntax highlighting if support does not already exist.

Similar works include TeXonWeb project on Mendel University in Brno accessible at http://tex.mendelu.cz/ which originally served just as online TeX compiler (new version now added support for storing files) MonkevTeX and project at http://monkevtex.bradcater.webfactional.com/. They both lack advanced versioning features like showing differences between files or adding comments to versions. Also they only provide you a service, not the whole software. You cannot deploy the application yourself, change it or have it changed. Mainly you have to trust the provider with your document's safety.

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PID Controller Tuning Method Comparison with Respect to Industrial Practice Requirements

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There exist several PID controller tuning methods. They differ in their basis, in their usage and in their possibilities, advantages and disadvantages. PID controller tuning method comparison with respect to industrial practice requirements is presented in this paper.

The basic and most common tuning methods are Ziegler and Nichols methods. There exist three Ziegler and Nichols methods – critical frequency method, step response method and quarter damping method. All three methods are very simple to use, there is no requirement of controlled plant model, so it is possible to use these method even in the case of non-linear controlled plant. But these methods have some disadvantages which eliminate them from the use as continuous tuning methods. There are several modifications of Ziegler and Nichols methods, for example Chien, Hrones and Reswick method, Cohen and Coon method, and Tyreus and Luyben method. The disadvantage of Ziegler and Nichols step response method and quarter damping method is the necessity to interrupt the control process when the identification experiment is made, because the controlled plant parameters are unable to obtain from closed control loop. The Ziegler and Nichols critical frequency method does not require to interrupt the control process but in the other hand it require to set controller parameters which leads to the control process near the stability boundary where the undamped oscillation occurs. In the non-linear controlled plant case this can lead to unstable process. The second Ziegler and Nichols critical frequency method disadvantage is unpredictable undamped oscillation amplitude.

Foxboro Exact method. The method name is derived from Expert Adaptive Controller Tuning. It is based on the pattern recognition. Foxboro experts made set of rules how to change controller parameters when some known pattern occurs. The method does not require control process interruption. The ungrateful situation is that Foxboro did not publish its rules. It is possible to evolve own rule set but it takes a lot of time to evolve sufficient number of rules to get satisfactory results.

Relay method is the extension of Ziegler and Nichols critical frequency method. It allows finding the critical parameters without the necessity of reach the stability boundary. This is possible due replacing controller in closed control loop by relay. Then the closed control loop starts oscillating because the relay has no state which can produce equilibrium state. It is possible to influence oscillation amplitude by the relay parameters. The disadvantage of this approach is that it is not possible to control controlled plant during relay identification experiment. The method is easy to use.

Internal model control method. The disadvantage of this method is controlled plant model requirement which eliminates this method from common use in industrial practice.

Method of relative damping is method that guarantees the desired damping of closed control loop response. The disadvantage of this method is controlled plant model requirement, which eliminate this method from common use in industrial practice. The second disadvantage is that only two controller parameters can be set by this method. Only controller parameter pairs can be obtained by this method with not exact recommendation which of obtained controller parameter pairs to chose. This eliminates the method from the use it as controller autotuning method.

Modelbased predictive control (MPC) is sometimes called PID controller successor. Its advantage is a possibility to take into account the actuator limitations as minimal or maximal value or maximum velocity during the manipulated value course computation. The disadvantage is the controlled plant model knowledge necessity that can cause problems while strong non-linearity occurs in the controlled plant. This method requires higher computational performance and has higher memory requirements than other presented methods. This was significant disadvantage when high performance computation circuits and memory were expensive. Nowadays, this disadvantage is not so significant nevertheless the industrial practice does not seem to want the common use this kind of controller.

The disadvantages of PID controller tuning methods motivate the author of this paper to new tuning method development.

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Handoff with Movement Prediction in Mobile WiMAX

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WiMAX stands for Worldwide Interoperability for Microwave Access and it is a wireless technology based on standard IEEE 802.16, which ensure broadband communication in area of MAN (Metropolitan Area Network). System using WiMAX technology can be used to send signals point-to-point on range of 30 miles (50 km) with a throughput of 72 Mbps and for last-mile users, point-to-multipoint, on range up to 4 miles.

As IEEE 802.16 solutions evolve to address portable and mobile applications, the required features and performance of the system will increase. Beyond fixed access service, even larger market opportunities exist for providing cost-effective broadband data services to mobile users. Initially this includes portable connectivity for customers who are not within reach of their existing fixed broadband or WLAN service options. This type of service is characterized by access that is unwired but stationary in most cases, with some limited provisions for user mobility during the connection. In this manner, 802.16 can be seen as augmenting coverage of 802.11 for private and public service networks and cost-effectively extending hotspot availability to wider ranges of coverage. Based on this described capability, this phase of deployment is referred to as 'portability with simple mobility'. The next phase of functionality, known as 'full mobility', provides incremental support for low-latency, low-packetloss real-time handoffs between access points at speeds of 120 km/h or higher, both within and between networks. This will deliver a rich end-user experience for high-quality multimedia applications [1].

The mobile version of WiMAX, 802.16e, was ratified in December of 2005 and supports full mobility of clients. At this moment the 802.16 amendment has implemented three handoff methods – Hard Handoff (HHO), Fast Base Station Switching (FBSS) and Macro Diversity Handoff (MDHO) [2].

The reasons for handoff can be various and here are listed only some of them:

- . signal strength is not enough for maintaining proper connection at the edge of the cell
- . BS capacity is full and more traffic is pending
- . disturbing co-channel interference from neighboring cell
- . behavior of MS changes, for example in a case of fast-moving MS suddenly stopping, a large cell size can be adjusted to a smaller one with better capacity.

To be able to perform handoffs, the technology must define a scheme for decision making to initiate them. A procedure for discovering competing BSs is also needed.

Handover can be divided into two main categories:

- soft handover, also define as make-before-break HO, where current connection with serving BS is maintain till second connection to target BS is established, which make connection uninterrupted;
- hard handover, also define as brake-before-make HO, where current connection with serving BS is break first, then new connection with target BS is established, which make connection interrupted in moment of changing BSs [3].

The hard handoff can be very efficient because of its channel usage. Only one channel is occupied simultaneously. Because the equipment does not have to support two or more channels in parallel the production is cheaper. However, it can cause unrecoverable damage to the connection in case the handoff fails. The advantage of soft handoff is the reliability since the connection is broken only in case, that a new working connection was found. The drawback of soft handoffs is the required computational capacity in the equipment, which consumes money and power. Additionally, the use of several channels per user decreases the overall capacity of the BS.

The main idea of the proposed mechanism is to predict movement of mobile user with use of Global Positioning System. We are taking under consideration only the decision for the handoff, actual handoff performance is not a part of this research. Making that decision in different way could lead to perform handoff more efficient and reduce number of unnecessary handoffs. The handoff should also be as fast as possible, at least fast enough to keep current IP connections alive. Data traffic is not so sensitive to larger delays but real-time voice or video (or both simultaneously) requires a swift change of the serving BS.

First requirement is for mobile user equipment to posses GPS receiver; as we know GPS receiver are already installed in mobile phones, so to implement it also in devices of other kind like notebooks or PDAs is not far from the future.

Wireless network direction of development is to make mobile user devices light, uncomplicated and cheap; along with it users that want to have influence on some decisions made by the network. We assume that mobile station will be able to send GPS data to base station. That information can be gathered and proceed by additional module supporting an intelligent map of the terrain. It means that based on maps of terrain and GPS data (position, direction for pedestrian and auto) it could predict user movement and gather information that could prevent unnecessary handoffs. Landform features will play here an important role.

An algorithm for handoff decision will be implemented, making all necessary calculation and choosing the best base station candidate. Here we will apply some elements of fuzzy logic. As fuzzy logic is a method for sorting and handling data and has proven to be an excellent choice for many control system applications since it mimics human control logic. It can be built into anything from small, hand-held products to large computerized process control systems. It uses an imprecise but very descriptive language to deal with input data more like a human operator. It is very robust and forgiving of operator and data input and often works when first implemented with little or no tuning [4]. In our case data input would be a signal strength (time delay), crosstalk, geographical data etc. All this management along with intelligent map may create new handoff mechanism form 802.16e amendment.

Features like giving a mobile station a possibility to choose its target BS would be possible. For instance, signal strength from target BS along the predict way isn't sufficient in compare to adjoining BS. By gaining this information user is capable of making decision, either to stay on the road, change the route or even stop. Thanks to it the handoff mechanism may be more efficient and user friendly.

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Influence of Noise on IPTV over xDSL

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Nowadays expansion of telecommunication technology is specified grow of telecommunication services based on fast transmission of data. In economics term is to maximize use of existing metallic loops and applied to them fast data transmission service for example triple play (internet – data, VoIP – voice, IPTV – video). The service IPTV (Internet protocol television) is defined as multimedia service delivered over IP based networks managed to provide the required level of quality of service (QoS) and experience (QoE). The IPTV is the television and radio broadcasting and the video on demand (VoD) over the fast broadband network.

The technology xDSL (Digital Subscribe Line) is used to fast transmission of data on metallic loops. The main advantage of this access technology is the ability to use built metallic loops directly to the customer premises and using the Internet Protocol (IP) to transmit digital television with additional services directly to the customer premises. Especially ADSL/ADSL2+ and VDSL are among the most commonly used technology. Both technologies preserve the primary function of the analog (or the ISDN) phone and in addition they create sufficiently fast data channels for high-speed services. The distance between a DSLAM and a modem is the disadvantage, because the growing distance causes a decrease of transmission speed. The attenuation of transmission environment and some more interference cause decrease speed.

In particular mutual close coupling between pairs of cable profile (may contain to thousands of pairs) can be regarded as the interference influencing on the transmitted data. These couples mutual influence the penetration signal from the transmitter to neighboring couples in the same cable – this is referred as the near end crosstalk (NEXT) and the far end crosstalk (FEXT). Other transmission systems deployed to the same cable, radio frequency interference (RFI) and impulse noise are also the serious sources of interference.

Impulse noise is a non-stationary stochastic electromagnetic interference which consists of random occurrences of energy spikes with random amplitude and spectral content. The electromagnetic radiation from power cables, high voltage lines, power switching and control and electrical discharges. The impulse noise which is specific short time duration is composed spikes. The spikes occur in bursts, which cause so-called block errors in transmitted data.

The project has been focused on the impact of the impulse noise. How will be affected the broadcasting in the data networks based on xDSL technology. The measuring workplace has been implemented with project to monitor the impact of impulse noise on the transmitted video stream. The impulse No. 1 has been used for test purposes according to recommendation ITU-T G.996.1. The impulse No. 1 and the interference profile (model A) have been injected to the subscriber lines. The model A simulates the high level of crosstalk in the subscriber lines."

The measurement has been carried out the connection ADSL2+overISDN without interleaving and distance loop 1.2 km. A video stream in the SDTV quality has been used for test. The video stream was encapsulated to the MPEG-TS stream (compression MPEG-2, size 16:9, resolution 720x576, bit rate 4-5 Mbps) provided with satellite ASTRA 19,2°E, FTA programme Simul SD. The interference profile – model A (voltage peak-peak Upp = 100mV) has been sent to background to simulate the real state in the access network. It has been sent fifteen times (N=15) impulses with period of one second (T=1s) with recommended ITU-T 90

G.996.1. The measuring contained these parameters: period – T (0,5 second, 1 second and 1 minute), voltage peak-peak – Upp (50 mV and 150 mV) and number of impulses noise in burst – N (15 and 500).

Artifacts in the video stream, which generate to effect impulse noise, display as bricking, smear in the picture and out-of-order. The deformation of audio signal is displayed as a crackling sound. This is on the higher number of impulses (from 100). The period has the highest impact on the deformation of video stream. If the period is longer, the deformation of video stream will be less frequently. Therefore it is possible to expect lower incidence of artifacts in the picture and then also the better quality of experience in the video stream.

The deformation of group of pictures (GOP) has also examined whit impulse noise. The GOP contains this structure IBBPBBPBBPBI. It was found that it leads to the occurrence of deformation in the B-frames. Deformation is also occurred in other B-frames and P-frames in one GOP before I-frame will have arrived. I-frame is key frame, which is independent on the other frames. If this I-frame is also infected, deformation will be also in the next GOP, before I-frame will have arrived without deformation.

The impulse noise occurs very randomly and the occurrence of impulse noise is not possible to predict in the future. The impact of impulse noise is very dangerous and therefore a protection is necessary opposite the impulse noise. The effective protections can be for example: forward error correction – FEC and interleaving. Those protections cause delays between packets, which has a negative impact on the IPTV service.

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Distributed Planning and Coordination in Multi-agent Environment

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The problem of controlling entities in heterogeneous distributed environment is crucial for many domains [1]. Classical centralized methods depend on one central planning system. Such a system gathers all required input data before the planning process take place. Then the plan (set of plans respectively) is generated using these data. This approach faces various problems. One problem is enormous demand for performance of central planning system. The other problem is the need for real-time re-planning based on dynamically changing environment and conditions in the time. On the other hand, in distributed methods of planning each entity plans it's own plan. Cooperation and heading to common goals is done by negotiating methods.

Presented approach is based on newly designed multi-layer planning architecture. The whole planning of overall plan is distributed among arbitrary amount of autonomous agents. The planning hierarchy of the entities is not predefined, it emerges during the process of planning. Each agent knows only its own planning domain, which describes the agent's capabilities in the terms of the environment domain. This private personal domains are described in the form of Hierarchical Task Networks. The planning process is initiated by externally tasked agent(s). The tasks are typically added by human operator using system humane-machine-interface (HMI). As the HMI, it is used the I-X Panel, which is part of the I-X architecture developed by AIAI in Edinburgh, England. The agent tries to fulfill the task goals and may need to incorporate the sub-plans of other agents, in the case it is not able to fulfill the task on its own. These agents recursively runs the same planning process until the whole plan is formed and ready for execution. In the phase of incorporating of the sub-plans, the agents need to mark parts of the plans, where the other agents continue in the plan execution. For that purpose, the designed concept of plan interconnection by synchronizationpoints can be used. The parameters of the spatio-temporal synchronization-points are negotiated during the process of forming of the planning hierarchy. The synchronizationpoints are later used in the plan execution.

From the perspective of one agent, the planning process can be divided into three layers, which form the multi-layer planning architecture. In the strategic layer (the topmost layer), it is used the HTN I-X Planner creating abstract plan for long-time horizon. The planner is part of the I-X architecture and originates in the O-Plan planner. The plan instantiating process uses distributed resource allocation based on the well-known multi-agent Contract Net Protocol. With the help of this protocol, the appropriate subordinate agents are found and the responsibilities of the plan actions are fixed. The tactical layer (the middle layer) optimizes the plan using the early-as-possible scheduling heuristic. The heuristic causes the earliest possible execution of the plan actions which affects the length of the whole plan in the non-deterministic environment. The effect is directly proportional to the amount of the non-determinism in the world. The personal layer (the bottommost layer) plans potential planned using the A* algorithm. The other responsibility of the personal layer is the execution of all low-level actions in the scenario simulator.

The simulator is based on ACROSS 2 testbed developed by ATG at FEE CTU. The testbed is heavily supported by the A-Globe multi-agent platform. The testbed and platform are implemented in the Java programming language, similarly as the whole system.

All plans are described in the form of social commitments (substituting plan actions). The commitment is knowledge-base structure describing agent's obligation to change the world-state and a set of rules what the agent should do if the obligation is not satisfiable. The proposed structure is an extension of widely used formalization of the commitment [4]. The proposed commitment recursiveness enables more expressive description of the decommitment rules and thus the re-planning process. Formally, the recursive commitment can be described using the BDI (Believe-Desire-Intention) formalism as follows:

$$(\operatorname{Commit} A \ \psi \ \varphi \ \lambda^*) \equiv \\ ((\operatorname{Bel} A \ \psi) \Rightarrow \operatorname{A}((\operatorname{Int} A \ \varphi) \land \bigwedge_{j} \lambda_{j}^*) \curvearrowleft \bigvee_{i} \gamma_{i}).$$

where A denotes a committing agent, ψ is an activation condition, φ is a commitment goal, and λ^* is a set of the de-commitment rules. The introduction of the causal commitment interreferencing enables the real-time re-planning constraining. The mutual bindings and commitments form a commitment graph. The graph notation can be used for the process of the successive solving of the exceptional states (the re-planning). The process is based on the traversing through the commitment graph. The traversing starts with the first violated commitment. One of the de-commitment rules is triggered. In the case, that the decommitment rule inter-references other commitment, the process crosses on the referenced commitment and starts one of the de-commitment rules on the side of the referenced commitment. Provided that the de-commitment rule terminates the commitment without a need of crossing to other commitments, the process ends here, the violation is fixed and the plan is successfully re-planned. In other words, the re-planning process by means of social commitments can be described as successive re-committing [2]. For the de-committing purposes, there are three basic de-commitment rules: full de-commitment, delegation, and relaxation [3]. The influence of the particular de-commitment rules and its ordering was experimentally measured and several configuration was compared. The measurements shows, the most suitable de-commitment configuration for the non-deterministic domains is: delegation, relaxation, and full de-commitment, in this particular order.

The system was verified on several different scenario setups: multi-tasking, crossbooking, over-booking, scalability tests, robustness tests, external system integration (AGENTFLY system) and others.

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Searching Approximate Covers of Strings using Finite Automata

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Searching regularities of strings is used in a wide area of applications like molecular biology, computer-assisted music analysis, or data compression. By regularities, repeated strings are meant. Examples of regularities include repetitions, borders, periods, covers, and seeds.

String *w* is a cover of string *T* if *T* may be constructed by concatenations and superpositions of copies of *w*. String *w* is an approximate cover of string *T* with maximum distance *k* using some distance function *D* if there exist strings $u_1, u_2, ..., u_v$ such that *T* may be constructed by concatenations and superpositions of strings $u_1, u_2, ..., u_v$ and $D(u_i, w) \le k$ for all i = 0, 1, ..., v. String *w* is a restricted approximate cover of string *T* if *w* is an exact factor of *T*. Note that a non restricted approximate cover may be any string, not necessarily an exact factor of *T*. We have considered restricted approximate covers only.

It clearly holds that any approximate cover w of string T must be an approximate prefix of T and an approximate suffix of T. Therefore, w must be from intersection of set of all approximate prefixes and suffixes with respect to D and k. The set of all approximate prefixes, suffixes is accepted by an automaton called prefix, suffix, respectively. An automaton accepting intersection of sets of words accepted by other two automata may be constructed by the already known algorithm. Such automaton may be used as a filter, as only strings accepted by it need to be further analyzed.

Each finite automaton $M = (Q, A, \delta, q_0, F)$ consists of nonempty finite set of states Q, initial state q_0 , set of final states F and transition function δ . Left language of any its state q consists of all strings w such that it holds $\delta^*(q_0, w) = q$.

Approximate prefix and suffix automata may be constructed as nondeterministic. Such construction is simple and fast. Approximate prefix automaton for string *T* over alphabet *A* and maximum distance *k* may be constructed in the following way. Create the initial state q_0 . For each position *i* of *T* create a state q_i^0 and define depth of q_i^0 equal to *i* and level of

 q_i^0 equal to 0. For each symbol of *T* at position *i*, denoted by T[i], define $\delta(q_{i-1}^{0,i}T[i])=q_i^0$. The already constructed part of the automaton is called 0-th layer. Construct a layer for each j = 1, 2, ..., k and define level of each state q_i^j equal to *j*. Rest transitions depend on a distance function. For Hamming distance, for each i = 1, ..., |T| and j = 1, 2, ..., k define $\delta(q_{i-1}^{j-1}, a)=q_i^j$ for all $a \in A \setminus \{T[i]\}$. For Levenshtein distance, there are all the transitions as for Hamming distance and moreover $\delta(q_{i-1}^{j-1}, \varepsilon)=q_i^j$. Also for each i = 0, ..., |T| and j = 1, 2, ..., k, define $\delta(q_i^{j-1}, a)=q_i^j$ for all $a \in A \setminus \{T[i]\}$. In a prefix automaton, Q = F holds. A suffix automaton is constructed the same way, moreover $\delta(q_0 \varepsilon)=q_0^i$ for all i = 1, ..., |T| and $F = [q_{|T|}^{j}]$ for all j = 0, 1, ..., k.

A deterministic finite prefix or suffix automaton may be created using subset construction from a nondeterministic one, which is previously constructed the way described above. Such deterministic automaton has states that consist of subsets (called *d*-subsets) of states of the nondeterministic one. For any string *w* of left language of state *q* of the deterministic suffix automaton holds that *d*-subset d(q) is equal to end-set of *w*, i. e. depth of any state from d(q) is equal to an end-position of *w* in *T* and level of any state from d(q) is equal to an 94 approximation with which w occurs in that end-position in T. Therefore, states of the deterministic suffix automaton consisting of d-subset of states with non-zero level may be removed (as left language of such states contains no exact factor of T and recall that restricted covers are exact factors).

Therefore, algorithms for construction of an automaton accepting intersection and subset construction are combined to create an automaton accepting cover-candidates. Each string w of left language of each final state of the deterministic automaton is then analyzed whether it covers T.

The condition to determine whether a cover-candidate w is a cover of T is relation between length of w and its approximate end-positions in T, known from a respective d-subset. When difference between any two consequent end-positions of w in T is greater than the length of w, then w cannot cover T (because it occurs in T with gap).

This simple and straightforward approach, presented in [1], may be used for a variety of distance metrics, it was shown for Hamming, Levenshtein and generalized Levenshtein distance.

For Hamming distance [2], it is not necessary to construct automaton accepting intersection to recognize approximate prefixes (in contrast to Levenshtein distance). Having state q of a deterministic suffix automaton for string T and maximum Hamming distance k: when string w of left language of q has length equal to the smallest depth of states from d(q), then w is an approximate prefix of T, because its end-position is equal to its length. Moreover, it is not necessary to hold whole deterministic automaton in memory at a time. It is possible to perform a depth-first-search-like construction, where each d-subset is analyzed immediately after it is constructed. States that are closed (within depth-first search) may be removed from memory, as they are no longer needed. This reduces the space complexity from $|T|^3$ to $|T|^2$.

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Compression algorithm for camera security systems

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In this paper author presents his study results on using Karhunen- Loeve transform in image processing, especially for compression algorithms. The task of bitrate reduction is very important because of increasing quantity of multimedia content and limited capacity of communication channel (telephone links, GSM networks etc.). Karhunen- Loeve transform (KLT) provides an efficient mathematical tool which can be used for reduction of quantity of transmitted image data.

In [1] is described videoconferencing system based on KLT. Image data from videoconferencing systems have specific properties such as relative unchanging content with face in foreground, low frame rate. The main idea of this system is based on using representative set of frames with videoconference participants as the substitution for captured frames. The representative frame is selected on the basis of comparing captured frame with all representative frames. This comparing cannot be executed in spatial domain because of significant similarity between frames. This is the reason for using KLT as the efficient tool for comparing frames in eigenspace. If there isn't the most similar frame (distance in eigenspace between captured frame and representative frame is higher than the adjusted threshold value), the representative set is updated with captured frame (there is also transmitted captured frame to the receiver). Otherwise, there is transmitted pointer (the number of transmitted bytes equals to the size of data type used for this pointer) to the most similar frame in the representative set. Both videoconference participants use the same representative set of frames. Described principle can be used not only for videoconference frames.

Reduction of time redundancy for an image data can bring perceptible reduction of output bitrate. Let us consider camera security system. Captured frames are relative unchanged because of similar content (people, traffic, corridor etc.). There is also significant time redundancy between captured frames. In [2] is discussed compression algorithm which is based on the three- dimensional KLT (3D KLT). The third dimension is shaped with time evolution of the scene which is represented with N captured frames. The basic problem is in construction of the input 2D matrix X for KLT. This matrix should also contain image data from N frames and can be constructed as follows: pixels from positions (1, 1) in all N frames are stored in the first row of matrix \mathbf{X} , pixels from positions (1, 2) in all N frames are stored in the second row of matrix X, etc. Matrix X has also WxH rows and N columns, where W, H are dimensions of captured frames. Each row also represents time evolution of one pixel. Eigenpairs (eigenvalue and eigenvector) of covariance matrix, which is evaluated from matrix X, represent transformation matrix of KLT (eigenvectors are contained in transformation matrix). Reduction of time redundancy is based on excluding some eigenpairs from transformation matrix. This step isn't defined unambiguous (depends on application, for which will be used mentioned compression algorithm). Transformed image data have lower dimension and it also brings lower output bitrate.

Further discussion and simulations about 3D KLT are in [3]. There is presented algorithm for compiling transformation matrix only from relevant eigenpairs. The criterion is based on image recognition in beforehand known image database. Selected image from 96

database is compressed using first n eigenvectors and then is compared with all images from database. If the recognition isn't successful, the previous two steps are repeated with using first n + 1 (n = n + 1) eigenvectors. Otherwise, the number n determines first n eigenvectors for compiling the transformation matrix.

The computational complexity is very considerable for finding the transformation matrix. In [3] are also described two methods which reduce the computational complexity. In the first method is the captured sequence of N frames divided into two sequences; each divided sequence contains N/2 frames. The transformation matrix is found only for the first sequence, the second sequence uses the same transformation matrix. In the second method are replaced group of pixels with one pixel whose value can be computed as the average, minimum, maximum or random value from all pixels in the group. Input matrix with image data has also smaller size. After the reconstruction (inverse KLT) is the obtained pixel value assigned to all pixels in the group. Block structure, which is visible for relative large groups of pixels (approx. 8x8 pixels), can be reduced with using suitable low-pass filter. As the alternative, the size of group of pixels can be adapted in frame level- frames with relative invariable structure can use larger size. Both mentioned methods are relative simple but also effective.

There was realized camera security system which consists from two black and white cameras with infrared illuminators and from PC with frame grabber for capturing and image data processing. There is also developed software application for this camera security system which enables image data processing. In our learning laboratory is placed LCD monitor which enables real-time presentation of this software application. Students can also imagine what they can study in our department.

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New Architectures of Railways Interlocking Systems with High Demands of Safety and Reliability

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Design of railway interlocking systems has evolved though more than a century from classical mechanical interlocking elements to recent fully electronic devices. Most of the todays solutions are based on processor platforms running applications implemented in C Language.

Microprocessor systems have to deal with problems resulting from the rules for safe designs of railway interlocking systems, which are hard to solve. In particular, complex structure of HW does not allow for simple structure description making verification and proof of safety difficult. Lack of suitable programming languages, verification tools and methodologies for design of applications with high safety and reliability demands is also a problem. It is also problematic to implement continuous run-time testing which would reliably and effectively detect degradation of microprocessor structure. Diversification in design as a precaution for systematic errors is also complicated. These topics are discussed in [1],[2].

Real control systems, which certainly include railway interlocking systems, typically demand high parallelism in their functionality, thus FPGA integrated circuits provide with great advantage for this. However, recent implementations of railway interlocking systems avoid usage of FPGA. These facts are motivations for implementation of FPGA based system with high demands for safety and reliability.

An electronic device, FDPR module based on FPGA platform Virtex-4 by Xilinx, was designed and debugged as a part of the project. The module is fully pin compatible with processor module PM-2B (by AZD) and may be used as its replacement in CM-1 unit (CM-1 unit by AZD is part of electronic automatic block system ABE-1) and thus could be used to try out the design of a system with high demands for safety and reliability.

The choice of Virtex-4 was made because of its suitable properties – dynamic partial reconfiguration, built-in PowerPC processor and configuration port integrated directly into the FPGA structure (ICAP).

The FDPR module was designed with emphasis on technique of storage and testing of configuration data for FPGA, to minimize time necessary for reconfiguration of module inside FPGA structure, and further, possibility to debug both FPGA structure and autoblock function in the run-time.

Technology of partial dynamic reconfiguration was used to implement safety functions by periodically running functions in tested area of the FPGA combined with redundant systems technology. The Virtex-4 is the first component offering new possibilities in technology of partial dynamic reconfiguration along with different organization of configuration memory and implementation of modules interfaces inside the FPGA architecture. In case of mature parts offering partial dynamic reconfiguration modules always 98

occupy the full height of the device and the topology and connectivity are limited to 1D and may use only limited number of so called "TBUF" macros to separate modules inside FPGA architecture. On contrary, Virtex-4 makes use of so called "slice" macros, which are composed of common logical cells of the FPGA (and thus their amount is limited only by the array size) and enable modules to be assigned arbitrary rectangular regions of the FPGA, which together brings possibility of practical usage of partial dynamic reconfiguration technology for real systems. Dynamic reconfiguration techniques are also discussed in [3].

Beside the design of the hardware platform, FPGA function blocks comprising base system to test autoblock function using technology of partial dynamic reconfiguration were developed - e.g. SDRAM controller, data integrity check module and configuration port controller. The FPGA structure was designed using Xilinx ISE and Xilinx PlanAhead.

In present, a method for testing an area of FPGA structure is being developed so that anomalies caused by hardware failure are eliminated before loading safe functions and bringing the system into safe state. In case of detection of a hardware failure there is a possibility to move the module into different, error free, area. Another related topic is elimination of SEU (Single Event Upsat – errors caused by alteration of configuration data by ambient high energy radiation).

Further, there will be a discussion on separation of real application – autoblock into part with high demands for safety and reliability implemented in parallel structure and safe module as well as part without such requirements which might be implemented by embedded PowerPC processor.

The aim of this work is to open up the FPGA to be used in systems with high demands for safety and reliability and its practical verification. The project is part of the doctor thesis "Proposal of Methodology for Development and Verification of Sale Algorithms Implemented by Dynamic Reconfigurable FPGA" which will especially cover methodology for design of safe and reliable systems using FPGA technology with partial dynamic reconfiguration using the practical results of this project.

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Solving Systems of Polynomial Equations for Minimal Problems in Computer Vision

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Many problems can be formulated using systems of algebraic equations. Examples are the minimal problems in computer vision, i.e. problems solved from a minimal number of point correspondences, such as the five point relative pose problem, the six point focal length problem, six point generalized camera problem, the nine point problem for estimating paracatadioptric fundamental matrices, the radial distortion problems and many others. These are important problems with a broad range of applications.

Often, polynomial systems which arise are not trivial. They consist of many polynomial equations in many unknowns and of higher degree. Therefore, special algorithms have to be designed to achieve numerical robustness and computational efficiency. The state of the art method for constructing such algorithms, the solvers, is the Groebner basis method for solving systems of polynomial equations. It was used to solve all previously mentioned computer vision problems.

Previously, the Groebner basis solvers were designed ad hoc for concrete problems and they could not be easily applied to new problems. In our work [3] we have created an automatic procedure for generating Groebner basis solvers which could be used even by nonexperts to solve technical problems. The input to our solver generator is a system of polynomial equations with a finite number of solutions. The output of our solver generator is the Matlab or C code which computes solutions to this system for concrete coefficients. Generating solvers automatically opens possibilities to solve more complicated problems which could not be handled manually or solving existing problems in a better and more efficient way. In experiments we have demonstrated that our automatic generator constructs efficient and numerically stable solvers which are comparable or outperform known manually constructed solvers.

Based on the mentioned Groebner basis method we have also created solvers to some new minimal problems in computer vision. We have proposed numerically stable solutions to three new minimal problems for the autocalibration of radial distortion.

- 1. The minimal problem of estimating one-parameter radial distortion model and epipolar geometry from eight image point correspondences in two uncalibrated views.
- 2. The minimal problem of estimating one-parameter radial distortion model and epipolar geometry from six image point correspondences in two partially calibrated views [1].

3. The minimal problem of estimating one-parameter radial distortion model and epipolar geometry from nine image point correspondences in two uncalibrated views with different radial distortions in each image [1].

In [2] we have proposed a general solution to the determination of the pose of a perspective camera with unknown focal length from images of four 3D reference points. This problem is a generalization of the P3P and P4P problems previously developed for fully calibrated cameras. Given four 2D-to-3D correspondences, we estimate camera position, orientation and recover the camera focal length. We have formulated the problem and provided a minimal solution from four points by solving a system of algebraic equations. We have compared the Hidden variable resultant and Groebner basis techniques for solving the algebraic equations of our problem. By evaluating them on synthetic and on real-data, we have shown that the Groebner basis technique provides stable results.

In the second part of our work, we have studied polynomial eigenvalue method for solving systems of polynomial equations. Using this method we have provide new fast and simple solutions to two important minimal problems in computer vision, the five-point relative pose problem and the six-point focal length problem [4]. We formulated these two problems as polynomial eigenvalue problems of degree three and two and solved using standard efficient numerical algorithms. Our solutions are somewhat more stable than state-of-the-art solutions by Nister and Stewenius and are in some sense more straightforward and easier to implement since polynomial eigenvalue problems are well studied with many efficient and robust algorithms available. We have demonstrated the quality of the solvers in experiments.

There are still many unsolved problems in computer vision which can be formulated using systems of polynomial equations. In future work we want to find such problems and try to solve them using our Groebner based solver or using polynomial eigenvalue method. We also want to continue studying Groebner basis method for solving systems of polynomial equations and extend our automatic generator of minimal problem solvers.

The automatic generator is available at http://cmp.felk.cvut.cz/minimal. This webpage also contains papers and source codes to many minimal problems in computer vision including ours.

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Spatial Directional Radiance Cache

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Introduction - Irradiance caching [Ward et al. 1988] is one of the most successful algorithms to accelerate global illumination computation. It is based on the idea that the slowly varying indirect illumination term can be computed only at several locations in the scene, stored in the cache, and later used for fast interpolation. Recently, we have witnessed a revival of the research on caching-based approaches to global illumination. Recent successful extensions of the original algorithm include the support for caching on glossy surfaces with low-frequency BRDFs [Křivánek et al. 2005] and even in arbitrary participating media [Jarosz et al. 2008].

In our research, we focus on indirect illumination on glossy surfaces, similarly to [Křivánek et al. 2005]. Our objective is to design a novel caching algorithm that addresses the limitations of Křivánek et al.'s radiance caching. First and foremost, we aim to avoid the conversion of the scene BRDFs into the frequency domain (spherical harmonics) in the preprocess. Instead of working in the frequency domain, we use BRDF importance sampling both for generating new cache records and for interpolating the records from the cache. Using importance sampling allows us to apply caching not only on low-gloss surfaces but also on shiny materials with highfrequency BRDFs, such as metal, lacquer, or some types of plastic for which the radiance caching algorithm breaks down. Another advantage is the support for heterogeneous (spatially varying) materials.

Novel caching algorithm - Our algorithm is built on the fundamental idea behind the original irradiance caching, the "lazy evaluation procedure": query the cache, perform interpolation if possible, otherwise compute a new illumination value and store it in the cache for later reuse.

When we evaluate a new record (if none is available for interpolation), we generate random directions using BRDF importance sampling and compute incoming radiance for each direction by ray tracing. We then map these directions from the sphere into a unit square using an area-preserving octahedral mapping and construct a quadtree over the samples. We call the quadtree the L-tree (L stands for radiance). The whole L-tree is then stored in the cache as a single record. The cached L-trees may later be selectively up-dated during the interpolation as described in the following paragraph. To determine the area over which the new record can be reused, we estimate the upper bound on the illumination gradient from the radiance samples. The gradient formula takes the BRDF into account, hence the record spacing is automatically adapted to the surface reflectance properties.

The major novelty of our caching algorithm consists in performing the "lazy evaluation procedure" not only in the spatial but also in the directional domain: To compute indirect illumination at a point, we first collect existing nearby cache records, or L-trees, (in space) and we attempt to use them for interpolation. However, for each sample direction (generated by BRDF importance sampling at the point of interpolation), we check if there is a nearby radiance sample stored in the L-tree and possibly reuse it. If not, we shoot a ray to obtain a 102

new radiance sample and update the L-tree. The process is applied to all contributing L-trees separately. Finally, outgoing radiance is computed as a weighted average of the contributions from individual L-trees. The major benefit of the directional caching is that it ensures a smooth integration of the view-dependent BRDF importance sampling with the view-independent overall caching algorithm.

Results and Discussion - Our results demonstrate the feasibility of our approach and the wide range of supported materials. The main disadvantages of our method are higher memory demands and potentially difficult parallel implementation due to the continual updates of cache records.

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Semantic user profile acquisition and sharing

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In the project we focused on an adaptation of web resources based on standards developed for the Semantic Web [1]. The main goal of our research is an architecture for semantic user profile interoperability which allows to maintain high quality of user profile and in consequence provides more precise results of the adaptation.

Adaptation is a very actual topic solved worldwide. It is a process supporting each user accessing, retrieving and storing web resources and information contained in them and in consequence prevents the user from information overload which occurs very often nowadays. Such process requires available metadata about the domain, user etc. to adapt the content to the user's needs and requirements helping him to found the requested information easier. Many systems trying to fulfill user's needs have evolved, e.g. AHA!. All these system employ a certain kind of domain description and also maintain a form of user profile. Unfortunately, the format of required metadata differs system to system.

Addressing these issues W3Consortium proposed Semantic Web – set of standard languages for describing knowledge on the web. Also there has been declared a claim for effective adaptation methods as integral part of Semantic Web. Although some issues have been solved, new ones have arisen. Generally, quality of adaptation process depends, except other factors, on quality of domain ontology and accuracy of user profile. However, creating and maintaining user profile at high-quality can be very complicated (and/or expensive).

Various approaches for user profile acquisition have been described for example in [1] and can be adopted for use with semantic web technologies. Acquisition by means of filling it in by a user can be employed but these profiles tend to degrade over a period of time and also represent subjective view of the user himself. Better results can be obtained accompanying web usage mining techniques etc. Time plays very important role in the process of user profile acquisition – profile truthfully reflecting characteristics of the user typically requires observation of the user for long period of time.

To overcome issues arising from complexity of high-quality user model acquisition, profile sharing can be employed and there are several possibilities. The easiest solution is based on client-server model which implies a single point of failure and also scalability is very limited. Therefore we propose a distributed environment equipped with similar features as a solution.

In the project we designed architecture suitable to semantic user profile interoperability [2] based on peer-to-peer networks, especially on the Distributed Hash Tables (DHTs) [3]. The architecture overcomes issues with scalability, extensibility and removes single point of failure. The architecture for interoperability consists of four layers. Each layer extends or wraps the set of features available through lower layers (if available).

The bottom one – DHT layer – is responsible for distributed storage of the data, lookup and retrieval based on hashes of keys. In our case data is user profiles represented as ontologies in standardized OWL format. DHT forms highly organized peer-to-peer network. However, knowledge of an identifier is anticipated – DHT supports only exact search. Therefore supporting similarity computations or approximate search must be introduced to the system but without more semantic information it is proved that such task is NP-complete. Therefore, solutions based on approximate algorithms must be employed – as associative overlays, guided rules or use of locality preserving hash functions instead of consistent hash functions in DHT.

Core layer introduces features related to ontologies. Ontology mapping and mediation should be supported at least at minimum level, e.g by providing a mapping to an upper level ontology to identify common concepts in profiles used in different applications.

Agent layer consists of agents cooperating on computations of the results. Agents must be able to use features provided by previously mentioned layers to search, store and retrieve required data. Previously mentioned issues in the DHT layer must be solved at first. Main responsibility of the agents is process of the adaptation itself.

Top layer is formed by the clients which are supposed to relay requests to specialized agents in the system who process the request. On the other hand, clients are responsible for the observation of the particular user and proposing updates to his/her profile.

For this project and several others a framework called E-WAIT was designed and partially implemented by WEBING research group at FEE CTU. The framework is intended to ease implementation of algorithms, simplify data retrieval and storage and support experiments by means of providing experiment definitions with versioning, execution plans, results management and visualization of results. The resulting framework is mainly intended for use with Semantic Web but there is no limitation that forbids it use in other fields of research.

Whole framework is built upon Common Data Type (CDT) that ensures data interoperability. Algorithms are seen as transformations of the CDT. Such approach guarantees universality of proposed solution. CDT assures that data can be taken from different sources, e.g. files, relation databases, RDF and many others. Algorithm is a single transformation or a defined sequence of them, branching and iterations are allowed in transformation processing. The framework is built up on modern technologies as JavaTM 6 and JavaTM Enterprise Edition 5, Spring framework and Google Web Toolkit. Most of the required functionality is currently available but there is still a need for integration of implemented parts.

In the project we identified the importance of high quality user profile for adaptation and pointed out solution for several issues as lack of scalability, single point of failure, insufficient mobility and quality of the user profile. Proposed solution is architecture for adaptation with focus on user profile interoperability – user profile storing in P2P networks. However, implementation and evaluation of the project is still ongoing due to delays and insufficient integration of parts of the E-WAIT framework. In the future work we plan to finish implementation and evaluation and based on the results we plan to continue in greater detail with the adaptation part [2] of the architecture which forms together with semantic interoperability main topics of my PhD. thesis.

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New Modifications to Ant Algorithms

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Stochastic algorithms derived from Ant Colony Optimization metaheuristic proved to be successful in solving NP-complete optimization problems. While using these algorithms, we often face a problem of slow convergence and of getting stuck in a local optima. To avoid these problems, several approaches were developed. We can utilize natural parallelism of ant algorithms and use multiple colonies to increase a probability of a faster solution discovery. Also, approaches originally developed in the field of Evolutionary Computation, such as niching techniques, can be used to sustain a diversity in the (population based) ACO. Another option is to take into account the dependence of the optimal parameter settings on the concrete instance of the problem. Parameters can be adapted during the computation or derived from statistical evaluation of the solved problem instance. We can also see this as a continuous optimization problem and solve it. There is a chance that the hierarchy of optimization problems might be able to reduce the dimension or the impact of parameters in the higher levels. However, this process would be very time consuming indeed.

We tried another way to improve the ACO performance by using principles inspired by nature. In nature, ants of the same species are divided into a different number of castes, like queen(s), workers, soldiers etc. Each caste has unique capabilities depending on its size, body structure, ability to reproduce and encoded behavioural acts. This functional specialization called polyethism allows the whole colony to act as a sophisticated system with division of labour while keeping the individuals simple. Social insects are also often forming so called temporal castes because their behaviour together with physiology can change depending on their age. Various mechanisms of castes management across all social insect species are ranging from discrete castes to the continuous ones. These mechanisms include timedependent, pheromone and environment driven changes in the structure of castes.

In the proposed modification of ACO metaheuristic [1], we utilised nature developed approach by simulating ant castes. The idea is to split the population of ants into several distinct groups. Ants from different groups have different sets of behavioural acts. For example, we can create "workers" which are moving along the strongest pheromone trails with only minor random changes. Or we can create "explorers" with high probability of random movements, problem heuristics exploitation or pheromone avoidance. As all ants are solving the problem together, explorers can help the algorithm escape from local optima in which the workers are stuck. By assigning different pheromones to each caste and setting, we can achieve a parallel solving of the problem by several castes.

We introduced Ant Colony Optimization with Castes (ACO+C) which is a general extension to algorithms based on ACO metaheuristic. The idea of dividing ants into several castes with different parameters was tested on the MMAS algorithm which follows the structure of ACO metaheuristic. We used 11 instances of Travelling Salesman Problem (8 symmetric, 3 asymmetric) from TSPLIB as benchmark data. Results for experimentally designed set of castes show better performance than standard MMAS. The average number of iterations was reduced and average solution was shorter in all cases. These differences were 106

significant according to Wilcoxon test. We also showed that the different instances of TSP are more effectively solved by different castes and that the number of improvements made by ants from one caste can vary in different stages of computation. These results are promising and we suggest at least two potential ways of further research. Firstly, more complex castes should be designed, for example castes for local search and castes with different types of pheromone. The second step could be optimization of castes developed by evolutionary computation techniques.

This improvement can be also used together with algorithms for continuous optimization, inspired by ant behaviour. We proved some of them to be successful on the field of model optimization [2] and we hope that the combination of these algorithms with the previous approach would bring improvement mainly in the speed of convergence. While constructing inductive models of a given system, we need to optimize parameters of units the system is composed of. These parameters are often real-valued variables and we can use a large scale of continuous optimization methods to locate their optimum. Each of these methods can give different results for problems of various nature or complexity. In our experiments, the usually best performing gradient based Quasi-Newton method was unable to optimize parameters for a well known problem of two intertwined spirals; its classification algorithms performance on this particular problem. Our results show that two probabilistic algorithms inspired by ant behaviour are able to optimize parameters of model units for this problem with the classification accuracy of 70%.

We also designed algorithm inspired by ACO modified by adding parallel subsolutions heuristic [3]. By combining solutions of its subproblems, ACO can be parallelized simply by simultaneous execution of the algorithm with eventual exchange of the best solutions between all computational units. This approach requires access to a whole state matrix (which is of size $O(n^2)$) for each of them. It can limit the size of solvable problems on special architectures with different available memory capacities such as Cell Broadband Engine Architecture (CBEA). Our modification of the algorithm keeps only one pheromone matrix in the memory of a main unit. The matrix is updated by subsolutions computed by ACO on other units in parallel. We show that this approach performs significantly better than greedy algorithm, even though it generates the whole solution from solutions of subproblems.

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Measurement of Transaction Throughput in Native XML Database

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XML based technologies became standard in many areas of informatics, especially where is required data exchange among information systems. Originally XML documents were stored in particular files/resources in a filesystem/internet. This manner of storage is unsuitable for processing queries and updates. Many APIs were designed for this file-oriented approach. DOM API is one of them. The problem arises if we want to access large portion of data. In a file-oriented API we have to load whole document into a memory and then execute a query. If the document content is changed during query execution then the document has to be saved back. Another problem arises if we want to grant access to many users for one resource. Then we have to ensure ACID transaction safe processing of the resource. The better way is to save documents into a central database. Hence, queries can be executed by a database engine implemented on the database side. Finally, native XML database stores XML documents in a natural way for it.

Transaction Manager

Important part of each native XML database (NXD) is a transaction manager module and a lock manager module. These modules are used to ensure ACID properties for each transaction, especially atomicity and isolation. Transaction manager module also provides general operations as a *beginTransaction()*, *a rollbackTransaction()* and *a commitTransaction()*. We achieved atomicity property by locking using protocols from a taDOM locking protocol family [4].

taDOM3+

taDOM3+ is a DOM-based locking protocol [3]. DOM operations can be easily mapped on XPath axes [1]. We have implemented taDOM3+ [4] locking protocol into the CellStore experimental NXD. The implementation is based on design patterns and it is focused on "cleanness of code". The correctness of the implementation has been checked by more than 100 unit tests and by more than 10 integration tests. The implementation is described in [2]. The important aspect is also verification of the protocol if it ensures ACID properties correctly. The proof was given by Valenta and Siirtola. Finally, we showed [1] the mapping of taDOM3+ protocol on a functional update language XML-LAMBDA.

Benchmark

This grant has been focused on the measurement of transaction throughput in CellStore database. Update operations are not widely supported by native XML databases and no suitable benchmark was designed yet. We have found update oriented benchmark in [3], but it has not been well described to reproduce measurement. All other existing benchmarks are designed to measure queries performance not update operations performance. Then we have decided to design appropriate benchmark for concurrent transactions. The benchmark have consisted of update operations and read operations. Operations have been interleaved with 108
wait operations (0 – 5000 ms). We have used XMARK database model. A database have had depth 6 and size 5 MB. We have defined following schedule for each transaction: < WAIT, BID, WAIT, CLOSE_AUCTION, WAIT, INSERT_AUCTION, WAIT, GET_CATEGORIES, WAIT, REMOVE_ITEM >. Semantics of these operations is :WAIT – waits a random time (0 – 5000ms), BID – bids on a random item in a random auction, CLOSE_AUCTION – moves random auction to closed auctions, INSERT_AUCTION – inserts new auction on a random item, REMOVE_ITEM – removes random item including all referenced auctions.

Measurement

We have designed a new benchmark to measure transaction throughput in the CellStore database. Nowadays, the benchmark is not able to run inside CellStore environment, because XQuery update facility module, needed to execute update operation, is not integrated to CellStore. We have decided to run benchmark using in memory DOM storage as a backend. For this purpose we have used Xerces DOM parser to build a DOM tree in a main memory. Then we have designed five simple tests, which are intended for measurement of a Transaction Manager time complexity. This benchmark is for single transaction mode only. In multitransaction mode we have not been able to obtain relevant results. We have been measuring system deceleration caused by a single transaction.

Conclusion

The measurement has been done in a single transaction mode. Hence, we have been able to gather real load caused by the Transaction Manager and its subcomponents. In the first test, loading of a document, transaction manager embodied 2x - 5x deceleration depending on a size of loaded document. The second test has added initialization of Transaction Manager during document loading. It has not been significant deceleration observed in this test. The third (read operations), fourth (update operations) and fifth (read + update operations) test have embodied 2x deceleration. We would like to present our results on SYRCoDIS 2009. Our future work will be focused on the integration of XQuery Update module into CellStore. Finally, we will run the benchmarks in a multitransaction mode.

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Wavelet Transform Based System for Perceptual Audio Coding

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Perceptual coding of digital audio is a topical issue. Many papers have been presented and many systems for perceptual coding were introduced. Presented project investigates potentials of wavelet transform principles in perceptual coding of digital audio.

Most of the current wide-band audio coders use either Pseudo Quadrature Mirror Filter (PQMF) filter banks or Modified Cosine Transform (MDCT) for transformation of an input digital audio signal into its frequency domain representation. Both methods suffer from the origin of artifacts. Wavelet transform represents compromise between PQMF filter bank and MDCT transform and should be more resistant to the origin of artifacts.

Novel Wavelet Filter Bank Based Wide-band Audio Coder [1] was introduced during the project realization. This coder uses Wavelet Filter Bank (WFB) for time/frequency transformation of an input digital audio signal. WFB decomposes the signal into 28 critically sampled sub-bands, coding is than performed in these 28 sub-bands. WFB was designed with the respect of human hearing therefore distribution of sub-bands bandwidths is close correlated with Bark scale [3]. Signal in each sub-band is than windowed to cut it into finite blocks. Time lengths of the windows depend on the sub-band. Low-frequency window is much longer than high-frequency one, which correspond with the theory of human hearing [3]. Exact length of the window depends on the time-masking effects. Windowed signal is normalized in the next step to increase dynamics.

Psychoacoustic model is an important part of the coder that analyzes input signal from the psychacoustical point of view. Psychoacoustic model briefly analyses components of the signal and determine frequency dependant masking curve that describes border between perceptible and imperceptible sounds. Masking curve is sometimes converted into Signal to Mask Ratio (SMR). SMR describes distance of the given frequency component of the analyzed signal from the masking curve. Negative value denote, that the given frequency component is not perceptible. Obtained masking curve or SMR is than used to control coding process.

Two different psychoacoustic models are designed for the Wavelet Filter Bank Based Wide-band Audio Coder at the moment. The first is a simple static psychoacoustic model that takes into account hearing threshold only not masking effects. This simple model is used mainly during the development process and for the first evaluation of the designed coder. The second psychoacoustic model is based on the ISO/IEC MPEG-1 Psychoacoustic Analysis Model 1 of MPEG 1 audio standard [4]. This model takes into account frequency masking effects. Description of the advanced psychoacoustic model can be found in [2].

All the processing before this point was lossless, purpose of it was to prepare signal for re-quantization that is performed in the next step. Input audio signal is expected to have standard CD quality - sampling frequency 44.1 kHz and 16 bit quantization. Re-quantization block performs reduction of the bit depth of the samples in each window according to the information given by psychoacoustic model. Bit depth of the samples differs in frequency (sub-bands) and time (windows in each sub-band). Saved bit space is not constant and differs according to the character of the coded audio signal.

Output data stream is formed by the last block of the Wavelet Filter Bank Based Wide Band Audio Coder. Information that is necessary for the decoding of the original audio content is multiplexed with the coded audio data in this block. Special format of the output data stream is necessary for the storage and transmission of the coded audio data. Standard Matlab functions are used at the moment and special format is expected to be created.

For the purposes of evaluation of perceived quality of digital sound signals was created mobile measuring system. This system consists of a quiet mobile computer MSI PR200, professional external sound card RME Fireface 400 and professional headphones Koss MV1. Computer is equipped with software Cubase 4, Adobe Audition 2, Opera and Matlab environment with Wavelet Toolbox. This software set makes it possible to perform all necessary measurement including subjective and objective evaluation tests. Software Cubase 4 and Adobe Audition is used for signals generation, reproduction and recording. Opera software is an implementation of the recommendation ITU-R BS-1387 (PEAQ) that defines methods objective evaluation of perceived audio quality.

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Adaptive Hypermedia with a Semantic Data Store

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At present, the web is a widely used source of information. To allow users to work effectively, current research focuses on the development of new methods for easier information access. There is an increasing need of adaptive personalization. Current systems face the problem that data are not machine-understandable and automatic processing of data is limited. This problem could be solved by using Semantic Web technologies. In our work, we utilize this approach and we are developing a general model for adaptive hypermedia that should provide a formal description and allow simple development of such systems.

We would like to be able to create good adaptive systems with the ability to re-use data and cooperate with each other. The identified problems were defined as research questions in [1]. Our work should find answers to these questions. We need a formal theory of adaptive hypermedia, which is still missing. In our work we have analyzed the most desirable requirements of good adaptive systems. Based on these requirements we have extended the modeling loop of adaptive systems and proposed the General Ontological Model for Adaptive Web Environments (GOMAWE). Our model is based on the semantic data representation. The architecture of GOMAWE can be divided into several layers – storage layer, reasoning layer, integration layer, interface layer and application layer. More detailed description of the model can be found in [1].

Based on the theoretical model proposal, we have performed several experiments. We started with experiments in the field of e-learning. Adaptive environments are very closely related to the area of e-Learning [2]. We have analyzed students' requirements on adaptive systems by a questionnaire, where the students marked their preferences, e.g. significant information for adaptation or the most important adaptation techniques. We have developed an ontology for e-learning adaptive system and a core of the system used to access the stored information. The full implementation of an e-learning system will be done in our future work.

Following the first experiments in the field of e-learning we have implemented an adaptive system, where adaptation is focused on recommending the most suitable items for the user [3]. The system has two interfaces. One of them is a bookstore and the other is a library. The implemented system was used for simple experiments focused on data interchange. Another important result was the evaluation of the speed of information access using the semantic data layer.

We have presented our innovative approach to the design and development of intelligent information systems. We have proposed the theoretical foundations of our General Ontological Model for Adaptive Web Environments model (GOMAWE). We have implemented an adaptive system prototype and performed several experiments.

In our future work we will focus on formal description of the GOMAWE, complete implementation of the model and perform experiments to verify out theoretical proposals. We assume that the adaptive system is an interactive system. Therefore, utilizing the graph grammar theory seems to be a promising approach. The storage layer implementation will be

extended with the multidimensional matrix as described in the proposal of our model. Rules stored in the multidimensional matrix will add the possibility to infer user preferences that are not directly stored in the user model. We will implement an e-learning system, which will be used for experimenting with a variety of adaptation techniques. We will focus on those parts of the model that were omitted in the previous implementation and experiment with the semantic data storage at a more general level.

The results of our research are part of the work of a special research group WEBING (http://webing.felk.cvut.cz).

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Transmission Methods for Multi-point Radio Link

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In 2006, the project -Research and development the multipoint microwave systems- was initiated with support of the Ministry of Industry and Trade. Team from the Department of Telecommunications Engineering FEE, Czech Technical University in Prague participates in the project with main SVM Microwaves Ltd. The project is an industrial research in the field of microwave distribution systems, primary research and development of a new type of high-speed multipoint microwave links.

The first part focuses on problems with signal spreading in mobile wireless networks. The next part describes possible problems' solution on the physical layer of the Reference Model ISO/OSI (further as RM). The solution on the physical layer is represented by the system with signal transmission and receiving diversity (SIMO, MISO and MIMO). Thanks to a special link and network layer protocols the diversity system is capable of working also on upper RM layers. The upper layer diversity system is explained in 3rd part. The last part describes our application of the upper layer diversity system in mobile wireless communication. This system was implemented to the aerobatic plane and used for high speed video streaming from aerobatic plane to the ground.

Technique of diversity radio transmission is effectively measured for avoidance of multi-path propagation. These diversity systems operate on layer one of RM. The oldest diversity systems are based on space diversity and are called SIMO (Single Input – Multiple Output). The transmitter has one transmitting and several receiving antennas, where the distance between receiving antennas must be at least half wavelength. Each antenna receives the signal from different place and transfers it to the receiver, which was chosen as the strongest and uncorrupted one for further processing. This technique of diversity receive is implemented in GSM and WLAN networks.

The next diversity technique is based on several transmitting and one receiving antennas. This diversity system is called MISO (Multiple Input – Single Output) and it is working in the following way: each of transmitting antennas transmit the same signal to the one receiving antenna.

Both of described principles expressively avoid fading creation. The last but not least of the layer one diversity systems is MIMO (Multiple Input – Multiple Output). It exists in two versions, where one of them is based on spatial diversity and the other one on the spatial multiplexing. Both of them have several transmitting and receiving antennas and transmit on the same frequencies. Spatial diversity is characterized by transmitting the same data through the separate antennas (full redundancy). Each antenna has different space-time code that is reciprocally orthogonal. Separated antennas and orthogonal space-time codes make communication more stable and reliable. Spatial multiplexing system differs from spatial diversity in several parameters. The main dissimilarity is that, they are transmitting different data through the separate antennas. This feature enables high throughput contrary to the full redundancy but to achieve good functioning, in comparison with the system with spatial diversity, a better signal to noise ratio is needed. Thanks to this function it also possible to use Space Time Multiplex, which enables independent data transmission from each antenna. In Spatial multiplexing system every data signal is coded by Spatial-Time Code, because individual data signals must be differentiate as it is in the spatial diversity.

The MIMO technique utilizes the Non Line of Sight communication in comparison with common wireless systems, which do not work in this case. Layer one diversity resolves only optimal transmitting and receiving, but it does not resolves integrity of transferred data. Problem of transferred datagram and packets integrity can be tackle on upper RM layers.

The diversity on upper RM layers can be realized with use of special network protocols, which operate on link and network layers. Ethernet usually uses the Wireless Point to Multi-Point system as its transmission system. It operates on link layer of RM and is compatible with diversity features. The diversity on link layer is implemented in standard IEEE 802.3ad. GNU Linux also implemented diversity and called it Bonding. Both link layer diversity systems are able to make parallel channels with possibility of transmission the same or different data. Also they are capable of increasing the throughput or making a redundancy in data transmission. A big disadvantage of these systems is optimization for wires. Therefore it is necessary to have a minimal delay between datagram transferred in parallel channels. Requirements of minimal delay exclude use of wireless systems without additionally diversity protocol correction.

The diversity is also realizable on 3rd layer, where it is possible to make backup or load balancing between parallel data channels, thanks to the dynamic routing protocol. Dynamic routing protocols work only in IP networks. The most famous routing protocols with this featuring are OSPF and EIGRP.

Diversity on link and network layer makes delay greater than on physical one. The delay on upper layers is created by manipulation of datagram and packets in comparison with physical layer, where we are working with signals. Working with data on upper layers is preferable, because it is possible to check integrity there. It is more preferable to use diversity solution on the second layer because data system exchange is very slow on the third layer. As it was mentioned, the diversity on the third layer is very slow and unusable to our purpose from this point of view. It is very complicated to implement layer one manipulation into wireless devices, the same as the diversity is unusable on the third layer.

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Innovation of subject "Integrated Services Network"

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For a graduate in our profession it is important to gain not only theoretical foundation through education, but also an adequate practical proficiency. The main aim of the project was to innovate educational process in subject "Integrated Services Network" in practical courses as well as in theoretical level.

Innovation of practical courses

Main work has been done in innovation of practical courses. Hereafter there is refreshed practical courses syllabus that contains two rebuild practical tasks (Task 3, Task 5) as well as two completely new practical tasks (Task 1, Task 2).

Task 1	SS7 Signaling System Analysis
Task 2	QoS – delay impact on speech quality
Task 3	ISDN B- and D-channel Data Transmission Analysis
Task 4	SIP Signaling Analysis
Task 5	H.323 Signaling Analysis
Task 6	H.323 – Cooperation with Gatekeeper
Task 7	VoIP Gateway Configuration
Task 8	VoIP Numbering Plan Implementation

Innovation of theoretical workshops

Three theoretical workshops consist of segment of theory and segment of simulation presentation. Simulation should enrich educational process with demonstration of behavior theoretically known methods and principles.

Simulations are mainly in a manner of

- · basic principles of SS7 signaling system
- SS7 frame and message formatting
- · call flow and interchange of SS7 messages in network behavior

All simulations are done by multimedia presentation.

Innovation of practical tasks

All input study materials for practical tasks have been innovated and transformed into Internet—ready form and then published to server that belongs to our department (www.comtel.cz \rightarrow Předměty \rightarrow X32SIS \rightarrow Materiály pro výuku) and therefore are anytime easily accessible not only by our students.

Innovation of Task 1 – old laboratory local private branch exchange (PbX) has been replaced by powerful computer based solution equipped by Ethernet and SS7 cards with software that can manage internetwork signaling interchange (SS7 and SIP/H.323). Moreover

material and tools to successful task realization (cables, connectors ...) has been bought, repaired and re-measured.

Innovation of Task 2 – new laboratory measurement device that can emulate real network behavior has been bought. This network emulator hardware comes with specialized software that can generate mostly all types of network traffic and can catch and analyze all of event (bits, frames, packets and messages) within exchange between communicating parties and well arranged results present on a monitor screen.

Innovation of Task 3 – new terminal endpoints equipped by software analysis tools for detailed analysis of both transmission services over B- and D- channel ISDN has been bought.

Innovation of Task 5 – new VoIP terminals supporting H.323 signaling and software for detailed and educational analysis of signaling messages exchange has been bought.

Innovation of theoretical lectures

The revised basic of telco knowledge that has been deeply studied has extended a spectrum of lectures. Mainly English written literature has been translated into new lecture base that is in form of MS PowerPoint presentation. This chosen format is able to show new concepts with animated explanation. This is more didactical. An electronic form of new lectures has been placed on Internet (www.comtel.cz \rightarrow Předměty \rightarrow X32SIS \rightarrow Materiály pro výuku) and therefore is easily accessible by students.

Conclusion

Main goals of subject innovation are:

- New knowledge implementation.
- New simulation implementation in theoretical workshops.
- Workplace innovation for practical tasks.
- Practical tasks optimization and material, tools and device complementation.
- New study material creation for theoretical parts of course.
- All study material is now in electronic form of presentation.
- Motivation of students to study modern telco technologies.

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Simulation Tools Used in Subject Data Networks

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Subject Data Networks at Czech Technical University in Prague acquaints undergraduate students with an overview of principles and current state of Data Networks. The subject is mainly focused on WAN technologies such as Point-to-Point Protocol (PPP), High-Level Data Link Control (HDLC), Frame Relay, X.25, Ethernet and Asynchronous Transfer Mode (ATM). An important part of theoretical lectures is focused on Multiprotocol Label Switching (MPLS) technology which is now replacing technologies such as Frame Relay or ATM, mostly because it is better aligned with current and future technology needs. The practical exercises of subject are focused on practice with specialized networking equipment, such as routers, switches and protocol analyzers. The practical courses have been improved in following points:

- Practice exercise: Configuration and management of ADSL service has been equipped with an ADLS2+ DSLAM. This equipment newly allows students configuration and management of provider's part of ADSL network.
- ISDN switch used in practice exercises has been extended with a new ISDN module. This extension increases number of simultaneously available ISDN lines.
- A new practical exercise and materials focused on QoS and design of data networks have been prepared.

Quality of service (QoS) is an important part of converged network in which voice, video, and data traffic use the same network facilities. Multimedia streams, such as those produced by video-conferencing or IP telephony, are very sensitive to delivery delays and create unique QoS requirements. The following problems usually encountered when we discuss about QoS in packet networks:

- *Bandwidth* is one of the key factors that affect QoS in a network; the more bandwidth there is, the better the QoS will be. However, simply increasing bandwidth will not necessarily solve all congestion and flow problems.
- *End-to-end delay* is the time taken for a packet to be transmitted across a network from source to destination. Factors contributing to total delay are for example: compression, packetization, queuing, serialization, propagation, processing (switching), and decompression.
- *Variation of delay (jitter)* is defined by RFC 3393 as the difference in end-to-end delay between selected packets in a flow.
- *Packet loss* occurs when one or more packets of data travelling across a computer network fail to reach their destination.

Implementing QoS involves three major steps:

- Identifying traffic types and their requirements [1].
- Classifying traffic based on the requirements identified.
- Defining policies for each traffic class.

Simulation software presented in practical exercises can help network designers (students) simulate and then analyze the effect of various parameters on the network performance and QoS. There are many network simulation tools available today (for example commercial: OPNET Modeler, NetRule, NetSim or non-commercial: ns-2, OMNeT++, SSFNet, GNS-3, J-Sim, REAL). The following network simulators are available for students in laboratory:

- ns-2 is a discrete event simulator targeted at networking research. It provides support for simulation of many protocols (TCP, UDP, HTTP ...), traffic models (Web Traffic, CBR ...), routing, and multicast protocols over wired and wireless networks.
- OMNeT++ is a discrete event simulation environment based on C++. It has a component-based, modular and open-architecture simulation environment with strong GUI support and an embeddable simulation kernel. The simulator can be used for modelling: communication protocols, computer networks, traffic modelling, multi-processors and distributed systems, etc.
- NetSim is a network simulation tool that simulates Cisco Systems' networking hardware and software and is designed to aid the user in learning the Cisco IOS command structure.
- GNS3 is a graphical network simulator and an excellent complementary tool to real labs for administrators of Cisco networks or people wanting to pass their CCNA, CCNP, CCIP or CCIE certifications.

The new practical exercises allow students to gain additional skills in data networks and QoS area. Students will be able to implement QoS tools such as congestion management or queuing methods on a converged network. All innovated practical exercises will be introduced into education in the summer semester 2009.

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Modern solution for access networks - Passive optical network and its demonstration in education

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In the last few years have requirements for the amount of transmitted data and transmission speed in the field of telecommunication applications and access networks rapidly increased and this trend is supposed to continue further. With the fast development of new technologies and related telecommunication services and their expansion is related constant growth of requirements for transmission speed. Higher customer demands for fast access to the Internet, services such as VoD (Video on Demand), IP TV in High Definition (HD) and others, bring together increasing demands for transmission speed and overall performance of access network infrastructure. Nowadays digital connections via metallic pairs will no longer be sufficient. One of the possibilities to offer the end users necessary transmission capacity is to use the optical telecommunication technologies, such as passive optical networks (PONs), whose parameters and descriptions were already presented in several articles [1-2]. However the development of optical access networks in Czech Republic is still very slow, the main barrier appears to be the cost of necessary optical lines and components of optical networks. That's why we decided to build the demonstration laboratory workplace of passive optical networks.

Typical PON configuration consists of several basic components. Optical line termination, which provides services of network interconnection between access and core telecommunication networks. This unit also arranges central management and controlling services. Optical distribution network, which is a set of all optical transmission sources, such as optical fibers and splitters. And optical network unit serves mainly as an optical – metallic converter to provide connection for devices through metallic cable (such as metallic Ethernet). This unit is mostly located in end user place. For the realization of the optical workplace, several practical assumptions were prepared first, which should the final solution satisfy. Basic assumptions were mainly about devices' configuration, documentation, proportions, and of course the summary price. Considering these requirements, products of Allied Telesis were chosen. Optical termination is of modular type, the used configuration contains management module with uplink ports as well as management and console interface, another module for passive optical network realization (EPON) and module with ten optical Ethernet ports for point - to - point connection. As for optical network units were chosen two standard types with gigabit Ethernet interface. The workplace consists furthermore of three passive optical splitters, four optical attenuators for long optical lines simulations and three rolls of optical fibers with different length (2,2 and 7,8 km). Thanks to optical attenuators together with fiber rolls it is possible to provide different network topologies as well as their various lengths. All devices were mounted into standard server rack, optical ports of all units were plugged into central optical panel to easily make connections between them by using only short optical patch cords.

The workplace was projected for maximum universality, so it may serve for many different purposes. The predetermination was to use it for laboratory tasks for education and demonstration in several subjects concerning transmission systems. Students now have the unique opportunity to compare parameters and capabilities of currently most widespread 120

digital metallic connections xDSL with potentials of the modern technology of passive optical networks. The workplace can be due to its universality also used for example for demonstration of optical time – domain reflectometry (OTDR) or measuring of optical signal level with optical analyzers, which allow rapid detection and diagnosis of the functioning of the entire optical tract.

The proposed laboratory task is about providing services through optical access network, for a demonstration of its capabilities and transmission parameters, distributing of High Definition (HD) video stream was selected. Students' task is to establish a proper connection in the central optical panel first. The second step is to configure necessary parameters for successful connection, which is indicated by receiving IP addresses for end stations from a local DHCP server. Students can also prepare several profiles with different transmission parameters (transmission speed for both directions, length of transmitting frames, delays) and then subsequently use them for comparison of their influence on the quality of transmitted video stream. Next step is establishing connection with local media server, where high definition video previews are stored, and start receiving video stream. In addition, students can connect one computer to the media server through ADSL2+ digital connection and make direct comparison of transmission performance between these two access networks (PON and ADSL2+).

This workplace of passive optical network was successfully designed and created and is already being used for education of several subjects at the Department of Telecommunication Engineering. It can be used for demonstrations of modern access network solution, testing optical network performance and simulations and testing various optical tracts. It can also provide practical simulations and testing for students working on their bachelor or diploma thesis. Together with this workplace were also prepared new or updated previous learning materials (presentations, laboratory manuals, description of workplace) about this workplace and about passive optical networks, and were distributed to the students. During the process of designing and creating of this workplace also came into being several publications and presentations, the results of the whole project were already presented at conferences (Pedagogický Software 2008, Research in Telecommunication Technology 2008 [3]).

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Intelligent web technologies - 2006/2008

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The target of the grant project 201/06/0648 is to suggest new intelligent solutions in the web technologies area, which would qualitatively improve the user access to information on the web. By the formulation of the main aspects of proposed solution of the project we put emphasis to structure the main goal to sub-goals not only in the topics but also in the time. *Research covers three basic areas of the web intelligence and eight of its sub-domains*:

Task A. Intelligent methods of information searching on the web

Task B. Adaptation of information of hypertext documents

Task C. Unification of access to information on the web

Grant has supported research in the specified area of internet computing and has been achieved very interesting results objectified by the publications on international platforms (participation on 27 conferences with 45 papers), An expected contributions from the proposal of this grant were carried out - see the proposal from the 2005 year:

Expected assets in the frame of information technology are and among investigated areas belong especially

- research on intelligent and heuristic technique to support information searching in web environment,

- research on searching methods on the web with consideration to the semantics the information sought,

- investigation on adaptability of access to information on web according to the user requirements, types and possibility,

- formulation and implementation of integrated access to heterogeneous type of information on the web.

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Accuracy and Preference of Color-to-Grayscale Image Conversions

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Converting color images to grayscale is used for various reasons, like for reproducing on monochrome devices, subsequent processing, or for aesthetic intents. Color-to-grayscale conversions perform a reduction of the three-dimensional color data into a single dimension. Some loss of information during the conversion is inevitable, so the goal is to save as much information from the original color image as possible. At the same time, the aim is also to produce perceptually plausible grayscale results. Recently, various approaches to the color-to-grayscale conversion problem have been proposed. While the problem's complexity is currently recognized, the performance of existing solutions is not. Even though researchers frequently claim that their methods advance the field with respect to previous ones, it is important to evaluate the performance of these algorithms in comparative, subjective experiments and analyze their strengths and weaknesses.

In this research [2], we run two subjective perceptual experiments (*preference* and *accuracy*), for which seven state-of-the-art color-to-grayscale conversions were evaluated by 119 human subjects. The set of inputs consisted of assorted 24 color images. Those images depicted plants, foliage, fruits & vegetables, portraits, various photos, paintings, cartoons, color testing images, and computational images. By means of statistical analysis of the subjective experimental data, we assessed the strengths and weaknesses of the conversions, with respect to the preference and accuracy of color reproduction. The design of the experiment with a reference (*accuracy*): every time, two grayscale images were displayed along with the color original in the middle. Observers were asked to select the one of the two grayscale images that was closer in appearance to the original color image, i.e. to select the image that better reproduced the original. In the experiment without a reference (*preference*): every time, two grayscale images that they preferred. Specifically, the instructions stated: "Your task is to select the preferred grayscale image from the presented pair."

We used Thurstone's Law of Comparative Judgments, Case V [2], to convert the observed experimental data into interval z-score (standard score) scales. To inquire the significance of the input images, the experiments (accuracy and preference), and the conversions (i.e. the factors) on the observation data, we applied the multifactorial analysis of variance (ANOVA) test [2]. The results show that the only significant main effect is the conversion, which means that there are significant differences in the performances of the inquired conversions. Neither the experiment type, nor the input image can alone explain the variability in the data. However, two statistically significant interaction effects imply that the observed scores depend on the combination of the conversion and the input image, and (with the smallest probability, but still with a statistical significance) on the combination of the conversions depend on input images and on experiment type, and it makes sense to show the results separately for each input image and for each experiment. Then, we performed a multiple comparison test over all the subjective data. This test returns an *overall ranking* of the 124

conversions with the indication of the statistical significance of the differences between them. The results show that the best ranked conversion in our study is Decolorize [3], but it performs statistically similar to Smith08 [4]; the worst ranked is Bala04 [1].

The *overall accuracy* and *preference* scores were obtained by averaging the percentage matrices over all input images *separately* for the accuracy and preference experiments. Altogether the best score in the accuracy experiment was achieved by Smith08 [4], while Decolorize [3] produces the most preferred grayscale images. Bala04 [1] was ranked the worst in both the accuracy and preference experiments. Comparing the overall accuracy and preference scores, we see similar trends in the results of the experiments.

Furthermore, we examined the experimental data for all the color images *individually*. We converted the observation data into z-scores independently for each input image using the Thurstone's Law of Comparative Judgments. The results of the χ^2 test [2] show that there is some agreement between observers, as all the p-values of the null hypothesis are clearly below the threshold. This means that there are differences in the performances of the conversions, which is also revealed by the ANOVA test. Moreover, numerical analysis suggests that each subject was fairly consistent in their judgments. On the other hand, the agreement amongst subjects varies from high values to lower agreement, which indicates that the complexity of judgments differ depending on the input image.

Generally, our results [2] show that the Decolorize [3] and Smith04 [4] conversions are the best ranked approaches, and the approach of Bala04 [1] performed the worst. However, the analysis of individual images reveals that no conversion produces universally good results for all the involved input images. Specifically, each of the seven inquired conversions was ranked the worst for at least one input image and, apart from Bala04 [1], each conversion was ranked the best for some input image. These results suggest that there still exist areas for improvement of current conversions, especially in the robustness over various inputs. Furthermore, we found a high degree of correspondence between the accuracy and preference scores. Specifically, the results indicate that one dimension prevails in the subjects' judgment of the quality of the grayscale results. We believe that this is of particular importance and it is necessary to conduct experimental subjective studies, such as the one presented, to validate and evaluate color-to-grayscale conversions properly in order to expose their strengths and weaknesses, and to attain a deeper understanding of the examined field.

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Business Process Model Transformation

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The Business Process Model (BPM) is a model, which describes business processes of an organization. It is an important tool for understanding the activities and information, which are typically used to achieve business goals. Creating of the BPM is recommended by the Unified Process methodology for software development. Some development processes are even BPM oriented (e.g. BORM). The BPM can be described in various notations: in the Business Process Model Notation (BPMN), in the Eriksson-Penker's notation or sometimes as the UML activity diagram. The BPMN contains the largest number of information about the real processes; therefore it is the center of our work. Our research group is interested in model driven software development (MDD), so transformations of one model into another are very important task for us.

There exists is the description of a process of transformation from the BPMN to the analytics class diagram in [1]. This work describes rules and recommendations, how an analyst can make the transformation manually. Although the manual transformation is possible, the goal is to make this transformation automatically. The automatic transformation can save time of people working on the project.

There also exists the description how to transform the BPMN to analytic models (diagrams) – use cases diagrams and diagram of analytic classes in [2]. And in [3] there is described a tool for Microsoft Visio, which is implemented according to the rules described in [2]. This tool transforms any model in BPMN automatically. This solution of the BPMN transformation problem uses a QVT which is a transformation language developed by OMG and it can be used to transform both BPMN and SBPM [4]. The SBPM is an extension of the classic BPMN, which contains instruments adding information about security requirements. The QVT rules defined in [2] can be used in any tool which transforms the BPMN to the use case diagram and a class diagram; however there are some questions which are not solved. All of these questions are connected with the entireness of the transformation.

The first question is about entirety of transformation – concretely if all information included in the BPMN is also in the result of transformation. As was said the BPMN includes a large number of information, not only about the order of the actions and states and their grouping, but also about actors responsible for actions, about time delays or time triggers. After the transformation according to [2] we get a sufficient class model and the use case diagram but this transformation is information-loss. Created use case diagram contains only atomic operations and actors. This also means that the information in class and use case diagram is the same, only described in different notation - both diagrams describe actors and their methods. The information about the order of actions in the global operation, which was modeled in the original BPMN, is lost. There are two possible solutions – the first one is a transformation of BPMN to the UML sequence diagram, the second one is to create some use case textual description. The first solution seems easier than the second one; it is again transformation, which can be realized by QVT rules. The second solution is difficult because it is transformation from a model to a natural language. It brings complications with the grammar, but for some languages it can be solved (on some basic level). The second question about entireness of the transformation described in [2] is connected with the fact, that the transformation is forward-only. However, the question, if it is necessary to do the backward transformation, has no definite answer. The backward transformation can be useful in case of reverse engineering, which can be used in case of getting information about existing code, or in a case when the business process analyst wants to see a difference between business processes before and after usage of the software, then he/she needs to have two models (BPM before and BPM after) to compare. The backward transformation cannot have the class diagram or the use-case diagram as the initial transformation model, because these models do not contain all information needed to create a description of the business process. The information needed to meaningful backward transformation to BPMN is contained in the UML sequence diagram (again the transformation from the use case text can be used, but it will be very complicated). It means that although the transformation from BPMN to the analytics diagrams is the transformation from one model into three diagrams (from one BPM will be created a class diagram, a use case diagram, and a sequence diagram). The backward transformation is on the other hand one to one transformation.

The BPM is used in the MDD for business process analysis. The transformation of the BPMN to the UML analytic diagrams is possible and some transformations are described. Next goal of our project is obvious - to create and describe transformation from the BPMN to the UML sequence diagrams and back. The output will be the theoretical description of transformation and a tool which will allow using this transformation in praxis. The second goal could be to study the possibility of the transformation from BPMN to the use case text. The research should check usability of the Czech and the English language, but we think that the transformation could not be fully automatic. The results of our research will be useful in the area of business process analyzing and improvement and in the area of the software development.

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Recent Development Progress within Project INDECS in Year 2008

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Recent progress of project INDECS (leading towards designing of a system for controlling experiments on the KSN-2 neutron diffractometer) within the last year 2008 was mainly targetted on the development of tools for the actual communication with the new measurement devices of our KSN-2 neutron diffractometer.

The main part of the diffractometer, the position sensitive detector (PSD), has a computer interface in the form of an ADLink PCI-9812 A/D converter card. The card can deliver up to 20 M samples per second, which is at 16 bit data (though sampling is only at 12 bits) with 2 channels (needed for one PSD) reaching towards the maximum throughput of the PCI bus that the card uses. Up until now we've been using a specially written real-time driver that required the RTLinux to operate. It had guaranteed response time (assured by the fact that RTLinux is a hard real-time OS), but there were downsides to this solution, such as the lack of support of recent HW in the free RTLinux, a requirement of the RTLinux itself, and most importantly the lack of dynamic resources during the actual data acquisition.

So, an alternative to this solution have been developed in the form of a special stream buffering engine called the *Q-Buf*. It has a form of an ordinary Linux kernel module providing buffering services which try to mimic the behaviour of a hard real-time system as close as possible, while still using standard kernel mechanisms. Of course under an ordinary Linux kernel we can not really deliver the guarantees which the real-time solution provides. We may, however, try to compensate this setback more than enough with the here available possibility to use dynamic resources even during the data acquisition, which gives us also the biggest advantage over the old RTLinux driver.

The engine uses simple algorithms to dynamically preallocate memory buffers, so that there is always some free space available when it is needed to store the acquired data. The dynamically allocated memory also allows us to use a lot of memory for buffering when the application that processes the data does not catch up for some time. That prevents loosing precious data in critical moments. And since we consider not loosing these data the top priority, the buffers may extend throughout the whole available physical memory. The more memory you have, the longer time you can allow to compensate for. But consuming all the physical memory for the buffers may ultimately proove counterproductive, since the whole system slows down dramatically or even crashes, when that happens. That is why an arbitrary limit of the amount of memory the buffers may consume in total has been implemented, so that everyone may choose how much he or she would want to let the buffers grow in order to compensate for occasional system delays and how many would be left for the rest of the system (in the critical moments).

Another aim of the Q-Buf is to provide the buffering services with as little overhead as possible. In this case it imposes some restrains on the buffers, so that they can do both DMA mapping to the device it communicates with (which spares CPU time, since the device accesses the buffer directly), and memory mapping (using the system mmap(2) call) into the user-space for direct access of the application that does the data processing. The latter also saves the CPU time and memory, since normally when using standard read(2)/write(2) system calls for accessing the data of the driver from an application, the CPU has to manually copy the data from the kernel-space buffer into another buffer in the user-space.

There is a reason why we call the Q-Buf an engine and not a driver. The Q-Buf was designed to be just a skeleton of the actual driver. It provides the buffering services, it also provides the bulk of the user-space memory mapping services and some support for the DMA services of the buffers. However it has no knowledge of any of the actual devices it interacts with. That is supposed to be done by a series of callback functions that the Q-Buf interface expects to obtain from the real driver, which is supposed to be built around the Q-Buf skeleton. So the driver just needs to handle the device-specific interactions and leave all the things related to the buffering up to the Q-Buf engine. Design like this allows the usage of Q-Buf engine with various devices, not only the ADLink PCI-9812 that we intent to use it for, and at the same time, it makes the writing of a driver for such devices much more simple.

Another part of the KSN-2 diffractometer that has recently contributed to our development efforts is the new 2-axis Eulerian cradle goniometer made by Huber together with its Huber SMC9300 stepper motor controller. The controller is actually a fully functional PC computer runnung Windows OS, that can control the stepper motors of the cradle (plus other possible stepper motors up to the count of 8 total) either manually using the touch-screen of the controller or remotely via a TCP connection over the Ethernet network using a series of simple ASCII commands that it can follow.

Since the former method is not really practical for doing the experiments, the latter has caught our interest and made us develop a relatively straight forward (yet necessary) tool for remote control of the SMC9300 controller from a terminal of a remote Linux computer.

The tool is called *hubersmc* and it is in fact a daemon (background resident program) that uses named pipes to communicate (bidirectionally) with applications on one side and TCP sockets to communicate with the SMC9300 controller over the Ethernet on the other side. As an implication the stepper motors can be controlled both from any other application running on the system and manually by redirecting handwritten commands to the named pipe of the daemon (of course, preferrably not at the same time).

Among understanding commands of the SMC9300 needed for the direct control of the goniometer axes, it adds several meta-commands that allow preprogramming of hierarchical loops with predefined steps and ranges and a handshake commands that can be used to say when the cradle can execute the next step of a loop and on the other hand replies back to the application when the movement has been completed, so that the measurement can continue.

That was the summary of our main work on project INDECS done within year 2008. There is still some work on the actual drivers to be done, but we expect to do first practical experiments using these newly developed tools in the first quarter of the year 2009.

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Section 4

ELECTRICAL ENGINEERING & INSTRUMENTATION

An iterative statistical methods application in the reconstruction problem of pictures gained from digital cameras with CCD (CMOS) sensor

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Image capturing via CCD (CMOS) cameras is corrupted by numerous perturbing influences. Some of these influences are time-invariant and some others temporal. The time-invariant influence is an image blurring (rising from various causes) that can be mathematically understood as a deterministic 2D ISI channel (2D Convolution with the core **A**). On the other hand among temporal influences especially noises dominate. In this kind of cameras there are three significant noise sources: thermal noise (Poisson process), readout noise (Gaussian process) and quantization noise (uniform process) [2], [4].

All sources create single composite noise source that affects the captured blurred image as a random memory-less channel with independent eliminated states (IECS-ML). The behavior of such random channel (advanced noise model) [4] is biased by three parameters μ_R , σ_R (mean value and standard deviation of the readout noise), depending on the sensor readout rate, and μ_T (mean value and squared standard deviation of the thermal noise), exponentially raising according to the sensor temperature T_S . The knowledge of blurring and formation of the mentioned noise model, emulating precisely real noises in the given image processing system, consequently enables the application of the powerful iterative detection methods based on the criterion of maximum a posteriori probability (MAP) which make the restoration $\hat{\mathbf{D}}$ of true image \mathbf{D} from corrupted signal \mathbf{R}_d . These methods embody a high numerical effectivity, performance and robustness and in one-dimensional forms, they have found utilization in the area of Turbo code detection.

The optimal 2D MAP detector is based on the criterion

$$\hat{d}(i,j) = \arg\left(\underline{M}\right) \left[\underbrace{(m)}_{\bar{d}(i,j)} \mathbf{S}[\mathbf{R}_d, \mathbf{\breve{D}}] \right],\tag{1}$$

where $\hat{d}(i, j)$ denotes the wanted estimation, $\hat{d}(i, j)$ testing estimator (pixel), $\hat{\mathbf{D}}:\hat{d}(i, j)$ set of possible image realizations containing the estimator $\hat{d}(i, j)$ and (*M*) with (*m*) certain types of marginalization operators. The quantity S[\mathbf{R}_d, \mathbf{D}] is to be understood as some kind of joint probabilistic measure consequent upon disposition of both 2D ISI channel and IECS-ML channel.

The direct evaluation of the \hat{D} from the criterion (1) (single stage detection) is impossible because it requires a sequent substitution of all potential image realizations \tilde{D} . But IECS-ML channel makes possible decomposition of the detection problem from the entire page **D** to the level of individual (mutually overlapping) convolution regions, corresponding to individual captured pixels. Therefore we can substitute the single stage MAP detector by the sub-optimal iterative detection network (IDN). Such network is formed from a definite number of functional blocks so-called soft inversions (SISO modules) that present statistical devices complementary to the functional blocks in the appropriately designed, hypothetical modular model of the deterministic image blurring (2D convolution with the core **A**). In the course of each iteration I of the IDN, from count N_i , is every SISO module once activated at the least. The activation rests in the reading of soft measures (whole probability densities $\{SI[\tilde{\xi}^{(l)}]\}_i$, corresponding to certain random variable ξ in the hypothetical model) on inputs of a SISO module, followed by the enumeration of output soft measures (whole densities $\{SO[\tilde{\xi}^{(l)}]\}_i$). The current iteration concludes an exchange of soft measures $\{SO[\tilde{\xi}^{(l)}]\}_i \rightarrow \{SI[\tilde{\xi}^{(l)}]\}_i$ among the neighboring modules. After execution of all iterations N_i , the estimations of all wanted (output) random variables are performed from the formula $\hat{\xi} = \arg(M)[SI[\tilde{\xi}]SO[\tilde{\xi}]]$ so-called hard decision [1], [2], [3], [4].

The IDN closely cooperates with the SODEM (Soft output demodulator) providing fundamental hypothesis about captured signal \mathbf{R}_d (sufficient statistic). This functional block contains knowledge of IECS-ML channel statistical properties (likelihood function) and presents a gateway between the domain of real realizations (realizations of certain random variables), where are operated with scalars (factual realizations), and the probability domain of the IDN, where are operated with whole densities.

The IDN is able to converge to the solution of the optimal MAP with numerical exigencies incomparable lower. However these exigencies can be unbearable high in the cases of IDNs recovering grayscale or color images and such systems will require additional sub-optimality insertion. Therefore, the IDNs for restoration only of black & white images are presently examined. One of the possible real applications of these systems is presented in [3].

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Investigation of novel techniques for excitation of coil-less fluxgate

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Coil-less fluxgates are e new type of orthogonal fluxgate (sensors of magnetic field) invented in our Department, and successfully patented [1]. They are composed of a magnetic microwire as core; an ac current flows into the wire: the magnetic field generated by the current saturates the wire in circumferential direction. Traditional orthogonal fluxgate use a pick-up coil wound around the wire to measure the variation of magnetic flux in circumferential direction. Coilless fluxgates use no coil, as the output voltage is measured directly from the terminations of the wire. This effect is due to stress induced helical anisotropy of the magnetic microwire[2]. Therefore the sensor is composed only by a microwire without any coil: this makes possible high miniaturization of the sensors.

The first attempt to use this sensor has been done using traditional sinewave excitation current. This technique was useful to show ho the sensor works, and to give a model in order to explain the physical principal the sensor is based on [3]. However it was not very useful for practical applications. Indeed we should consider that high saturation is necessary, for instance if we want to achieve good parameters in terms of rejection of perming (offset change after exposition to very high field). The saturation of the wire depends only on the maximum value of the current flowing into the wire, regardless its waveform. Using sinewave current is highly inefficient; we should rather achieve the maximum required value as soon as possible, then rapidly decrease the current to zero. In other word we should try to minimize the RMS value of the current while keeping the peak value constant.

We therefore tried to use pulsing current: we have proved that the physical principle the coilless fluxgate is based on still works when excited by pulsing current instead of sinewave [4]. In this way we strongly reduced the power consumption of our sensor. For example, using a 70mA peak current with 10% duty cycle pulses, we obtained as 40 μ W power absorption, which is very low value. This achievement is particularly important when we consider that reduction of the absorbed power means reduction of thermal dilatation of the sensor, which generally results in instability of the sensors parameters.

Moreover we should consider that for practical application is not so easy to produce a pure sinewave, without spurious even harmonics. On the contrary, it is very easy to generate pulsing current using mosfet bridge.

Once we proved that the coil-less fluxgate can be employed also by using pulse excitation current, we further investigate a new method to extract the output voltage. Second harmonic extraction is commonly used for sinewave excited fluxgates, but this technique is not very useful in case of pulse excitation. Moreover it is not easy to implement phase sensitive detection circuit, with good parameters, in portable instruments.

Therefore we developed an other method, which consist of gating integration of the Voltage pulses on wire's terminations [4]. In order to achieve this method we first studied the behavior of the output voltage while changing the external magnetic field. We have identified two time ranges in each pulse which have different behavior: if the voltage increases as the magnetic field in the first range, it will decrease in the second range, and vice versa.

We then selected integrating window to be only in a range with uniform behavior, both for negative and positive pulse of the voltage.

The integral of each chopped slice of voltage both for negative and positive pulse are strongly non linear, but the sum of them is linear, due to the symmetry of BH loop of the magnetic wire.

We have proved the functionality of this method for output voltage extraction by using two boxcar averagers, available in our laboratory. Unfortunately it is not easy to set the width of the integrating window with a good accuracy: therefore we can expect some mismatch between duration of the window on the positive and negative pulse. This mismatch determines a lack of non-linearity compensation, resulting in a non-linear output characteristic.

Therefore we developed a electronic circuit which provides accurate timing signals: it includes PIC microcontrollers which generate PWM signals, digital decoder which transform the PWM signals to gate signals, solid state switches AD613 to chop the voltage and AD620 instrumentation amplifier in integrating configuration to obtain the sum of the integrals of the chopped voltage pulses. Using such circuit we have achieved a 0.6% maximum non linearity in a ±100 μ T range, which is a good result for open loop sensor, in such a wide range.

Moreover we included into the circuit the excitation unit which generates the pulsing excitation current.

All parameters like duty cycle, frequency and amplitude of excitation current, as well as all parameters like position and duration of integrating windows, can be adjusted from PC via USB connection.

Finally, we have developed an easy method for excitation and signal extraction of coil-less fluxgate, which allows strong reduction of power consumption. Moreover we have developed an electronic circuit which employs this method including all necessary components to generate pulsing current and gating integration. We are currently testing its features in terms of noise rejection.

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Applications of the Medipix Type Detectors Combined with X-Ray Optics

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The Medipix2 [1] is a semiconductor detector of ionizing radiation from approx. 3keV of energy. Medipix2 consists of a silicon sensor chip bonded to a read-out chip. The sensor is equipped with a matrix of 256x256 square electrodes (pixels). Each electrode (of area 55x55 microns) is connected to its own electronics made in the read-out chip. One of the main advantages of this device for astronomic applications is the fact that each pixel works as a single channel analyzer with a digital counter counting individual registered photons. Measurement time (exposition time) is not limited. Each pixel has two discriminators for setting energy window.

The Medipix2 have low noise, can work at room temperature and it has low power consumption. From this reasons, Medipix2 look as the very convenient detectors, mainly for astronomic and astrophysical applications with the lobster eye optics.

The Timepix device [2] is derived from the Medipix2. Both devices have the same basic properties (matrix size, energy range, energy resolution, etc.). Electronics in Timepix is modified and allows several additional modes. On of these modes (TOT mode) allows to determine incoming particle energy.

Lobster eye optics [3, 4] represents an X-ray optics of reflective type, i.e. optics consists of reflecting surfaces. For the experiment, the optics of a Schmidt type [3] has been used. This optics consists of two orthogonal sets of reflecting surfaces. Lobster eye provides good efficiency and wide field of view. Disadvantage of its optics is multiplication of the image. This effect can be neglected using reconstruction algorithmes.

Although the lobster eye optics looks to be a suited optics for the Medipix2 or Timepix detector, the problem arises with the energy range. Medipix2 (and Timepix) have lower detection limit about 3keV and lobster eye optics are to being used for the energies about 1keV. Nevertheless, the lobster eye can be used at higher energies. Presented results show possibility of using a lobster eye optics with Medipix2 (or Timepix) detector at energies of approx. 8keV.

Measurements have been performed in the laboratories of Rigaku innovative technologies, s.r.o. The used setup consists of the X-ray tube source with copper target, lobster eye optics and a detector. X-Ray tube has been set to accelerating voltage 40kV. The detector and x-ray tube was fixed in the focuses of the optics. Optics is located on the device allowing vertical and horizontal translations. The used optics is designed for imaging from focus to focus. It has outer dimensions 65x30x30mm, mirror dimensions 22x20x0.1mm, mirror spacing 300 microns. Mirrors are gold coated, Mirrors at the side of the X-ray source

mirror spacing 300 microns. Mirrors are gold coated, Mirrors at the side of the X-ray source are curved and they are oriented vertically. Mirrors at the side of the detector are planar and they are oriented horizontally. Distance between the edge of the optics and the X-ray source was 455mm, distance between the edge of the optics and a detector was 580mm.

The image obtained with the centered optics indicates, that the optics is operative at the chosen energy (approx. 8keV). To determine field of view, it has been found as in the entire as here.

it have been found positions of the optics, when

the center of the cross lays at the edge of the image. Distance between these positions is 16.8mm. If, for the sake of simplicity, it is supposed that the optics lays at the middle of distance between the X-ray tube and detector, i.e. at 550mm, field of view can be determined as approx. 1.7 deg. Spatial resolution can be estimated from the dimensions of the central part of the cross, which is approx. 20 pixels in the horizontal axe and 45 pixels in the vertical axe. These data lead to values 6.5' spatial resolution in the horizontal axe and 15' in the vertical axe.

The image distortion and intensity as a function of a source position have been measured. For the applications, these effect have to be known, because they have to be corrected. In this measurement, the Medipix2 detector have been used. The X-ray tube source and the detector has been situated in fixed distances from the optics. Imaging of the source from various angles was simulated by movements of the optics in the axes

perpendicular to the optical axe. Shifts of the centers of the crosses from an ideal positions (i.e. with linear optics) to a measured positions have been compared with the theoretical model. It has been found, that measured shifts qualitatively corresponds to the theoretical model. Quantitative results are different in the vertical axe. It is probably caused by the inaccurate focusing.

To get knowledge about functionality of the lobster eye for higher energies, spectra in various regions of the image have been measured. With the Timepix detector and optics centered, spectra have been measured in the center of the cross, in the arms of the cross and in the remainder parts of the image. The obtained results indicates, that the used lobster eye operates also at energies higher than 10keV. Getting the more exact information of the behavior of the lobster eye optics at higher energies will be the subject of the further research.

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Detection of Magnetic Markers using Array of PCB Fluxgate Sensors

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Detection of magnetic markers requires increased reading distance. However, the spatial resolution is not the main concern, as in magnetic imaging, where the reading distance can be as low as few hundreds of microns [1, 2]. Keeping this distance brings always problems when moving the sensor head or the investigated object. Increasing the gap requires sensors of the magnetic field with high sensitivity (GMR, AMR, fluxgate). The spatial resolution is decreasing because of the flux-lines closing with increasing distance. Magnetic markers with remanent field high enough can be detected in DC mode – this is the case of security strips of amorphous materials in goods, or ferrimagnetic particles in printing ink used in banknotes and cheques. However, superparamagnetic particles, as they do not have detectable remanent field, require an excitation with external AC field.

Increasing the reading distance to several millimeters results in field values even below 1 nT, which for room-temperature measurements and even in DC mode clearly favors fluxgate sensors. Having a suitable shape, they can be used because of their high resolution, superior DC stability and low noise at room temperatures. They also do not suffer from the large cross-field effect unlike the AMR sensors, used e.g. in [3]. Slim printed-circuit-board (PCB) fluxgate sensors allow a close spacing of the sensors in the array and allow forming a gradiometer with very short gradiometric base. The good repeatability of sensor's parameters, achieved by the PCB manufacturing process, guarantees a good balance of the gradiometer.

We used PCB race-track fluxgate sensors of our design $(33 \times 15 \text{mm}, 1 \text{mm} \text{thick})$ with the sensitivity of 460 V/T. They form a sensor head, which was placed on a movable non-magnetic arm allowing positioning in the 2D plane. We used 2 PCB fluxgate sensors, with the sensitive axis aligned perpendicularly to the measuring plane, so we were measuring the normal component of the magnetic field. When subtracting the output signal of the two sensors (e.g. directly at the input of the 2nd harmonic detector), we obtained the horizontal gradient of the normal field component. This geometry suppresses well the Earth's field vector as the main homogenous field source.

The signal from the two fluxgate sensors is being fed to a difference amplifier and is detected with 2^{nd} -harmonic detector (Signal-Recovery 7265 lock-in amplifier). With the sensors 5 mm above the plane, we were able to scan the gradient field of the 1-US dollar banknote, which uses magnetic ink for safety purposes. Similar test was performed on 20 Euro banknote, but only the metallic security strip was detectable. The measurable horizontal gradient was in the range of \pm 30 nT/mm. These good results were obtained because of the well-matching parameters of PCB fluxgate sensors.

One of the possible applications is detecting of hidden magnetic markers (e.g. in clothes, or in goods before de-magnetizing at the cash-desk). We tested the setup with a 0.2 mm thin Permalloy (NiFe) wire. The wire was still detectable in a distance of 10 mm, on a 5 mm distance, we could even observe the dipole character of the wire. The spatial resolution

was however low, as the magnetic flux lines are closing too fast over the increasing reading distance, so the proposed barcode scanning is not realistic with our sensors.

The final aim of this work was to detect superparamagnetic particles, as they are widely used in biomedicine. In [4], AC excitation field and SQUID gradiometer were used to detect breast cancer lymph nodes using superparamagnetic particles. Ludwig et. al. are using fluxgate sensors with pulse excited particles and detecting the signal in time-domain [5]. We used our race-track fluxgate sensors, and arranged them perpendiculary to the AC excitation field, because our sensors exhibit low sensitivity to perpendicular fields. The sensor spacing was 2 mm and we used two lock-in amplifiers - first one (Stanford Research Systems 830) was used as 2nd harmonic detector to process the output of the two fluxgate sensors (connected to difference input of the instrument), while the second lock-in amplifier (Signal Recovery 7265) supplied a low frequency reference sinewave which was driving the excitation field, applied by the Helmholtz coils. It served also as reference for the first lock-in amplifier. With applied field of about 200 µT, 200 Hz, and with sensors carefully aligned, we measured the normal field component present due to the magnetization of the particles in the marker. We used a volume of 0.6 ml (0.15 µmol, 15.8 mg/ml) Endorem marker, which is a colloidal solution of iron oxide particles in water and is used for MRI imaging. When sweeping a container with the solution under the sensor head, we were able to detect the movement on a maximum distance of 10 mm (see Fig. 5). The drift of the sensors and the electronics has to bee kept as low as possible, since it was clearly observed as a limiting factor in the setup, and should be improved for future applications in detecting of superparamagnetic markers.

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System for Automated Calibration of Magnetometers

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Magnetometers are important instruments in many fields, like navigation [1], ferromagnetic objects detection, Earth's magnetic field exploration. The more accurate measurements are needed the more precise instruments have to be used. Fluxgate magnetometers, often used in these applications, do not have an absolute output (in contrast to scalar proton magnetometers), thus they have to be calibrated. The calibration procedure is essential for reaching high accuracy.

There are two basic techniques which are used to calibrate a magnetometer. The first one uses a set of three orthogonally positioned Helmholtz coils which can create an arbitrary vector of magnetic field. The calibrated device (magnetometer) is then exposed to the set of predefined magnetic field vectors. The vectors (with different directions but the same magnitude) are chosen in such a way that they uniformly cover a surface of a virtual unit sphere. Then some iterative algorithm (or linear parametrization) is used to calculate the calibration parameters (three sensitivities, three offsets, three non-orthogonality angles) from the recorded data. One of the benefits of this approach is the possibility to determine also the alignment of the sensor axes with the magnetometer's case. Unfortunately this method has at least one significant drawback – the time-temperature stability of the calibrating device has to be better than that device we want to calibrate. This is actually very difficult to achieve and there are only a few laboratories around the world which can fulfill these strict requirements (e.g. Magnetsrode in Germany, Nurmijärvi Geophysical Observatory in Finland [2], Canberra Observatory in Australia).

The second method is a reversal of the first one. A positioning of the calibrated magnetometer in a static and homogenous magnetic field is used to collect the desired set of data samples. Undisturbed magnetic field of the Earth can be used for this purpose. The calibration should be performed in an area free of ferromagnetic components, away of sources of magnetic fields (railways, metro...) and the magnitude of the field should be continuously monitored with a scalar magnetometer (to prevent the influence of some diurnal field variations or even magnetic storms). This procedure is called "scalar calibration" [3,4]. It is obvious that this method can be used in a same way for a calibration of accelerometers (instead of magnetic field the gravity field is used, which limits the value of calibrated acceleration to ± 1 g).

The work presented here deals with the second mentioned method. The original idea comes from a similar project which was carried out at the Danish National Space Institute. On site testing and calibration of space grade magnetometers for ESA's SWARM mission was the main motivation. A calibration and testing of a compact compass module is one example of application at the Czech Technical University. In order to reach high accuracy a relatively high amount of data samples has to enter to the calculation algorithm (hundreds). This requires a device which accomplishes the automated positioning of the magnetometer. The design and construction of such a system was the main objective of this project. There are two main requirements: the platform has to be absolutely, completely non-magnetic and computer controllable. In order to get the desired set of magnetic vector samples at least two axes of freedom are needed (roll and pitch). The addition of a third axis (azimuth) gives us a

possibility to calibrate and test more complex devices (an electronic compass with electronic tilt compensation). A motor-powered gimbaled suspension is the operational principle.

Motors based on a piezoelectric friction principle are the only suitable commercially available (non-magnetic) actuators. Motors from a Japanese company Shinsei were selected (type USR60-E3, with the biggest torque available on the market - 0.5N.m). They are controlled through a dedicated controller board (high voltage is needed for their operation). The mechanical design of the platform was developed with the use of modeling software. The software allows to check the mass of the components (moment of inertia) and to easily create a production data – most of the parts must be custom-made. The main construction materials used are: aluminum profiles (frame, tooth-wheels), brass (axes, screws), plastic & glass (bearings). The aluminum is very suitable as a main construction material, it brings rigidity to the design and is easily machinable. A drawback of aluminum is its relatively high value of magnetic susceptibility (2.3×10^{-5}) , which will also slightly distort the magnetic field. Very difficult task is the design and construction of the position sensing. Due to the friction principle of the drives some position feedback is needed. The scalar calibration does not require very high exactness of the position setting (only its equal distribution). Preciseness of one degree is satisfactory. No commercially available non-magnetic position sensor was found on the market. An optical incremental sensor was built from scratch for this purpose. The problem is that even small SMD (surface mount device) components usually contain some amount of ferromagnetic material. Finally there are only two SMD infra-red diodes and phototransistors in the vicinity of the sensor in the current design. All other electronic parts have to be placed several meters away.

An electronic control unit with single-chip microcontroller has been built. The unit receives commands from PC (via USB) and controls the operation of piezo-motor drivers and optical incremental sensors. The PC software was programmed in National Instruments LabWindows/CVI. A text file with a predefined set of positions serves as an input to the algorithm. The measured data have to be stored separately and merged with a file with timestamps when the platform reached each position. Then a script (for example in MATLAB) is used to calculate the calibration coefficients. The system is now in a testing phase, ready for final assembly a measurements.

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Development of a Low-cost Inertial Navigation Unit and a Testing of Filters for Inertial Navigation

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Introduction

This document concerns the development of a low-cost inertial navigation unit. This includes a testing of inertial sensors, implementation of a navigation algorithm (enhanced by sensor output data de-noising) and the design of a filter for sensors output data fusion based on Kalman filtering. Over the last decades there was a remarkable increase in demand for low-cost inertial navigation systems (INS) to serve as car navigation, personal navigation or navigation for unmanned aerial vehicles and aviation in general. A rapid technological advance in the precision and reliability of micro-electro-mechanical sensors is a promising key factor in the area of low-cost INS. Although the precision and reliability increases, the low-cost sensors still exhibit large long-term errors, giving the opportunity to seek for solutions. Such a solution was sought by introducing innovations into the hardware concept [1] as well as into the conventional signal processing algorithms.

Inertial Navigation System

With an ability to measure specific force using an accelerometer, it is possible to calculate the change in velocity and position by performing successive integrations of the acceleration. A conventional low-cost INS usually contains three accelerometers and three angular rate sensors, mounted perpendicularly to each other in order to create an orthogonal frame of reference. To navigate with respect to this frame of reference, it is necessary to track the directions in which the accelerometers are pointing. Rotational motion of the navigated object can be sensed using angular rate sensors. These sensors are therefore used to determine the orientation of the accelerometers as well as to obtain the attitude angles. In practice, to enhance the INS performance, additional sources of information are added, such as the GPS or magnetometer. A filter used for sensor output data fusion is called Kalman filter (KF).

Development Procedure

As mentioned in the introduction, the actual development procedure was divided into three main stages: the sensors performance analysis and the hardware realization; the design of the navigation algorithm and the actual Kalman filter proposal. For each stage, comparison measurements using two professional AHRS (Attitude and Heading Reference Systems) were performed. The units were the 3DM-GX2 (MicroStrain) and the AHRS M3 (Innalabs).

In the majority of the inertial navigation applications simple approximation of the random sensor errors, such as drift and sensor noise, is done by random processes, especially Gauss-Markov processes. Shaping filters are designed according to the sensor performance analysis –static and dynamic measurements of the power spectral densities of sensors output. Such shaping filters were designed by using random processes as well as untraditional autoregressive approach. Beside the random errors, the sensor bias, scale factor and sensing axis misalignment errors are in general compensated by calibration. This will be done in the final stage of development using a rotational tilt platform and both the 3DM-GX2 and AHRS M3 units for comparison purposes.

In order to convert the rough sensor output data into position and velocity, so called INS mechanization needs to be implemented. Firstly, sensors output data are de-noised using 142

the Wavelet Multi-Resolution Analysis [2] which is an untraditional but effective procedure. Secondly, corrections obtained by calibration are applied and finally, the appropriate differential equations [3] are solved. This algorithm was implemented in Matlab and the differential equations were solved with respect to the navigation frame of reference.

Kalman filtering is primarily a procedure for combining noisy sensor outputs to estimate the state vector of a system model. The system state vector includes any system variables (such as position and velocity) as well as inner variables for modelling sources of timecorrelated noise (sensor errors). Seeking optimal solution, Kalman filter is however "optimal" if and only if physical world and a mathematical model coincide to each other. Since this is impossible due to the nonlinear behavior of the real world, suboptimal solution is to be sought. The theoretical background used to design such KF is described in [3, 4].

There exist three different approaches in the research to estimation methods for INS, all based on KF: the minimum mean-square error based methods (linearized and extended KF), the sampling-based methods (unscented KF and particle filters) and the artificial intelligence based methods. As a part of this project, a research into these possibilities was carried out and namely the extended and unscented KF algorithms were chosen for the actual implementation. **Hardware Realization**

The actual hardware realization is based on a usage of Inertial Measurement Unit (IMU), which includes an orthogonal system with 3 accelerometers and 3 angular rate sensors (ADIS16355), and 2 biaxial accelerometers (ADIS16201) placed in modified framework. All sensors and the IMU are manufactured by Analog Devices, Inc.

Conclusions

A hardware prototype of inertial navigation unit was created using low-cost inertial sensors ADIS16201 and ADIS16355. Signal processing procedures for sensor output data denoising were implemented in Matlab to enhance the navigation algorithm that was developed as well. The final stage of the project - the Kalman filter based data fusion algorithm development is currently under evaluation in Matlab. As soon as the hardware implementation issues will be solved, the inertial navigation unit prototype will be ready for calibration and field tests. The two professional navigation units 3DM-GX2 (MicroStrain) and AHRS M3 (Innalabs) are used in all measurements as reference.

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DSP Evaluation Modules

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1. Introduction

This paper presents the design and use of new evaluation modules for effective education of digital signal processing at Czech Technical University in Prague, Faculty of Electroengineering.

Education of digital signal processing may be divided into two parts: theory and implementation. Theoretical part does not usually demand some special requirements for the education means while the implementation part does. In the implementation part of the digital signal processing there is the need for modern hardware, in most of cases either digital signal processors (DSP) or field programmable gate arrays (FPGA) are used.

For the implementation part of the subject Digital signal processing in Telecommunication tought in Master study program we have designed and manufactured new evaluation modules with digital signal processors TMS320C6455 and TMS320C6713 in addition with daughter cards for video communication.

Evaluation modules allow students to implement chosen algorithms of digital signal processing (FFT, echo cancellation, FIR and IIR filtering, LPC analysis, DTMF coding, etc).

Daughter card for video communication includes the video RGB output and thus it can be used for displaying image results used for example in digital image processing algorithms.

2. DSP Evaluation Module

First type of designed evaluation module is based on the TMS320C6455 digital signal processor, which is the member of the highest-performance fixed-point DSP generation in the TMS320C6000[™] DSP platform [1]. The TMS320C6455 device is a member of the thirdgeneration high-performance DSPs, with peak performance of up to 9600 million instructions per second thanks to advanced VelociTITM very-long-instruction-word (VLIW) architecture developed by company Texas Instruments, making these DSPs a suitable choice for applications including video and communication infrastructure, medical imaging, and wireless infrastructure. The TMS320C6455 device includes high bandwidth peripheral Serial RapidIO which allows high bit rate transfers like image and video signals.

Second type of designed evaluation module is founded on the TMS320C6713 digital signal processor. This processor is also member of TMS320C6000[™] DSP platform, it has similar peripherals, but it is floating-point architecture DSP, so it does require different programming approach which is important for student's DSP implementation skills.

Designed evaluation modules are controlled and programmed from the PC computer with installed Code Composer Studio development software. Programs, which realize DSP algorithms, may be written in C programming language or in lower level language called linear assembler.

3. Daughter Card for Video Communication 144
The video daughter card output displays a video signal on the screen of a PC monitor. The video format may be chosen color or monochrome with the resolution of 640x480, 320x240 or 160x120 pixels [2]. The brightness of each pixel is represented by 8 bits, 4 bits and 2 bits. The choice of resolution, number of colors and brightness states per pixel is limited by the maximum transfer rate for the multichannel buffered serial port (McBSP) - peripheral of the DSP used on the evaluation module. On the card there is implemented fast and precise D/A converter and programmable integrated circuit which also generates all necessary synchronization signals. The use of this daughter card is especially suitable in digital image processing algorithms where can be used for example for displaying of results.

4. Old syllabus of seminars (the innovated part only)

Development tools for realization of discrete systems using digital signal processors DSP instruction set Design and simulation of discrete systems using MATLAB Video and speech signal compression Evaluation of properties of discrete systems using MATLAB DSP Hardware DSP Implementation techniques

5. New syllabus of seminars (the innovated part only)

Evaluation module with DSP TMS320C6455 and TMS320C6713, description, instruction set, Code Composer development Studio (CCS) Implementation of quantization, convolution and correlation on DSK TMS320C6455 or TMS320C6713 Implementation of DFT, FFT, DCT on DSK TMS320C6455 or TMS320C6713 Implementation of FIR filters on DSK TMS320C6455 or TMS320C6713 Implementation of IIR filters on DSK TMS320C6455 or TMS320C6713 Implementation of DTMF decoding on DSK TMS320C6455 or TMS320C6713 Implementation of image filtering on DSK TMS320C6455 or TMS320C6713

6. Conclusion

The use of new evaluation modules and special daughter card for practical training led to innovation and improvement of the subject digital signal processing in telecommunication. The education of the subject is now much more effective due to new seminars where students implement chosen algorithms of digital signal processing on designed two types of evaluation modules using modern digital signal processors; first with fixed-point TMS320C6455 and second with floating-point TMS320C6713. Moreover, students can work on their individual projects focused on the implementation of DSP on these evaluation modules.

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Inovation of Digital Signal Processing in Telecommunication

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The article deals with innovation of the Digital Signal Processing in Telecommunication which is a subject at Czech Technical University. New laboratory workplaces utilizing TM320C6455 Digital Signal Processors are created. Furthermore, new laboratory exercises that allow students to get acquainted with specifics of Digital Signal Processors with VLIW (Very-Long Instruction Word) architecture and its application in the field of telecommunication are described. The laboratory exercises are especially focused on DTMF signal decoding, echo cancellation and digital modulations. The Digital Signal Processors are programmed in most of the cases in C language.

The subject of Digital Signal Processing in Telecommunications (IAT) is an optional subject of Faculty of Electrical Engineering at Czech Technical University in Prague within the framework of doctoral study program. At the present time the contents of this subject are palpable unsatisfactory due to relatively old-fashioned equipment. Consequently, the subject falls behind modern trends in given technical area. The following contribution sums up the solutions and objectives of the project which main purpose is to modernize and make the whole education of aforementioned subject more effective.

The objective of IAT subject is to provide students with theoretical and practical understanding of the following topics:

- The possibilities of Digital Signal Processor (DSP) utilization and its architecture understanding;
- The Hardware and software tools necessary for development of DSP applications;
- The address language and its relationship with DSP architecture;
- The employment of C programming language in order to implement various applications on DSP;
- The understanding how DSPs are implemented into telecommunication equipments and devices;
- Power optimization techniques.

The IAT subject is focused especially on PhD students. The primary objective is to pass on knowledge in such a form, quality and scope to allow students implementation and utilization of DSP in the very areas which are investigated by them. The areas to be investigated are mainly compression algorithms, algorithms for move detection and many others.

Up to date, quality and also quantity of such kind of information is more than critical for research activity not only for PhD students but for bachelor and magistral students as well. However, DSP based on TMS320C50 [1] can not meet the current requirements due to its architectural and technological limitations in comparison with processors based on modern

architecture. To be more specific, we are talking about DSP processors which exploit and benefit from contemporary VLIW architecture [2], [3].

In order to keep in contact with current trends and technologies in given area is necessary to innovate IAT subject accordingly.

The primary goal of IAT subject innovation is to make education more efficient together with quality improvement. Additionally, higher competitive strength of individual students is foreseen in their research activities. Proposed modifications are supposed to be implemented into the summer half of year 2008. A respective imagination about the effect of subject innovation can be made on the basis of simple comparison of existing and new subject contents. Nevertheless, a great deal of innovation is accomplished also thanks to new laboratory equipments.

The subject is oriented in such a manner which shall allow students to gain theoretical knowledge in the area of modern DSP architecture. Furthermore, also practical understanding in digital signal processing in telecommunication is enabled to the students. More than that, students may acquire new skills in areas of image processing which is even not possible with existing laboratory equipment at all. While debugging of individual algorithms is done in Matlab system, for concrete implementation of algorithm in real time is used laboratory equipment with DSP based on TMS320C6455 [4].

The subject of Digital Signal Processing implementation in telecommunication is especially determined for students whose work is focused on the field of digital signal processing. For these students is knowledge about implementation of DSP algorithms on modern equipment as key factor. The contribution of the innovation described in this article rests in creation of suitable conditions necessary for education and research activity of students. Moreover, new laboratory equipments may be used for solution of problems concerning area of digital signal processing in bachelor, diploma or dissertation thesis.

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Starter Kits for Practical Education of Digital Signal Processing in Communication

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This paper introduces several simple daughter cards useful in the education of digital image and video processing in communication technology. The daughter cards complement the popular Texas Instruments DSP starter kits based on the high performance DSP family TMS320C64, preferably TMS320C6416 and TMS320C6455.

Texas Instruments [1] and third parties [2] offer several DSP starter kits based on the DSP family TMS320C6x [1]. The widely spread DSP starter kits DSK6713, DSK6416 and DSK6455 are popular in the teaching of the digital signal processing at numerous universities. Moreover, they are popular in the industry, too. However, the low cost DSP starter kits lack the input and output for the image and video processing. On the other hand the specialized industrial starter kits with video input/output capability are much more expensive. In our experience, the image and video processing tasks like image and video filtering, enhancement, recognition, compression, coding etc. do not require the full TV resolution in the education process. The image and video algorithms can be demonstrated and exercised even in a reduced resolution successfully. We have developed, tested and successfully used several simple daughter cards for the image and video input and output and for the graphic output. In order to keep the hardware of the daughter cards as simple as possible, the data transfer between the daughter cards and the Digital Signal Processor occurs via the Enhanced Direct Memory Access channel and the Multichannel Buffered Serial Port.

The first card is a bilevel graphic display card. The proposed graphic output displays the graphic data on a PC monitor. The graphic output is useful e.g. in the real-time visualization of signals and their spectra. We use the graphic output in our courses in the FFT and spectral analysis. The spatial resolution of the graphic output amounts 640x480, 800x600 and 1024x768 pixels with 1 bit per pixel and 60Hz frame rate. The circuitry consists of the monostable multivibrator 74HC221 only. The data transfer is accomplished by the Enhanced Direct Memory Access channel via the Multichannel Buffered Serial Port. The Central Processing Unit is not involved in the data transfer at all.

The second card is a color graphic display card. The color graphic output displays the graphic data on a PC monitor. The spatial resolution of the color graphic output amounts 640x480 pixels with 4 bits per pixel and 60Hz frame rate. Three bits are fed to the RGB inputs of the PC monitor. Consequently, there are 8 colors available on the screen. The fourth bit is used for pixel blinking by the gating of the RGB signals. In the latest version all the circuitry consists of one CPLD XC9572XL [4] only. The data transfer is accomplished by the Enhanced Direct Memory Access channel via the Multichannel Buffered Serial Port. Hence the Central Processing Unit is free for the DSP specific tasks.

The third card is a graphic display card. The video output displays a video signal with the resolution of 320x240 monochrome pixels on the screen of a PC monitor. The brightness of each pixel is represented by 8 bits. The timing of the video output is compliant with the timing of the PC monitor in the 640x480 pixels VGA mode at 60Hz frame rate. It is one of

the standard modes of most PC monitors. The RGB signals (R=G=B) are output using the Enhanced Direct Memory Access channel via the Multichannel Buffered Serial Port. The Central Processing Unit is free for the DSP specific tasks. The deserialization of the video data stream provided by the Multichannel Buffered Serial Port is accomplished by the CPLD XC9572XL. The 8bit digital luminance value is converted to the analog form either by the TDA7802 digital to analog converter or by the passive R-2R digital to analog converter. The color component is not generated. Both the vertical and horizontal synchronization signals are generated by the CPLD XC9572XL. The Central Processing Unit of the Digital Signal Processor is not involved in the data transfer at all. Hence the Central Processing Unit is free for the digital signal processing.

The fourth card is a video input card. The video input accepts both the NTSC and PAL video signals. The video decoder TVP5150A [1] digitizes the video signal with the frame rate of 25/30 Hz. Only the subsampled luminance component of the video signal is transferred to the Digital Signal Processor. The color component is discarded. The subsampling of the luminance component to the resolution of 320x240 pixels and its serialization is accomplished by the CPLD XC9572XL. The serialized video data stream is transferred to the internal RAM of the Digital Signal Processor via the Multichannel Buffered Serial Port and Enhanced Direct Memory Access channel.

The fifth card is a USB web camera interface. The image and video input using the web camera consists of the USB/SPI converter MAX3421E. The SPI port of the MAX3421E is connected to the Multichannel Buffered Serial Port of the DSP. The data transfer is accomplished by the Multichannel Buffered Serial Port and Enhanced Direct Memory Access channel. The resolution of the image transferred to the DSP depends on the resolution of the web camera. The resolution usually varies between 320x240 and 1024x768 pixels.

All the introduced hardware was intentionally kept as simple as possible. The essence of the expansion cards is in a clever programming of the integrated peripheral on the DSP chip. For the programming of the Texas Instruments DSP chips, the software Code Composer Studio is used. The programming occurs usually in the C language. The integrated C compiler and Code Optimizer ensure a very good code quality in most cases. In rare cases the low level programming in Linear Assembly or in pure Assembly is necessary. The pure Assembly is the most tedious way of programming. Each instruction requires to specify which of the eight available functional units will perform the instruction. In order to produce an industrial grade code, a careful instruction planning process cannot be avoided in this case.

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Synthesis of novel defects in silicon by ion irradiation for future application in semiconductor technology: low-temperature formation of deep donor layers

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Irradiation of silicon with high energy protons is very effective method to control excess carrier lifetime in silicon power devices and, therefore, to improve their dynamic characteristics [1]. Recently, another application of proton irradiation, low-temperature formation of deep donor layers, was reported [2]. Radiation defects introduced by protons can react with impurities in silicon and give rise to local donor layer appeared in the proton end of range. The activation of so-called hydrogen-related thermal donors (THDs) depends on substrate material and also on post-irradiation treatment. The formation of deep donor layers is particularly attractive for semiconductor technology (field-stop layers, superjunction transistors, etc). This method of doping proposes several advantages compared with classical substitutional n-type doping made by diffusion of phosphorous or arsenic: much lower thermal budget is required for THDs generation and they can be formed in any desirable depth of semiconductor device by proper choice of proton energy.

In this work, we present effect of proton irradiation and subsequent isochronal annealing on formation of local donor layers in three types of silicon substrates. First, the low-doped (phosphorous concentration below 10^{14} cm⁻³) <100> oriented float-zone oxygen-rich (FZ OR) n-type silicon was used. This material formed n-base of the planar p⁺nn⁺ diodes containing a relatively high concentration of O_i due to long term diffusion used for fabrication of deep p⁺ and n⁺ emitters. The diodes were irradiated with 1.8 MeV protons with fluences ranging from 5×10^{10} to 4.6×10^{14} cm⁻². Second test structures were p⁺nn⁺ diodes based on <111> FZ n-type (phosphorous concentration 9×10^{13} cm⁻³) oxygen-lean ([O_i]~ 2×10^{16} cm⁻³) silicon (FZ OL) with shallow p⁺ and n⁺ emitters. Identical structures made on Czochralski <111> n-type (phosphorous concentration 6×10^{14} cm⁻³) oxygen-rich ([O_i]~ 1×10^{18} cm⁻³) silicon (CZ) were also used. The diodes with shallow anode emitter were irradiated by 700 keV protons to wide range of fluences ranging from 1×10^{10} to 1×10^{14} cm⁻².

After irradiation, samples were isochronally annealed on air for 30 minutes in the temperature range from 100 to 550°C. Deep levels resulted from irradiation and subsequent annealing were characterized using deep level transient spectroscopy (DLTS). The capacitance-voltage (C-V) measurement was applied to characterize spatial distribution of active doping profile. All C-V measurements were performed at 85°C to eliminate influence of ionized deep acceptors on donor distribution. We also monitored diode leakage and breakdown voltage of diodes under test. Excess carrier lifetime was measured using OCVD technique.

Our results showed that proton irradiation introduces shallow hydrogen donors (HDs) at the proton end-of-range. The distribution of HDs has Gaussian-like shape and coincides with implanted distribution of proton. The HDs have maximum concentration after irradiation in all three substrates used in the experiment and their introduction rate linearly depends on proton fluence. The HDs anneal out at approximately 250 °C. Series of thermal hydrogen donors (THDs) appears after higher annealing temperature [3, 4] and they reach maximum

concentration at 350°C. Annealing above 350°C results in formation of thermal donors (TDs). In both oxygen rich materials, the formation of TDs was enhanced in the region towards to implanted surface as well as in the bulk of the n-base. In the first case, thermal donors enhanced by radiation damages (RETDs) participate on increasing of integral donor concentration. The increased concentration of thermal donors in bulk corresponds to pure TDs. Both RETDs and TDs reach maximum concentration at about 475 °C. For proton fluences up to 1×10^{13} cm⁻², excess donors almost disappear after annealing at 550 °C but, for higher fluences, they still remain in the vicinity of R_P and also spread into the bulk. Results showed that for the same energy and fluence of protons, the peak concentration of excess donors in the CZ material was higher by the factor of 1.5 compared with FZ OL silicon. This proportion remained unchanged even after annealing at 400 and 500 °C. In contrast with materials with high oxygen concentration, where formation of RETDs and also TDs in the bulk region was enhanced, the profiles of excess THDs in FZ OL silicon are always well localized in the vicinity of proton range and formation of bulk TDs was not registered for this material.

When hydrogen donors are introduced into the low-doped n-base of power diode, they strongly effect charge balance in this region and decrease blocking voltage V_{BR} . This was confirmed on power p^+nn^+ diodes irradiated with 1.8 MeV protons to different fluences. For all fluences, the blocking voltage has the lowest magnitude directly after irradiation, that corresponds to maximum concentration of HDs. Thus, after annealing at 250 °C HDs anneal out, V_{BR} starts to recover. It decreases again at 450 °C that corresponds to higher TDs concentration. The breakdown voltage recovers to the magnitude of not irradiated dide only for fluence 1×10^{13} cm⁻² after annealing at 550 °C. The measurement of excess carrier lifetime on FZ OR samples irradiated with 1.8 MeV protons to fluence 1×10^{13} cm⁻² showed that annealing at temperatures as high as 550 °C recovers carrier lifetime only to 65 % of the initial magnitude. Therefore, the donor layers formed by proton irradiation with following annealing, are effected by residual radiation defects that decrease carrier lifetime.

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The VHGT Triplex Filter for the Hybrid Photonic Integrated Circuits with the Polymer Optical Waveguides

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We report on theoretical results and measured parameters of the VHGT triplex filter, which was used for input part of the bidirectional transceiver TRx module. The photonic receiver is the main part of the hybrid integrated microwave optoelectronic transceiver TRx (transceiver TRx). The hybrid integrated microwave optoelectronic transceiver TRx is main component for the optical networks PON (passive optical networks) with FTTH (fiber-to-thehome) topology. The hybrid integration photonic receiver consists of an Epoxy Novolak Resin polymer planar lightwave circuit (PLC) with volume holographic grating triplex filter VHGT and surface-illuminated photodetectors. Planar lightwave circuit (PLC) hybrid integration technology enables us to construct component by combining PLC with passive function (fiber and planar optical waveguides) and active optoelectronics devices (laser diodes, optical amplifiers and photodiodes) hybridized on a PLC [1]. The VHGT filter diffracts the 1550 nm and 1490 nm wavelength radiation into separate directions, while transmitting the 1310 nm wavelength radiation. The VHGT filter is diffractive element with volume holographic gratings, which containing volume periodic changes index of refraction. When optical radiation incidents on holographic grating and wavelength satisfy Bragg phase condition, then radiation is diffracted for wavelength λ_B of the transmission grating $\lambda_B = 2\Lambda \sin\theta$, where λ_B is Bragg wavelength, Λ is grating period and θ is angle of the diffraction.

Recently in foreign sources optical waveguides and hybrid circuits based on the polymeric materials such as the Polymethylmethacrylate (PMMA), Deutered ethylene glycoldimetacrylate, (for the wave length of 1300 nm) or Pentafluoro-phenylmetacrylate (for the wave length of 1550 nm) [2]. Our photonics receiver module has been designed with RSoft simulation programs and constructed using a polymer PLC hybrid integration technology. The photonics receiver module consists of a planar polymer waveguides with a volume holographic grating triplex (VHGT) filter, surface-illuminated photodetectors (SI-PD). Photonics receiver is the main part of the optical TRx module transmits a 1310 nm radiation upload and receives a 1490 nm download data as well as a 1550 nm download digital video signals for wavelength division multiplexing WDM cable TV application [3]. For measuring insertion losses VHGT triplex filter was used configuration with laser sources OFLS-5 1550 nm, laser diode (LD SLT4460-DP-G120B) 1490 nm, collimate lens diameter 1.8 mm, photometer Anritsu ML910B with sensor MA9302A (750 nm-1800 nm). Triplex filter was set on the aluminum base with system 3D mechanical micromanipulators. Inserting losses VHGT triplex filter for optical source with 1550 nm was 0.84 dB and 0.96 dB at diffraction optical power with triplex effect. Average inserting losses (results from two measurements) VHGT triplex filter for optical source with 1490 nm was 0.53 dB and 0.2 dB at diffraction optical power with triplex effect. Value transmission losses state from producer VHGT is 0.1 dB (from 1260 nm to 1360 nm). For measuring deflection angle 1550 nm, 1490 nm for triplex effect VHGT triplex filter was used configuration with laser sources OFLS-5 1550 nm, laser diode (LD SLT4460-DP-G120B) 1490 nm, wave multiplexer, collimate lens diameter 1.8 mm, beam analyzing system Beam Profiler BP 104-IR from Thor Labs. The diffraction angle of the VHGT filter was measured by the beam analyzing system Beam Profiler BP 104-UV, VIS, IR from Thor Labs. Triplex filter was set on the aluminum base with system 3D mechanical micromanipulators. Collimate lens with input fiber was set at the system with 3D mechanical micromanipulators. Further parameters were the temperature sensitivity 0.01 nm/°C of the VHGT filter. The difference in Z-axis is 4 mm, difference in X-axis is 1.2 mm, diffraction angle is 17 degree at wavelength 1550 nm. The difference in Z-axis is 2 mm, difference in X-axis is 0.7 mm, diffraction angle is 19.3 degree at wavelength 1490 nm. Value diffraction angle state from producer VHGT is 19 degree at 1550 nm.

In this paper were presented first steps which guide to the design and construction of a VHGT attached WDM triplex transceiver module TRx using polymer PLC hybrid integration technology. Inserting losses VHGT triplex filter are 0.84 dB and 0.96 dB for optical source at 1550 nm. It was measure at triplex effect (diffraction optical power). Average inserting losses (results from two measurements) VHGT triplex filter for optical source at 1490 nm was 0.53 dB and 0.2 dB at diffraction optical power with triplex effect. Value transmission losses state from producer VHGT is 0.1 dB (for 1260 nm to 1360 nm). Diffraction angle VHGT triplex filter is 17 degree for wavelength 1550 nm and 19.3 degree for wavelength 1490 nm. Difference measured value and value state by the producer is given the temperature sensitivity 0.01 nm/°C VHGT triplex filter and inaccuracy value from graphs Beam Profiler BP 104-UV.

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Performance of the Planar Hybride Optoelectronic Receiver

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We report on construction and measuring of a planar Optoelectronic receiver module (OE receiver) for subscriber part of the passive optical network PON for a fiber to the home FTTH topology. Our work will first concentrate on design and construction of a conventional microwave optoelectronic receiver, where the fiber 50/125 um waveguide is aligned to the PIN InGaAs photodiode and it is connected to the HBT amplifier by a microstrip line. The second step will construction of the planar hybrid OE receiver, which it has advantages in planar integration of the optical and electronical part of the integration circuit on one substrate. Other advantages are easy connection with other microwave devices, namely photodiode, amplifier, and bias circuitry e.g. easier bonding with the general lithography process, (easier compared to the monolithic process), other advantage is that the OE receiver can be fabricated using existing technology together with devices in SMD packaging, which have been substantially optimized. The OE receiver optical part consists of the epoxy novolak resin polymer SU8-2000 Planar Lightwave Circuit (PLC) aligned with the OE receiver microwave section and the both parts are placed on the composite substrate. The optoelectronic part of the OE receiver was created by PIN InGaAs photodiode in SMD package with a bandwidth operation of 2.5 GHz. The photodiode is placed in the groove for elimination height offset. The electrical part is made by thin layer hybrid microwave electrical integrated circuit, where PIN InGaAs photodiode is connected by microstripe line to the output of OE receiver. The microstripe line is a thin film-type and has been formed using a standard lithographic technology by sputtering process. The all parts are placed on the low loss composite material substrate.

First stage of the PLC design is to couple the radiation from the single mode optical fiber radiation source to the polymer waveguide on a planar substrate [3]; the high-performance hybrid integration platform was made with piezoelectrically driven manipulator which has the accuracy necessary for low-loss coupling between fiber-waveguide components. In this case, the light is sent by a Single Mode Optical Fiber (SMF) which has a core of 9 μ m with a cladding of 125 μ m, the NA = 0.27; The coupling coefficient between the fiber and waveguide is about 81%, this value was calculated using the Hunsperger equation and simulated in BeamPROP software.

The second part of our research will be the design of the connection between the polymer waveguide and PIN InGaAs photodiode. The optimal distance between optical polymeric waveguide facet and PIN InGaAs photodiode was calculated and simulate in program Beam Prop for fundamental mode TE_0 . The simulation was optimized to maximum

transfer optical power. The optimal distance of the output facet optical waveguide and the detection area of the photodiode were derived to $220 \,\mu$ m.

The network analyzer HP 8510 was used for the dynamic characteristics measuring of the OE receiver. We sent the modulated radiation from the E/O transmitter pig tail to the polymer waveguides on a planar substrate, consecutive the light from the waveguide is detected by the PIN InGaAs photodiode and changes to the electrical signal. The experiment in this part consists in measure the transmitted electrical power from the network analyzer to the photodiode. The limited bandwidth (500 MHz) is because the connection from the photodiode is connected to the analyzer was made with long parallel cable but when the photodiode is connected to the amplifier and measured the dynamic characteristics the bandwidth is about 3.5 GHz because after the amplifier the OE receiver has a SMA jacks for RF output.

The O/E transmitter operates with bandwidth 5 GHz at wavelength 1.3 μ m. The signal detected in the output of the PIN InGaAs photodiode had an average value of -65 dBm, after the amplifier the value is -35 dBm and the noise introduced by the equipment is in the range of -90 dBm. The signal-to-noise ratio is a term for the power ratio between a signal (meaningful information) and the background noise. The value of SNR of whole OE receiver is 55 dB.

Further work will be concentrate to the implementation of the HBT amplifier in the OE receiver and simulation of the whole receiver with bandwidth 2.5 GHz as the main optoelectronic part of the hybrid PLC integrated microwave OE receiver for the FTTH topology optical PON networks.

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Engineering of MOVPE grown InAs/GaAs Quantum Dot Structures

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Quantum dots (QDs) are structures where the charge carriers are confined in three dimensions within a region smaller than their de Broglie wavelength. They behave as artificial atoms and can provide novel properties which are advantageous for device application. In semiconductors, they can be realized, e.g., as self-assembled three dimensional InAs islands that spontaneously form during the initial phases of heteroepitaxial growth of InAs layers on the GaAs substrate. These InAs/GaAs QD structures are a subject of intense research since it is expected that they become a base for cheap, low threshold, high output and heatsink free lasers for the 1.55 μ m communication band. The uncovered InAs islands are hardly ever employed and must be covered by a capping layer (CL) providing their protection and suppressing the non-radiative recombination through surface states. During the overgrowth, residual strain in the QD layer increases and QDs also significantly change their size, shape and stoichiometry. Since the electronic and optical properties of QDs strongly depend on these parameters, a detailed understanding of the capping process is essential for engineering of InAs/GaAs QD structures.

During first two years of the project, we studied the effect of metalorganic vapor phase epitaxy (MOVPE) growth conditions on structural and optical properties of InAs/GaAs QD structures. We focused mainly on the effect of wetting layer thickness, QD growth time, CL composition, and stacking of multiple QD layers [1-2]. This year, we investigated in detail the effect of QD CL thickness and composition on optical properties of MOVPE grown QDs.

InAs QD structures were prepared by low-pressure MOVPE on semi insulating GaAs (001) substrates using the Stranski–Krastanow growth mode. The structures were grown in AIXTRON 200 reactor equipped with a reflectance anisotropy spectrometer from Laytec. TMGa, TMIn, and AsH₃ were used as precursors. The structures were grown at 490°C except the first GaAs buffer layer (650°C). InAs wetting layer was deposited with a growth rate of 0.06 monolayer per second, V/III ratio was 83 and a growth time of 27 s. The growth was then interrupted for 15 s to allow QDs formation. QDs were then covered by GaAs (or In_{0.23}Ga_{0.77}As) CLs with different thicknesses ranging from 0 to 42.5 nm. Atomic force microscopy (AFM) images were taken in the contact mode using the NTEGRA Prima system from NT MTD. Room temperature photoluminescence (PL) spectra were excited by semiconductor lasers (670 nm and 980 nm) and recorded by a standard lock-in detection technique. Quantum transitions were simulated by the nextnano³ 3D simulator using a calibrated model of the QD structures [1].

AFM images obtained on uncapped samples revealed that uncovered QDs are InAs lenses which are slightly elongated in the [-110] direction. Their average density is 1.6x10¹⁰ cm⁻², lateral dimensions along [-110] and [110] axes are 25±10 and 22±8 nm, resp., and their average height is 4.0±1.3 nm. A significant spread of QD sizes causes that the uncovered layer of ODs exhibits a broad PL spectrum which peaks at 1.43 um. Gradual covering by the GaAs CL reduces QDs height and density. With increasing GaAs covering, the density of QDs decreases to 1.3x10¹⁰ cm⁻² probably due to the dissolution of smaller dots. QDs are transformed either into approx. 2 nm high plateaus elongated into the [-110] direction or rhombus shaped objects with a central hole [3]. These undesirable, optically non active rings with a central hole which extends up to the GaAs substrate develop preferentially from the bigger QDs. The QDs shrinking is caused by the deposited Ga atoms which accumulate at QDs base, preferentially along the [-110] direction, forcing In atoms to migrate from the top of QD to its base. The driving mechanism of In outdiffusion and alloying weakens and vanishes with decreasing QD height or increasing In content in the capping layer. PL measurement performed on GaAs capped samples showed that very thin CLs (thinner than OD height) improve homogeneity of ODs structures (the PL peak significantly narrows) and increases the PL intensity. However, thicker GaAs capping causes an undesirable blue shift (up to $1.26 \ \mu m$) of the emitted wavelength. Comparison of the experimental (PL) and calculated room temperature transition energies originating from the InAs QDs covered by GaAs CLs with different thicknesses showed that this blue shift is mainly caused by the change of the QD band structure due to increasing strain in the layer which lifts up the conduction band in the upper part of the QD structure [4]. Results of AFM measurements obtained on QD structures covered by In_{0.23}Ga_{0.77}As CLs revealed a favourable effect the In content in the CL: the bigger OD structures preferentially developed and their height was conserved. As a result, PL maximum measured on In_{0.23}Ga_{0.77}As capped QDs showed a red shift very close to the required wavelength of 1.55 µm.

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Scintillating BaF2 Detector for Low-Energy Nuclear Excitation at PALS

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Low-energy nuclear excitation by laser-induced plasma

The possibility to excite low energy nuclear states by laser induced plasma is being experimentally investigated [1] on the Prague Asterix Laser System PALS (see www.pals.cas.cz). This medium-energy high-power system yields interaction intensities at the level of $10^{16} - 10^{17}$ Wcm⁻² producing subrelativistic plasmas with electron temperature of the order of 1–10 keV. These low-energy electrons from hot dense plasma can excite low-lying nuclear states. The nucleus ¹⁸¹Ta was chosen [2] for this first study in view of the relatively short decay time (6 µs) of the excited level (6.2 keV). The laser plasma pulse lasts 250 ps.

Active detectors for direct detection of plasma radiation

In frame of this project, particular effort is placed on the use of active detectors (i.e. real-time digital charge integrating devices) inside the interaction chamber for the direct detection of plasma radiation and/or subsequent nuclear radiation. Two types of detector systems (see www.utef.cvut.cz/medipix) are being implemented and adapted for this purpose: Hybrid semiconductor pixel detectors (Medipix2, TimePix of the CERN Medipix Collaboration) [3] and scintillating detectors of which BaF₂ was selected as the most suitable type.

BaF2 scintillating detector for soft X-ray detection

We investigated the spectrometric response of a BaF₂ scintillating detector (Korth Kristalle GmbH) of dimensions $5x5x5 \text{ mm}^3$, decay time 630 ns (slow component) resp. 0.6-0.8 ns (fast component), light yield 10 photons/keV (slow comp.) resp. 1.8 photons/keV (fast comp.) and photoelectron yield 16% of NaI(TI) for gammas (slow comp.) resp. 3% (fast comp.). A fast photomultiplier (Hamamatsu No. H5783-04) was used. The energy threshold of this system was determined at 1 keV (noise level) corresponding to 2 mV. Tests done with 5.9 keV X-rays from ⁵⁵Fe yield a maximum at 12 mV with a mean measured signal at about 4 mV.

Detector shield for very high radiation and EMI environment

In addition to the particular experimental setup – i.e., Ta or W target, direct target or indirect geometry (using either a secondary target such as an ion collector or also an X-ray diffracting crystal), the shielding of the detector systems presented the major challenge. A massive and complex shield was required in view of ionizing radiation noise. However, the non–ionizing (i.e. Electromagnetic Interference – EMI) noise which also arises at such high power and short plasma pulses resulted namely in a marked but gradually varying disturbance of the detector/preamplifier signal. The design of the system shield against ionizing radiation was conceived of three segments/layers: outer, intermediate and inner. The outer shield consisted of polyethylene of generally 2 cm with the goal to stop or slow down electrons emitted by the target. The intermediate layer consisted of dural foils of a total 5 mm thickness placed namely at the interfaces and loose edges of the surrounding shielding blocks. The task is to stop charged particles which eventually arise and cross inter block apertures. The inner layer

contains three lead sheet plates of full thickness usually 15 mm. The task is to shield photons originating both from the target and from ion interaction in the chamber and other shielding blocks. This inner layer should already avoid any direct charged particle impact with exception of relativistic electrons. Further thick Al and Pb plates as well as thin Al/C paper foils were additionally implemented. The detector window was also (optically) protected by a 125 μm thick Be foil.

Measurements at PALS

The system used was tested with a number of varying and massive shielding settings of varying geometry and thicknesses of the three layers above with and without hole aperture on target. Measurements at PALS were carried out on two different targets (Ta and W) in three different arrangements:

- (i) <u>Direct view of detector on target</u>: Even the fully closed and massive shield yielded signals. Thus, even this strong shield is either not sufficient and/or penetrating radiation is non-negligible (i.e. relativistic electrons and/or high energy gamma rays).
- (ii) <u>Indirect view of detector on secondary target i.e. collector</u>: In this geometry the massively protected detector with sealed aperture resulted in full shield. The space between the target and detector was complementarily shielded by massive lead plates. However, opening the aperture even with varying collimator size and composition resulted in strongly disturbed response.
- (iii) <u>Indirect view of detector on diffracting crystal by secondary target</u>: Similar results as (ii). Even shielded but collimated apertures did not fully shield the detector. At least a thin plate of Pb and Al are required even in this geometry.

Conclusions

In addition to the huge primary laser plasma flash and ensuing plasma and ion induced noise, penetrating radiation in the form of gamma rays and electrons is present. It is thus not possible to measure with an unshielded detector. The BaF_2 detector is most suitable to follow the time evolution of the plasma radiation as a whole. This is possible namely by the full energy of the emitted particles in consecutive time intervals (e.g. 5 ns). This detector could be used up to now for the detection of deexcitating nuclear radiation only from an indirect target. Moreover the detector entry window must be at least partially shielded by thin Pb/Al foils which significantly reduce the overall detection efficiency of the desired radiation. Work is in progress.

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Electromagnetic Interference Shielding for Medipix Detectors for Laser–Induced Plasma Radiation Detection

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Active detectors for direct detection of plasma radiation

The possibility to excite *low–energy* nuclear states by laser induced plasma is being experimentally investigated [1] on the Prague Asterix Laser System PALS (www.pals.cas.cz). This medium–energy high–power system yields interaction intensities at the level of 10^{16} – 10^{17} Wcm⁻² which produce subrelativistic plasmas with electron temperature of the order of 1– 10 keV. Such low–energy electrons can excite low–lying nuclear states. The nucleus ¹⁸¹Ta was chosen [2] for this first study. In frame of this project, particular effort is placed on the use of active detectors (i.e. real–time digital single radiation quantum counting devices) inside the interaction chamber for the direct detection of plasma radiation and/or subsequent nuclear radiation [1]. Two types of detector systems (see www.utef.cvut.cz) are being implemented and adapted for this purpose: Scintillating detectors (such as Medipix2 and TimePix developed in frame of the CERN Medipix Collaboration – see www.cern.ch/medipix) which are the subject of this paper.

Portable radiation camera TimePix/USB-interface

State-of-the-art hybrid pixel semiconductor detectors of the Medipix family provide position-, energy- and time-sensitive spectrometric properties which make them attractive for nuclear and particle spectroscopy [3]. In addition to position-sensitive and single quantum detection capability, the new device TimePix (www.cern.ch/medipix) provides the possibility to determine detection time and/or energy deposition in each individual pixel. Real-time operation of this device and data readout and visualization are made possible by the integrated USB-based readout interface (see www.utef.cvut.cz/medipix) which links by standard USB port into any PC. Operation and control of the system as well as data acquisition are driven by a Windows-compatible software package Pixelman (see www.utef.cvut.cz/medipix). Data stream acquisition and storage proceed on-line at overall rate of about 5 frames per second. The assembled TimePix/USB device [4] has dimensions $142 \times 50 \times 20 \text{mm}^3$ and serves as a versatile portable real-time handheld radiation camera of multi-particles (X-rays, e, p, α , t, ions, n) with position-, time- and energy-sensitive capability [4] for single-quantum and on-line particle and nuclear spectroscopy [3].

Adaptation for laser-induced plasma radiation detection

High power laser induced plasma is characterized by (*i*) high vacuum, (*ii*) very high radiation and (*iii*) extremely high electromagnetic noise. In particular the last condition results in significant challenges for the shielding and operation of active detectors inside such hostile environment. Namely the influence on the real-time active digital hybrid chip device which consists of highly integrated state-of-the-art microelectronics of over 65.000 individual pixels acting as individual detectors. With this in mind, and in an effort to minimize the amount of components in the very high field noise inside of the interaction chamber, the USB-based interface board (of dimensions $64 \times 50 \times 20$ mm³) was distanced from the Medipix detector chip board. This was possible by implementing a devoted radiation hard communication LVDS module linking three Ethernet communication and data cables between the detector board (placed inside the interaction chamber) and the USB-based interface (outside the chamber). Power supply to the module and to the detector board is provided for each device separately.

EMI shield

Given the strong electromagnetic interference (EMI) with very high and short gradients a devoted shielding assembly was put together for all components namely those inside the interaction chamber. Communication and power cables were EMI protected by a flexible shielding insulating tube through which a cable or bundle of cables are conveyed. The material used is mu-copper for both electrical and magnetic screening (Holland Shielding). Electrostatic screening was guaranteed by separate insulated ground contact to the vacuum chamber walls. The detector board was also EMI shielded by a gradual onion–like assembly of several (up to three) independent screening arrangements of reinforced Amucor and mu-copper foils (hollandshielding.com). These successive layers were insulated from each other by additional insulating material. Ground was taken out independently by always one connection to avoid induced loops. The interface and contacts between the cable shielding tubes and the detector board shield casing were secured by EMI insulating metal conductive tapes. To ensure reliability of operation the cabling and the USB-based interface outside the interaction chamber were also EMI shielded.

Measurements at PALS

Tests were carried out at PALS on two different targets (Ta and W). With the shielding assembly above the detector managed to remain operational even at the desired laser energies (170 J). Nevertheless, in view of the relatively short decay time (6 μ s) of the excited level (6.2 keV) in ¹⁸¹Ta and the duration of the laser plasma flash pulse (250 ps) the use of a trigger is essential to separate the expected spectrometric signals from the large primary laser pulse and subsequent plasma intensive radiation.

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SPAD active quenching circuit optimized for satellite laser ranging applications

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We are presenting novel active quenching circuit for Single Photon Avalanche Diodes (SPADs). Research and development of the Single Photon Avalanche Diodes (SPADs) based on silicon were started in our labs at the Czech Technical University in Prague in 1984. The primary goal of the work was to develop a solid state option to the micro-channel plate photomultiplier based photon detector for laser ranging applications. The anticipated application required the minimal active area size of 100 micrometers in diameter and a timing resolution lower than 40 picoseconds rms. In our design we focused on the diode structure design and the chip manufacturing technology. The chip manufacturing technology tuning resulted in a process, internally called K14, which permits the creation of SPAD structures with a diameter 20 to 200 micrometers, timing resolution better than 50 picoseconds FWHM and an acceptable dark count rate. Example of the detection chip mounted on a socket can be found in [1]. Various versions of active quenching and gating circuits have been optimized for various applications. We have experienced, that the active quenching and gating circuit has a key influence on the final detector performance. For each particular application, the detector setup has to be tailored to obtain top performance [2].

The circuit was designed and optimized for satellite laser ranging applications, where the specific requirements are put on the gating performance. The goal of this work was to be able to detect the photons in short time after gate ON with constant detection delay and sensitivity to minimize the measurement errors on one hand and background photon flux induced false count on the other hand.

In the new circuit the SPAD can be pulse operated up to 5 volts above its breakdown voltage, the gate is opened by the incoming external pulse and is closed by the first photon detection. The circuit consists of five main blocks. The input signal receiver is terminated with 50 Ohms and by incoming pulse opens the detection window. The detection window is voltage level shifted to match ECL voltage levels of fast comparator. It was essential to choose the comparator with low dependency of propagation delay on temperature. It lovers the demands to very good temperature stabilization of the whole circuit. When the photon detection is occurred, the SPAD is quenched by closing the detection window. The output of the comparator drives the circuit, which sharpen the edges of the output pulse and convert the pulse to NIM signals.

The entire was designed using SMD technology and is produced on two sided printed circuit board of size 55x30 millimetres. The circuit is power with in past developed voltage power supply, which produced ± 6 volts and negative SPAD bias voltage.

The circuit was tested with the 200 micrometers K14 chip, which was pulse biased from 1 up to 4 volts above its breakdown voltage. The conventional scheme of Time Correlated Single Photon Counting (TCSPC) experiment was used. The picosecond laser diode Hamamatsu C4725 providing 42 ps wide pulses at 778 nm has been used as a signal source. The timing consists of new pico event timer with resolution of 0.8 ps. The dependency of detection delay on gate on before photon of interests of arrival has been closely investigated. The detection delay drops down about 140 ps during the first 15 nanoseconds when the gate is switch on before photon of arrival. After that the detection delay stays constant with overall jitter of 10 to 20 ps.

The increasing character of effective dark count rate with increasing of gate ON repetition rate was successively chained down in comparison with previously develop circuits. This effect is very important in the way to high repetition measurement rate in satellites laser ranging. By here introduced circuit has ~200 kHz of effective dark count rate at 2 kHz repetition rate of gate ON with 200 micrometers cooled chip in comparison with ~550 kHz of time walk compensated circuit.

The new circuit has been built and tested, the detector package for the field operation at the satellite laser ranging station was completed. The detection delay remains constant after 15 nanoseconds after gate ON before photon of interests of arrival. The effective dark count rate at 2 kHz of repetition rate of gate ON pulses has been measured of 200 kHz.

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Single Photon Detector Operating in Extremely High Background Photon Flux Conditions

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We are reporting our results in research and development in the field of avalanche semiconductor single photon detectors and their application. Our goal was a development of a solid state photon counting detector capable of high precision photon arrival time tagging in extremely harsh operating conditions.

The recent applications in laser ranging to space objects, time transfer using laser pulses in space [3] and others require the photon counting operation under the conditions of extremely high background photon flux. The typical background photon flux in these experiments is up to 3×10^8 photons per second. Under these background photon fluxes the photon counting detector must be able to detect individual photons and the detection delay and detection timing resolution must remain independent of the background photon flux. Additionally, the photon counting detector should tolerate direct solar illumination of the active area when biased or not biased without detector damage. This optical damage test was performed focusing 1 mW of optical power on the 25 µm detector active area repeatedly for 8 hours. Such a photon flux corresponds to the direct illumination of the optical receiver package by Sun in space [3].

The background photon flux exceeding 10° photons per second hitting the detector active area should not avoid the useful signal detection and recognition on the signal level of units of photons per second. This is background photon flux about two orders of magnitude higher than the conventional solid state photon counters accept.

We have developed and tested the active quenched and gated avalanche structure on silicon providing the required features in connection with the K14 detection chips. The detector has been tested in a conventional scheme of Time Correlated Single Photon Counting (TCSPC). The picosecond laser diode Hamamatsu C4725 providing 42 ps wide pulses at 778 nm has been used as a signal source. The timing chain consisted of an ORTEC Time to Amplitude Converter 566, feeding data to a multi-channel analyzer card in a personal computer. The timing resolution of the entire chain is 50 ps Full Width at Half Maximum (FWHM). The background photon flux was generated by the Tungsten lamp.

Two different detector packages planned for space related applications were tested. The active quenching and gating logic based on ECL comparators and TTL gating circuits was used in connection with the 200 μ m diameter K14 SPAD, which was biased 4 V above its breakdown voltage. The detector package was optimized for one way laser ranging in space. Detection timing resolution of this detector was 22 ps rms. The excellent detection delay stability ±4 ps over an entire background photon flux up to 100 millions of photons per second hitting the detector active area.

The active quenching circuit based entirely on ECL logic was optimized for 25 μ m diameter K14 SPAD chips control. The circuit enables both gated and not gated operation of the detector. The K14 SPAD detector 25 μ m in diameter was operated in gated mode 0.8 V above its break down voltage. The detection delay and timing resolution are stable \pm 8 ps over an entire background flux range exceeding 0 to 2×10^9 photons per second. The detector was gated ON about 30 ns prior to arrival of photon of interest. This version of detector package is under development for time transfer by laser light via satellite, for the LTT project by China [4]. In this application the background photon flux of the order of 3×10^8 photons per second is common.

We have developed and tested solid state photon counter on silicon capable of high precision photon arrival time tagging in extremely harsh operating conditions. The goal of presented results interpretation was not to show the detection probability (that is quite low, of course), but to demonstrate stable timing properties of developed detector package. The detector is able to operate under the conditions of background photon flux exceeding 2×10^9 photons per second. The operational detector tolerates long term exposures to the input photon flux exceeding 10^{15} photons (>1 mW) per second without damage. The detector timing parameters are stable within tens of picoseconds within above mentioned operational environment changes.

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The First Year of Operation with Consolidated Prediction Format at Satellite Laser Ranging Station Helwan

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Satellite laser ranging (SLR) station close Helwan, a suburb of Egyptian capital city Cairo, is the cooperative lab of the astronomical department of National Research Institute of Astronomy and Geophysics (NRIAG), Egypt and the department of physical electronics of Czech Technical University, FNSPE, Czech Republic [1]. The aim of station, alike as many other similar stations around Earth, is the accurate and precise measurement of distance between station reference point and some artificial satellites. The measurement is based on an optical radar principle. To obtain scientifically valuable results the operation of SLR must be internationally coordinate. The coordinator is International Laser Ranging Service (ILRS) supported by NASA. Technical improvement and new types of retroreflecting targets, not only on satellites, forces using of new type of calculated predictions called Consolidated Prediction Format (CPF) [2] instead of inter-range vectors (IRV) used so far.

The software package for using CPF has been designed, written and debugged for implementation of the CPF in the SLR Helwan. The package is designed is such a way, that the codes and files should be direct added to the existing prediction and data analysis package based on IRV type of prediction. The main functions of the software package are input ephemeris data file manipulation, satellite position prediction, SLR measurement, and post-pass data analysis by means of orbital data fitting.

After CPF implementation several aspects have to be traced:

- effect of principal limitation in software package (nonsupporting of midnight passes, short time window)
- effect of the change of operational procedure (for non-qualified part of staff)
- effect of hidden algorithmic error for specific time and satellites constellations

The founded and solved problems and results hes been summarized in references [3, 4] and mutuals reports from end of 2008. The station is in operational state, however, the data yield in second half of has been limited by atmospheric conditions and limited personal capacity of station staff.

Measurements from the Helwan Station help strengthen the reference frame for defining tectonic motion and enhancing the basic models which are used to define crustal deformation at the boundaries of the African plate with European and Arabian plates. This helps in monitoring of deformation at the boundaries of the Adriatic, Aegean, Anatolian and Red Sea

regions, and we hope with the development of earthquake hazard assessment risk models in Southern European and North African countries. Measurement of internal deformation of the African plate will also be facilitated in combination with observations from the satellite laser ranging stations at South Africa with other geodetic techniques such as GPS in the region. This deformation would help identify areas of potential earthquake hazard within the African continent.

The new challenge for mutual scientific cooperation in next year is the implementation of Consolidated Laser Ranging Data Format (CRD). Due to recent technology changes, the existing ILRS formats for exchange of laser fullrate, sampled engineering and normal point data are in need of revision. The main technology drivers are the increased use of kilohertz firing rate lasers which make the fullrate data format cumbersome, and anticipated transponder missions, especially the Lunar Reconnaissance Orbiter, for which various field sizes are either too small or nonexistent. Rather than patching the existing format, a new flexible format encompassing the 3 data types and anticipated target types has been created. In fact, the effect of CRD for station Helwan will be negligible, but its implementation will be necessary for station network integration keeping.

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Section 5

MATERIALS ENGINEERING

Polymer Layers Doped with Rare Earth Ions for Photonics Applications

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The optical properties of Rare Earth (RE) doped photonics materials have been demonstrated in numerous papers [1, 2] because RE doped photonics materials play a key role not only in optical communication systems and also in solid state lasers and full colour displays.

Steckl group reported in [3] about properties GaN layers doped with Eu^{3+} , Er^{3+} , and Tm^{3+} ions. They obtained photoemission from higher excited RE states in GaN covering the entire visible spectrum: light emission in the green (from Er at 537/558 nm), red (Pr at 650 nm and Eu at 621 nm), and blue (Tm at 477 nm) spectra region. The second important courses of study are RE ions which can emit at infrared region. For these purposes are the most often studied RE ions for telecommunications systems. For telecommunication systems operating at 1300 nm are investigated RE ions such as Nd³⁺, Pr³⁺ and Dy³⁺. For telecommunications applications at 1530 nm are investigated Er^{3+} and Tm^{3+} ions. In the last decade are also investigated sensitizers to produce more efficient RE doped sources. The most often used sensitizer is Yb³⁺ for Er^{3+} -doped optical amplifiers. Except Yb³⁺ are nowadays examine other RE ions as sensitizers such as Ho³⁺ for Tm³⁺ or Ho³⁺ for Yb³⁺ doped photonics materials and etc..

Optical materials such as semiconductors, glass and optical crystals doped with RE ions are conventional materials for accomplishing lasing action. Recently there has been considerable interest to develop new photonics materials such as polymers with better properties and lower price. In this contribution we present the results of study the properties of RE doped polymer layers. As a polymer core material we chose Polymethylmethacrylate (PMMA) due to its low optical absorption, simple synthesis and low cost. Except PMMA for our research we chose Epoxy Novolak Resin (ENR) polymer due to its excellent optical properties (opt. losses 2 dB·cm⁻¹ at 980 nm, 0.77 dB·cm⁻¹ at 1310 nm and 1.71 dB·cm⁻¹ at 1500 nm) [4] and easy fabrication process.

We doped and investigated properties of PMMA polymer layers doped with Er^{3+} , Yb^{3+} , and ENR polymer doped with Er^{3+} , Yb^{3+} , Dy^{3+} or Tm^{3+} ions. Polymer layers were fabricated by the spin coating on silicon substrate, or, the polymer was poured into a

bottomless mould placed on a quartz substrate and let to dry in air. As source PMMA were used small pieces of PMMA (Goodfellow) were left to dissolve in chloroform for a few days before being used in the fabrication of PMMA layers. For Er^{3+} doping solutions whose content ranged from 1.0 at. % to 20.0 at. % erbium was added to the PMMA. For $\text{Er}^{3+}/\text{Yb}^{3+}$ co-doping, ErCl_3 , ErF_3 or erbium(III) tris(2,2,6,6-tetramethyl-3,5-heptanedionate) (Sigma-Aldrich) and YbCl₃, YbF₃ or ytterbium(III) tris(2,2,6,6-tetramethyl-3,5-heptanedionate) (Goodfellow) were together dissolved in chloroform. Samples containing 1.0 at. % erbium was co-doped with ytterbium in amounts also ranging from 1.0 at. % to 20.0 at. %. The ENR samples were also fabricated by spin-coating and after deposition the samples were baked at 90°C for 45 min and then UV light were used for hardening. Finally hard baking at 90°C for 60 min was applied. The doping occurred using anhydrous ErCl₃, YbCl₃, DyCl₃ or TmCl₃ dissolved in C₂H₆OS (Sigma-Aldrich). For the RE doping, solutions where the content of ranged from 1.0 at. % to 20.0 at. % was added to the ENR.

Absorption measurements were performed in the spectral range from 350 to 2800 nm. The content of RE ions had a significant effect on the occurrence of the bands attributed to the RE transitions: while they were rather strong in the samples with higher RE concentration they almost vanished in the background in the case of the samples with low RE concentration. Infrared spectroscopy (FTIR) was used for investigation of O-H and C-H absorption bands. For PMMA samples we observed FTIR absorption band around at 3349 cm⁻¹ correspond to the O-H vibrations and three bands at 2994 cm⁻¹, 2953 cm⁻¹ and 2843 cm⁻¹ correspond to aliphatic C-H bands. For ENR samples we observed three strong broad bands occurring at 2873 cm⁻¹, 2930 cm⁻¹ and 2965 cm⁻¹ correspond to aliphatic C-H bands while that one corresponding to aromatic C-H band is at 3060 cm⁻¹. We also observed stretching vibrations at 3380 cm⁻¹ (Nd:ENR) and 3366 cm⁻¹ (Dy:ENR) correspond to the O-H.

The Er³⁺ doped PMMA and ENR samples exhibited typical emission at 1530 nm (λ_{ex} = 980 nm) due to the Er³⁺ intra-4f⁴I_{13/2} \rightarrow ⁴I_{15/2} only at samples with higher content of Er³⁺ ions. It was also found that the addition of ytterbium ions had positive effect on the photoluminescence spectra at 1550 nm. This result will be subject for future research.

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Optical Properties of Gallium Nitride Layers Doped with Erbium and Erbium + Ytterbium Ions

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Rare earth (RE) doping into Gallium Nitride (GaN) layers is still a very new area and there are only small number of groups active in this field (for example: Steckl, Bishop, Zavada, and Abernathy of the universities of Cincinnati, Urbana-Champaign, and Florida, Gainesville) [1]. GaN is a promising wide band gap direct semiconductor material (3.4 eV) and interest in the GaN as an optoelectronic material is due to success of blue/green emitting solid state lasers and light emitting diodes [2]. It was previously shown at [3] that the thermal quenching in RE-doped semiconductors decreases with increasing band gap. Therefore wide-band gap semiconductors such as GaN are attractive hosts for RE elements.

Optical materials doped with the RE ions can be used as optical sources or amplifiers. The most studied RE ion has been so far Er^{3+} . Materials containing Er^{3+} ions can lase or amplify at 1530 nm due to the Er^{3+} intra-4f emission that corresponds to the ${}^{4}I_{13/2} \rightarrow {}^{4}I_{15/2}$ transition. The wavelength 1530 nm is used in the optical telecommunication systems due to minimal optical losses in silica fibers (Er^{3+} -doped optical fiber amplifiers – EDFA, Er^{3+} -doped planar waveguide amplifiers EDPWA). Er^{3+} -doped amplifiers can be directly pumped into the first excited manifold using an optical source operating at either a wavelength of 1480 nm or at one of the higher absorption bands (e.g. 980 nm). At 980 nm an erbium laser system with emission around 1530 nm corresponds to ${}^{4}I_{13/2} \rightarrow {}^{4}I_{15/2}$ transition in the three levels system. Erbium-ytterbium co-doping of EDFAs has been proposed as a method for the production of high-power amplifiers in very short waveguides. Besides Er^{3+} doped photonics materials other RE ions, such as praseodymium, neodymium and dysprosium, are intensively studied as well [4], in this case because their emission at 1300 nm corresponds to the wavelengths where the dispersion of silica optical fibers is minimal.

In this contribution we present optical properties of GaN layers doped with Er^{3+} and Er^{3+}/Yb^{3+} ions. The GaN layers fabricated by MOCVD on 2 inches sapphire substrates were doped with Er^{3+} and Er^{3+}/Yb^{3+} ions. The doping was done by ion implantation at energy of 190 keV or 210 keV at room temperature or 300 keV at 450 °C and the applied dose varied from $1\cdot10^{13}$ $Er\cdot cm^{-2}$ to $1\cdot10^{15}$ $Er\cdot cm^{-2}$ for Er^{3+} doping and from $1\cdot10^{14}$ Yb·cm⁻² to $1\cdot10^{16}$ Yb·cm⁻² for Yb³⁺ doping. After the implantation all samples were annealed at temperature around 800 °C under flowing nitrogen for 30 minutes. The depth of erbium 172

concentration profiles of the introduced ions were calculated by using SRIM98. Simulation shown that for energy 300 keV is maximum concentration about 50 nm and for implantation energy 190 keV is maximum concentration about 35 nm.

The structure of the deposited GaN thin films was studied by the X-ray diffraction (XRD). The GaN layers correspond to the (002) and (004) faces of single crystalline GaN (c-GaN) with hexagonal wurtzite structure and the XRD measurement also showed that GaN elemental cells had dimensions a = 3.1891 Å, b = 3.1891 Å and c = 5.1855 Å. The XRD spectra of the GaN samples doped with Er³⁺ and Yb³⁺ ions after the annealing at 800 °C in nitrogen atmosphere were the same as samples without ion implantation doping. As we did not observe any difference between the reference XRD spectra and those samples containing erbium and ytterbium ions we assume that the doping process did not include any structural changes. The compositions of the fabricated samples were determined by nuclear chemical analysis as Rutherford Backscattering Spectroscopy (RBS) and Elastic Recoil Detection Analysis (ERDA). The evaluations of RBS and ERDA spectra were done by GISA3 and SIMNRA code, respectively. As the Er and Yb have very close values of atomic weights these two elements cannot be distinguished in the RBS spectra, so that only sum of both elements can be obtained. The range of the RE total content (sum of Er and Yb) spread from 0.02 to 3.38 at %, depending on the actual Er or Yb implantation dose. The photoluminescence measurement was done by using semiconductor laser P4300 operating at $\lambda_{ex} = 980$ nm at room temperature and He-Ne laser operating at $\lambda_{ex} = 632.8$ nm at temperature of 4 K. The FEU62 photocell was used for detection of the wavelength from 500 to 1000 nm, while the Ge detector was used for the wavelength from 1000 to 1600 nm. The samples exhibited typical emission at 1530 nm even pumped at 980 nm at room temperature. The layers co doped by Yb ions increased intensity. The best results we obtained by applied energy 300 keV and implantation dose $1 \cdot 10^{15}$ Er·cm⁻², $1 \cdot 10^{15}$ Yb·cm⁻². We observed only weak photoluminescence at room temperature but we suppose that after ion implantation annealing in temperature higher than 900°C the intensity would decrease. We hope that we can improve the photoluminescence at 1530 nm by the post-implantation annealing to temperatures up to 1100 °C and it will be subject for the further examination.

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Plasma Spraying of FeAl Intermetalics

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Systems such as gas turbines or jet engines demand application of special materials capable of withstanding high temperatures and aggressive environments, providing good erosion resistance and low density.

Superalloys have been successfully used in high temperature applications but it turns out that they can be replaced by intermetallic compounds [1,2]. Intermetallic alloys are stable up to high temperatures and resistant to the wear and oxidation, having lower density compared to the conventional iron or nickel based super-alloys. On the other hand such ordered microstructure can lead to reduced dislocation mobility and therefore intermetallic alloys tend to be more brittle.

Another approach to achieve desired working conditions is to manufacture parts from materials with lower costs and sufficient fracture toughness and provide them with the protective intermetallic surface layer.

Plasma spraying represents suitable method for production of such surface layers because it can provide satisfactory deposition rates with reasonable costs. Plasma spraying is also well established in the industry.

Unique splat-like structure of thermally sprayed coatings can result in a new quality of the coating. For example, bulk intermetallics produced by powder metallurgy are very brittle, but in case of sprayed intermetallics can be major cracking to some extend restrained by mutual slide of the splats. On the other hand, spraying process has to be carefully optimized with respect to the chemical and phase changes in the feedstock material, porosity of the prepared layer, residual stresses, spallation of the material, reproducibility etc.

In this research, initial experiments with deposition of FeAl layer were performed. Two different plasma spraying technologies were used for spraying of FeAl powder (LERMPS, Belfort, France) on both faces of low carbon steel sheet substrates [3]. Substrates were degreased and grit blasted immediately prior to the coating deposition. Atomized Fe-29(wt%)Al powder and mixture of atomized and fused&crushed Fe-38(wt%)Al powder were sprayed with Gas Stabilized Plasma (GSP) torch F4 (Sulzer Metco, Wohlen, Switzerland). Fe-29(wt%)Al powder was also sprayed with Water Stabilized Plasma (WSP) torch PAL 160 (Institute of Plasma Physics, Czech Republic). Thicknesses of prepared layers were approx. 200 microns for APS and 500 microns for WSP coatings.

Cross-sections of the coatings were prepared using standard metallographic procedures: mechanical grinding and polishing up to 0.05 um OP-S suspension. Prepared samples were observed using scanning electron microscope JEOL JSM-5510LV coupled with energy-dispersive X-ray spectroscopy.

Influence of protective layer on the fatigue behavior of steel substrate was studied on electromagnetic computer controlled testing device "SF-Test" with the loading frequency tuned to the first natural frequency of mounted specimens [3]. Flat specimens were loaded at room temperature by cyclical bending with constant deflection amplitude of the free-end u = 4 mm. Decrease of natural frequency corresponds to the growth of the fatigue cracks in the specimens. Fatigue endurance of specimen is given by N – number of cycles to the failure. The frequency change f(N/2) - f(N) = 3 Hz was used as a failure criterion. Failed specimens were cooled in the liquid nitrogen below the transition temperature of the substrate and ruptured to access the fracture surfaces, their micromorphology was observed using scanning electron microscope JEOL JSM-840A.

Microstructure observation proved oxides formation during the spraying process. Both interlamellar and intralamellar cracks and pores were observed. Two different types of the splats can be distinguished in the coatings – some particles were fully molten and created splats with high flattening ratio while others were not molten or resolidifed during the flight stage and remained round. Only limited number of pull-outs was noticed at the polished cross-section, which indicates satisfactory bonding between the splats.

Results from fatigue testing show different influence of the coatings on the fatigue endurance of the samples. Highest mean fatigue life N = 177722 cycles was obtained for GSP sprayed Fe-38(wt%)Al. Mean fatigue lives of Fe-29(wt%)Al sprayed by WSP and GSP technologies were N = 156035 and N = 121107 cycles respectively.

Fractographic analysis revealed that in the substrate fatigue cracks initiated from the coating side and grew by striation mechanism. Area of the residual cross-section of the substrate could be distinguished by presence of cleavage fracture. It was not possible to distinguish areas of fatigue and static failure of the coatings. Coatings failed by intrasplat cracking and intersplat decohesion. In some cases, partial delamination of the coatings from the substrate was observed.

It was showed that the preparation of the coating with the plasma spraying is feasible. Observation of coating microstructure proved presence of oxides and some contamination of substrate-coating interface with grit blasting material. It was observed, that coatings had different influence on fatigue life of the specimens. Reasons of these differences as well as tests of some other technologically important properties such as corrosion resistance or mechanical behavior of the coatings are subject of the upcoming research.

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CREEP STRENGTH MODELS USED IN EUROPE AND ASSESSMENT OF THEIR ACCEPTABILITY

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Creep is an important degradation mechanism of components working at high temperatures. Time to rupture presumption is set up laboratory tests. PAT (Post Assessment Test) created by ECCC (European Creep Collaborative Committee) was implemented to enhance a credibility of the presumption [1]. Dataset of 15 121 steel was used to obtain time to rupture presumption by selected phenomenological models of creep. PAT methodology was applied on these results. Models (1) [2] and (2) [3] are most common in Czech Republic:

$$\log(\sigma_0) = \sum \beta_k \cdot P^k , \text{ where } k=0,1,2; P=T \cdot \left[\log(t_u) + \beta_{n+1}\right], n=1,2$$
(1)

$$\log[t_{u}] = \beta_{0} + \beta_{1} \cdot \log[\frac{1}{T} - \frac{1}{\beta_{4}}] + \beta_{2} \cdot \log[\frac{1}{T} - \frac{1}{\beta_{4}}] \cdot \log[\sinh(\beta_{5} \cdot \sigma_{0} \cdot T)] + \beta_{3} \cdot \log[\sinh(\beta_{5} \cdot \sigma_{0} \cdot T)]$$
(2)

Following models are recommended by ECCC [1]:

$$\log(t_u) = f(T,\sigma_0) = \beta_0 + \beta_1 \cdot \log(T) + \beta_2 \cdot \log(\sigma_0) + \beta_3 / T + \beta_4 \cdot \sigma_0 / T$$
(3)

$$\log(t_u) = f(T,\sigma_0) = \beta_0 + \beta_1 \cdot \log(T) + \beta_2 \cdot \log(\sigma_0) / T + \beta_3 / T + \beta_4 \cdot \sigma_0 / T$$
(4)

$$\log(t_u) = f(T, \sigma_0) = \beta_0 + \beta_1 \cdot \log(\sigma_0) + \beta_2 \cdot \sigma_0 + \beta_3 \cdot \sigma_{0^2} + \beta_4 \cdot T + \beta_5 / T$$
(5)

$$\log(t_u) = f(T, \sigma_0) = \left[\sum \beta_k \cdot \left[\log(\sigma_0)\right]^k\right] / T + \beta_5 \qquad n=2,3,4 \qquad (6)$$

$$\log(t_u) = f(T, \sigma_0) = \left[\sum \beta_k \cdot \left[\log(\sigma_0)\right]_k^k\right] \cdot T + \beta_5 \qquad n=2,3,4$$
(7)

$$\log[t_u] = f[T,\sigma_0] = \left[\sum \beta_k \cdot \left[\log[\sigma_0]\right]^k\right] + \beta_s / T \qquad n=2,3,4 \qquad (8)$$

Symbols in eq. (1) – (8) are: T – temperature, t_u – time to rupture (presumption), σ - stress, β_1 - β_n – regression constants.

Requirements of PAT can be resumed as follows [1]:

PAT1.1a – visual control of a model and credibility of isothermal lines to individual data points in abscissas $\log \sigma_0$ - $\log t_u$

 $\ensuremath{\textbf{PAT1.1b}}\xspace$ – visual control of shape and function dependency of presumption with literature data

PAT1.2 – visualization of log σ_0 - log t_u dependency at 25°C intervals from 25°C bellow the minimum test temperature, to 25 °C above the maximum test temperature. For times between 10h and 10·t_{max} and stress $\geq 0.8 \cdot \sigma_{min}$ lines must no cross-over, come-together or turn-back

PAT 1.3 – partial derivation
$$-\partial |\log t_u| / \partial |\log \sigma_0|$$
 should not be $\leq 1,5$

Second group of these test judges effectiveness of a model in range of dataset. For evaluation of a single melt (**PAT2.1**) this recommendation are used: a *log* t_u versus *log* t_u' diagram should show the *log* $t_u' = log t_u$ (ideal line), the *log* $t_u' = the log t_u \pm 2,5$ where s is standard deviation of the residual log times and the *log* $t_u' = the log t_2 \pm log$ (2) boundary lines. The diagram is plotted for times from $t_r = 100h$ up to $t_r = 3 \cdot t_{max}$. The model equation should be re-assessed if more then 1,5% data point fall outside of the $\pm 2,5$ s boundary lines or if the slope of the mean line is not in interval $\langle 0,78;1,22 \rangle$ or if the mean line is not contained within the $\pm log$ (2) boundary lines between $t_r = 100h$ and $t_r = 100000h$.

Similar process is used for assessment of more melts (PAT 2.2)..

The last criterion is repeatability and stability of extrapolation. According **PAT3.1** evaluation is repeated with dataset from which is randomly culled 50% of data between $t_{max}/10$ and t_{max} . If strength prediction determined with using of original and reduced dataset is not reproduced within 10% the procedure have to be repeated. If the acceptability criterion is not met after the second cull, the main assessment should be repeated using a different model equation or procedure.

PAT was applied on dataset of 15 121 steel. Nominal chemical composition under ČSN and composition of tested material is in Tab. I. Benefit of the described methodology is clear from Tab. II. There are presumption of creep strength at 38 000h based on models (1) - (8). If the PAT procedure is not applied the strength presumption differences are larger then 600%. After application of the methodology the differences fall down on 33%. Creep strength of the tested material is able to determine using models (1,3 and 4) whereas other models are improper for the dataset.

Element		С	Mn	Si	Р	S	Cr	Mo	Al
Composition		0,15	0,66	0,35	0,009	0,013	0,92	0,42	0,049
Requirements of	min	0,1	0,4	0,15			0,7	0,4	-
ČŚŃ	max	0,18	0,7	0,35	0,04	0,04	1,3	0,6	-

Table I – Chemical composition of tested	material
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Model		Cree	ep strength [Assessment results of described methodology		
		Tempera				
	500	525	550	575		
(1)	134,8	84,8	49,4	26,7	Meet all requirements	
(2)	168,4	87,4	30,13	6,5	Unsuited PAT1.3	
(3)	168,8	97,1	47,7	20,1	Meet all requirements	
(4)	169,9	97,2	47,8	20,1	Meet all requirements	
(5)	169,4	92,2	61,1	45,2	Unsuited PAT2.1	
(6)		165,7	97,7	61,8	44,8	Unsuited PAT2.1
(7) (n=3)	132,5	85,9	63,9	49,9	Unsuited PAT2.1	
(8) (n=3)	168,3	91,2	62,7	49,4	Unsuited PAT1.3	
Creep strength presumption - models (1-8)	min	132,5	84,8	30,13	6,5	
	max	169,4	97,7	63,9	49,4	
Creep strength presumption - models (1,3,4)	min	134,8	84,8	47,7	20,1	
	max	168,9	97,2	49,4	26,7	

Tab. II – Presumption of creep strength based on models (1)÷(8)

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Pozzolanic Activity Determination of Municipal Incinerator Wastes

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Nowadays we are standing behind lack of natural raw materials and our lifestyle brings the pollution and greenhouse effect. On that score, there is a growing tendency of maximal recycling of all types of wastes and reducing their disposal. Each day we emit huge amount of combustion gases together with solid wastes that are formed during incineration processes. These solid wastes can be generally divided into three basic groups: under-furnace grate slag materials, solid wastes from electro-filters (ash materials) and fly ashes from sleeve and catalytic filters. These slags and fly ashes differ in grain size distribution, composition and amount of heavy metals, and many other parameters. Among them, the toxicity is from the point of view of their utilization at the top of the interests.

Depending upon the source and makeup of the coal being burned, the components of the fly ash produced vary considerably, but all wastes materials include substantial amounts of silica (silicon dioxide, SiO_2), both amorphous and crystalline, and lime (calcium oxide, CaO). Toxic fly ashes are contaminated with toxic organic compounds, especially with polychlorinated dibenzo-p-dioxines, benzofurans and biphenyls phenols (POP compounds – persistent organic pollutants). These highly toxic fly ashes should be detoxifying by safe technologies because the current practice of landfilling these materials is quite provisional from an environmental point of view.

Under-furnace grate slag materials represent majority part of solid waste produced in incinerators. Fly ashes are fractionally separating in the electro-filters with respect to particles size. It can be used for the optimization of composition in the study of fly ashes recycling from the point of view of optimal properties of solidified products for building purposes. However, the amount of solid waste is highly dependent on the type of burnt material, it is possible to say that approximately one weighted third of the total amount of burnt waste will come out of incinerators in thr form of solid waste.

Also the energy and natural materials consumption should be taken into account. Hence, the secondary raw materials (i.e. waste materials) will find widespread use in building materials production. The application of solid waste materials in building industry is oriented first of all into the production of building materials, such as concrete, artificial light aggregates, bricks and ceramics [1]. Also, their application in grouting mortar and cast floor layers is possible. Fly ashes from municipal waste incinerators can be applied in a similar way, using all the experience gained at power and heating plant fly ashes. However, their chemical, mineralogical and granulometric composition and the toxicity remainders have to be taken into account.

Fly ashes, as waste materials, can be characteristic by latent hydraulic properties and hence they can substitute certain amount of Portland cement, in the composition of cement based composites and concretes, or some quantity of lime in lime based composites. However, fly ashes together with grate slag materials can be used also as partial aggregate replacement. Partial replacement inorganic binders in composite materials with the recycled waste materials is profitable from ecological as well as from economical point of view.

In this paper pozzolanic activity of solid waste materials produced from municipal incinerators according to the Czech-European technical standard [2] and Czech technical standard [3] was determined. Two under – furnace grate slag materials, wet and dry ground bottom slag, solid waste from sleeve and catalytic filters and fly ash from electro – filters were tested. Firstly, all waste materials were drying in an oven at 110°C to remove majority of moisture. There were 100 ml of distilled water gauge into the polyethylene flasks which were then placed into the thermostatic chamber at 40°C. Tested mixtures, 12 g of cement with 8 g of waste material, were added to distilled water after two hours and sended back into the thermostatic chamber. Stored tested materials were mixed up during eight days period and finally solutions with Büchner funnel were filtrated.

Determination of OH⁻ ions concentration, the total alcality, was done with methylorange indicator and HCl titration. The point of equivalence was indicated with colour change, from yellow to orange. The same solution was then complete with NaOH solution to exchange pH, and murexid indicator. Solution was titrated with EDTA and the point of equivalence was given of red – violet change. Concentrations of OH⁻ ions and CaO were finally calculated according appropriate equations. Each waste material was tested three times and results represent average from the three measured values. The national standards comprise the graph of pozzolanity. According these graphs the tested material is pozzolana active if measured values uderlie of solubility isotherm. None of tested waste materials satisfy conditions of solubility isotherm. It means these solid wastes cannot be designate as pozzolana active materials.

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Fracture Toughness of Spark Plasma Sintered Fe-Al Based Intermetallics

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The Field Assisted Sintering Technology (FAST) is a novel non-conventional powder consolidation method. It is recently used for the very fast densification of ceramic as well as metal powders. Times needed for the whole process of sintering are within the range of few minutes compared to conventional powder metallurgy processes lasting for few hours. A large number of variations of FAST methods, according to the exact features of the process, are distinguished. These are: Spark Plasma Sintering (SPS), Pulsed Electric Current Sintering (PECS), Plasma Activated Sintering (PAS), Electric Discharge Consolidation (EDC), Pulse Current Pressure Sintering (PCPS) and many others. Presented work deals with the properties of compacts sintered via SPS [1, 2].

The SPS equipment used (HP D 25/1, FCT Systeme) consists of a punch-and-die unit where the powders are loaded. The die and the punches are made from graphite (steel-made are also possible to be employed). The two punches are connected via graphite protection plates to two electrodes. The whole unit is placed in a sealed chamber. To prevent sticking between the loose powder and the graphite parts these are carefully interspaced by graphite paper.

The process starts with the evacuation of the sealed chamber. After reaching sufficient vacuum, the pulsed electric current is applied. The electric resistance of the loaded powder results in an increase of its temperature. The pressure is applied at given temperature of the compact. When the pressure reaches its maximum value (usually up to 100 MPa) the pulsed electric current provides very fast heating up to the sintering temperature. The sintering process is terminated after obtaining full densification of the compact [1, 3].

The sintering parameters used for the studied specimens were 450° C as the temperature for the application of the pressure and 1000 and 1100°C as the sintering temperatures. The maximum pressure applied was 60 MPa. The duration of the sintering process was around 10 minutes. The diameter of the die was 40 mm, the total weight of the loaded powder was more than 100 grams.

The loose sintered material was a gas-atomized Fe-Al intermetallic powder produced in LERMPS, Belfort, France. The chemical analysis of the powder led to the composition of 71 wt.% Fe and 29wt.% Al. The XRD analysis showed B2 ordered intermetallic structure being the domain structure. The powder was sieved; the fraction used for SPS specimens was >32 μ m.

During the production, all sintering parameters, except the sintering temperature, were identical. The sintering temperatures were set to be 1000 and 1100°C. The specimens were discs with round basis of approximately 39 mm in diameter. The heights of the specimens were around 16 millimeters. The specimens were sand blasted in order to relieve them of the remains of the graphite paper. They were machined in shapes of round compact tension 180
(RCT) specimens. The central notches were obtained by electrical discharge cutting. The purpose was to produce thin notches without any internal stresses.

SPS RCT specimens were subjected to the fracture toughness tests under identical parameters. The increase of the sintering temperature resulted in slight increase of fracture toughness (from approximately 30 to 33 MPa.m^{0.5}).

Fracture surfaces were studied by means of the scanning electron microscopy (SEM). The study revealed similar fracture mechanisms. The SPS specimens exhibit decohesion of the initial powder particles. The fracture surfaces exhibited huge amount of secondary cracks. Only very few areas of transparticle cracks were observed in case of 1000°C as well as 1100°C specimens. No pores were detected.

The SPS specimens exhibited higher values of fracture toughness than that of conventionally produced intermetallics (casted). In conclusion, the SPS process allows precise controlling of metallurgical parameters such as grain size, phase composition etc. More complex description of the properties of SPS FeAl intermetallic specimens is the question of further research.

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Early Stage of Cement Past Hydration P. Tichá^{1,2}, Š. Hošková¹, P. Demo^{1,2} petra.ticha@fsv.cvut.cz

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Cementitious materials and products of their hydration doubtlessly belong to the most widely used substances. Their applications range from civil engineering to stomatology or biophysics. Cement-based systems have been used for millenia and became practically indispensible because of their relative abundance and their unrivalled characteristics such as variability, formability and high-strength. Moreover, a certain tunability of cement mixtures' properties represents an extremely useful feature.

In spite of such a long record of usage, a detailed and complete understanding of processes leading to final products is still lacking. There exist several reasons for this void in knowledge, the foremost one lies in the complexity of the hydration process when arrays of intermediary products are formed and both physical and chemical processes are under way. However, the above mentioned complexity also offers an option of describing the cement hydration from several points of view utilizing various physical and chemical theories and approaches which can appropriately supplement each other and, thus, lead to a more profound insight.

From a macroscopic perspective, the hydration can be divided into two stages, setting and hardening. In general terms, setting of cement paste can be related to successive transformation of initially liquid substance to a final solid state. Whereas the term setting is used to describe the stiffening of the cement paste, hardening refers to the gain of strength on a set cement paste.

The most commonly used Portland cement contains both crystalline and amorphous phases; the most notable are four minerals alite, belite, aluminate and ferrite. The process of hydration of Portland cement is initiated by the contact of cement grains with water and, almost instantaneously, rapid chemical reactions, mostly exothermic by nature, are in progress. During this stage, the so called inductive period, dissolution of followed by aluminates is swiftly portlandite Ca(OH)₂ and ettringite 3CaO·Al₂O₃·3CaSO₄·32H₂O formations. Shortly afterwards, the viscosity of the system markedly increases and the process of setting starts, the amount of calcium silicates is lowered and the clusters of a new, solid phase of calcium-silicate-hydrate are formed.

The whole process of cement hydration can be characterized by time behaviour of hydration heat which can be represented by the calorimetric curve illustrating the heat release during the setting and initial hardening of Portland cement.

From a chemical point of view, monomers, like Ca^{2+} and OH⁻, are formed during the earliest stages of hydration. These charge carriers, which are free to move within the system, contribute to the acceleration of cement setting. The accelerating impact varies according to their concentration, electric charge, temperature, and geometrical size [1]. Calcium ions are acknowledged to have the strongest accelerating effect in cement paste [2].

A possible approach to cement paste setting can be based on the idea of nucleation when the sub-nanosized domains of a new, solid phase are formed via sufficiently large fluctuations. Such domains, or clusters, grow only if they consist of more particles than n_{c_3} which is the so called critical cluster size. Vital parameters of setting are temperature and water-to-cement (w/c) ratio. The goal of our experiments was to assess the impact of different w/c ratios in respect to the time behaviour of calcium ions concentration. Moreover, temporal dependency of Ca²⁺ concentration represents boundary condition related to equations governing the evolution of newly-forming clusters distribution. The results are a necessity for computation of numerical solution of nucleation equations.

There exists a feasible way of evaluating the amount of calcium ions in the chemically-reacting system which is based on the application of a certain type of retarding admixture. Generally, the retarding admixtures act in two modes; (i) forming partially soluble compounds on the cement grains surfaces via reactions with hydration products and hence inhibiting the access of water to cement grain, or (ii) acting as a protective colloid, inhibiting the gel swelling and elimination of capillary forces.

In our experiment, actual concentration of calcium ions has been determined by a modified analytical chelatometric method which differs significantly from the most commonly used modified Franke method [3] for calcium ions extraction in combination with titration against a suitable solution. The applied method allows us to determine calcium ions concentration at a very beginning of the setting process.

Apparently, there exists a simple relation between the parameter of supersaturation and the w/c ratio; by its definition, the supersaturation increases with decrease in w/c ratio. Monomers' concentration and w/c ratio are mutually related when the following model is considered: the higher supersaturation, the more building units (monomers) are present in the system which increases the probability of cluster creation that inherently accelerates the setting of cement paste. The measured temporal dependencies of calcium concentration are in accordance with such assumptions. The results show lower Ca²⁺ concentrations for larger w/c ratios (ie, smaller supersaturations) which means longer setting time of cement paste.

The novel applied procedure of estimating the actual calcium ions concentrations is comparatively straightforward, simple, effective, and well reproducible.

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Humidity Effect on Properities of Lime Plaster Modified with Metakaoline Used for Historical Building Renovation

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Moisture monitoring in building materials and structures has been a topic of interest in the area of civil engineering science for many years. Problems such as structural and biological degradation, mildew growth or marked changes of thermal, hygric and mechanical parameters may arise, when moisture accumulates in building materials and structures. This phenomenon is occurred particularly on historical building that is why restoration of historical facades and load bearing structure belongs to the most pursued activities from the point of view of historical monuments care. The reconstruction works are focused especially on preservation of authentic materials, which are as close as possible to the original materials in their chemical composition and physical properties which determine their technological compatibility with original materials.

As the chemical analyses of many historical buildings plasters show, the past centuries external plasters that are preserved until today contain products formed by lime reaction with pozzolanic or hydraulic admixtures. In the work presented in this paper, metakaolin is used as the pozzolanic admixture in lime – pozzolana plaster. Application of metakaolin in lime mortars for restoration of renders of historical buildings is not in a contradiction with the historical reality because burnt clay containing more or less kaolinite was used in Rome and Greece 2000 years ago, as well as in further historical periods. Metakaolin is burnt kaolinite at temperatures between $500 - 850^{\circ}$ C, i.e. above the temperature of kaolinite dehydration. The products of their chemical reaction are CSH gels and crystallization products [1]. The developed compounds implicate then higher strengths, resistance against environmental conditions and in this way of the durability of these plasters. Therefore, in this paper the main attention is paid to the water vapour transport of lime – metakaolin plasters as a property for estimating their durability.

The moisture transport, it means water vapour diffusion, through building materials is a natural phenomenon. The water vapor transport properties of building materials are of considerable importance in determining the comfort condition in built environment. Water vapour transport through porous building materials may occur due to both diffusion (driven by vapour concentration differences) and convection (driven by gas pressure differences).

In season there is the different behaviour of water vapour transport in building materials. Moisture transfer through walls in summer is usually negligible, because the actual moisture transfer rate is quite small and the corresponding heat gain is hardly significant. During cold weather, vapour pressure inside a building is usually higher than that outside. The difference in vapour pressure leads to moisture diffusion through the walls from inside to outside. In a cold massive building, especially in historical building, a sudden influx of warm moist air causes condensation because vapour diffuses faster than the increase of temperature in the massive wall. Condensation means a process whereby water is deposited from air containing water vapour when its temperature drops to or below dewpoint, temperature at which air becomes saturated with water vapour.

In the description of mechanism of water transport in porous materials are often used model, where the basic driving force is pressure gradient and the basic transport parameters is velocity of the water vapour [2]. For air permeable porous materials, a very small pressure gradient can produce large convective flows through the pores in the structure. During the water vapour transport through a porous medium, a part of molecules is absorbed on the surface of the porous matrix due to the interaction between the molecules of the gas and the solid surface. The absorbed molecules can then diffuse along the solid surface, what is further mechanism of water transport in porous materials. The method used for water vapour transport determination is based on the one – dimensional water vapour diffusion, measuring the water vapour flux through the specimen placed between two chambers and partial water vapour pressure inside both spaces.

Apparatus for transient measurement of the water vapour diffusion coefficient consists of two airtight glass chambers separated by the measured sample [3]. Each of the chambers was provided with probes for relative humidity measurement. The size of tested sample is usually 100 mm in diameter x 20 mm. In the first chamber a state about 98% relative humidity is maintained (achieved with the help of a cup of salt solution, e.g. saturated K₂SO₄ solution), while in the second one there is a state close 0% relative humidity (set up using silica gel, or burnt CaCl₂). Then, the cups with salt solution and silica gel are placed on automatic balances, which are connected to the computer. The changes in the mass both of the salt solution and silica gel in the cups are measured in the dependence on time. From the known mass changes of salt solution and silica gel it is possible to determinate not only water vapour diffusion coefficient as a single value but also the flux of water vapour incoming to the sample.

The experiment of water vapour transport took place in air-conditioned laboratory at $23\pm1^{\circ}$ C. The experimental method presented in this paper is very significant for achievement of higher – accuracy results using current models of water vapour transport in porous building materials.

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Detection of Gaseous Ammonia Using Fiber Optic Sensor

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Ammonia leakage is a very serious problem for all the industrial facilities utilizing large-scale cooling systems. Consequently, monitoring of ammonia gas and localization of ammonia leaks represent an important issue of the environmental control. Our research is focused on the development of distributed fiber optic sensor. This contribution deals with the influence of gaseous ammonia on a sensitized optical fiber consisted of a silica core and polymer clad. The sensing system is invented primarily for location of a large scale, potentially harmful ammonia leaks, featuring the concentration of ammonia in air being close to the lethal limit (0.5 - 1 pph). The research related to preparation and tests of prototype sensing fibers by means of optical spectroscopy and optical time domain reflectometry (OTDR).

The aim of this research is to understand and to achieve a repeated reversible chemical reaction in which a proper reagent, an organometallic dye composed of a bi-valent complex ion and selected anions, substitutes NH_3 for the organic ligands. The mixture of dry nitrogen and ammonia was used as the probing gas. The ligand exchange process is accompanied by changes of optical absorption spectrum within the VIS-NIR range. Two types of ligands, marked as L_1 and L_2 , were tested [2]. The type of ligands plays an important role in the change of absorption properties. On the other hand, the impact of anions (in our case NO_3 , Br_2) on the bathochromic shifts was very small [1]. A very good reaction with ammonia associated with the drop of the original complex peak in absorption spectrum was revealed. The spectral shifts were described before and after the formation of a complex. The influence of time degradation on characteristic of reagents and gas was tested. Probably the saturated state of the detection system corresponds with the complete reagent decomposition. The changes of absorption spectra (position of absorption band) by reactions of ligands with ammonium hydroxide were not showed and as expected, the ligands by reactions with NH_4OH did not dissociate and did not change their chemical composition. The complex ions containing L_1 ligand showed larger shifts than the ions containing L_2 ligand. Cuprous and cobalt salts were found as the optimal metallic complex compound. Sensitivity of the selected reagent to ammonia exposition was evaluated both in liquid and solid phase (short fiber sections).

The cladding of the optical fiber is made of polymer material and so the diffusion process is a very crucial factor in the whole measurement. The pilot spectroscopic experiments showed the crucial importance of the initial fiber wash for the long term spectral stability. During the washing of the fibers in aceton, the residues of the initiators and catalysers are deleted from the siloxane cladding. In case of unwashed samples a rapid decay of the optical absorption was observed. The optical properties of treated fibers remained stable for several months of storage under laboratory conditions.

Immobilization of reagent into the fiber cladding is a very important part of a diffusion process. This part is affected both the matrix structure and the composition of solvent. Suitable solvent is featured by good solubility of selected reagent and proper absorption coefficient. The primary diffusion tests showed that the mixture of ethanol and chloroform in the exact ratio is the best solution. The ratio of these solvents influences the diffusion and stability of reagent in cladding of optical fiber. The diffusion can be described as a double-step process. In the first part, chloroform causes a swelling of polymer cladding and then the diffusion process is executed. Cladding of fiber acts as membrane or as filter for the liquid solution of reagent [4].

If a polymer matrix acts as the solvent, the possible diffusion of water into the cladding can modify the actual degree of dissociation and then contribute to the remarkable dependence of the sensor signal to the ambient humidity. The existence of hydroxyl and hydronium ions in the cladding can lead to the creation of ammonium salt, which disturbs sensor function. The degree of dissociation also varies with the types of anions and central ions. The appropriate selection the cladding polymer and other types of ions is necessary to reduce of undesired effects.

The OTDR method was then applied to test longer fibers for localization of ammonia exposition [3]. All experiments were performed in respect of unsensitized optical fiber which created a reference level. The results were evaluated by means of simulation software for qualitative comparison the measured OTDR traces with the theoretical predictions. OTDR signal from the beginning of fiber is affected with pulse width. Increasing the reagent concentration in the fiber cladding could increase the ammonia sensitivity, but, on the other hand, it would also enhance the total fiber attenuation and likely decrease the resolution at low concentration. The ammonia molecules react probably with the reagent molecules located in the outer shell of the fiber cladding.

The saturation time, concentration and coefficient of diffusion was investigated and evaluated. However, the full reversibility of the complex re-formation is very difficult to achieve. A selection of a suitable agent ensuring the sufficient solvation of the reagent molecules within the cladding matrix was identified as the crucial technological factor.

The forthcoming research will focus on the manufacturing of new experimental setup which will be used in the following tests. Furthermore, we will test the alternative reagents based on amino-quinolin ligands with the aliphatic lateral chains.

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In-situ Failure Observation of Thermal Sprayed Coatings

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Surface of the component is typically exposed to the different loads, e.g. mechanical and thermal loads, corrosion in aggressive environments, wear etc. Due to the synergy effect, failure of the part typically initiates on the surface. Application of protective surface layers can protect base material and lead to prolonged lifetime and better reliability of the system.

Thermal spraying represents one of the methods for preparation of such surface layers. For example, in plasma spraying is feedstock material in form of powder or wire injected into the plasma jet where it melts and after deposition on the substrate forms so called splats. Resulting microstructure consisting of splats, pores, cracks, or impurities, differs from the microstructure of cast material and can be tailored to the desired application. Microstructure of the coatings results in special properties of thermally sprayed coatings which can outweigh higher costs compared to classical technologies.

Failure of the coating (e. g. by cracking, delamination or spallation) can result in malfunction of the whole assembly. Processes leading to the fracture of the coating are typically studied "post-mortem" by fractographic analysis of the fracture surfaces. Interpretation possibilities of the fractographic analysis can be extended when observing real-time microstructure changes in-situ or comparing changes before and after the failure.

In this project, special device developed for loading in the vacuum chamber of the scanning electron microscope was used. This device was designed for tensile loading and 3-point bending of samples in shape of small beams (cca 2x2x25 mm). For the observation of crack growth in thermal sprayed coatings 3-point bending mode is more appropriate. In tensile testing mode, specimen mounting can be troublesome and release of the deformation energy can lead to sudden cracking. Specimens were prepared from free-standing deposits of stainless steel 316 sprayed with water stabilized plasma (WSP) gun PAL 160. Specimen preparation had to be optimized to produce flat and scratch-free surfaces without pull-outs.

Precision cut-off machine with diamond wheel was used for preparation of specimens with desired dimensions to prevent damage of the specimen. Prepared bars were mounted with thermoplastic raisin into special sample holder to ensure planarity. Specimens were polished on one side using standard metallographic procedures – mechanical grinding and polishing up to 0.05 um OP-S suspension.

Samples were mounted into the loading device with 3-point bending setup so that the polished face could be observed. Area under the middle support, where growth of the crack was expected, was documented by series of micrographs at high magnification with scanning electron microscope (SEM) JEOL JSM-5510LV equiped with energy-dispersive X-ray spectrometer IXRF500. Load was imposed "ex-situ" outside the SEM vacuum chamber in several steps by controlled displacement of the middle support of the loading device. Crack evolution was observed in the light stereomicroscope during each loading step. Resulting changes in microstructure were observed in the SEM at high magnification and whole procedure repeated until the final rupture of the specimen. Terminal fracture surfaces were subjected to classical fractographic analysis.

Microstructure observation proved presence of splats and oxides in the coating, which is typical for thermally sprayed materials. Crack initiation site was successfully determined on

the cross-section of the coating. Crack was documented for 5 different loads which enables reconstruction of its growth.

Crack initiated in the area of higher concentration of brittle oxides on the free surface. Typical mechanism of crack propagation was intersplat decohesion and intrasplat cracking in areas of imperfect bonding of the splats mainly due to the presence of oxides. It was observed, that major crack tended to bifurcate and only some of many branches developed to major cracks leaving behind net of small cracks and occasionally leading to the coating spallation.

The method described above makes it possible to study terminal stages of the coating failure during the bending in the microscopic level. As an alternative so called bonded interface technique [1] was used to study response of the microstructure to the indentation. This test should simulate contact of coated part with other objects. The indentation was carried out across artificially created polished cross-section of the coating. Changes in the microstructure were observed with the SEM microscope.

Results were successfully obtained for WSP sprayed Al_2O_3 and Ni20Cr sprayed with High Velocity Oxygen Fuel (HVOF) gun. It was shown, that compaction of the porous microstructure, as well as crack formation, debonding or plastic deformation of the splats is possible under the indent. Mutual slide of the splats was also observed. It was also stated, that sometimes splats tend to move in "clusters" rather than individually.

Several different tests were also performed to characterize the mechanical behavior of the selected thermally sprayed coatings in the macroscopic level. For example, an evolution of coating modulus and stress-strain dependency using 4-point bending test has been extensively studied for the ceramic Al_2O_3 coating as well as indentation moduli in two main coating directions using instrumented indentation and finally response of the coating to the thermal loading. Results confirm assumptions [2], that stiffness of the coating is higher in compression due to the closing of the pores while in tension pores and cracks are opening and therefore stiffness is decreasing. Significant microcracking, permanent deformation and delamination also occurred. Details are given elsewhere [3].

Each of these techniques gives us better insight into in the coating behavior during different types of loading and at different scale. Therefore their combination, especially with numerical simulations [4], can be very useful in comprehension of complex coating failure.

For the quantitative description of changes in the coating microstructure special strain mapping procedures were proposed and are currently under development.

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Development and Application of 3D Optic Method for Determination and Description of Porous System of Silicate Materials

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Porous system of silicate materials (concrete, ceramic, mortars) influences final mechanical and physical properties significantly. Frost resistance, absorptiviti and permeability of silicate composites is very significantly influenced by distribution and shape of pores. Amount of pores with diameter up to 300 μ m is fundamental for frost resistance of concrete for instance. The production of fair-face concrete components is growing up, too. Fair-face and architectonic concretes are extremely technologically difficult elements because of high requirements on final esthetic view and because of many factors that influence production and result. Very important role in building up of top surface layer of concrete plays application of separation agents on formwork surfaces.

The project was focused to improve a to develop methodology of application of Confocal Laser Scanning Microscope Lext OLS3000, that presents a now generation optical systems for ultra-precise measurement and observation with the highest levels of reliability.

LEXT meets a diverse range of needs in fine surface profile measurement. Both 3D observation and high-precision 3D measurement are possible in real time. With an outstanding horizontal resolution of 0.12µm and a magnification range from 120x to 14,400x LEXT is designed for researchers working between the limits of conventional optical microscopes and scanning electron microscopes (SEM). Unlike the situation in SEM any sample can be placed directly on the microscope stage without pretreatment. LEXT is ideally suited for ultra-fine surface observation and measurements required for micro fabrication devices like MEMS (Micro Electro Mechanical System), for new materials development, and for today's thinner devices, with more compact surface mounting requirements.

In construction industry it is used for measuring of real distances, volumes, areas and projections, measuring of roughness of surfaces, measuring of profiles, analysis of particles, control of materials, coatings and many other functions directly in 3D projection. Abilities of such system can be utilized very well also during analysis of faults and defects (such as cracks, porosity, etc.) and it also exceeds a frame of conventional microscopy significantly by the fact it presents a very efficient 3D projection tool with high accuracy of measuring.

3D microscopic observation and measurements were performed on silicate materials (concrete, ceramic, mortars) porous system. Roughness and pores of concrete surface treated by different separation agents were observed, too.

In the frame of the project was developed methodology of concrete surface roughness measurement. For analysis of roughness of a microscopic area 15 characteristics are described

altogether, but for evaluation of a surface just three were chosen because quality and structure of the surface is manifested the most at these chosen quantities. It is middle height Z_{tm} , maximal height of a profile R_t and arithmetical middle height R_a .

Standardized methods and new methods of pore system analyze resulting from LEXT technical abilities were compared and studied. Ability of system LEXT to determine spacing factor of pores and pore distribution of silicate materials as concrete, mortar, ceramic was proved.

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THE STUDY OF SPECIMEN SHAPE AND SIZE ON TEST RESULT OF MODULS OF ELASTICITY

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Modulus of elasticity is main material parameter for concrete structures, that goes into series of static computing and is near by other physically-mechanic characteristic of concretes as creep, shrinkage, frost resistance, durability etc.. Modulus of elasticity describes ability of concrete to conduct lively under load. Modulus is determining from deformations, which impending after known loading. Values determined on same material test specimen, who were made and treated identically, have not same rate for series of technological influences.

New Europe standardization causes some dubiousness not only on application of this material constant but on measurement method, too. Project was focused on comparison study of specimen shape and size on test result of elasticity modulus. Cylindrical and prism concrete test specimens of different size were tested and results were compared.

The following statement can be made from gained results:

- It is obvious that shape must have some influence on result but the difference is very significant even the shape of specimens corresponds with required limits of test standard ČSN ISO 6884 i.e. cylinder 150x300 mm and prism 100x100x400 mm.
- Value of modulus is significantly higher if tested on prism with slenderness ratio 1:4 compare with cylinder with slenderness ratio 1:2.
- Max difference for concrete C25/30 XC1 gained from tests was 20,5 % if results on cylinders were considered as 100 % level. Control test on several types of common concrete shoved difference between cylinders and prisms in range of 2,5-20,5 %.
- Significant difference of modulus of elasticity value was observed between specimens prepared in moulds and specimen cut from concrete blocks. Cut prisms give lower results. It was 13 % lower for tested concrete C25/30 XC1.
- Bulk density of hardened concrete was homogenous and we consider this influence as no significant.

In the frame of project were gained very important information and markers about some unacceptable influences on test value of modulus elasticity if measured according to standard ČSN ISO 6784. The volume of test program was limited and further measurement is strongly recommended.

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Biocompatibility of Metal Sintered Materials in Dependence on Multi-Material Graded Structure

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The implantation of integrated biomedical devices to the human body provides challenges to the engineering materials science and technology. Because the production has rising tendency, new materials and innovated approaches are still required [1]. In this respect multi-material functionally graded sintering has been introduced into production.

In the multi-material functionally graded implants the mechanical, physical and chemical properties change from one side of the product to the other. Biomaterials with excellent osseointegration and low Young's modulus on one side of the implant and other materials with perfect mechanical properties such as hardness, abrasion resistance etc. on the other side, are advantageous for various bio-applications. For example, the disadvantage of joint requirements in bioimplants can thus be eliminated and the risk of screw connections or corrosion of welding avoided [2]. These appliances can also present contrasting adhesive requirements over very short distances along the same structure [3]. The additional requirements such as simplicity of manufacture, low cost production and individual demands such as design which can differ from patient to patient should be met as well [1]. Fundamental materials which are recommended especially for joint and bone implants and can withstand complex operating conditions are pure Ti, Ti-6Al-4V alloy and Co-28Cr-5Mo alloy [4, 5]. Especially titanium and its alloys currently constitute the most favored implant materials for joint replacement [6]. Moreover the powder metallurgy is involved in improving the boneimplant contact by making the implant structure porous and thus friendlier to bone cell anchorage [7]. In comparison to other metallic implant materials, titanium is characterized by a high biocompatibility, a good workability and corrosion resistance with suitable mechanical properties (low Young's modulus - high strength) [1]. Ti and Ti-6Al-4V alloy also perform a highly inert behavior while they develop a very sable oxide layer when exposed to air or to aqueous media [8]. Among all implant materials, Co-Cr-Mo alloys demonstrate the most useful balance in strength, fatigue and wear along with resistance to corrosion. Powder Metallurgy (P/M) route offers additional advantages [9]. It has been shown, that the extent of bone growth in implants where powder metallurgy was used was markedly greater, attributed to the microstructure of these implants [10]. There are numerous manufacturing processes employed nowadays in the Powder Metallurgy (P/M) field. The most promising ones are Selective Laser Sintering (SLS), Three-Dimensional Printing (3DP) or Metal Printing Process (MPP). These processes build components ready for use directly from metal powders using layer manufacturing principles. By changing the powder in the powder reservoir form layer to layer, graded materials can be thus produced [11].

Ti6Al4V and CoCr alloys were supplied in a powder form by Arcam AB. The powder was produced by a gas atomization process and particle sizes laid within a size range from 10 to 70 μ m. Multi-material functionally graded samples of CoCr alloy and Ti6Al4V alloy were 194

manufactured by the MPP. They consisted of one part of CoCr and one part of Ti6Al4V. These were built in the shape of disks (30mm diameter, 3mm thickness) by the successive application of 10 to11 pattern layers of CoCr and Ti6Al4V on a foundation of pure Ti6Al4V powder, consolidated at various temperatures. For comparison, one sample of pure CoCr alloy and one of pure Ti6Al4V alloy were also manufactured by a similar procedure. The consolidation took place in a protective atmosphere of 95% Ar and 5% H, while the compaction pressure during consolidation was set to 170 MPa.

Hardness was measured with the help of Brinell test, where the hardened steel ballshape indenter was used. The diameter of indenter was 2.5mm and the applied load was 612.9N for 10 seconds. Specimens were measured at Ti6Al4V part and CoCr part three times to determine an average value.

Contact Angle was measured by Surface Energy Evaluation System. The samples were ultrasonic cleaned in ethanol bath and dried with agitated air. The sessile drop technique was used to measure the water contact angle using the See System software. The contact angle was measured three times on each part of the samples.

Surface topography was evaluated using the JEOL JSM 5410 Scanning Electron Microscope. Images were taken to show the most realistic information about the surface topography of the samples.

Viability: The Balb/c Mouse Fibroblast cell line was used in this study. For the precise evaluation of number of live cells the MTT test was used. The cytotoxicity level was evaluated on the basis of cells viability in culture with presence of tested material extraction compared with control culture without presence of any cytotoxic material.

In-vitro cultivation with PBMC: Isolated leukocytes were cultivated with the selected samples on 24-well cultivation plate for 18 hours in H-MEMd cultivation medium. 5×10^5 cells from each specimen were then stained with Hoechst 33258 five minutes prior to measurement for exclusion of dead and damaged cells. Samples were measured on BD LSRII flow cytometer. Data were evaluated by TreeStar FlowJo software.

In this study a possibility of application of functionally graded metallic materials was studied. From the obtained results it can be stated that such combination of materials is likely to be applicable in the field of bioimplants. Samples where the higher temperatures of sintering were applied are recommended for further testing in order to meet high requirements on mechanical properties and biocompatibility.

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Reflectance Anisotropy Spectroscopy for MOVPE

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During the last decade, big progress has been achieved in the fabrication of optoelectronic devices based on self-assembled semiconductor nanostructures. These structures are mostly based on InAs quantum dots (QDs) on GaAs substrates [1, 2]. The aim of the research is to realize devices based on GaAs suitable for long wavelengths (1300 and 1550 nm) important for optical telecommunications. Recently, nanostructures combining more than two semiconductor compounds are studied. The example is GaSb/InAs/GaAs due to the type-II band alignment between arsenides and antimonides. Successful epitaxy of these structures requires precise control of sensitive growth parameters.

Reflectance anisotropy spectroscopy (RAS) is a non-destructive in-situ optical probe of surfaces that is capable of operation within a wide range of environments. In-situ monitoring of growth using RAS is in contrast to simple reflectance (R) measurements capable of real-time detection of the properties of surfaces, interfaces and doping induced surface electric fields. Since RAS includes reflectance measurement, it allows also to analyze layer thickness, growth rate and composition. In cubic semiconductors, reflectivity of bulk is isotropic. This does not apply to the surface of the crystal where reconstructions are formed as a result of symmetry breaking. In order to be sensitive to anisotropic dielectric contribution of the surface, RAS measures under normal incidence the reflectance of light polarized along two axes x and y of the crystal. The anisotropy in reflectance is $\Delta r = r_x - r_y$ and r is the isotropic reflectance:

$$\frac{\Delta r}{r} = \frac{r_x - r_y}{\frac{1}{2}(r_x + r_y)} = \operatorname{Re}(\frac{\Delta r}{r}) + i\operatorname{Im}(\frac{\Delta r}{r}).$$

In the case of $A^{III}B^V$ semiconductors with cubic symmetry the anisotropy of (001) surface can be described as:

$$\frac{\Delta r}{r} = \frac{r_{[\bar{1}10]} - r_{[110]}}{\frac{1}{2}(r_{[\bar{1}10]} + r_{[110]})}$$

Only the real part of RAS signal is used because the noise on measurement of $Im(\Delta r/r)$ is usually an order of magnitude greater than on $Re(\Delta r/r)$.

In this contribution I present RAS measurement of basic growth properties of different $A^{III}B^{V}$ semiconductor structures prepared in the Institute of Physics of the ASCR in Prague. I focused on the calculation of growth rate of thin InAsSb layer covered by GaSb layer on GaSb substrate, growth and simulation of reflectance fingerprints of a stack of five Al_xGa₁.

_xAs layers on GaAs substrate (x = 0, 0.9, 0.2, 0.9, 0), and p (6E16, 3E17, 8E18 cm⁻³) and n type (1E17, 5E17, 2E18 cm⁻³) doped GaAs layers by C, Si and Te on GaAs substrates.

The structures were prepared by low-pressure MOVPE in AIXTRON 200 on semiinsulating (100) oriented GaAs and on GaSb Te doped (100) substrates. The growth was insitu monitored using EpiRAS 200TT from LayTec. GaSb and InAsSb layers were grown from TMIn, TESb and tBAs precursors at 560°C and 15 kPa total pressure, AlGaAs layers were prepared using TMAl, TMGa, and AsH₃ at 700°C and 5 kPa, GaAs was grown at 650°C and 5 kPa using TMGa and AsH₃ precursors and CCl₄, SiH₄ and DETe as dopants.

Measured growth rate of InAsSb layer, using Fabry-Perot reflectance oscillations at 1.3 eV, is in a good agreement with the intended one. However, the measured changes in RAS signal are high enough to correspond only to surface reconstruction because the signal is mainly influenced by surface roughness. This effect often occurs if prepared epitaxial layer contains Sb.

Graphical visualization (so-called colorplot, a color coded RAS or R signal) of the sequence of $Al_xGa_{1-x}As$ layers (x = 0, 0.9, 0.2, 0.9, 0) on GaAs substrate was measured from 1.5 to 5.0 eV photon energy. The changes of reflectance depend on the thickness of monitored layer, its band gap energy Eg, as well as on the energy of photons. If this energy is higher than Eg, no reflectance signal will be seen due to absorption of light. Therefore, it is possible to distinguish different layers and estimate their composition (Eg of ternary materials like $Al_xGa_{1-x}As$ depends on composition: for x = 0.2 the material is close to GaAs with Eg = 1.44 eV, while x = 0.9 is close to AlAs with Eg = 2.16 eV). The colorplot of reflectance (normalized to GaAs substrate) was then simulated by AnalysR - thin-film analysis software. It uses a multi-layer model based on a set of high-temperature dielectric functions. The simulated data proved a good crystallographic quality of prepared heterostructure.

It was confirmed in case of GaAs that n-type doping decreases and p-type doping increases RAS signal. The influence on the RAS spectra of p- and n- type doping of GaAs is caused by the formation of doping-induced electric fields, which affect surface dimer configurations.

The results of this work will be used in further improvement and optimization of the growth parameters of more complex $A^{III}B^V$ MOVPE prepared structures containing quantum wells or quantum dots.

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Mechanical and Low-Cycle Fatigue Properties of Aluminum Alloy D16CT1

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A finite element model of growing fatigue crack is being developed at the Department of Materials. A set of experiments concerned to cyclic elastic-plastic mechanical properties of a typical aircraft aluminum alloy as well as low-cycle fatigue experiments had to be done as an entrance experiment for numerical simulations. The tests were concentrated especially on the determination of hardening parameters of the Chaboche model [1] and on the study of the surface fatigue crack initiation. All experiments and results are described in detail in [2, 3].

Aluminum alloy D16CT1 (AlCu4Mg1 type) was delivered in a form of the rolled plate with a thickness of 11 mm. Two types of specimen were produced. Smooth cylindrical specimens were 5 mm in diameter. Notched specimens were round bars with U-shape groove with 2 mm radius and the diameter of the smallest cross-section 4 mm. The surface of all specimens was worked with emery paper and polished by diamond paste (particles 15 μ m).

All loading experiments were performed at room temperature on Hegewald&Peschke loading machine equipped with the special extensioneter. Cyclic tests were strain controlled; the loading was always symmetrical to avoid the mean stress relaxation. The frequency of cyclic loading was about 0.1 Hz.

Fatigue tests on both smooth and notched specimens were performed in a complicated and non-standard way. After relatively short loading sequence the specimen was always released from the loading machine and his surface was carefully studied by the mean of the metallographic microscope. The crack was said to be just initiated if there was a crack with the surface length 70-130 μ m. After such initiation was observed the specimen was loaded to fracture.

The tensile test on a smooth specimens determined basic material constants: Young's modulus E = 73.5 GPa, Poisson's ratio v = 0.314, yield strength $\sigma_y = 469.2$ MPa, and ultimate strength $\sigma_{UTS} = 497.3$ MPa. The material turned out to substantially strain hardened. During cyclic loading it proved significant cyclic softening before the process became saturated.

Data for cyclic curve (plastic strain vs. stress) were obtained from saturated hysteresis loops of smooth specimens. Parameters of Chaboche kinematic model which fit well this experimental curve were determined as follows: cyclic yield stress R = 375.7 MPa, constants of kinematic hardening C = 7756.8 MPa, and $\gamma = 66$.

Fatigue curves (number of cycles vs. strain level) and energy to failure were obtained for the total fracture of the specimen as well as for the stage of initiation (so called French curve). The initiation curve seems to have more relevance to the modeling of growing fatigue crack which could be regarded as repetitive re-initiation of the crack on the short distance.

Notched specimens were tested for examination of the stress triaxiality influence on the fatigue crack initiation. Both the failure and initiation curves were obtained but the finite element simulation of the cyclic stress-strain field at the notch revealed that in a such low depth, where the initiation crack reaches, there is very low triaxiality of stress due to proximity of free surface. Initiation curves for the smooth specimen and for the root of the notched specimen are nearly the same.

Scanning electron microscopy revealed that the alloy contains very much small cracks in the brittle structural inhomogenities still before the cyclic loading. It means that all fatigue process lies in the growing of these cracks. The magistral fatigue crack is initiated predominantly at the surface and the role of the subsurface cracks in the fatigue process should be further studied.

To sum up then the research permitted to determine the elastic-plastic mechanical properties and strain life fatigue curves of the aluminum alloy D16CT1, which would be directly applied in phenomenological finite element model of growing fatigue crack.

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Municipal Incinerator Waste Materials and Possibilities of Their Use in Concrete Production

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Waste as a by-product of our daily living represents significant task for us to deal with. There are several possibilities to deal with waste such as burning, damping, recycling etc. Each has its own price and place in today's society. After the Czech Republic joined the European Union it had to obey its regulation such as "Waste elimination". It makes waste management a significant problem for the public authorities today.

The current time is characterized by the tendency of maximum recycling of all types of wastes and reducing their disposal. The direction of the European Union No. 1999/31/EC sets to the member states the obligation to reduce the total amount of waste damps. According to this direction, in 2010 the amount of disposed waste should be reduced to 75%, in 2013 to 50% and in 2020 to 35% as compared to state in 1995. From the data evidence of wastes in Czech Republic there is evident that the meeting of above given requirements of European Union will be not feasible without progressive building-up of incinerators equipped with modern technologies ensuring safe waste combustion. For example the present capacity of Czech municipal waste incinerators that is about 700 kt per year will be increased to 1500 kt per year. In accordance with EU direction the amount of municipal solid waste incinerator ash (MSWIA) will increase in near future and its industrial use is necessary from the environmental point of view as well as from the financial benefits. Especially the recycling of industrial wastes in the concrete manufacturing is of increasing interest worldwide, due to the high environmental impact of the cement and concrete industries and to the rising demand of infrastructures, both in industrialized and developing countries [1].

In this paper we analyze the possibilities of MSWIA for application in concrete industry. Although the use of fly ash from power plants is well established in concrete manufacturing, fly ashes from municipal waste incinerators are technologically an open field from this point of view, until now.

MSWIA materials possess a chemical composition that is not dissimilar from that of FAs. In fact, they are mainly composed of amorphous silica, alumina, iron oxide and calcium oxide. This suggests that MSWIAs could have pozzolanic or hydraulic behavior and its addition to the concrete mix could have a beneficial role in the development of the microstructure of the hydrated cement paste. Hence, a great advantage in the sustainability of the concrete industry would be achieved if MSWIA materials, which are available in great quantities throughout the world, could be used to produce quality concretes. In literature there can be find several papers that proved the pozzolanic activity of MSWIFA and showed their reactivity with calcium hydroxide. Because the waste treatment represents highly actual topic, several researches have studied the possibility of recycling of MSWIA materials in the concrete and cement manufacturing, both as aggregates or mineral additions. MSWI bottom ash and fly ash have been also used as raw materials for manufacturing cement, ceramics,

bricks, or tiles. Probably the most frequent application of MSWIA materials is replacing of part of Portland cement in concrete mixture. For instance in [1] the authors deal with 30% replacement (by mass) of Portland cement by MSWI materials in concrete structure. They have used dry or washed MSWI fly ash or MSWI bottom ash (slag material). The authors refers that the concrete mixtures with the addition of different types of MSWI materials did not show any workability problems and their fresh density was comparable with that of the control concrete. Nevertheless, the concrete with addition of dry MSWI bottom ash experienced a remarkable expansion during setting. Because of such expansion, the density of the hardened concrete decreased, what led to the decreasing in strength characteristics. This feature was observed also by other authors and the causes of this phenomenon have been discussed in several papers [2]. This harmful effect of MSWI material addition into concrete mixture can be explained by chemical reactions on non-ferrous metals, particularly on aluminum and zinc that cause an increase in volume. On the other hand, in case of application of wet waste materials, no volume expansion during setting was observed and a good pozzolanic behaviour of MSWI materials proved the possibility of these materials to give a significant contribution to the development of the strength and impermeability of concrete.

Another way how to avoid the volume expansion of concretes containing the MSWI materials is to immerse the waste materials in a solution of sodium hydroxide, till all hydrogen is produced. For instance Pera et al. [3] have immersed MSWI bottom ash in sodium hydroxide solution for 15 days. The ash was then washed and dried. The concrete mixture with such treated ash addition has than revealed very perspective strength characteristics.

This paper shows that MSWI materials are potentially attractive for application in building industry. They can find use above all in cement and concrete manufacturing as mineral binder or aggregate addition. Nevertheless, it should be pointed out that their widespread utilization in practice is limited by the variability in their composition. Therefore, detailed chemical and physical analysis has to be performed before their application. Some of MSWI materials require also pre-treatment like wetting, washing, vitrification (melting) etc. for optimization of their properties.

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In-flight State of Dual-phase Fe-Al Based Powder Particles Subjected to WSP Spraying

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The study of the in-flight state of powder particles subjected to the plasma spraying is usually the first research carried out before the application of the sprayed coatings. The purpose is to describe the processes which take place during the deposition of the powder. [1]

The deposition method was the Water Stabilized Plasma (WSP) technology. The feedstock material was gas-atomized dual-phase Fe-Al based intermetallic powder produced by LERMPS, Belfort, France. The chemical composition obtained by chemical analysis was 61wt.% Fe, 39wt.% Al. The particles had a spherical morphology, the granulometry fraction for WSP technology, 90-140 µm, was obtained by sieving. The microstructure of the particles consisted of a mixture of two ordered intermetallic phases: FeAl and FeAl₂. [2]

The particles were sprayed and directly trapped into liquid nitrogen to provide rapid cooling. The spraying distance (the barrel - liquid nitrogen level) distance was about 400 mm. The trapped particles were wetted by ethanol to prevent water condensation and immediately dried. For the purpose of analysis, the particles were mounted into epoxy resin and then grinded and polished to obtain a standard metallographic preparation. The particles were observed by means of light optical (LOM) and scanning electron microscopy (SEM). After spraying, the particles exhibited near spherical shapes and their diameters were not heavily affected. During the flight, some particles have merged and formed bi-particles. Small darkened areas, so-called caps [3, 4], were formed on the surfaces of few particles. The formation of the caps can be explained as follows: after passing through the plasma torch, particles enter the atmosphere and are subjected to very severe decelerations. A considerable oxidation also takes place. During the deceleration, the phase separation occurs since there are huge differences in densities. The oxides are forced to certain places on the particle surface where they form caps. Two or even more caps which were found on some particles can be formed if the particle suddenly changes its orientation when entering the atmosphere. The SEM micrographs taken using backscattered electrons revealed particles composed of much heavier elements then the caps.

The cross-section of the particles was subjected to etching in the solution of 80% HNO₃ and 20% HF. The observation showed the presence of two different kinds of particles. One group of the particles seemed to be not affected by etching; another group was affected much more. Moreover, less and more etched particles exhibited single-phase and dual-phase like microstructures, respectively. The examination of the caps formation revealed that these caps were created on both types of particles. Very rough estimation of the ratio between the more and less etched particles led to approximately two thirds of less and one third of more etched particles. The study of the bi-particles revealed that when merged, more etched particles maintained their shapes at the expenses of the less etched.

The energy-dispersive X-ray spectroscopy (EDS) point analysis was performed in order to find the differences in composition between particles differently responding to etching. It was found that the more etched particles showed somewhat higher aluminum levels (not less then 35%wt.) comparing to the less etched (from 30 up to approximately 35wt.% Al). The EDS was carried out also in the inner structure of the more etched particles in order to find any differences in composition between different areas in the microstructure. Two different constituents were found: one having approximately 35 wt.% Al, the other 42wt.% Al. Nearly no experimental scatter in the measured values indicates two different phases: FeAl and FeAl₂.

Several conclusions can be drawn from this introductory experiment. The more etched particles seemed to be harder, since their spherical shapes were not harmed. In all observed cases the changes of the shapes were noted only on the less etched particles. This could be due to the turbulent flow in the plasma torch resulting in different areas having different temperatures. When merging, particles of different temperatures meet. This indicates that the more etched particles were those exhibiting lower temperatures.

EDS analysis showed higher level of aluminum in more etched particles. Later it was observed, that the evaporation of aluminum during plasma spraying is much faster then that of Fe. Particles with slightly higher Al content were probably exposed to lower temperatures (or for shorter times) comparing to the particles with lower Al contents. This conclusion also fits together with the fact that the more etched particles were maintaining their shapes during merging.

The results can be summarized as follows: during the process of plasma spraying, some of the melted particles had lower temperatures. These particles maintained their dual-phase nature which responded well to etching (the particles appeared darker – more etched). The less etched particles (which appeared brighter) were subjected to severe evaporation of Al; their structure reached the single phase field (FeAl).

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Fracture of Fe-40Al Based Intermetallic Alloys

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Iron aluminides based on Fe-Al have good oxidation, corrosion and wear resistance, low density (5.6 g.cm⁻³) and material cost. They have some properties even better than stainless steels; moreover, they offer conserving of strategic elements such as nickel and chromium. They can be used as heating elements or furnace fixtures in automotive or chemical industry [1].

FeAl based intermetallic alloys suffer from poor room temperature (RT) ductility, and the tensile and creep strength of FeAl rapidly decrease after reaching temperature above around 600°C. The room temperature brittleness is mainly caused by hydrogen embrittlement and can be solved by reducing the grain size, or by alloying additions that will either interfere with the formation of atomic hydrogen at the surface or impede its diffusion (e.g. carbon and boron) [2]. Although the influence of the environment and alloying elements on tensile properties of iron aluminides such as strength and ductility is widely reported, very little work has been published on the fracture toughness.

The difficulties in conventional metallurgy processing have focused many efforts on these materials to powder metallurgy technology. It was shown that Fe-40Al alloys can be prepared by recently developed (less expensive) conventional processing technology of hot-rolling [3]. FeAl based intermetallic alloys with addition of carbon, titanium, zirconium and boron (Fe40Al1C, Fe40Al1Ti and Fe40AlZrB). The alloys were prepared by modified processing technology of vacuum induction melting and hot rolling in special stainless steel sheath. The ingots were hot rolled to plates 12,5 mm thick at 1200°C and subsequently quenched into mineral oil.

In all alloys, more or less equiaxed grains were observed in three independent planes (perpendicular to the rolling direction, transverse and short transverse direction), which is characteristic for recrystallized microstructure. The Fe-40Al-1C alloy exhibited grains size around 500 μ m. Inside grains and on grain boundaries there were many carbon bearing second phase particles, corresponding to graphite and perovskite-type carbide Fe₃AlC_{0,5}. The Fe-40Al-1T alloy exhibited grain size around 250 μ m with much less second phase particles inside grains and on grain boundaries than Fe-40Al-1C alloy. EDX analysis revealed composition of second phase particles close to TiC. The particles were formed due to the residual carbon content in the raw Fe. The Fe-40Al-Zr-B alloy showed coarsest grains (of size almost 1 mm) with a number of Zr rich particles. Wavy character of grain boundaries in the Fe-40Al-Zr-B alloy indicates unfinished process of grain boundary movement during the hotrolling or slow air-cooling.

Tensile tests were carried out at temperatures 20, 600, 700, and 800°C at the constant crosshead speed 2 mm/min (corresponding to the strain rate $\sim 10^{-4}$ s⁻¹) on INSPEKT 100 kN and INSTRON 1195 testing machines equipped with a resistance-heated furnace. All alloys had very low elongation (less than 0.2%) at room temperature; the specimens failed very early

after yielding. The Fe-40Al-1C alloy showed highest room temperature yield stress. The Fe-40Al-Zr-B alloy displayed highest yield stress at temperatures higher than 600°C.

Fracture toughness tests were performed according to ASTM E1820 standard. The fracture toughness K_Q was measured from the load *vs.* load-line displacement. The methodology of fracture toughness testing of iron aluminides based intermetallic alloys was developed in Ref. [4,5]. The fracture toughness of Fe-40Al-1C alloy increased from 21 MPa.m^{1/2} at 20°C to 45 MPa.m^{1/2} at 400°C and then decreased to about 40 MPa.m^{1/2} at 600°C (Tab. 2). The fracture toughness of Fe-40Al-1Ti alloy increased from 14 MPa.m^{1/2} at 20°C to 35 MPa.m^{1/2} at 400°C and then decreased to about 26 MPa.m^{1/2} at 600°C (Fig. 3). The fracture toughness of Fe-40Al-Zr-B alloy increased from 34 MPa.m^{1/2} at 20°C to 49 MPa.m^{1/2} at 400°C and then further increased to 60 MPa.m^{1/2} at 600°C.

The fracture surfaces were observed using SEM JEOL JSM 840A operated at 25 kV. Addition of Zr and B improved the tensile properties at elevated temperatures and significantly increased the fracture toughness. Up to 600°C, the fracture micromechanism was predominantly transgranular cleavage in both tensile and CT specimens. At 800°C, the fracture micromechanism changed to ductile dimpled fracture.

Carbon addition increased RT yield stress. Fracture toughness was also improved, though less than in the case of Fe-40Al-Zr-B alloy. The beneficial effect was due to the grain boundary strengthening by carbon bearing particles. With increasing temperature, the fracture mechanism in tensile specimens gradually changed with temperature from intergranular decohesion to ductile dimpled fracture. In CT specimens from Fe-40Al-1C alloy, there was a change of fracture mechanism comparing to the tensile specimens. Fracture morphology of CT specimens tested at room temperature was characterized by transgranular cleavage facets. At 400°C, CT specimens failed mainly by the mechanism of intergranular decohesion, while at 600°C by the mechanism of transgranular ductile fracture.

Alloy with Ti addition displayed lowest strength and toughness. Both tensile and fracture toughness specimens failed by intergranular decohesion at temperatures up to 700°C.

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Alternative Cement-Based Composite Materials: Selection of Composition and Production Technology

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The project pursues one of the basic trends in current building industry which is an increasing demand for high-quality environmental-friendly building materials. Its main subject is the investigation of advanced building materials and their properties. The research work in this field is directed to materials of high-level utility properties which in comparison to currently used materials can be characterized by higher durability and lower demand for raw materials belonging to exhaustible resources, by the decrease of greenhouse gases emissions necessary for their production and by the reduction of the total energy consumption [1-3]. The main aim of the project is to contribute to the development of high-performance materials containing alternative silicate binders and to analyze their durability properties.

The main task in the initial period of project solution was the design of composition and production technology of cement based high-performance materials containing alternative silicate binders. Preliminary studies have shown that among this type of binders, metakaolin is in the conditions of Czech Republic the most perspective. The supply of ground granulated blast furnace slag is almost exhausted in the Czech Republic because it became a common raw material in cement industry. Fly ash from Czech sources has quite unstable composition so that the properties of the resulting composite are variable. Silica fume became too expensive and its sources are very limited. On the other hand, in the Czech Republic there are rich sources of kaolin. Therefore, the choice of metakaolin as the alternative silicate binder for the investigations within the framework of this project was a logical solution.

The effect of metakaolin as partial replacement of Portland cement on the properties of HPM mortars was investigated for 33 mixes prepared as follows: 6 reference mixes without metakaolin, 6 mixes with the extra addition of metakaolin to Portland cement, 21 mixes with metakaolin used as partial (5, 10, 15% of the cement mass) replacement of Portland cement. The water to cement ratio (w/c) was chosen in three alternatives: 0.33, 0.45, 0.55. Superplasticizer was used to improve the rheological properties of mortars with w/c = 0.33.

The effect of metakaolin on the properties of above listed mortars was tested by the measurements of flexural and compressive strength (28 days old samples), consistency of fresh mixture, density, volume density and porosity of hardened mortars. These properties served as the basic criteria for the choice of the most perspective solutions which are supposed to be investigated in more detail in the second year of the project solution.

It was found in the experiments that the type of cement had a systematic effect on the mortars density for the reference mixes only; the density of mixes with CEM I 52.5 N was significantly higher. For the mixes with metakaolin a similar effect was not observed. The amount of metakaolin also was not a decisive factor for density values. Differences of measured bulk densities and porosities were more significant. The lowest porosity was determined in mixtures with low w/c (0.33) and 10 to 15 % of metakaolin and 2 % of superplasticizer. Metakaolin was active not only as pozzolanic admixture but also as microfiller; porosities of reference mortars (w/c 0.33) were about the same value as in case of mortars with added metakaolin and higher w/c. Effect of superplasticizer dosage (1 or 2 %)

on porosity was detected in mixtures with cement CEM 42.5 R where its higher dose led to decrease of porosity by 10 % absolutely. In mixtures with cement CEM 52.5 N this effect was less than 3 %.

The effect of the higher amount of superplasticizer which positively affected the mix workability on the compressive strength was not straightforward and the obtained results did not allow any generalizations. Therefore, it seemed reasonable to choose 1 % dosage for the final mix, considering the price. The amount of metakaolin as a parameter influencing the compressive strength was not important for the samples made from cement CEM I 42.5 R with w/c = 0.33 only. In all other cases the compressive strength increased up to 10% or 15% of metakaolin as cement replacement. So, the replacement of 10% of cement by metakaolin could be considered a safe solution from the point of view of compressive strength where the effect of metakaolin was always positive. The decrease of compressive strength with the increasing w/c was quite remarkable, in the range of 20-40%. The value of w/c = 0.33 was then an apparent solution, taking into account the quality of the hardened mixture on one side and the only slightly higher demands on the technology on the other. The type of cement was found a very important parameter. The mixes with CEM I 52.5 N achieved in most cases higher compressive strengths than those with CEM I 42.5 R. This effect was more pronounced for w/c = 0.33. For the most prospective mixes from the point of view of previously mentioned parameters the increase of compressive strength was approximately 10 %. The flexural strengths followed similar trends as the compressive strengths. The differences were for mixes with the same w/c mostly lower than in the case of compressive strength. On the other hand, the increase of w/c was manifested in more remarkable decrease of flexural strength, up to 60 %.

As it follows from the results given before, the relative improvement of the analyzed properties was higher when metakaolin was added to lower grade cement CEM I 42.5 R. However, generally better properties achieved the mixes made using the higher grade cement CEM I 52.5 N. Summarizing the experimental findings, the following mix could be considered as the most promising with respect to the expected durability: Portland cement CEM I 52.5 N, 10 % of cement replaced by metakaolin, w/c = 0.33 and 1 % of superplasticizer to improve the rheological properties of fresh mixture. This mixture which met best our requirements will be further studied, possibly also slightly modified in the further course of the solution of the project.

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Mechanical Properties of Cement Mortars Containing Alternative Silicate Binders.

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In concrete production, around 90% of all energy consumed is used to obtain cement, which is also a major source of CO_2 emissions. On this account, partial replacement of cement binder with the alternative silicate binder materials is profitable from ecological as well as from economical point of view. Also one of the principal trends of present civil engineering is demand for high quality building materials. The addition of ground solid materials, collectively called mineral admixtures or supplementary cementing materials, to concrete is an established practise in modern concrete technology. Admixtures are added for a variety of aims above all to replace cement improving the workability of fresh mixture or mechanical and durability properties of hardened concrete.

Alternative silicate binders such as fly ash, ground granulated blast furnace slag, silica fume and metakaolin have a high potential to replace a part of Portland cement in concrete due to the generally recognized necessity to decrease the amount of carbon dioxide in atmosphere. Fly ash, ground granulated blast furnace slag and silica fume appertain to the waste materials, while metakaolin is produced by thermal decomposition of kaolin without production of CO₂. Metakaolin is burnt kaolinite at temperatures between 500 - 850°C, i.e. above the temperature of kaolinite dehydration. The mineral admixtures interact chemicaly with the hydrating Portland cement to form a modified cement paste microstruxture [1]. The mechanism of pozzolanic activity of metakaolin, similarly as with other pozzolanic materials, is based especially on the ability of amorfous or glassy silica, which is the major component of a pozzolan, to react with calcium hydroxide formed from the hydration of the clacium silicates. The products of this chemical reaction are C - S - H gels and crystallization products, e.g. C₂AH₈ and C₂ASH₈ (gehlenit hydrates). The developed compounds should implicate higher strengths of cement mortars with pozzolana addition compared to pure cement mortars. Quality of pozzolanic activity of particular types of metakaolin is based on the sort of raw materials used for their production, method of calcination and on granulometry of the final product.

Mineral admixtures can be used in two ways, as an addition or as a replacement of the Portland cement. When used as an addition, the cement is kept the same, while pozzolan substitutes sand in mixture. When used as a replacement, it replaces cement. Metakaolin can replace 5 - 15% of cement by weight at concrete production where it can be used instead of microsilica. It can also be utilized in the production of geopolymers. The reason for using metakaolin in the mentioned applications is the supposed increase of compressive and flexural strength and frost resistance, decrease of water-absorption and reduction of the occurrence of efflorescence. Positive influence of metakaolin on mechanical properties as well as chemical resistance of concrete has been already documented in several studies [2, 3]. Regarding the price of metakaolin, one of the goals was to find an ideal quantity of metakaolin to be used as admixture in concrete.

To find an admixtures influence to tested cement mortars it was prepared some sets of mortar mixtures, finally thirty five different cement mortars. The metakaolin was used as a replacement 5, 10 or 15 % weight of Portland cement. For the comparison also pure cement

mortars were mixed. The water/cement ratio was 0.33, 0.45 and 0.55. In the case of the lowest w/c ratio polycarboxylate superplasticizer was used to improve workability of the fresh mixture.

Both inorganic binding materials were of the Czech origin, cement CEM 42.5 R was manufactured in cement mill Hranice and CEM 52.5 N was produced by cement factory in Radotín. Used silica aggregates of fraction 0/2 mm were produced by Heidelberg Cement Group, Brněnské písky Inc., affiliate Bratčice. Metakaolin MEFISTO K 05 was delivered by company "České lupkové závody Inc.", Nové Strašecí. It is a highly active pozzolanic material on metakaolinite basis, which dominant parts represent SiO₂ (55%) and Al₂O₃ (41%). The minority compounds represent Fe₂O₃, TiO₂, CaO, MgO, and Na₂O. Average particle size of metakaolin is in the interval of 3 to 5 μ m.

Tested mixtures were prepared using laboratory mixing machine with forced rotation for 3 minutes and then compacted using vibrating machine. Each mixture was cast into standard prism forms, with dimension 40 x 40 x 160 mm. After two days all prisms were taken out of forms and then cured for 28 days in high relative humidity environment. Investigation of mechanical parameters was carried out according to the Czech-European technical standard [4]. The compressive and flexural strengths were determined as the most important mechanical parameters for composite materials. The compressive strength was determined using the hydraulic press ED 60 on the remainders of the specimens after bending test. The flexural strength was measured using standard three-point bending test with power press FP100.

The measured values show the both compressive and flexural strengths of tested mortars with metakaolin as a replacement of Portland cement visible increased or hold the same, closely, strength of mortars with Portland cement CEM 42.5 R increased about 20%, while no influence on tested parameters of mortars prepared from Porltand cement CEM 52.5 N was observed. The compressive strength rises the most, about 26%, by mixture with 10% of metakaolin and w/c = 0.45 in the comparison with pure cement mortar, while in the case of Porltand cement CEM 52.5 N the highest values of compressive strength for samples with 15% of metakaolin replacement was found. In the case of flexural strength no remarkable trend was traced but we can say all values increased due tu metakaolin addition in the comparison with pure cement mortars. Regarding to metakaolin price and influence on tested mortars as an optimal amount of Portland cement replacement 10 - 15% can be recommended.

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Hygric Properties of Lime Plasters Containing Metakaolin

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Directed design of properties of new materials and their systems becomes a recognized treatment in civil engineering in the last decades. This leads on one side to the increasing quality of products but on the other to an increasing need of complex testing methods that are able to evaluate this quality with a sufficient reliability and in a reasonable time in different conditions. The computational methods used for estimation of hygric parameters of porous materials which meet the requirement of obtaining results very fast already belong to well established techniques (see, e.g., [1], [2]). However, most of the researchers in this field work solely on computational techniques, without a direct contact with experimental measurements. In this project, the multi-scale modeling procedures are combined with experimental techniques which makes possible an immediate calibration and verification of the applied computational models. Therefore, the quality of the computational outputs for hygric properties and their accuracy should be significantly higher than in most other applications of multi-scale modeling. In this paper, apparent moisture diffusivity and water vapor diffusion coefficient of several lime-metakaolin plasters are measured.

The composition of lime-metakaolin plasters is shown in Table 1. They differ in the lime used for their preparation, which is chosen in such a way that all major lime producers in Czech Republic are present, and are denoted as S2-S5. Metakaolin MEFISTO produced by České lupkové závody Inc., Nové Strašecí, was used as the pozzolanic admixture.

Material	Lime (kg)	Natural quartz and basalt sand with continuous granulometry 0 to 4 mm (kg)	Metakaolin (kg)	w/b (-)
S2- Štramberk 2.08		7.5	0.48	0.258
S3-Vitošov 2.08		7.5	0.48	0.263
S4-Čertovy schody	2.08	7.5	0.48	0.223
S5- Mokrá	S5- Mokrá 2.08 7.5		-	0.266

Table 1 The composition of lime-metakaolin plasters

The water vapor transport parameters of the studied lime-metakaolin plasters are shown in Table 2. The measured values of water vapor diffusion coefficient D and water vapor diffusion resistance factor μ of all studied materials exhibited not very high differences. The fastest water vapor transport was observed in the material S5 (the only lime plaster without metakaolin), the data measured for other materials were within the error range of the experimental method.

The data for liquid water transport parameters are shown in Table 3. The apparent moisture diffusivity κ of the material S5 (as well as the water absorption coefficient A) was significantly higher than for the other materials where the differences were within the error range of the experimental method. So, the results were in a qualitative agreement with the water vapor transport parameters in Table 2.

	5/25-30%	97/25-30%	97/25-30%	
Material	D	μ	D	μ
	$[m^2s^{-1}]$	[-]	$[m^2 s^{-1}]$	[-]
S2	3.00E-06	7.7	1.43E-06	16.1
S3	2.54E-06	9.1	1.53E-06	15.1
S4	2.63E-06	8.7	1,41E-06	16.3
S5	4.00E-06	5.8	1.91E-06	12.2

Table 2 Water vapor transport properties of studied lime-metakaolin plasters

Table 5 water transport parameters of studied inte-metakaonin plaster	Table	3	Water	transport	parameters	of studied	lime-metakaolin	plasters
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Matarial	А	κ
Wateria	$[\text{kg m}^{-2}\text{s}^{-1/2}]$	$[m^2 s^{-1}]$
S2	0.159	1.89E-07
S3	0.127	1.60E-07
S4	0.130	1.53E-07
S5	0.182	2.78E-07

The experimental results presented in this paper have shown that the addition of metakaolin in the amount of about 25% of mass of lime led to an about 20-35% decrease of water and water vapor transport parameters compared to the lime plaster which is a relatively small difference. The type of lime as for the different producers was not found to be a significant factor affecting the hygric transport parameters.

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Effect of Metakaolin on the Properties of Portland Cement-Based Composites

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Despite the gradual shift in the high performance materials (HPM) design and application philosophy towards a generally recognized necessity to measure a wider scale of HPM parameters, mechanical properties still remain the far most frequent parameters investigated. For water and water vapor transport and storage properties of HPM containing alternative silicate binders only very few references were found in common sources within the last years. For instance, Khan [1] determined the sorptivity of several high-performance concretes incorporating fly ash and microsilica prepared with different water/binder ratios. Khatib and Clay [2] studied water absorption characteristics of metakaolin concrete. Razak et al. [3] compared water sorptivity of concrete with metakaolin and silica fume. Bai et al. [4] measured sorptivity of concrete with metakaolin admixture are investigated. The obtained data can be applied as input parameters of computational models for hygrothermal performance simulation and service life prediction.

The high performance concrete mix studied in the paper was prepared with Portland cement CEM I 42.5 R (the specific surface area 341 m^2/kg) as the main binder. A part of cement was replaced by metakaolin MEFISTO K 05 (ČLUZ, a.s., Nové Strašecí, the specific surface area 13.06 m^2/g). The amount of metakaolin in the HPC mix was optimized according to the compressive strength of the resulting concrete. The best results in this respect were achieved when the quantity of metakaolin was 10% of the mass of cement. For the sake of comparison, also a reference mix BR with only Portland cement as the binder but all other components the same as in BM was investigated. The total mass of binder in the reference mix was the same as in BM.

The basic physical properties of studied composites measured by the water vacuum saturation method are shown in Table 1. The bulk densities of both materials differed by about 1.5%, matrix densities by 1%, open porosities by 6%. These differences fall within the error range of the measuring method.

Material	Bulk density [kg m ⁻³]	Matrix density [kg m ⁻³]	Open porosity [% m ³ m ⁻³]
BR	2380	2715	12.3
BM	2366	2691	13.0

Table 1 Basic physical properties of the studied concretes

The results of measurements of water vapor diffusion resistance factor μ of the analyzed composites are presented in Table 2. The μ values of BR were in the both ranges of higher and lower relative humidity about 2-3 times lower than for BM. This does not agree with the open porosity data in Table 1. The apparent moisture diffusivity of BM (Table 3) was almost two times lower than of BR which agrees reasonably well with the results of water 212

vapor transport measurement but not with the measurements of open porosity. The most probable explanation of the poor agreement of water and water vapor transport parameters with the porosity data is probably in the topology of the porous space of both materials and their pore distribution.

	97,	/25 %	5/25 %		
Material	Water vapor diffusion coefficient [m ² s ⁻¹]	Water vapor diffusion resistance factor [s]	Water vapor diffusion coefficient [m ² s ⁻¹]	Water vapor diffusion resistance factor [-]	
BR	3.63E-06	6.6	1.50E-06	15.8	
BM	1.10E-06	21.0	7.09E-07	32.4	

Table 2 Water vapor transport properties of the studied concretes

Table 3 Water transport properties of the studied concretes

Material Water absorption coefficient [kg m ⁻² s ^{-1/2}]		Apparent moisture diffusivity [m ² s ⁻¹]	
BR	0.0099	7.15E-09	
BM	0.0070	4.09E-09	

The experimental results presented in this paper showed that the application of metakaolin as partial replacement of Portland cement was a successful technological solution. Both water and water vapor transport parameters decreased in a significant way which was very substantial finding from the point of view of durability of concrete.

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Sorption Properties of Biological Agricultural Materials Measured by TDR Method

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Monitoring of quality and health harmlessness of biological agricultural products during their manufacturing and storage requires complete knowledge of physical material properties. The quality assessment and guarantee of the safety of foodstuff belong to the main priorities in food industry. Within the technological processing of agricultural products, temperature and moisture content of rare materials have the crucial importance on the quality of final products. They present the most important parameters having clear relation to the character of physical, chemical and physiological processes in biological agricultural materials. On this account, advanced and sophisticated devices and testing methods have to be developed for moisture, relative humidity and temperature measurement in agricultural materials.

For the relative humidity measurement, several methods was developed and tested till now. Among them, especially sorption methods based on changes in physical-chemical properties of materials due to the change of the amount of absorbed water can be used for the relative humidity measurement in biological materials. The moisture absorbed by the material can cause a change of its volume, mass, electric resistance, permittivity, etc. Therefore, the sorption moisture meters can be divided into several groups; dilatation, resistance, capacitance, resonance, and semiconductors moisture meters [1]. Also electrolytic relative humidity meters can find use in measurement in agricultural materials. This method is based on the determination of an equilibrium state between a hygroscopic substance and water vapour. It employs the fact that for every ionic salt, the temperature of the equilibrium state between the water vapour pressure above a saturated solution of the ionic salt and the water vapour pressure in the surroundings is exactly defined and known. This can be utilized for the determination of the absolute moisture content of the measured gas. Electrolytic moisture meters employ mostly LiCl as the ionic salt, because its equilibrium water vapour pressure is sufficiently low at room temperature.

The currently applied methods for the temperature measurement are also highly precise and sophisticated. For application in agricultural and food industry, especially electric resistance and thermoelectric thermometers can be used [2].

On the other hand, measurement of moisture content in agriculture products is affected by several groups of factors that have clear relation to the accuracy of moisture meters. These are, first of all, conditions of measuring, followed by inaccuracies introduced by measuring equipment and especially the errors introduced by investigated material. Physical properties of agricultural plant materials have varied effect on an accuracy of moisture measuring. These properties are in very complicated mutual relationship. Biological materials are macroscopically and microscopically considerably non-homogenous. They have nonhomogenous chemical composition, their components are of varied density, they contain admixtures and pollutants. Moreover, many of them exert continuous biological activity. Their properties are dependent on many parameters, among whose are such as chemical composition and structure of material [3]. Therefore, development of moisture measurement method for general application for agricultural materials is not an easy task. We have already referred in paper [4] about the applicability of TDR method for the moisture assessment in granular agricultural products. Since the results were very promising and proved the capability of TDR method for measurement of moisture content in agricultural products, the TDR method was used also in this paper for monitoring sorption process in several types of granular agricultural materials.

In the hygroscopic moisture range, where the transport of water vapour is the dominant mode of moisture transfer, the moisture storage function is called the sorption isotherm. The sorption isotherm presents the dependence between the water content in the porous matrix and the relative humidity in the system. In this paper we have focused on measurement of sorption isotherms of spring oat, wheat mixture Axis, barley mixture Expres, and corn mixture. The material samples were provided by Slovak University of Agriculture in Nitra, Faculty of Agricultural Engineering, Department of Physics. Within the sorption isotherm measurement, the dried samples were placed into the desiccators with different solutions to simulate different values of relative humidity. The experiment was performed parallel in all desiccators in thermostatic chamber at 21 °C. The water adsorption and desorption in a porous material are based on van der Waals forces between the surface of the porous matrix and water molecules. The dry material mass increases after a contact with moist air because of gradual bonding of water molecules from the air to the pore walls, in the case of adsorption. At the moment of achieving the equilibrium state between the water vapour pressure in the moist material and in the surrounding air this process is stopped. The moisture content in specific samples was measured by the TDR method based on relative permittivity measurement and by weighing the mass of samples in specified periods of time until steady state value of mass was achieved.

The obtained results give clear evidence about the high binding capacity for water vapour of all studied materials. From the point of view of applicability of TDR method for such type experiments it can be conclude, the TDR method can be used for monitoring of sorption process in granular agricultural materials typically from 30% of relative humidity. In the lower range of relative humidity, the accuracy of TDR method is not sufficient.

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Modeling of behaviour and stress field of 15Ch2MFA reactor pressure vessel steel

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The aim of this study is to determine the stress – strain field generated in the Charpy specimen taking into account the effect of thermally activated deformation.

The degradation of mechanical properties of reactor pressure vessel (RPV) due to neutron irradiation is still worldwide discussed. The main indicator of change in mechanical properties is ductile to brittle transition temperature (DBTT), obtained by Charpy impact tests. Additional information to Charpy impact energy can be obtained by using instrumented Charpy impact pendulum device. Nevertheless, this test does not report direct information about stress - strain field in the instant of fracture. The stress strain field should be obtained indirectly by numerical computation. Frequently there is a lack of experimental data on irradiated material. In some cases, the only way of obtaining the material parameters is identification procedure using the numerical model [1,2].

It is not still well understood influence of the irradiation on strain rate hardening. Generally, it is supposed that irradiation has no effect on the hardening caused by the high strain rate. In Ref. [3], the thermally activated processes were studied by means of tensile test with various crosshead speeds. There were not observed differences of activation parameters in the unirradiated and the irradiated conditions [3], but the investigation was done only in limited range of strain rates.

The steel chosen for this study was the 15Ch2MFA (15Cr2MoV) tempered baintic steel [4]. This steel is used for fabrication of pressure vessels of VVER 440-type nuclear reactors.

The specimens were enclosed and neutron-irradiated in the same capsules as standard surveillance specimens. The chains contained the set of activation monitors (including fast as well as thermal neutrons) and also fission monitors. Each capsule contained two rings of copper wire to evaluate the azimuthal fluence. The capsules were irradiated in emptied surveillance channels in the VVER 440-type nuclear reactor. The mean irradiation temperature was estimated after evaluation of the melting temperature monitors to 275 °C.

Tensile tests were carried out on the INSTRON 1342/8500+ hydraulic testing machine at room temperature at constant crosshead speed of 0.5 mm min⁻¹. Charpy tests were carried out on an instrumented impact pendulum device Tinius-Olsen 74 (sampling frequency was 1 MHz) with nominal impact energy 358.5 J and nominal impact velocity 5.1 m s⁻¹ at various temperatures ranging from -190 °C to +240 °C. The results of the instrumented Charpy tests of neutron-irradiated and non-irradiated specimens are shown in [4].

The finite element method was used in order to compute the stress-strain distribution in the Charpy V-notch specimen. For numerical modeling, the methodology developed by Rossoll et al. [1] was adopted. 23 000 linear elements with selective integration were employed in the finite element analysis (Marc® 2007). The mesh size in the notch root region was about 10 μ m. The striker was modelled by a rigid surface contact element. A friction coefficient of 0.1 was assumed for contact surfaces. Loading of the specimen was made by imposing a fixed
displacement to the striker. The computations were performed in the framework of finite strains, with an updated-Lagrangian formulation. 3D quasi-static formulation was used. Due to the symmetry only one quarter of the specimen was modeled. The mesh consisted of 8 layers in the thickness direction with decreasing node distance to the outer surface to account for a gradient of stress and strain.

It was shown by Rossol [1] that the inertial effect is damped by viscoplasticity ahead of the notch and vanishes rapidly so that the quasi-static computation is sufficient for the fracture time which occurred in the DBTT range. On the other hand, 3D modeling is required. Heating of specimen caused by impact test is confined to notch root, and practically does not affect the stress - strain field [1]. Viscous effects due to high strain rates during the Charpy test were modeled using the constitutive equation which takes into account the effect of thermally activated deformation.

Strain hardening was identified from tensile tests of irradiated and non-irradiated specimens. Extrapolation to strains larger than the uniform strain has been carried out with a Hollomon formulation taking into account the deformation preceding the onset of necking. For first 2% of deformation, linear extrapolation has been used as in Ref. [1].

The results of numerical modeling of Charpy impact test were compared with experimental data. At the beginning, the identification was done for non-irradiated material. Subsequently we made again identification for irradiated material and find out activation volume dependent parameter for different neutron fluences.

The stress level computed using activation volume identified in non-irradiated state is higher (more conservative) than with activation volume identified in neutron-irradiated state.

The activation volume was determined for non-irradiated state and for several different irradiation conditions and it was found to increase with increasing fluency.

It was find out, that the maximum of stress distribution next to the notch in Charpy specimen is shifted and increase with irradiation. Using of activation volume identified for non-irradiated material can therefore lead to an overestimation of stress peak value in irradiated material.

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Neutron Diffraction Texture Analysis of Rock Materials (Limestone) by Inversion Pole Figures

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From the industrial point of view the research activities of the Laboratory of Neutron Diffraction (Faculty of Nuclear Sciences and Physical Engineering CTU Prague) are concentrated to the quantitative texture analysis based on the ODF (orientation distribution function). We have developed the experimental and data treatment procedures for this type research. For example, we have determined the texture parameters on the oriented Si steel sheets, the zirconium alloys (tubes for nuclear reactors), polymer materials (PVC foils) and rock materials (CaCO3 test samples).

During last years the texture analysis methods were used to the investigations of the preferred orientations of a many different rock samples. Neutron texture studies are especially interesting because the high penetration of neutrons through the majority of materials is the main advantage for examination of the textures of coarse-grained materials and rock materials. Our study deals with the preliminary investigations connecting with the quantitative texture analysis of rocks (calcite - limestone samples) by neutron diffraction with the Rietveld method. Calcite belongs to the group of sedimentary rocks with very complicated polycrystalline fabrics. The investigation of the structure parameters and the determination of the preferred orientations of these crystal aggregates could help to give the answer whether the possible structure constrains and features depends on the sedimentary processes of the rock structures.

The investigated limestone samples were collected near Choteč, Bohemia, from a single limestone fold. Two selected sampling points (C1, C2) represented a different level of the fold inversion: The sample C1 was collected from the fold part with the original sedimentation direction (SD) oriented nearly horizontally, in case of the sample C2 the later was turned upside down. Distance between the sampling points was approximately 1m. Specimens for the neutron experiments were then prepared in the two ways. Firstly, it was cut and shaped to the oriented cube (the edges of the 20 mm) with the edges parallel to the three principal directions forming a Cartesian co-ordination system: the SD, the direction perpendicular to the contour lines of the fold (PD), and the contour direction (CD). Secondly, the powder sample was prepared by ball milling.

Diffraction diagrams were collected on the neutron diffractometer KSN-2 equipped by the texture goniometer TG-1. The obtained diffraction patterns were corrected for non-linear background and then evaluated using the Rietveld method implemented in software packages GSAS and Material Studio (Accelrys). We have defined an instrument coordinate system (I,J,K) and a set of right-handed goniometer angles (Ω ,X, Φ) after the description given in [2]. The set of the measured patterns is consists the 43 sample diffraction vectors for data analysis of the C₁ limestone sample and the 29 sample diffraction vectors of the C₂ one. Crystalline structure of calcite was refined within the space group R-3c by means of the GSAS software package [2,3]. Firstly, we refined the powder samples and we determine the complete set of structure parameters (Table 1). In the beginning, the individual scale factors and background coefficient for each powder pattern were determined. Then the average values of the lattice parameters were used in the refinement process for the spherical harmonic determination. The orientation distribution function (ODF - spherical harmonic coefficients $C_1^{m.n}$) were determined by the Rietveld method [2,4]. Final refinements for the both samples C_1 and C_2 were done with *mmm* sample symmetry and maximum harmonic order L=8. Results are given in Table 1.

			1	
Sample	C1 _{powder}	C2 _{powder}	C1 _{aver}	C2 _{aver}
space group	R-3c	R-3c	R-3c	R-3c
a /Å/	4.9764(5)	4.9769(5)	4.9846(6)	4.9840(6)
c /Å/	17.013(4)	17.014(4)	17.041(7)	17.046(7)
x ₀ /Å/	0.2577(5)	0.2580(5)	0.2571(6)	0.2577(7)
μ /cm ⁻¹ /	0.298(3)	0.285(3)	0.302(4)	0.297(6)
Р	-	-	1.14	1.47
R _{wp} / % /	5.51	5.92	11.8	12.3

Table 1. Crystallographic parameters for calcite samples.

Remarks: Samples: $C1_{powder}$, $C2_{powder}$ - powder samples, $C1_{aver}$ - average values from 43 powder diffraction diagrams, $C2_{aver}$ - average values from 29 powder diffraction diagrams; Atomic coordinates: x, c and x₀ (oxygen parameter); μ linear absorption coefficient /cm⁻¹/; P texture level (maximum) in MRD (multiple of random distribution); GSAS refinement: sample symmetry: *mmm*, maximum harmonic order L=8.

Texture of the samples can be characterized as follows: (i) the sample C1 posses a moderate texture (the calculated ODF sharpness f = 1.14) and the remarkable declination of crystalline c-poles from the SD (ODF maximum occurs within the β -range 50° - 70°; β is the polar angle). (ii) Texture of the sample C2 is more pronounced (f = 1.47), and the c-poles orientation is closer to the SD ($\beta \cong 0^\circ$ - 20°). Crystallographic and texture parameters are given in Table 1. The diffraction patterns gave evidence about traces of additional crystalline phases; their identification is under progress.

The results show that the procedures can be successfully applied to investigation of rock materials and can provide the valuable information about the texture forms and related properties.

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Porosity Characterization of Aerated Gypsum Based Composites

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Currently, gypsum is the subject of increasing research attention as low-energy demand and ecological building material. Possibilities of a wider use of gypsum in building industry are searched. One of the promising ways of new gypsum utilization is production of lightened composite materials – gypsum based foams. Such material features, besides the lower bulk density than common gypsum, significantly lower heat conductivity. On the other hand, the foamed materials generally have lower strength than the "compact" ones.

There are several ways how to reduce the bulk density (increased porosity) of gypsum. Pores can be introduced to the plain gypsum by adding of a granular porous filler or a preprepared foam. The alternative way is preparation of mechanically aerated gypsum by vigorous mixing of gypsum slurry with added surfactants. The last, but most interesting possibility is to generate bubbles directly in gypsum by a suitable gas-evolving chemical reaction. The most common foaming gas is carbon dioxide (CO_2) which is generated by reaction of an acid compound with a carbonate or bicarbonate in situ. Many types of the acid component are mentioned in literature, e.g. HCl, organic acids, H₂SO₄ or various sulphates [1]. As the carbonate component was mostly used CaCO₃.

The main problem of chemically foamed gypsum composites is un-even size distribution of generated pores and bubbles. The large bubbles (diameter in range of a few cm) are formed randomly and they cause undesirable variability of mechanical and thermal properties of such foamed materials. This problem was attempted to be solved in the present work by addition of fine granular filler to the chemically foamed gypsum composite. The pore size distribution of prepared materials was determined.

Three materials were prepared. The fundamental material was β -gypsum produced as by-product in process of flue gas desulphurization in power plant Mělník. The reference sample P1 was prepared just by mixing of gypsum powder and water. The sample P2 was chemically foamed by adding of calcium carbonate and aluminium sulphate solution. They react according Eq. 1 while CO₂ is evolved. The sample P3 was foamed chemically in the same way as P2, but the fine granular filler – perlite – was added in addition. The sample P3 may be hence called hybrid lightened composite material. The samples were mixed in laboratory mixer and three test samples (40 x 40 x 160 mm) were prepared from each mixture. The samples were characterized from the point of view of materials texture [2]: bulk density was determined by measuring and weighing of dried prisms. The matrix density was determined by helium pycnometry by apparatus Pycnomatic ATC (Porotec, Germany). The pore size distribution was determined by Mercury Intrusion Porosimetry (MIP) performed by help of PASCAL 140 and 440 instruments (Thermo, Italy). The MIP data were combined with total porosity determination in order to overcome the MIP restrictions [3]. The thermal conductivity coefficient was measured by ISOMET 104 (Applied Precision, Slovakia).

$$Al_2(SO_4)_3 + 3 CaCO_3 + 3 H_2O \rightarrow 3 CO_2 + 3 CaSO_4 + 2 Al(OH)_3$$
 (Eq. 1)

	Density	Bulk density	Porosity	Thermal conductivity
Sample	kg m ⁻³	kg m ⁻³	%	W.m ⁻¹ .K ⁻¹
P1	2314	945	59.2	0.39
P2	2193	661	69.4	0.16
P3	1940	547	71.1	0.12

Table 1: Fundamental properties of foamed gypsum based composites.

The fundamental texture properties and thermal conductivity coefficient of the studied materials are presented in Table 1. The total porosity was determined by means of density and bulk density. The plain gypsum (P1) porosity is cca 60 %, the chemical foaming by aluminium sulphate and calcium carbonate (P2) increases the porosity to cca 70 %. The addition of perlite (P3) does not have any large influence on the total porosity. The measurement of thermal conductivity of prepared materials is in agreement with the total porosity increase in the foamed samples. The crucial difference between samples P2 and P3 lies in pore size distribution. The MIP measurement showed that plain gypsum (P1) is unimodal material having whole pore volume concentrated in narrow range of pores of diameter around 1 μ m. The chemical foaming (P2) shifted the maximum on the pore size distribution curve to the largest pores (diameter > 100 μ m). When the perlite filler was added (P3) the measured pore size distribution was much more flat than in P2 and the maximum was shifted back to smaller pores. It means that the filler reduced the formation of the undesirable large bubbles.

The hybrid foaming of gypsum by in situ evolved gas and fine granular filler was found to be successful way to formation of an evenly distributed pore system [4]. The prepared material P3 will serve as fundamental point in further development of hybrid lightened gypsum composites.

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Creep of the Concrete Slab Reinforced with Prestressed GFRP Tendons

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Popularity of using composite materials in civil engineering is rising throughout the whole world. Corrosion-proof ability, high strength and low weight namely point on GFRP as a new effective material. This trend places big emphasis on good design. Lack of information about these materials intended for concrete reinforcement is caused by short term of using these materials in civil engineering in the Czech Republic. Therefore some fundamental researches have been done regarding basic material properties assessment. Nevertheless concrete structures for civil purposes are design for more than 50 years so creep test was performed in order to clarify long time behavior.

This paper is focused on creep of concrete slab which is reinforced with prestressed GFRP (Glass Fiber Reinforced Polymers) tendons. Prestressing of GFRP tendons is very useful because it decreases the negative effect of low elasticity modulus (six times lower than steel) of GFRP tendons. This long term experiment was made in Experimental Center of Faculty of Civil Engineering, CTU in Prague. Experiment has begun in January 2008. Proposed testing time was one year.

The concrete slab is 4,5 meter long and 4 meter span. Cross-section is 600 x 200 mm (width x height). It was reinforced with four prestressed GFRP tendons which were placed 50 mm from lower fibers. Four vibrating wire strain gages (VW) were embedded in the slab. Two were placed on the end of the slab and the other two in the middle of the slab. One strain gage from each pair was embedded close to the upper fibers of slab and the other one to the lower fibers of the slab. GFRP tendon's basic characteristics were:

- Modulus of elasticity: 41,0 GPa
- Tensile strength: 654,0 GPa.
- Diameter: 14,0 mm
- Stress-strain diagram: Linear elastic

GFRP tendons were pre-tensioned to circa 30 % of its tensile strength before concrete were casting according to the [4] recommendation. That refers to the force 30 kN in each tendon. Pre-stressing was put into the slab 14 days after casting. Concrete slab was loaded at the age of 28 days after casting with two 1000 kg weights in thirds of the span. Slab was designed as a simple supported beam. Three displacement sensors were placed under the slab for measurement of the deflection. One was set in the middle of the slab and the other two were set under the each loading point.

Four concrete cylinders were cast in order to determinate concrete shrinkage and temperature effects. VW strain gages were embedded into all cylinders. Two cylinders were moreover permanently loaded.

The concrete slab and the cylinders were loaded in the same time. Regular measurement of the strain and deflection has been implemented since the load has been set. Duration of the experiment was designed for one year.

After 330 days the deflection in the middle of the slab had seems to be stabilized on the value 19 mm. Service-ability limit state allows maximal deflection 1/250L which equals to 16 mm. Therefore SLS requirements were already overstepped The strains of both of the VW strain gages placed on the end of the slab were caused only from shrinkage of concrete that corresponds to the theoretical predictions of simple beam. Values of these strains were about - 400,0 μ m/m after 330 days. The reading of the middle VW strain gages are affected by the stress in the upper and lower fibers as well as the shrinkage. The upper VW strain gage's value was -700 μ m/m. Lower VW gages value was +700 μ m/m after 330 days. These values correspond to the theoretical prediction of simple beam. The experiment was not finished while writing this paper.

There will be numerical model executed after the experiment is terminated which includes the creep and shrinkage numerical models with data from experimental readings from GFRP tendon relaxation.

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Fatigue of Concrete Slabs Pre-stressed with CFRP Tendons

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Service life of steel-reinforced concrete structures is in many cases limited by the durability of the reinforcement itself. There are several possibilities how to improve corrosion resistance but none of these measures or its combination has proved to eliminate the long-term risk of steel corrosion [1]. For this reason in recent years non-metallic reinforcement, such as fibre-reinforced polymers (FRP), has gained great deal of interest by many researchers [2].

FRP reinforcement is by nature corrosion resistant and therefore it can be successfully used in highly corrosive environments such as bridge decks, off-shore structures and slabs in chemical factories where high corrosion resistance is required. Furthermore, FRP reinforcement has other great properties such as low self-weight, magnetic transparency, thermal non-conductivity and generally higher tensile strength than steel.

Behaviour of FRP bars, however, is different than that of steel and is highly dependent on the type of fibre and the production process. Typical mechanical properties of glass (GFRP) and carbon (CFRP) fibre reinforced polymer bars in comparison with steel are shown in Tab. 1.

Reinforcement	Modulus of	Yield strength	Tensile strength	Bulk density
type	elasticity [GPa]	[MPa]	[MPa]	[kg/m ³]
Steel B500	210	500	550	7850
GFRP	20 ÷ 45	—	$450 \div 900$	$2000 \div 2300$
CFRP	$110 \div 140$	_	$1500 \div 3000$	$1700 \div 2000$

Tab. 1: Material characteristics of FRP reinforcement

Because of its promising properties, FRP bars have been studied all over the world. The main research areas include durability of FRP bars in alkaline environment, flexure and shear behaviour of structures reinforced with either normal or pre-tensioned FRP reinforcement. However, virtually no work has been in done in terms of fatigue of concrete members pre-tensioned with FRP tendons.

In general FRP bars have significantly higher creep than steel [3] and therefore large prestressing force losses can be expected. Because of this different behaviour a preliminary research program in terms of fatigue was conducted in Experimental Centre, CTU. This paper presents the most important findings as well as experimental layout and procedure description.

The experimental setup was as follows. Six 4.5 m long concrete slabs with rectangular cross-section $(0.6 \times 0.2 \text{ m})$ were prepared for this experimental work. Each slab was reinforced with five CFRP tendons with a bar diameter of 6 mm. Before each slab was casted, the tendons were pre-stressed so that the stress level corresponds to 950 MPa stress in every one of them. After the slabs were demoulded (ie. 15 days) the tendons were released from the pre-stressing apparatus and the jacking anchors were cut. The class of the concrete used was C30/37 XF, with D_{max} 22 mm.

Seven slabs were prepared and tested in total. Three slabs were subjected to cyclic loading and the other ones were kept still in laboratory environment. Based on the previous 224 experimental work the amplitude of the loading force during the cyclic loading was set up to 20 kN and the frequency of the loading was set to 4 Hz. The magnitude of the loading force was selected so that the macro-cracks do not propagate into the concrete tensile zone. The total number of loading cycles was approximately 1.2 million. After the cyclic loading was finished slabs subjected to fatigue were tested in four point bending test until destruction. The reference samples were tested after approximately 28 days from concrete casting. Ultimate load resistance and stress-strain diagrams were compared for the reference samples and slabs subjected to fatigue. The ultimate load and central deflection at failure of the slab is compared in Tab. 2. Because the first slab (PCFRP 1) cracked during the setup of the experiment the results are excluded from Tab. 2.

10012	The span					
Sample	Age of the slab at	Ultimate load at	Deflection at the			
	testing	failure [kN]	centre [mm]			
PCFRP 2	44	56.2	70.1			
PCFRP 3 fatigue	43	53.7	72.0			
PCFRP 4	28	60.4	77.2			
PCFRP 5 fatigue	48	55.4	70.6			
PCFRP 6	30	55.0	66.9			
PCFRP 7	34	53.5	77.3			

Tab. 2: Ultimate load and deflection at the center of the span

Table 2 clearly shows that there are no significant differences between the slabs which were subjected to fatigue loading and slabs which were kept still in laboratory environment. It is also important to mention that the differences in the load bearing capacity can be caused by slight deviations in curing procedure and concrete batch mixing.

Based on the experimental data obtained it can be concluded that fatigue has no significant influence on both stiffness and load bearing capacity of the slab. This result can be expected as structures from reinforced concrete are usually very massive and they do not tend to be influenced by fatigue and residual stresses. Also the service loads of concrete structures are relatively low compared to its self weight. From the long term point of view, creep of the composite tendons is much more significant issue than fatigue and therefore needs to be taken into account. As the composite reinforcement is a visco-elastic material it was proved [3] that it will creep more than steel. Also the interfacial bond between the reinforcing bar and concrete can be influenced over time. However, more intense testing is purposed and more research on long term behaviour of CFRP reinforced structures is needed.

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Relaxation of Glass Based Composite Reinforcement Subjected to Pre-stressing of Concrete Members

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A significant demand for new materials is today especially for materials that can withstand more than usual and bring better properties within. Answer can be found in composite materials when dealing with reinforcement in concrete. Carbon lamellas externally glued to the structural elements are well known. Application of prestressed composite rod as internal reinforcement brings many new questions. Regarding losses in pre-stressing tendon relaxation is one we focus on in this paper. Main objective of this paper is therefore presentation of GFRP rod relaxation which has been tested in Experimental Centre of CTU in Prague. Furthermore a numerical model of relaxation has been created hand in hand with experiment outcome. This paper shows results of test which has run for 132 days.

Many experiments have been done in the Experimental centre of CTU in Prague regarding pre-stressing of GFRP rods (Glass Fiber Reinforced Polymers). Especially concrete girders with GFRP rods and concrete girders with pre-stressed GFRP rods. Simultaneous numerical approach has been carried out as well. Nevertheless both results form experimental and numerical work haven't fit at all. Therefore it has been searching for a reasonable answer why it is so. It has been found out that if the pre-stressing force in the numerical model is decrease compared to experiment the results are more close to the experimental data. In this way it has been decided that some serious relaxation curve must be given in order to say correctly what a force is really acting in the pre-stressing rods after certain time.

Relaxation test has been carried out in order to establish a stress decrease curve of GFRP rod. Five hundred and forty centimeters GFRP rod has been prestressed to the tensile stress 237,9 MPa that means circa 40% of its strength (600 MPa) and corresponding elongation has been fully fixed. From this time on force acting in the GFRP bar has been observed. Measuring has been recorded after regular time intervals. It has been verified experimentally that the tensile stress decrease after 28 days to 218,633 MPa which is 8,1 % loss. At the end of experiment at the age of 132 day tensile stress has reached 206,941 MPa which is 13,01 % loss. Nevertheless the declaiming trend has not been fully settled. Therefore another and longer relaxation test should be carried out in order to record a wider time range.

GFRP bars consists of thousands micro fibers glued together with a matrix - epoxy resin. Single fibers carry all tensile stress. Epoxy resin takes care of the proper placing and divides equally tensile stress in to all fibers. Fibers and epoxy resin work together side by side. Therefore parallel model layout is chosen in order to set up physically reasonable model.

GFFR rod cross-section is consisting of glass fibers (73%) and matrix - epoxy resin (27%). Young's modulus of GFRP bar is set to 41,247 GPa. GFRP rod cross section has been subjected to nano indentation in order to established Young's modulus of single glass fibers and matrix. From histogram of all nano indents is possible to determinate Young's modulus of the glass fiber (E_1 =53 GPa) as well as Young's modulus of epoxy resin (E_2 =6 GPa).

From parallel layout it's obvious that total tension in GFRP rod is a sum of both tensions in glass fibers and matrixes together. Nevertheless all links of the material chain carry the same tensile stress.

Remaining parameters (E_{11} , $\eta_{11...}$ etc.) appearing in the model has been fitted according to the experimental data with sophisticated MATLAB 2007a algorithm. Solution of differential equations in the numerical model was approximated by the Runge-Kutta 4th order method (MATLAB 2007a).

Relaxation of GFRP rod is important process and its neglecting can cause a significant problems. Tests made in Experimental centre approved that prestressed GFRP bar loses its pre-stressing during time. The main outcome of this paper is that the GFRP bar relaxes and this relaxation is not negligible and can cause serious problems. Unfortunately the test has been ended at the age of 132 day when declaiming curve has not been settled so far. In the future experiments a longer period will be examined in order to record a longer time-depended behavior.

Concrete members with GFRP bars are obviously not suitable for enormously permanent loaded elements. When GFRP bars are used than minimum permanent load should be secured otherwise failure may occur.

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Determination of Material Characteristics of GFRP Bars from Nano to Macro Level

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Basic material properties have huge influence on the overall behavior of concrete members reinforced with glassed based composite reinforcement. Each producer performs another technology therefore basic material properties assessment should be carried out each time in order to set up exactly basic mechanical characteristics.

High strength, low self weight, high resistant to salt water and another chemicals are those that point of GFRP. Nevertheless small elastic modulus can be observed. GFRP bar is consisting of two main products - glass fibers and matrix. Each of them has its special behavior nevertheless together create a special product which behavior can be much different that just a simple summation of these two. This effect is called synergism and it is a typical composite material characterization.

Starting from nano level nano-indentation is performed o set up material properties at the nano-level. Basic E-modulus of glass fibers as well as E-modulus of matrix- epoxy resin. Huge scatter is found in the nano-indentation nevertheless the most values are situated around 6 GPa and 53 GPa. Therefore 6 GPa is Young's modulus of matrix and 53 GPa is Young's modulus of the glass fiber.

Overall modulus of elasticity is tested at the FPZ 100 loading machine. A special locksmith element is developed in order to record strain of the GFRP bar. Three sensors are placed at the element. The locksmith element is fixed only to the GFRP bar at two levels. In between distance is circa 160 mm. The acting force is recorder together with the elongation therefore Young's (elastic) modulus can be determinate. Five samples were measured. Average Young's modulus of elasticity was evaluated to 41,247 GPa with standard deviation 1,024 GPa. This overall value corresponds to the nano parameters investigation were equation (1) must be hold.

$$c_1 \cdot E_1 + c_2 \cdot E_2 = E_{GFRP}$$
 (1)

Where:

C is proportional volume of glass (73%) or matrix (27%)

E is elastic modulus of glass fibers (53 GPa) or matrix- epoxy resin (6 GPa)

Therefore E-modulus of GFRP bar according to the equation (1) is evaluated as 40,31 GPa which is not far from the experimental readings measured at the FPZ loading machine.

Maximal strength capacity of the GFRP bar has not been reached because of maximal loading capacity of the FPZ loading machine. The maximal capacity is 100 kN which performs tensile stress 650 MPa in the d=14mm bar. Therefore no rupture was observed. Nevertheless unloading part was recorded in the stress-strain diagram. The loading and unloading part of the stress-strain diagram proved elastic-linear behavior of the GFRP bar up to the tensile stress 650 MPa.

Last but not least coefficient of thermal elongation has been evaluated. Some problems were found under very high temperatures. Therefore elongation was tested only between room temperature and temperature 100°C. Nine specimens were subjected to the 100°C thermal heating for several hours. Afterward elongation was measured. From nine specimens average value 7,114.10⁻⁶ K⁻¹ with standard deviation 0,384 10⁻⁶ K⁻¹ was measured.

Low elastic modulus is disadvantage of GFRP. Low elastic modulus performs enormous deformations and indicates early crack development. Coefficient of thermal elongation slightly differs from the coefficient of concrete nevertheless no strict restriction are taken. More problematic is direction perpendicular to the fibers where coefficient of thermal expansion can reach values 4-5 times higher than concrete. Therefore one and half diameter cover must be secured as a sufficient restriction against cracking and spalling.

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XRD ANALYSIS OF ZIRCONIUM ALLOYS OXIDIZED AT 360 °C IN WATER WITH DIFFERENT pH

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The aim of the present study was to determine the difference of properties of oxide layers arising on zirconium alloys during high temperature oxidation in VVER environment, pure water and water with 36 ppm Li addition. The residual stresses σ , crystallite size D and micro strains ϵ were examined by means of XRD. It has been shown that oxide layers of alloys under investigation have had the different characteristics in the same oxidizing environments. The "dry" and "wet" samples of two differently manufactured types of Zr1Nb alloy (denoted 6 and 7) were investigated. The so-called "dry" samples were dehydrated on air after corrosion expositions and "wet" samples were permanently kept in water after corrosion exposition. A hydrated layer is formed in the oxide of wet samples. It can be interpreted as a compact system of amorphous gel-like formations and crystalline oxide. Since the amorphous gel cannot be detected by X-rays, the obtained characteristics are related only to the crystalline part of the hydrated layer.

A D-8 Discovery powder diffractometer with CoK α radiation was used to measure diffraction patterns. In oxide layers of the samples investigated, the measurements were performed on {10-4} planes with $2\theta = 85.2^{\circ}$ for CoK α radiation. The appropriate effective X-ray penetration depth $T_e^{(10-4)} = 3.68 \ \mu\text{m}$. The fitting procedure had to be used to obtain the accurate profile characteristics such as peak position 2θ and .integral breadth W_{int} . The X-ray diffraction method [1] was used to determine the macroscopic residual stresses σ in oxide layers. The method is based on determination of lattice strains e^{ikt} from which, subsequently, the stresses were calculated by using appropriate macroscopic Young's moduli. The evaluation of the crystallite size and lattice strains was performed by using a "single-line" method with the Pearson VII approximation of the profiles' shape. The results of the experiment are given in tables 1 and 2.

Table 1

Average values of XRD obtained macroscopic stresses for wet (W) and dry (D)oxide layers of Zr1Nb alloys (denoted 6 and 7) oxidized in several environments. $R\sigma$ D-W is the difference between the values of stresses for dry and wet samples. All the values are in Mpa

Environment	water	water	VVER	VVER	36 ppm Li	36 ppm Li
Alloy	60	70	61	71	63	73
Average σ W	-1229	-1128	-1316	-1154	-1090	-1184
Average σ D	-1218	-1110	-1240	-1084	-1197	-1171
RσD-W	11	18	76	70	-82	13
Error of measur.	65	83	70	65	71	58

Table 2

Average values of XRD obtained microcharacteristics D and ϵ for wet (W) and dry (D) oxide layers of Zr1Nb alloys (denoted 6 and 7) oxidized in several environments. The values of D are in nm

Environment	water	water	VVER	VVER	36 ppm Li	36 ppm Li
Alloy	60	70	61	71	63	73
Average D W	15	17	15	19	13	16
Average D D	17	19	16	21	15	18
Error of measur	2	3	2	3	1	3
Average e W	0,0081	0,0080	0,0084	0,0080	0,0078	0,0082
Average.e D	0,0082	0,0081	0,0082	0,0081	0,0079	0,0085
Error of measur	0,0006	0,0002	0,0003	0,0006	0,0002	0,0008

It follows from the data tabulated that:

- the values of macroscopic stresses σ in the crystalline part of hydrated layers decrease in comparison with those of dry samples. This effect is systematic except for the alloy 6 oxidized in Li environment.

- the values of crystallite size D in the crystalline part of hydrated layers decrease in comparison with those of dry samples. This effect is systematic.

- the values of crystallite size D in the crystalline part of hydrated layers for alloy 6 are smaller in comparison with those of alloy 7.

It can be concluded from the results of measurements that

- the characteristics of wet samples observed by means of XRD are affected by the aqueous environment for the alloys under investigation,
- the behavior of Zr1Nb alloys under investigation is found to be different in the same oxidation environments especially in Li-environment,
- the oxide layers of alloy 6 contain more of the gel component in comparison with alloy 7 in the all oxidation environments with different pH.

This study refers to recent research [2, 3].

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Optimalization of Laser Parameters for Heat Treatment of Selected Types of Materials

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A unique advantage of the laser hardening process over conventional heat treating processes is the possibility to adjust its spot ideally to the contour requiring hardening and, therefore, to achieve extremely high throughput.

Laser surface hardening is the heating of a surface by use of a laser and then allowing rapid quenching by conduction. This provides a hardening on the surface of the material through a solid-state transformation that results in the formation of a high-hardness microstructure, i.e. martensite. The depth of the hardened zone may be altered by varying the amount of heat input provided to the work-piece.

This work includes the results of the tests of heat treatment following materials:

- X210Cr12 high-alloy tool steel, used for cutting and cold molding tools, tools for sheet metal cutting and moulds
- 90MnV8 tool steel, used for cutting tools for non-metallic materials, tools for sheet metal cutting and tackle.

EN-GJL-200C $\,$ -gray cast iron, used for casts with the wall thickness 8 \div 45 mm The experiments were performed on two lasers:

550 W GSI LUMONICS 701H Nd: YAG laser and

3100 W Rofin-Sinar DL031Q diode laser.

Laser surface hardening was applied on two types of surfaces – circular and flat and than was analyzed the hardness on of the surface, the microhardness in the depth, the wear resistance and the changes of the microstructure of the hardened materials.

For the measuring of the hardness were used three hardness testers – Leco V-100-C, VEB HPO-250 and Shimadzu HMV 2.

Metallographical study was realized on JEOL JSM 5410 electron microscope.

For the testing of the wear resistance were used two different tribometers:

Amsler A135/275 tribometer, which is used for evaluating of wear of the circular surfaces (specimens). The basic function of this machine is following: two specimens are rolling on each other with a load, one specimen is hardened by laser, the second one is hardened convetionally.

EDA tribometer, machine designed for testing of wear of the flat surfaces and their coatings. The companion part is a ball made of ceramic or hardened steel.

Various trajectories of the laser beam were used there. There was also the problem with size factor. It's different to quench a capacious specimen, where the heat removal is very good, or a relatively small specimen with low heat removal. However, this was our case so there was a need of the optimalization of the laser parameters (especially feedrate).

Optimal parameters of both lasers were obtained.

Better results were obtained with the powerful diode laser. This laser is with its output power of 3100 W able to harden the depths overlapping 1 mm by the widths of the tracks about 10 mm.

In the case when the depth less then 0,5 mm is sufficient, it's possible to use the weaker Nd: YAG laser. The width of track is about 3,5 mm.

In general it's possible to say, it's better a little burned surface, which will be consequently grinded. For an optimal absorption of the beam laser is always important to keep a minimal surface roughness. When the surface is too smooth the beam will be reflected and the hardening depth will be very thin. The overlapping of the hardening tracks is bad for the hardeness at a depth, but the the effect for the wear resistance is positive. After these findings we can say that in the case of optimal laser parameters it's possible to reach a wear resistance which will be comparable to convential hardened components. So it's possible to use this technology for industrial applications.

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X-ray Computed Tomography Utilization for Flow Detection in Material.

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The task of this work was evaluate computed tomograph VT - 400 in using for nondestructive detection of hidden defects in material and in cooperation with Prague centre of industrial tomography at FNSPE CTU (The Faculty of Nuclear Sciences and Physical Engineering, Czech technical University) suggest and verify method or procedure how effectively and exactly from tomography image, almost without user's intervention, evaluate the percent of porosity in surveyed slice. Till now porosity from tomography image was determined hardly by estimation according with user experiences. For experimental purpose were used three types of samples, programming software Matlab and for results comparison was used destructive test of scratch pattern analyzed in program for image processing NIS Elements BR 2.30.

If we compare computed tomography with other non - destructive methods, it is the most perfect method, that we can use for checking components, because it makes possible to detect a size and distribution of surface and internal defects. But using of computed tomography has indeed certain limitation e.g.: size of controlled object, skills of CT operator, no portability of arrangement, time and financial demanding and therefore others NDT methods have its irreplaceable applications. Using of computed tomography is fit option for checking inwards complicated casts (turbine blades, engines blocks, etc.), for checking composite and ceramics products, for displaying three dimensional placement, etc.

In these work is introduced a proposal for porosity evaluation from tomography image. This procedure, method, replaced the estimation of porosity.

Proposed method for porosity evaluation from CT image is programmed by Matlab software and it is composed of following steps:

- 1) Processing of images data from CT image (image processing)
 - operations for removing undesirable noise and artifacts, which developed due to interaction of X rays and material of sample.
- 2) Application of algorithm in agreement with so called Grey level method
 - o computation the percentage of porosity from CT image

Subsequent destructive test of samples by scratch pattern (it was composed of cutting and making the scratch pattern at the same position as tomography slice and evaluation of surface ratio of exposed defects by the program NIS Elements BR 2.30.) was very demanding of accuracy (agreement defects in the CT image with defects in scratch pattern) and it was very time consuming. This destructive test was necessary for functionality verification of proposed method and for valuation of results deviations from proposed method. 234 Values of surface ratio of defects (pores) obtained by destructive testing and values of porosity computed from CT imaging were compared and following conclusions were deduced:

- 1) Proposed method gives altogether accurate results with samples with internal defects if they are displayed with higher intensity on CT image. Average deviation from surface ratio of defects is to the 15%.
- 2) Proposed method, in current version, can not be used for evaluation CT imaging when they are pores related with surface of sample.
- 3) Displaying of defects (pores) on CT image is suggested by:
 - a. setting of scanning parameters (voltage, filters, collimators)
 - b. display resolution of CT scanner (industrial tomograph VT 400 with its best resolution 1024x1024 can displays a pixel with minimal proportion 0.1mm)
- 4) Difference of results is influenced by:
 - image processing of CT image, the biggest error is bring with operation for noise removing from CT image
 - different resolution of both method (proposed method is influenced by CT scanner resolution, destructive test can detects defects (pores) smaller than industrial tomograph VT - 400)
 - occurrence of pores which sizes are close to resolution of CT scanner (fuzzy places on CT image)
 - certain difference of CT image and surface of scratch pattern.

All mentioned conclusions else appear from small quantity measuring, which was very time consuming, but in spite of they have influence for debugging of proposed method to getting most accurate results of porosity from CT images. If we would be accurate it had been done more measuring for eliminating statistical error. It is a subject of next research. If we would be accurate it had been done more measuring for eliminating statistical error. It is a subject of next research. Proposal method brings a new effective approach to quantifying porosity from CT image of aluminum castings.

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18TH ANNUAL CTU UNIVERSITY-WIDE SEMINAR

These are the Proceedings of the Eighteenth Annual university-wide seminar WORKSHOP 2009 which took place at the Czech Technical University in Prague from 16th to 20th February, 2009.

The aim of the seminar is to present and discuss the latest results obtained by researchers especially at the Czech Technical University in Prague and at collaborating institutions.

The organizing committee has selected a total of 221 contributions divided into 15 different areas of interest:

• Part A:

- mathematics
- physics
- informatics and automation engineering
- electrical engineering and instrumentation
- materials engineering

• Part B:

- mechanics and thermodynamics
- mechanical engineering
- production systems, technology and technological processes automatisation
- energetics and power engineering
- nuclear engineering
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- biomedical engineering
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Section 6

MECHANICS & THERMODYNAMICS

Modeling of Throttling Process inside Capillary Tube

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Faculty of Mechanical Engineering at CTU in Prague has cooperated with international research centre CERN in Geneva already for many years. Members and students of the Department of Physics are involved in various fields of research activities connected with design of unique particle detectors. Our team participates especially on design and consequent testing measurements on both the prototypes and the final installations of special cooling circuits intended for ATLAS and TOTEM experiments. These cooling systems are in principle special vapor cooling circuits which work with saturated fluorocarbons as refrigerants. Particularly according to space confinement and extraordinary large number of evaporative lines, the small diameter tubes, i.e. capillary tubes, are employed as expansion devices in the most of these circuits.

Expansion process inside the capillary tube is quite complex problem connected with gradual two-phase flow generation. This phenomenon has been studied by many researchers. Nevertheless a robust method for general design of the capillary tube has not been generated yet. Therefore both the single-phase and the two-phase flow inside copper, copper-nickel, and aluminum capillary tubes of different dimensions have been investigated also at the Department of Physics. The capillary flow of fluorocarbon fluids has been studied on special experimental set-ups both at the CTU and the CERN laboratory; see for instance [1].

In this project, the existing numerical simulation, presented in [2], of the fluorocarbon refrigerant throttled inside the capillary tube was modified. The model was extended by the solution of two metastable flow regions which usually occur in the throttled flow. The one-phase metastable flow of superheated liquid was correlated by the model similar to that of Chen et al. (ASHRAE Transactions 96, 1990) based on heterogeneous nucleation theory. The underpressure of vaporization Δp , i.e. main quantity describing the liquid metastable flow, was determined either from the original model of Chen et al. derived for standard refrigerant R12 or from the new correlation applicable on fluorocarbon substances

$$\Delta p = 0.645 \frac{\sigma^{3/2}}{\sqrt{KT_{sub}}} \left(\frac{\rho_l}{\rho_l - \rho_g}\right) R e^{0.876} \left(\frac{\Delta T}{T_{crit}}\right)^{0.229} \left(\frac{d}{d'}\right)^{-3.175} \,.$$

Presented correlation was evaluated by using 71 sets of our own experimental data measured with the saturated fluorocarbon. Relative error of the equation was ± 27 %. The two-phase metastable flow was defined on base of the model introduced by Feburie et al. (Int. J. Multiphase Flow 19, 1990).

Generated numerical simulation can be used for predicting the flow performance of both the standard refrigerants such as R12, R134a, R600a and the saturated fluorocarbons e.g. R218 and R610. The numerical model has in general simplified the procedure of capillary tube design and has significantly reduced the amount of necessary experimental tests of newly designed cooling system. Relative deviation of predicted mass flow rate from our measurements performed with R218 lied within the range of \pm 3.5%. The experimental results together with detailed model description were presented in [3].

The experimental measurements performed by our team revealed another quite interesting phenomenon affecting the overall performance of the throttling process. The refrigerant fill got contaminated by non-condensing gases, mostly by air, after some operational time. This event is quite common also in standard cooling circuits such as those for household freezers or air-conditioning units. It is well known, that the non-condensing gases accumulate inside the condenser and decrease the efficiency of the cooling circuit due to the increased condensing pressure. Nevertheless, our experiments showed that the non-condensing gases also partly dissolve in the liquid refrigerant and travel along the whole circuit. The one-phase flows of liquid and vapor phases remain practically unchanged, while the throttling process gets significantly affected by a presence of gas-impurities. Partial pressure of non-condensing gases concludes in earlier onset of vaporization located closer to the capillary tube inlet. Consequently the metastable flow regions vanish and the mass flow rate reduces by approximately 15 % even by quite low gas-contamination.

New numerical model of the throttling process of gas-contaminated refrigerant is being prepared now. The energy equation uses the temperature dependency of Henry's law constant describing solution of gases in liquids. Unfortunately, there is only limited set of data of gassolution in the saturated fluorocarbons available in the literature. The Henry's law constant had to be therefore determined theoretically by using an equation of state (EOS). Two different EOSs were employed in our study; the cubic Peng-Robinson EOS and the perturbedchain modification of statistical associating fluid theory (PC-SAFT). Solubility of oxygen, xenon and nitrogen was modeled by the both EOSs. Determined correlations were introduced at [4]. The evaluated Henry's law constant will be implemented into prepared numerical model of the gas-contaminated refrigerant flow.

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Simulation and Modeling of Air Supply Diffusers

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Computer simulation software of various types is nowadays widely used for estimating of air flow patterns, temperature and concentration distribution fields. Room air supply is provided with distribution elements that are in CFD software (Computational Fluid Dynamics) modeled using simplified methods. These methods enable an easier input of boundary conditions into CFD software and a faster calculation.

A vortex air supply diffuser was chosen and measured, because this type of distribution element is widely used in real applications. The reason is that it enables air supply with a large temperature difference Δt_{s} , thus leading to reduction of both investment and operating costs. The next reason for choosing a vortex diffuser as the subject of research was the fact that a large number of research studies dealing with air supply elements was carried out, especially in abroad.

On the other hand, currently just one study of a vortex air supply diffuser considering simplified boundary conditions for CFD is known. Applied simplifying boundary conditions for a vortex diffuser were derived using transformation of measured values of round ceiling diffuser, which is significantly different from the vortex diffuser. There is no study known to derive simplified boundary conditions for a vortex diffuser based on experimental measurement.

Department of Environmental Engineering at Faculty of Mechanical Engineering of CTU in Prague owns Fluent software. Simplified theoretical simulations based on experiment are carried out in this software tool. A numerical model has the same dimensions as the real element. During the numerical calculation, the vortex diffuser was divided into 9 sections with the same area. There is no air flow in the central section. The air stream flowing from each other section has always a different direction, with its angle shifted of 45° compared to the preceding sections. The outlet velocity from the particular section is entered in directions of x, y, z axes. For a faster and easier computation of velocities in directions of the defined axes, a calculation method was created in MS Excel, which gives velocity x, y, z components after entering of volumetric flow rate and outlet velocity angle. The results of numerical calculation are compared to experimentally measured values.

The vortex air supply diffuser with dimensions of 400 x 400 mm with 16 vanes (WDV type made by Trox Company) is placed into the center of ceiling in the experimental chamber in the laboratory of Environmental Engineering Department at Faculty of Mechanical Engineering of CTU in Prague. The chamber is symmetrically divided with this diffuser. The inner dimensions of the chamber are $4,2 \times 3,6 \times 3$ m. Supply air is handled in the air-conditioning unit Robatherm, the air flow rate is measured with orifice gauge. A unique positioning device was created for measuring purposes. At this device, sensors HT 400 are attached. They measure air flow velocity in the range from 0,05 to 5 m.s⁻¹ as well as turbulence intensity of the flowing air. Temperature of supply and exhaust air is measured with Pt 100 temperature sensors. Measured values are indicated on data loggers connected to a computer. Data recording interval is set to 3 minutes because of velocity sensors integration.
The evaluated measurement was carried out for a volume air flow rate of 400 m³.h⁻¹. The value of air exchange in the room was I = 8,2 h⁻¹. The temperature difference between inlet and outlet was $\Delta T = 0.8$ K. This value proves that this air flow is isothermal. A vertical temperature difference of 0,3 K/m is allowed. Also a visualization of air flow was carried out using a smoke test, by which the Coanda effect was clearly visible. The supply air, influenced by the Coanda effect, stays attached to the ceiling. It flows in the same way until it reaches the wall and then the stream falls along it down to the occupied zone. Because of so called induction, the polluted air is added to the fresh supply air stream under the diffuser and consequently these two streams are mixed.

The objective of the measurement was verification of the flow pattern symmetry. If this symmetry was proved, it would be possible to make calculations only for a half of the space, which would significantly accelerate the computation. The symmetry of the room is obvious; however the diffuser vanes are symmetrical only if they were turned over horizontally of 180°. The room was divided into four quadrants; the sensors for measuring air flow velocity and turbulence intensity were placed into the centre of each quadrant 100, 200, 300, 400, 2700 and 2850 mm beneath the ceiling. The air flow velocity was measured in the range from 0,11 to 0,47 m.s⁻¹. The highest velocity deviation for a single spot in quadrants adds up to 0.09 m.s⁻¹, which is 21.8 % due to low velocities of air flow. Uncertainty analysis determined the combined standard deviation to a value of $\pm 0.01 \text{ m.s}^{-1}$. The values of turbulence intensity vary from 19 to 49 %. The highest deviation of turbulence intensity for a single spot in quadrants is 10 %, which means an overall error of 28 %. The value of combined standard uncertainty is in this case $\pm 1,1$ %. Based on these facts, a conclusion can be drawn, that this air flow is not symmetrical. For this measurement, a plenum box with a horizontal inlet was installed. It was anticipated, that the plenum box would cause equalizing of static pressure and the outlet air flow would be uniform.

After the measurement and evaluation, a different type of plenum box with a vertical inlet is being installed. An additional measurement of air flow symmetry in the room will follow.

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Simulation of unconventional engine with rotary pistons for using heat with low potential

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The use of low-temperature heat has become the great importance due to the ever increasing cost of primary energy sources. Both renewable sources (e.g., solar radiation or biomass combustion products) or waste-heat utilization from other thermal engines require simple and efficient thermal machine. It should use external heat supply and air or water steam as a working fluid for the sake of simplicity. High pressure and sufficient expansion ratio create conditions for reasonable thermal efficiency. The use of reciprocating piston requires clumsy, unbalanced and expensive cranktrain. Lubricating oil may cause other problems, especially if inlet temperature is higher than 450°C.

The paper is focused on novel five period cycle [1],[2] realization in a positivedisplacement engine with cycling piston motion, where the working spaces are created mostly between pistons, i.e., not between a piston and stator ("cylinder") of an engine. The working fluid for is atmospheric air at this stage of development.

The engine was simulated in GT Power. The solution was found using authors' accumulated experience with very flexible GT Power simulation tool [4], although originally focused on single-acting reciprocating ICE. The flexibility in describing of engine volume, heat-transfer surface and port/valve area changes enables the authors to set up a model, which describes all involved phenomena, including gas dynamics in connecting pipes and inside a multiple-pipe heat exchanger. This tool was calibrated using the first experimental data from individual machines and used for optimization purposes then.

The novel engine simulation poses an issue: it is no routine task for existing simulation codes. From the other side, the unsteadiness of processes inside an engine calls for detailed description of engine gas dynamics.

The resulting traces of engine indicated power is 13 kW and indicated efficiency is 32%. Despite low temperature of heat supply the efficiency is not bad – it is comparable to competitive concept more complicated Stirling engine at realistic heat supply temperatures 650°C. On the other side, the specific power at 6 000 r.p.m. of crank (3 000 r.p.m. of double-acting piston) is not very high taking the swept volume into account – the swept volumes of individual stages are between 1.6 and 0.2 dm3. It is the major problem for a stationary unit but it is associated with low mechanical efficiency, which may hamper the brake parameters of engine – as well-known from any low-power engine. The results of preliminary measurements at cold machines gave mechanical efficiency estimate of 75-80%, which would give still acceptable results with temperatures of 600 - 650°C. The issue of mechanical efficiency will be topics of another paper in the future.

The difference between theoretical prediction in OBE_REG [3] and simulation is caused by detailed modeling of pressure and heat losses. The association between power

density and efficiency, which was predicted in OBE_REG [3], was confirmed by this simulation.

The paper presents the preliminary results for estimation of potential offered by a novel engine concept. The components – positive displacement machines – can be used, moreover, as compressors or expanders individually.

The current results show the reasonable level of efficiency achieved at low inlet temperatures but the limits may be posed by comparatively small power density. The experiments planned for the next year will elucidate the potential more. There are still other problems in design to be solved but the current experience offers realistic hope to overcome them.

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Ohmic Heating and Fouling of Foods

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General target of the heat processes like pasteurization or sterilization is to protect the food against microbiological changes (high temperature exposition is needed) and on the other side not to endanger quality of the food products too much. High temperature heating with very short temperature exposition is demanded. These conditions can be realized using UHT sterilization method. Classic convective methods to heat the process fluids by using plate heat exchangers are still most popular in food industry.

Direct ohmic heating (Joule's heating) is a quite old technology to warm up the food using an electric energy where electric current is passed through a material which gets heated by virtue of its electrical resistance. Unequivocal advantages over conventional indirect heating methods are speed and uniformity of heating. These properties can be used to improve microbiological safety of food or warming up the food without defection of nutritive values. The other advantage is an easy control of the heating process.

On the other side, direct ohmic heating has some problems, for example deposits creation on electrodes (fouling), which prevent wider applications of this technology in food industry. In the case that the fouling will be mitigated, the technology of the direct ohmic heating will find application in the dairy industry to realize an UHT processes, catering and others.

The research of fouling during ohmic heating of food concentrates upon the principle question: what are differences between the fouling in the classical convective and the direct ohmic heating? The other opened questions concern: effects of material properties of electrodes, shape of electrodes, surface properties of electrodes and the effect of power frequency, shape and width of the electric pulse on the process of the ohmic heating of food, corrosion of electrodes, deposit creation on electrodes and on the properties of food like a contamination with metals from electrodes and sensorial properties of heated food.

A continuous ohmic heater with rectangular cross-section was used for the fouling experiments. Two sides of the rectangular channel acted as electrodes. A skim milk was used as the process solution.

Presented experiments with the direct ohmic heating of milk identified effects of temperature of the flowing milk, flow rate, current density and material of the electrode (electrodes were made from stainless steel, stainless steel with TiN coating and graphite). It turned out that the deposit creation on electrodes is pertinent to the problem of the electrodes corrosion. Effect of the corrosion of electrodes can be eliminated using electrodes which are made from quite noble material (like gold or platinum). High price of the electrodes from noble materials amounts this principle unusable in the industry applications.

Other principle how to eliminate problems with electrochemical processes is based on using higher frequencies (about 10 kHz) and the right shape of the pulse from a pulsed power supply. For this purpose a new pulsed power supply for an ohmic heater was developed.

Our pulsed power supply is based on DC-AC converter which was built up using power MOSFET transistors in full-bridge connection. All MOSFETs are controlled by MOSFET driver. Timing and pulse shape selection attend programmable one-chip microprocessor. This design enables not only to adjust the feeding frequency but also an optimal delay between pulses that is necessary for discharge of an electric double-layer at the electrode surface.

Results of our research set oneself a task to check on suggested working hypothesis (demonstrated in numerous papers [1-3]) which can be summarized as follows: During the lagphase the corrosion of electrodes due to faradaic processes takes place, resulting in an initial microlayer of deposits. This layer presents inner volumetric source of heat. The microlayer is overheated owing to the electric current passing through. This cause gets started denaturation of the whey proteins in milk and formation of aggregates, sticking at electrodes. It makes itself power falling down. In addition overheating of the fouling layer some components from electrodes due to faradaic processes can be transferred to the process solution.

Undisputable results of our experiments follow from recorded increase of overall electrical resistance, which must be attributed to the deposit layer in view of the fact that the specific electrical conductivity of circulating milk is almost unchanged. Knowing increased electrical resistance the deposit layer overheating was evaluated and predicted temperature profiles across this layer indicate importance of the ohmic overheating phenomena.

Some information about composition and properties of the corrosion micro layer and the deposit layer were obtained from laboratory analysis of proteins and heavy metals concentration in flowing milk during ohmic heating in a closed loop. Amount of deposited proteins follows directly from the mass balancing and the amount of deposits is related to the observed increase of electrical resistance. Heavy metals content in periodical samples of circulated milk enables assessment of corrosion kinetic. In this way the fundamental relationship between the easily measurable electrical resistance and the corrosion as well as formation of deposit layer (that is not so easily measurable) can be identified and used for process optimization. The process optimization means first of all tuning of feeding frequency and shape of voltage pulses.

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Real Prediction of Bone Remodelling Effects in Human Body Using Thermodynamic Model

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Bone is a living tissue that is constantly being renewed. The cells that participate in the process are the OB osteoblasts(bone forming), MNOC osteoclasts(bone dissolving), and OCy osteocytes(bone cells). They form a temporary anatomical structure, called basic multicellular units, that carry out the remodelling process (for more details see [1]). A number of factors affect bone turnover, including hormones, cytokines, and mechanical stimuli. Mechanical loading is believed to be of very high significance as a stimulus for bone cells [3], which ensures proper bone strength and prevents high bone loss with age.

Bone remodelling also repairs an accumulated damage from everyday loading by renewing the tissue, plays an important role in metabolism since bone is used as a reservoir of many minerals (e.g. calcium, potassium) and hormones (e.g. parathyroid hormone PTH) and remodelling process is a way to access these storages.

In our approach, we describe the mentioned phenomenon using stoichiometric equations. Kinetics of these mentioned processes is governed by a system of ordinary differential equations (obtained from the law of active masses; for more details see some of our previous work - e.g. [3,4]).

The bone remodelling process together with its control is still not fully understood even if there has been a great step forward in last decade, especially on the cellular level. It is very important to be able to predict response of bone to varying condition - both mechanical (e.g. joint implants) and biological (e.g. hormonal) changes. Models that are nowadays used for simulation of BR are still not sufficient.

All used parameters in this model are realistic and measurable. Unfortunately, we do not have nowadays enough knowledge for precise identification of all of them. However, we can perform reasonable estimation based on experiments and nowadays knowledge of the process found in literature. It is very important to know stationary solution of the dynamic system because (if stable) it gives us some idea about solution of ODEs and necessary conditions for parameters may be derived. Because they describe evolution of normalized molar concentrations, it is needed to ensure that the solution is positive for all t>0. Moreover, appropriate linear combinations of solution which represent all the other involved substances need to be positive too. To satisfy these natural conditions several constraints for parameters arise.

Since ordinary differential equations are in dimensionless form, the parameters representing chemical reaction rate can be assigned just from ratio of reaction rates. Further, the resorption rate of bone is estimated which enables us to determine concentration of osteoclasts MNOC, osteoblasts OB, and osteocytes OCy. Moreover, a relation between real

time t and computational time τ can be found. This is of crucial importance since we may predict changes and their development in time.

The model here presented combines both the mechanical stimuli and biochemical control. With current settings of parameter the model has all the following features that already describe the bone remodelling process to reasonable extent:

- realistic and measurable model parameters
- positiveness of all molar concentration of involved substances
- unique positive stationary solution
- correct rate of chemical reactions
- resorption rate of bone (1 MNOC resorbs 390 μm³/hr)
- number of active BMU (active remodelling foci)
- molar concentrations: [MNOC], [OB], [OCy]
- relation between time scales(computational and real time)
- 1 mol of new bone transforms into 1 mol of old bone tissue (mass may differ)
- MNOC apoptosis (mean life in vivo is 3 days; compare to time scale of bone remodelling)
- initial concentration of involved substances
- the influence of mechanic stimuli on reaction rates satisfying e.g. $\rho_{max} = 20 \rho_{min.}$

We are about to start using the presented model for predicting bone adaptation in humans and use the results for further verification.

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Section 7

MECHANICAL ENGINEERING

Gears Quality Diagnostics

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Introduction

Gears quality diagnostic will be done with special measurement stand. This stand has been designed and realized. This paper describes it.

Niemann's back-to-back circuit

Niemann's back-to-back circuit is less energy demanding than open-loop. Testing circuit consists of measuring and additional gearboxes, driving electromotor, loading equipment, and sensors of torque, rotational speed, vibration and temperature. The torque in circuit is established during stand operation. The test-rig is adjust for possibility of geometry change for testing of pitting and tooth bending.

Testing conditions of gearwheels and its assembly should be similar as actual operational conditions. By reason of test time shortening it is necessary to select larger torque in closed-loop circuit than in industrial operation.

Sensors of torque and other circuit parts

Power losses and virtual power in circuit during running are recorded by two rotational speed sensors and two torque sensors. There is no attendance during the operation, an overload safety is needed. Torque sensors are mechanically secured against overload. Tooth root break can arise during testing of tooth bending fatigue and the inertia moment can exceed the torque sensor permissible overload during unexpected gear block. Maximal overload is 150 % of nominal torque. The breakable screws which are parallel with coupling axis are used for security against torque sensor damage. The disk with holes for fixing laminar springy element and breakable screw thread is between parts of Radex-N coupling.

Testing gearbox is divided in two parts because of easier test gearwheels change. Coupling with involute splines and ETP-Techno coupling is securing simple connection of the gearbox to the circuit. Measuring of torque, rotational speed (N1, N2), temperatures and oil pressure (P1, P2) can be placed in to group of global values.

The torque scanning between electromotor and additional gearbox (M1) is used for determining the whole circuit efficiency. This value corresponds to losses in gear assembly, bearings, coupling, etc.

Four thermocouples are attached on testing stand and they are used for measurement of oil temperature in the input and output (To1, To2, T6, and T8). These values are needed for the calculation of oil heat transfer.

Process loading of gearwheels

Process load is defined as history of gearwheels loading during its expected lifetime. In this case it is change of torque and rotational speed in time and description of all of abnormal cases in operation with gearwheels.

The history of loading is composed of different limited time periods, where loading process is sufficiently accurately characterized. For example, the process can be sectionalized

to these operating phases: run-up, steady regime, braking, run-out, idle regime, overloading etc. The loading regime has to be determined in advance.

Process of gearwheel load is opportunely characterized by the torque and rotation speed in the time. To control of these actions the automation is needed. For controlling of rotation speed, we used electromotor converter which is controlled by PC. The torque in circuit can be changed during operation by the turning of coupling parts. The automatic solution for control of torque is not applied yet, but the design of this device is ready to produce. At the start of the test it is possible to setup requested automatic periods. Setup is formed on control touch screen by putting requested values in time dependence.

Scuffing problem

In the test starts a problem with initial scuffing occurred. As scuffing influences the pitting lifetime, the scuffing elimination is necessary. Scuffing arises at specific conditions influenced by size of tooth line load, tooth geometry, specific sliding, lubrication, temperature and other factors. Test requirements did not allow a lot of changes (oil, temperature, geometry, load, etc.). Finally, the way to eliminate scuffing was found. Second (solid) line in figure 10 represents longer gradual run-in. The load starts on the same level and rises by 50 Nm every half an hour up to testing load. It probably causes the peaks effacement and better meshing condition. Residual edge wear should be removed by applying of modifications.

Fem calculation of gearing

The solution of the contact and geometry problem is made in the group gearing models, which are stored in the coordinates of intersections axis of the shaft and the front planes of the gearing on the deformed shaft in the given plane, to define the gear mesh, and are loaded of the loads moment.

Results

Measuring stand is ready to work, the first tests are done. Methodology of measurement is tuning now. Samples for testing are produced and the tests are planned to be done this year.

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Analysis, Modelling and Simulation of the Effects That Determine Conditions of Production Made to Order by Small and Middle - Sized Industry Enterprises

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Introduction

Because of principle growth globalization economical market in last years and it's supposed future itnensification, the job-order manufactur put on of meaning custom type production in all industrial regions, inclusive machine. Regarding high competition producers are forced to switch from seriál production to job-order manufacture or directly specialize. Job-order manufacture requires specific access to system scheduling and production control. Principle factors biasing whole industrial process are getting into the centre of attention – what, whereof, when, where, in what quantity, on what machine and how much will the production cost. Situation happen much complicated at necessary realization of more parallel orders.

The level of computer technology today already makes it possible to creation virtual model of job-order manufacture, through it's studies there will be the possibility to identify chief factor that influence production and after to create methodology for their optimalization. Without detection these factors and their influences the lean production odes not work, it is not possible to racionalize job-order manufactur and the grow of this production without any more specila costs, that makes the competitove advatage much more harder. Small and middle industrial compenies are very well informed about it and they are focused on analysis, simulation and malingering efficient production.

Make-to-order production system

Job-order manufactur of machinery made gain of importance in last years especially because of staggering competition in almost each segment of market. Main specification of job-order manufacturing is the high customization with it's low amount of it's corresponding products. To make the production company to be able to complete and was not adjudge to produce on the edge of market top marketing has to follow after system for planning and scheduling. Today the main insistence is to put on lean production and agility of company, on low production costs, flexible production and especially on quick reaction time to change of customer wishes and possibility of fulfilment of suppliers and this all without any delay, in a real time. These complex orders is possible to process just by computer systems, that are able scheduling and production control online, to safe and afford prediction watched parametres of production on the base of made changes.

Now we are located in the area so called Computer Integrated Manufacturing (CIM), by computers supported (intergrated) production. CIM is the philosophy of all control system of produciton company, implementation of information technology in all production activities and engineering practice. CIM is applied from proposal and production of product till it's expedition with the goal of decrease of materail and energy severity, decrease of reserves, increase of productivity of labour, shortening of development period and production, increase of time and usage performance of production system and increase of production and product quality.

Publicized effects of digital fabric in the area of automobile and aircraft industry: quicker production start as far as about 15%, general higher productivity as far as about 10%, increasing productivity of current production machines as far as about 20%, restriction production machines, tools as far as about 40%, decrease of cost on new production facility as far as about 20%, restriction product times as far as about 20%.

As evidenced by mentioned datums, introduction of CIM has high meaning of principle of decreasing all-in cost in development, so in production of concrete product, as well on restriction time of presentation product on market. Here I would like to refer the fact, that in meanwhile from accessible sources similar effect isn't demonstrated in the job-order manufactur production, where the above mentioned CIM will be more difficult in my opinion because of high costs of needed program systems as well as the need of high qualified workers who could use those systems.

I suggest the integrated system of technical disposition production that the shows one of the first turn-key solution of problems of job-order manufacture. The cohesion of single formations start from their real textures at passage order through whole system of operating production – current companies use big software products (SAP, Oracle, Microsoft Dynamics AX, MFG/PRO, JD Edvards EnterpriseOne, b2industry etc.), whose accosts will go out on million Czech crowns, plus high annual fees. However these tools however aren't able quickly respond to drive change in job-order production, valorize processing of new orders, in production flow to watch it and in the event of occurs problems is at once solve by malingering.

Advanced Planning and Scheduling Systems

Industry enterprises are compulsories all the time search optimum solving for drive production because of minimization diversification mistaken decision. By one of tools that is possible, are method malingering. Simulation model production and systems belong system Advanced Planning and Scheduling (APS). After introduction APS is able to come to this improvement: decrease supply with material and in course of manufacture production, increasing usage mechanical equipment, truncation delivery date consumers, possibility malingering and simulation "what, if..." ", possibility scheduling with full capacities and real availability material, scheduling on alternative sources (workplaces), scheduling alternative materials, real realizable front work on (almost) of all workplaces, increasing flow capacity (incomes), coming new consumers.

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Experimental Validation of Mathematical Model for Flate-plate Evacuated Solar Thermal Collector

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Computer modeling of solar thermal collectors is a principle approach for testing of new construction concepts and improvements in the development and design stage. Virtual prototyping of solar collectors can save the investments into number of prototypes and foreseen the collector performance in advance. Analyses of construction detail parameters impact on the collector performance is needed to make decision on efficient solar collector concepts for given application, operation and climatic conditions with respect to economic parameters of construction.

A mathematical model is always a simplification of reality to certain extent. Too complex mathematical models and numerical programs require huge amount of computer time for calculations, too simplified models don't take important influences of detailed collector parameters into account and result in considerable uncertainty in calculation. To find a good compromise between simplicity of the model and its accuracy is crucial for development of any design and simulation tool.

Detailed mathematical model of solar thermal flat-plate collector has been built and transformed into user-friendly software tool KOLEKTOR 2.2 (Visual Basic Studio) [1]. The model is based on energy balance of heat flows from absorber surface to ambient environment (external energy balance of absorber) and to heat transfer fluid (internal energy balance of absorber). Heat transfer calculation (convection, conduction, radiation) and temperature distribution for main solar collector surfaces (exterior glazing surface, interior glazing surface, absorber surface, heat transfer fluid, interior frame surface and exterior frame surface) is processed in the iteration loops. Detailed geometrical and physical parameters of individual collector elements are entered via tool cards (general, glazing, absorber, frame, calculation and results). Results are collector surfaces). Design tool KOLEKTOR 2.2 is universal for performance modeling in wide range of flat-plate solar collectors (nonselective, selective), especially with:

- different interior air pressure in solar collector (atmospheric, evacuated collector),

- different slopes,

- separate installation or building envelope integration (with given thermal resistance),

- different heat transfer fluids (water, water-glycols mixtures),

- advanced glazing structures (transparent thermal insulations).

Mathematical model KOLEKTOR 2.2 has been experimentally validated in the frame of solar collectors testing according to European standard [2] in the Solar Laboratory operated under Department of Environmental Engineering at Faculty of Mechanical Engineering, Czech Technical University in Prague [3]. Solar thermal collectors have been tested to obtain steady state performance thermal output at constant operation conditions of inlet temperature ($\pm 0,1$ K) and mass flow rate (± 1 %) of heat transfer fluid (water) entering collector and at constant climatic conditions of solar irradiation (± 50 W/m²) and ambient temperature 266

(\pm 0,5 K). Instantaneous efficiency has been calculated from collector thermal output related to total solar irradiation input (incident on collector reference area: aperture area). The efficiency curve (dependence of efficiency on mean reduced temperature difference) has been obtained from at least 6 points in the range of input fluid temperature from ambient (around 20 °C) to 90 °C. Expanded efficiency uncertainty has been assessed for experimental data from both type A (statistical) and type B (instrumental) uncertainties considering the coverage factor 2 with 95% level of confidence and for usual steady state conditions of measurements lies between 3 and 4 %.

Mathematical model has been validated in the field of atmospheric solar flat-plate collectors (nonselective absorber without conductive bond to register pipes; high-quality solar collector with state-of-art copper laser welded absorber coated with high performance selective coating and solar antireflective glazing) and especially in the field of evacuated solar flat-plate collectors. Experimental validation of evacuated type has been performed on commercial solar flat-plate vacuum collector with selective absorber and no insulation applied at the back of absorber (only air layers at given pressure). The collector envelope consisting of low iron glazing and moulded metal frame is equipped with pressure valve inlet for repeatable evacuation. Support pillars to bear the glazing at condition of underpressure stress are placed between the glazing and back side of the collector and penetrating the absorber through holes (elimination of thermal bridges, not considered in modeling). The atmospheric variant of the collector (interior pressure 100 kPa) has been evaluated as a reference case (atmospheric selective collector - but without insulation). The evacuated variant of the collector has been tested with interior pressure reduced and maintained by vacuum pump at 9 kPa. All tested variants of solar collector construction have shown a good agreement between the modeled and experimentally obtained solar collector efficiency curves within the range caused by uncertainty of model input parameters (uncertain values of thermophysical properties of used materials, optical properties of surfaces, etc.).

Experimental validation of the solar flat-plate collector model has allowed the use of universal design tool KOLEKTOR 2.2 for virtual prototyping of efficient solar collector constructions, including evacuated collectors for building integration applicable to advanced solar systems (solar heating and cooling systems). Results from validated model can be widely applied in parametric analysis of solar thermal systems with advanced building envelope integrated solar thermal collectors in numerous building simulation tools to investigate the system thermal performance, solar collector behavior and its influence to indoor environment.

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Section 8

PRODUCTION SYSTEMS, TECHNOLOGY, TECHNOLOGICAL PROCESSES AUTOMATION

Thermal Error Compensation of Machine Tools

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Nowadays thermal compensation of Machine Tools is highly difficult task due to requirements for machine accuracy and low costs. Another requirement is that compensation mechanism should be easy to compute by machine control system. Neither implemented directly into this system nor stand alone low cost hardware, which communicate with the control system only via very short and clear instructions. This guarantees that control system is not overloaded by compensation values calculation and its capacity can be fully used by machining process itself. Opposite to this stands a high machining accuracy requirement which requires sophisticated compensation algorithms.

Thermal error compensation is known as a process which usually uses temperature measurement at a few places on the machine. Question is where these places are. Sensors are usually placed to the machine frame and to the spindle surface. Disadvantage of these places is short reaction for heat generation caused by mass of material between heat source and measured surface. Effect of this delay is a variation of accuracy of used compensation algorithm and moreover of the overall machine accuracy. This article deals with the procedure how to eliminate this unwanted delay. An improvement of machine accuracy with this new system is also presented.

The main goal of the research is to improve machine accuracy of standard 3-axis machining center with the most used construction frame type C where the biggest deformation is in Z-axis. The main heat source of this machine is the spindle – electromotor and bearings. Temperature of these parts cannot be measured directly, so one possibility is to place sensors to the spindle outer surface. Another possibility, the unsearched one, is to measure the spindle cooling liquid, which flows around bearing and electromotor. Distance between liquid and bearing is much lower than between bearing and spindle surface. So the transport delay of heat transfer for liquid should be shorter than for spindle surface measurement. In this case temperature sensors are placed to both tubes for liquid – spindle enter and exit to compare how much heat is took away by liquid from spindle. Also the time from heat source (bearings) to the temperature sensor is very short because liquid flowing speed.

First step of the research is to find out thermal behavior of CNC machine center. There are many sensors placed to the frame, bed, and spindle surface and two sensors for cooling liquid. The overall machine thermal behavior and deformation is measured for different initial room conditions. Analyzed results validate the hypothesis of short transport delay for temperature of cooling liquid. For second step, multinomial compensation algorithm, it is necessary to choose a few sensors according to these requirements: good match of sensor temperature development and machine deformation; fast reaction to the heat generation; place of sensors to cover all main parts of the machine. Fast reaction rule is set up to temperature change of 0.5 degree of Celsius and good time reaction. These parameters are fulfilled by four sensors. One is on the machine frame; two are on the spindle holder and the sensor for spindle cooling liquid exit. Based on these four sensors a multinomial compensation algorithm is developed. Multinomial approach is chosen because it is unpretentious for machine control system. Algorithm verification is powered by measured data calculated throw evaluated

equation and compared with the real measured deformation. Compensation equation was formulated according standard form:

$$\delta = \sum_{n=1}^{4} a_n \cdot T_n$$

Results show an improvement compared to standard multinomial compensation. Machine deformation due to thermal deformation is reduced from 40 micrometers do less than 14 micrometers (at the first very dynamic phase) and less than 5 microns at the rest of the deformation process.

Results also verify special effect called "self-compensation effect". This is caused by the construction of this type of machine (frame type C) where the spindle deformation goes to the opposite direction than the machine frame which holds the spindle. Generally the spindle deformation is reduced by the frame deformation. But according to the different deformation time constants of machine parts the overall machine deformation has specific behavior which cannot be successfully compensated only by one multinomial equation. This effect is experimentally verified by special air-conditioned box within testing stand as a simulation of the machine.

The solution of this problem is to decompose the machine to the several parts. Each part has its specific deformation characteristic time constant and it is compensated with different multinomial equation. For example the deformation of the spindle is quicker than the deformation of the frame. On the other side the deformation magnitude of the frame can by higher than the spindle. Also the other influences inside the machine can by mapped and solved by this technique. Multinomial approach is relatively easy for machine control system computer so there is no problem with calculation time for several separated calculations. At the end of presented research special measuring technique for this type of compensation was evaluated and will be tested in a near future.

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The Effect of Temperature Gradient in PV Cells and Modules on the Electrical Yield

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To analyze the situation of parallel connection of PV cells and modules with different temperatures is important as it usually happens in string concepts of PV systems. Especially in case of façade systems the temperature distribution is far from being uniform. In concentration systems this situation happens due to non-uniform radiation and heat remove. In all these cases the resulting efficiency is negatively affected.

This paper describes the methods and results obtained by studying the effect of parallel connected cells with different temperature and temperature gradient within one photovoltaic cell on the I–V curve and maximal yield. Monocrystalline silicon 4" cell was chosen for the experiments as one of the commonly used cell types. Experimental verifications were done under $800W/m^2$ halogen lamp illumination.

The I–V curve of a cell is mostly described using a one or two diode model resulting in the I–V curve that can be described using Eq. (1).

$$I = I_{PH} - I_0 \left[\exp\left(\frac{e(V - IR_s)}{kT}\right) - 1 \right] - \frac{V - IR_s}{R_P} , \qquad (1)$$

where I_{PH} is the generated photocurrent, I_0 the saturation current, k is the Bolzmann constant, e the elementary charge, T the temperature and R_S and R_P are the serial and parallel resistance, respectively. If we were able to find out the appropriate coefficients, this equation gives an accurate result. But even knowing the coefficients, there is no way to explicitly compute the I–V curve. Other problems may lay in the fact, that the coefficients are not constant with respect to temperature and irradiance. The parallel resistance R_P is strongly affected by temperature and irradiance, the serial resistance R_S mostly by irradiance. As the PV cell is a non-linear circuit, computing the I–V characteristic using Eq. (1) of more parallel connected cells becomes too complex.

Another way is to threat the PV cell not as an electronic circuit, but as a unit reacting to a forced voltage with a specified current or to a forced current with a specified voltage. Thus knowing the I–V curve we can graphically express the behavior of any parallel or serial connection of cells with different parameters. To see, how exact this assumption corresponds with real measurement, two PV cells with different temperatures were connected in parallel with minimal resistance of the connection. The resulting current of two parallel connected cells is computed as a sum of currents of both cells operating at the same voltage.

If we operate such a parallel connection above the open circuit voltage of any separately working cell, this cell becomes a further load. This situation is in real situation rare, but on the other hand, it is impossible to operate both cells in maximal power points (MPP) at the same time. The resulting MPP shifts so that operating in the new MPP we loose energy on both cells.

A similar situation can be observed if one PV cell has a temperature gradient. It is not common to experience high temperature differences on a single cell unless we use a concentrating system or the cells are not uniformly cooled (i.e. in some photovoltaic–thermal systems). To find how the thermal gradient affects the overall performance, following experiment was done. Firstly the I–V curves of a uniformly heated cell were measured with cca. 5K step. The measured I–V points were fitted onto a curve expressed by Eq. (2), using a Matlab Fitting Toolbox

$$I = C_1 G + C_2 T^3 \exp\left(\frac{-E_{G0}}{kT}\right) \left[\exp\left(\frac{eV}{nkT}\right) - 1\right] + C_3 V$$
⁽²⁾

where G is the radiation, E_{G0} is the bandgap at 0K.

This equation is a rewriting of Eq. (1) using the diode voltage, it can be used for non-linear fitting methods to find the coefficients C_1 , C_2 , C_3 and n and gives sufficient estimation results. Additional I–V curves were graphically interpolated to get I–V curves with step less than 1K.

Using the graphical method of parallel connection, one can find the resulting I–V curve for any temperature distribution. The area of the cell was divided into 36 elements, each having a uniform temperature. The maximal and minimal temperature modeled was chosen 42°C and 79°C respectively, to have a comparison with previous measurement. The efficiency decrease caused by the temperature gradient (MPP mismatch) is not as high as having two cells with different temperatures separately (-1,7% for linear distribution, -2% for exponential distribution). This can be easily explained by the continually changing temperature and thus not high overall temperature dispersion.

To test real behavior of a temperature gradient in a single cell, the PV cell was fixed on a steel plate that was from one side heated, from the other cooled down. This way a temperature difference of maximal 35K was established. 9 thermocouples located in a grid were inserted into the steel block close to the cell side to measure the temperature field. Interpolation of the measured temperature points was used resulting in a more accurate temperature field (grid 6x6 elements). All 36 samples with their temperatures were graphically added in parallel. The solution of parallel addition is slightly better than considering the mean temperature in the area of MPP.

The results obtained by the theoretical approach (based on measured cell characteristics) and the real curves obtained by measurement of two parallel connected cells and a cell with a temperature field have been examined. The computed result corresponds with the experimental measurement in case of two cells. In case of temperature field on one cell, the computed result using 36 samples with different temperatures seems better than using just one mean temperature, but there are still deviations from the real measurement. The cause may be a deviation in measuring the thermal field and also problems by electrical contacting the cell to the steel block. A temperature field on one cell in typical PV systems does not seem to cause serious power losses due to MPP mismatch unless the temperature gradient is extremely high.

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Section 9

ENERGETICS & POWER ENGINEERING

Communication between Modulator and Superset Regulator of the Matrix Converter

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Introduction:

The matrix converter is a direct frequency changer. This converter consists of an array of $n \times m$ bidirectional switches arranged so that any of the output lines of the converter can be connected to any of the input lines.

Standard PC (regulator) extended by the peripheries realized in FPGA technology (modulator) was choice as a driver unit.

Driver unit:

Modulator for the matrix converter was designed as follows, that it is possible connecting an one desk PC with PC104 bus direct to a connector on the modulator PCB. The connector makes up full PC104 bus including power supply. Thanks that, it is possible to supply regulator direct from modulator through PC104 connector. HW of the superset regulator is determined by design of the modulator.

Superset regulator is one desk PC with the PC104 bus as was said in previous paragraph. Functions of one desk PC are the same as other PC. The difference between these two kinds of PC is in size. One desk PC, as the name prompts, is realized on one PCB (90.17mm \times 95.89mm). For interest one desk PC from RTD has standard operating temperature from -40° to +85° C. The PC104 bus is based on principles of ISA bus. All PC104 bus signals are identical in definition and function to their ISA counterparts [4]. Signals are assigned in the same order as on the edgecard connectors of ISA, but transformed to the connector pins.

Communication:

For communication between modulator and superset regulator we are using so called memory hole. That is BIOS setup, which was designed in memory space part useable for control ISA bus respectively PC104 bus. This place is typically between 15 and 16MB in size of 1MB. This was used for old ISA bus cards. Nowadays is this method obsolete, but in our case it has many advantages. Program in superset regulator can operate with address from PC104 as with memory. That means with all standard operations.

If we used memory hole with one desk PC by RTD and operation system Linux, the total size of memory is reduced of 1MB in comparison with situation without memory hole. When we use memory hole with one desk PC by Kontron and operation system Linux, the total size of memory is only 15MB. The rest of the memory is unusable.

We have been testing one desk PC from RTD and from Kontron. During the test of communication we found that the one desk Kontron PC read from PC104 bus in 16 bit mode in different way than it is described in the universal bus specification. If we want reading 16 bit from PC104 bus we have to read only even addresses. Due to the fact that one desk PC from Kontron read first from even address and after that from address + 1 which is odd address, special bus handling has to be implemented for this one desk PC. From the reasons 276

which are presented above, it is better using as a superset regulator one desk PC made by RTD.

Modulation:

In the matrix converter is used Indirect Space Vector Modulation (ISVM). We can imagine the matrix converter as the indirect frequency converter with virtual DC link. We can imagine the virtual indirect converter in different ways. The most spread out variant is with three two-state switches in the inverter and three three-state switches in rectifier. Thanks to this we can use some processes well known from classical indirect frequency converters.

It is necessary to ensure the right timing for command switching and generate guard delay and then the switching in the right moments. We reached this by adding or subtracting the given times of switching combinations and compare them with values of saw courses. Thanks to the proper switching combinations it is possible to reduce the necessary number

of switching IGBT during one switching period [2]. Switching commands and times of switching combinations are sending from superset regulator per PC104 bus.

Modulator:

The matrix converter modulator was programmed in VHDL language and consists of several parts. First part ensures the right switching signals for IGBTs and puts the guard delay between the separate switching steps. Second part ensures the generation of switching commands at their right time. Other parts ensure communication. There are also realized several control registers in FPGA and each of them has its own address. Some registers are "read only", some "write only" and some "read and write. In modulator is one state register which is cleared after read. The information about state of modulator and values from A/D converters can be read due to superset regulator.

Summary:

Communication between the superset regulator and the modulator was tested with developed program in C language. This program writes values to the registers realized in FPGA. These values are in FPGA circuit changed by defined processes and after that read from superset regulator. Program placed in superset regulator controls values from registers and if it founds mistake it notifies the error. This program was later modified for testing of the analog-digital converters and IGBTs drivers. Testing program does not work in real-time, but its speed is sufficient to measure signals on the FPGA board. Testing program allows to save measured values to the flash memory of superset regulator. So it is possible to process afterwards measured values in MS Excel or Matlab to the graphic form.

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Analysis of one-phase induction machine using Matlab F. Linhart

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Introduction

One-phase asynchronous machine is being applied for its simple construction for a long time. One-phase asynchronous machine has no starting torque. We must create such conditions in order to machine has had nonzero starting torque. This is being made by another winding with impedance, which shifts the phase of current in auxiliary winding. Both stator windings are connected to the same single-phase source. Therefore, asynchronous machine is unsymmetrical and unbalanced. Mathematical model for simulations is needful.

Mathematical model

The stator winding of one-phase induction machine has two axes in space quadrature. Main winding has turn number N_s and resistance R_{as} . Auxiliary winding has turn number N_S with resistance $R_{bs}.$ We can consider the rotor winding as two identical sinusoidally distributed windings arranged in space quadrature. Each rotor winding has turn number N_r and resistance $R_r.$ We can write the voltage equation for each winding:

$$v_{as} = R_s \cdot i_{as} + \frac{d\psi_{as}}{dt} \tag{1}$$

$$v_{bs} = R_S \cdot i_{bs} + \frac{d\psi_{bs}}{dt}$$
(2)

$$v_{ar} = R_r \cdot i_{ar} + \frac{d\psi_{ar}}{dt}$$
(3)

$$v_{br} = R_r \cdot i_{br} + \frac{d\psi_{br}}{dt} \tag{4}$$

Unsymmetrical windings of one-phase asynchronous machine are not identical and it is necessary transform all voltages and currents to the reference frame. After transformation we obtain equations with constant parameters.

In equivalent circuits of electric machines it is customary to refer the rotor variables to the stator windings by the turns ration. Final voltage equations:

$$u_q = r_s + \frac{X_{ss}}{\omega_1} \cdot p(i_{qs}) + \frac{X_{ms}}{\omega_1} \cdot p(i'_{qr})$$
(5)

$$u_d = r_S + \frac{X_{SS}}{\omega_l} \cdot p(i_{dS}) + \frac{X_{mS}}{\omega_l} \cdot p(i_{dr})$$
(6)

$$0 = \frac{X_{ms}}{\omega_1} \cdot p(i_{qs}) - X_{mS} \cdot \frac{\omega_M}{\omega_1} \cdot \frac{1}{n} \cdot p(i_{ds}) + i'_{qr} \cdot r'_r + \frac{X'_{rr}}{\omega_1} \cdot p(i'_{qr}) - X'_{RR} \cdot \frac{\omega_M}{\omega_1} \cdot \frac{1}{n} \cdot p(i'_{dr})$$
(7)

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$$\mathbf{0} = \mathbf{n} \cdot \mathbf{p} \cdot \frac{\boldsymbol{\omega}_{M}}{\boldsymbol{\omega}_{1}} \cdot \boldsymbol{X}_{ms} \cdot \boldsymbol{i}_{qs} + \frac{\boldsymbol{X}_{ms}}{\boldsymbol{\omega}_{1}} \cdot \mathbf{p} \left(\mathbf{i}_{ds} \right) + \mathbf{i}'_{qr} \cdot \mathbf{n} \cdot \mathbf{p} \cdot \frac{\boldsymbol{\omega}_{M}}{\boldsymbol{\omega}_{1}} \cdot \boldsymbol{X}'_{rr} + \mathbf{R}'_{R} \cdot \mathbf{i}'_{dr} + \cdot \frac{\boldsymbol{X}'_{RR}}{\boldsymbol{\omega}_{1}} \cdot \mathbf{p} \left(\mathbf{i}'_{dr} \right)$$
(8)

where p constitutes the derivation.

The rotor voltages are set equal to zero, because the machine has short-circuited rotor.

The instantaneous electromagnetic torque may be expressed as

$$m_{i} = p \cdot \left(\frac{N_{S}}{N_{S}}\right) \cdot \left(\frac{X_{ms}}{\omega_{l}}\right) \cdot \left(i_{qs} \cdot i'_{dr} - i_{ds} \cdot i'_{qr}\right)$$
(9)

Mathematical mechanical load model is derived from motion equation

$$M_d - M_l = J \cdot \frac{d\omega_M}{dt} \tag{10}$$

where M_d is driving torque, M_l is loading torque and J is moment of inertia.

Simulation

The simulation was made for three different capacitors and loading torque with constant characteristic

Conclusion

Increasing value of capacitor increases starting torque and maximal torque of motor and brake down torque of an induction motor However, these improved properties have some disadvantages. Primarily, starting current in main and auxiliary phase is major. Voltage of auxiliary winding is major, too and speed is lowering. It can happen to, that motor will be working at maximum torque and maximum current.

Mathematical model is only approximate to reality and it gives only rough values. Wide difference is in voltage of auxiliary winding. It is in virtue of real capacitor, which was used for measurements. Capacitor for simulation was ideal without figure of loss.

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Modification and Completion of the Hybrid-electric Drive Stand

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This paper describes the work on the laboratory working stand of hybrid-electric drive, which is placed in laboratory T2:H1-26.

The stand consists of four electric machines, five convertors (rectifiers, inverters and choppers), a lot of different sensors (for measuring voltage, current, speed and torque) and another sub circuits and auxiliary circuits. The short description of function is like this. The main power source is the combustion engine. It is represented in our model as electric machine. This machine has junction shaft with the special electric machine, the power splitter. This is a special synchronous machine, which has rotating rotor and stator. There are the permanent magnets on the rotor, there is winding on the stator. The transfer of mechanical energy is depended on the current, which is flowed through the stators winding. The mechanical power is transferred to the power splitter and there it is divided to two ways. The mechanical way is added to the power from the traction motor (the third machine) and this resulting power is transferred to the wheel of car. The mechanical output of power splitter has one junction shaft with traction motor and the last electric machine. The fourth electric machine absorbs the mechanical power and represents the flow resistance of air, the rollingresistance force and the up- and down rise of the road. The electric way of energy is from the power splitter's rectifies to the DC circuit. Another two convertors are connected to this circuit. First is DC-DC convertor, which controls the charging and discharging the supercapacitor. The second is the inverter, which controls the traction engine.

The stand is very complicated in these times. A lot off assistants is needed during the measuring, (minimal four or five). Every convertor has different method of control and it is only possible the local controlling. Every measuring instrument has different method of reading the value and we can't use the remote reading the measured value. In this time we work very intensive to connection all convertors and all sensors with one main computer. This computer has a lot of AD converters and can read the value from the sensors, which have the current output. This computer has a lot of binary output and output with DA converters, which allows controlling the converters or switch on/off particular components or the whole working stand. This computer can assemble the data from the whole working place. From analysis of this data it is possible to correct the input parameters. This system allows testing the machinery in special driving cycles, for example in European driving cycles. After this simulation we can verify the data from the virtual calculation and simulation.

Another work is in progress at the same time with the work of data acquisition. It is important to complete the work stand with one component or one function. The measuring detects the big problem. This problem consists of the voltage instability in the DC circuit. The power from the power splitter is restricted and in one moment it is constant. On the other hand the power, which takes the traction motor, is very variable and its volume is depended on the driver's requirement of car accelerating or breaking. Other relevant contribution to the voltage instability in DC circuit is the convertor of supercapacitor. His program tries to hold the voltage in DC circuit. But its time constant is too small and there is not any storage element in the DC circuit. It makes a pulse process, and the voltage in the DC circuit rises and

falls with period depended on the speed of the regulation loop. It is only possible to delete this process with adding any storage element to the DC circuit. The storage element will stabilize the voltage in the DC circuit. The optimal voltage is in the middle of the power splitters operating area that is 240 V. The voltage from the power splitter is depended on the difference speed. From the analysis of the power splitter operation it results, that in around the 50% of the working time the voltage is greater than 240 V and we must make the voltage smaller. And in about 50% of the working time the voltage is less than 240 V and we must make the voltage scale up. Supply voltage is controlled by the special rectifier from the power splitter in this time. Its great disadvantage is that it needs the voltage on its output greater than the voltage is on its input. When this condition is false, this rectifier works as normal 3-phasis uncontrolled diode rectifier, so all advantages are out of order and we can't control this rectifier. Because existing regulation doesn't allow the demagnetizing of the power splitter rotor, we can't make smaller the output voltage from the rectifier. To make new program to control the rectifier, which allows the demagnetizing of permanent magnets on the power splitter rotor exceeds the range of my work. On that account it was decided, that new convertor will be built. It will be a Buck-Boost pulse convertor, which will work as a controlled current source. It will work on the output from the power splitter's rectifier, which will work only as uncontrolled rectifier. New convertor brings two advantages. First is simplification of connecting between the power splitter's rectifiers and the main control computer. To control the rectifier it is used evolutionary kit with DSP 56F805 by Freescale (Motorola). The program on the main computer, which is used to visualization, is LabView. We haven't any way to simply connect these two systems. My idea is that the new convertor will be controlled by programmable gate array from company National Instruments, which is compatible with LabView. The second advantage is simpler start of measuring. On the stand there are used the incremental optical sensors as the sensors to measuring speed. The control system of the power splitter's rectifiers needs information about position of rotor and stator. There are only incremental sensors, no absolute position sensors. When we want to start with measuring, first we have to rotate both shafts minimally about one around. My idea is that the rectifier will work only as uncontrolled diode rectifier, then we will not need the information about the position of rotor and stator and we will not rotate the shafts first.

The new convertor will consist from two parts, the step-up part and the step-down part. Booth parts will be operated separate. One power transistor will be in each part. Both transistors will be controlled by microcomputer, probably by unit Compact Rio. The microcomputer will measure the input and output voltage and the transient current. The computer will decide from this data, which part will work. The current regulation will hold the transient current constant, it means the torque will be constant and the power carried to the mechanical way will be constant too.

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TWO-STEP COMMUTATION METHOD OF THE MATRIX CONVERTER BASED ON THE VOLTAGE SIGN MEASUREMENT

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Introduction:

In general, matrix converter is device, which allows connection any of n input phases with any of m output phases. Therefore matrix converter consists of $m \times n$ bi-directional switches, which are able to conduct currents and to block voltages of both polarities, depending on actual state of a modulation strategy. The bi-directional switch is realized in most cases by antiserial connected IGBTs and each IGBT has antiparallel connected diode [4].

Modulation:

Compact matrix converter, which is being developed on our department, uses indirect space vector modulation. The term "indirect" means that we can split matrix converter into virtual rectifier, inverter and DC link. Thus the matrix converter can be controlled like an indirect frequency converter. Through an efficient choice of switching pattern we can generate required waveforms on the output of the matrix converter. The modulator which realizes this switching sequence has to define the next switching state (switching combination of virtual rectifier and inverter) and the relative time of this state. But commutation strategy resolves the process of transition between two another states [2]. So it is possible to say that commutation strategy (or algorithm) is the functional part of modulator.

Two – step commutation method:

Commutation process is conventionally switch – over of one output phase from one input phase to another one. Two-step method was realized to reduce commutation time and is established on idea that the maximum number of IGBTs has to be switched on. Therefore some IGBTs of non-conducting input phases have to be switched on and they create a prearranged state for next commutation. This prearranged state must not cause an interphase short circuit and output current must not be interrupted. These are two important conditions for successful commutation.

The polarity of input phase-to-phase voltage is chosen as control variable for commutation. It means that the prearranged state is set based on polarity of phase – to – phase voltage between conducting phase and other two phases. For example if phase R was connected to output, we would monitor polarity of voltage U_{RS} and U_{TR} .

If phase R is connected to output and the modulator is going to switch to phase S, the following sequence of steps will be performed:

 First step:
 All IGBTs which are placed on the same side (load side or source side [4])

 like switched – on – IGBT on the phase S will be switched off. This IGBT on phase S will be let switched on.

 $\label{eq:second step: Second IGBT of phase S will be switched on. The new prearranged state will be set. Now we have to realize, that the new prearranged state will be set based on polarity of voltage of another phases than in previous case. Now polarity of voltages U_{ST} and U_{RS} is relevant.$

State diagram of two – step commutation shows a graphical representation of entire algorithm and was introduced in [2]. There are four prearranged states for each input phase depending on voltage polarity and each of them has two possible states after commutation.

Practical realization:

Control structure of compact matrix converter consists of FPGA and one-desk PC. Modulator with commutation blocks was implemented in FPGA and one-desk PC represents superset regulator that prepares information about sectors of input current and output voltage. This information and relative time are sent to modulator in FPGA via PC 104 bus. On the basis of this inputs modulator finds the switching combinations and through the commutation blocks realizes them [1].

Whole commutation algorithm was developed in VHDL language for FPGA. Each output phase has one commutation block which realizes connection of input phase R, S or T. Input to commutation block is signal MTSR (modulation switching word), which acquaint with required connection. Output from commutation block is signal, which is sent direct to IGBT drivers.

For simulation and debugging of two-step algorithm was created model of one output phase of matrix converter in Matlab – Simulink. Also it is suitable for comparison with existing four-step algorithm. This model includes co-simulation block "Link for Modelsim", because Matlab can work with VHDL code only under participation with Modelsim from Mentor Graphics [3].

Summary:

The developed two – step method is two – time faster than existing four-step. But the co-simulations in Matlab and Modelsim have demonstrated that two-step method has some limitations, which are not respected in theoretical analysis. Some serial diode of disconnected input phase can be positively polarized closely before (or after) polarity changing of input phase-to-phase voltage. It causes that one output phase of matrix converter is connected with two input phases for a short time. Two-step method is therefore inapplicable in this short time area. Thus we cannot tell that two-step method is a single and correct solution. By that time the solution consists of both methods combination.

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Experimental results measured on PWM rectifier and their comparison with thyristor rectifier

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Many modern electric devices need for its function DC voltage. For the conversion from AC to DC mostly thyristor rectifiers are used. These rectifiers are simple, but the phase controlled thyristor rectifiers belong to the category of the worse electrical network polluters. The phase control and the commutation of semiconductor devices impact on the phase displacement between the first harmonics of consumed current and supply voltage. This displacement leads to power factor degradation and to reactive power consumption. The consumed current harmonics cause the non-sinusoidal voltage drops on the supply network impedances and the supply voltage deformation which may cause the malfunction of the other devices that are sensible on the supply voltage sinusoidal shape. The reactive power rises with longer control angle delays, so the rectifier is acting as time variable impedance which is furthermore nonlinear and causes the deformed current consumption. To reduce these side effects the rectifiers are being supplemented by filters and compensators. One way is the application of the passive LC filter. The filter is usually constructed as inductors and capacitors connected to the grid. The values of the elements are chosen to have resonance frequency, which corresponds with the frequency of the harmonics, which should be eliminated. That means each harmonics $(5^{th}, 7^{th}, 11^{th} ...)$ requires its own filter. That is why filters can not be designed in general way, but must be designed according to each application. Such a solution is simple but requires additional place and reduces reliability of the whole system. Another way is the application of the rectifier, which do not generate or generate limited number of harmonics. The PWM Rectifier belongs to this category.

Such a rectifier is realized by semiconductors that can be switched off as IGBT transistors. The rectifier is controlled by pulse width modulation. The rectifier can be then controlled to consume current nearly sinusoidal without harmonics (*THD* below 5%) and to operate with chosen power factor (mostly unity), or the rectifier can be controlled so the current consumed by PWM rectifier will partly compensate the non-harmonical consumptions of other devices connected to the supply network. The application of IGBTs enables also bidirectional power flow, so recuperation is possible. The pulse width modulation enables the adjustment and stabilization of DC-link voltage (or current) and it reduces the size of capacitor (or inductor) due the continuous current. Furthermore, it can be properly operated under line voltage distortion and notching, and line voltage frequency variations.

According to the power part realization there are two types of PWM rectifiers. The current type, that is also called "buck" rectifier, has the output rectified voltage lower than the input side voltage amplitude. The other one is voltage type PWM rectifier, also named as "boost" rectifier, where, for the proper function, the output voltage must be greater than the input voltage.

The power part of the realized "boost" PWM rectifier is made by 4 IGBT transistors, which build the full bridge, on the input side is connected input inductance. For the control part the microprocessor MOTOROLA 56F508 was chosen and the control algorithm was developed in SW CodeWarior. For the proper function of the rectifier is necessary to know exactly when the network voltage crosses zero. So the synchronization circuit is needed. Also 284

the information about the amplitudes of the supply and output voltage are necessary. Therefore measurement interface with LEM voltage sensors is being used.

To test the abilities of the built pulse width modulated rectifier several measurements were made. The rectifier was supplied from the controlled AC source and loaded with DC motor. To prove the advantages the measurements with the same values of rectifier load were made also with the phase controlled thyristor rectifier. Obtained results were compared from the perspective of the current shape and reactive power production. To evaluate the consumed current quality, the coefficients THD (total harmonic distortion) and v (fundamental harmonic content) were counted and compared in all measured cases.

$$THD = \frac{\sqrt{\sum_{2}^{\infty} I_{(n)}^{2}}}{I_{(1)}}$$
(1)

$$v = \frac{I_{(1)}}{I} \tag{2}$$

The difference is clear. The PWM rectifier consumes nearly sinusoidal current and operates with power factor equal to unity. The phase controlled rectifier consumes current which is non sinusoidal and there is also the phase delay between the supply voltage first harmonic and first harmonic of consumed current. That means the supply network is loaded with reactive power and harmonics.

Usage of PWM control in rectifiers eliminates the problems that were caused by using of phase controlled rectifiers. The PWM rectifier can assert itself for its good behaviors in many applications, for example active filter, or as an input rectifier for indirect frequency converter. This application assets itself mainly in traction, where the AC voltage from trolley wire is firstly rectified and then from the output of the rectifier the traction inverters and also other auxiliary converters are fed. Traction vehicle equipped with PWM rectifier does not consume reactive power, won't lasts the supply network with harmonics and the recuperation is possible.

Another possible usage of the converter is as an active filter. Active front-end would have the capacitor at the output. The rectifier would be controlled in order to consume the current that contains all harmonics, as the device its negative effect should be suppressed. The current consumed by the rectifier would be in the opposite phase to the current consumed by the device, so the harmonics consumption from supply should be created.

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Control Strategy of Hybrid Drive for Motor-Car and Simulation of the Fuel Efficiency

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This paper presents the results obtained by means of experimentally verified mathematical model of a hybrid electric car drive equipped with electric power splitter. This work is related to the experimental working bench for hybrid car drive research, developed at the Faculty of Electrical Engineering at CTU in Prague. This is part of an ongoing project to develop a hybrid electric drive in the Josef Bozek Research Center for Engine and Automotive Engineering (RCJB) at CTU in Prague and also supported by CTU grant No. 0802513.

Commercial hybrid electric cars, for splitting energy from ICE use a planetary gear and a separate electrical generator for the electrical power supply of the traction motor and for charging the battery. In the hybrid electric model developed at CTU in Prague, power splitting is performed entirely electrically, with the use of EPS. Also, instead of a chemical battery for the breaking kinetic energy accumulation, a super-capacitor is used. This solution enables direct electric energy accumulation without transformation it from electrical to chemical energy and back. Therefore higher efficiency in energy saving and reusing is achieved.

The internal combustion engine is the main power source on the vehicle. It produces mechanical power Pice. EPS is a special type of synchronous generator with two rotating parts (a classic permanent magnet rotor and a rotating stator). The rotor is firmly coupled to the drive-shaft of ICE, and the stator of the EPS is firmly coupled to the transmission that leads to the car wheels and therefore rotates at a speed proportional to the velocity of the vehicle (speed V). This technical solution enables the ICE to operate on the optimal revolutions during the entire driving schedule. Mechanical power Pice is divided into electrical power Pepsel and mechanical power Pepsmh. The induction traction motor (TM) has been inserted on the shaft of the EPS rotating stator, and is the main electric propulsion source to the vehicle. EPS and TM are electrically connected through two traction AC/DC and DC/AC power converters, with an intermediate DC link. SC is connected to the DC link via a charging and discharging DC-DC converter. TM is powered by Pel, which is generated in EPS (Pepsel) and by additional power from SC (Psc). The traction motor TM produces mechanical power Ptm which, with mechanical power Pepsmh added from EPS, is transmitted to the car wheels, which drive the car. When the car is braking, TM changes its function from motor to generator. In this way, the decelerating energy of the car can be partially converted into electric energy by recuperation. This energy is accumulated in SC and later can be used during the acceleration.

In order to perform laboratory tests on this HEV concept, an experimental working stand was se up in the laboratory. In this HEV laboratory model, ICE and the car wheels are substituted by two regulated induction motors. The internal combustion engine and the traction load are simulated with two controlled AC induction motors. The entire working stand consists of four electric machines, five semiconductor power control units, a super-capacitor and all the necessary instrumentation, control, power supply and protection equipment.

The fuel efficiency of passenger vehicles is defined as the amount of fuel required (L_{car} [liter]) for a car trajectory distance (S_{car} [km]). In Europe, this value is measured according to a predetermined working regime defined as the European driving schedule (EDS), which is consisted of a 1200 sec. driving schedule, which combines 800 seconds of urban and 400 seconds of highway driving. This is the standardized European driving schedule for calculating the consumption and vehicle efficiency.

A simulation has been made by means of the Matlab programming interface. The main aim in this simulation is to determine the energy fluctuations in the hybrid drive during the driving schedule. For this purpose, the function and behavior of each component of the system is determined and taken into account, e.g., aerodynamic resistance, rolling resistance between the tires and the road surface, density of the ambient air, cross-sectional area of the vehicle, coefficient of drag, etc. The kinematic model has been mathematically created for the predetermined car specifications, e.g., car weight, efficiency of transmission, ICE fuel consumption and output power, number of accumulative units – SC, and the efficiency of the electric power converters. For each time unit of the drive, it has been calculated the acceleration a_n , car trajectory distance S_n , needed acceleration force F_a , and corresponding energy W_n . The program calculates all these values according to EDS. The data are presented in characteristics which are functions of time t, like the power on the drive-shaft of the internal combustion engine P_{ice} , and the required driving power P_{car} .

Fuel consumption is measured in each time interval. Knowing the total fuel consumed on the end drive regime and the total distance driven, the consumption of the hybrid-electric drive is calculated. For urban driving the fuel consumption is 3,9 [l/100km] (25,6 [km/l]), for the highway 4,67 [l/100km] (21,4 [km/l]) and for combined driving it is 4,31[l/100km] (23,2 [km/l]).

This technological solution enables standard passenger cars to consume almost 50% less fuel in urban driving and less then 20% in highway. The final numerical results for fuel consumption show the significance of this new technological approach. Enabling vehicles to drive a greater distance using the same amount of fuel is the main task in increasing the efficiency of passenger cars. The results show the main specifications of this new model of hybrid electric drive according to the European driving schedule. This mathematical model uses experimentally verified data from laboratory working stand and these simulations provide the results which prove the eligibility of this new technological solution.

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LV Installation Apparatus Impedance Characteristics in Wide Frequency Range

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Low voltage buildings installations and its protecting and switching apparatus are primarily determinate for electric power distribution. Its impedance properties are interested namely from the point of short circuit currents elimination and from the point of insulation resistances. But nowadays the new role of this power lines is tested. For data transmitting special lines are used up to now. Typically it is co-axial cable, twisted pair of wires or optical fibre. All this special lines must be constructed and in some cases it is very complicated. For instance in old and historical buildings to build new metallic or optic data network is really hard to do. But electric power lines are ready and its usage like transmitting media seems to be very practical. For high frequency power lines communication frequency carrier signal in range of 1,6 - 30 MHz are used. Therefore properties of power network cables and other installing and protecting apparatus must by study. For first study high frequency impedance characteristics of all elements on transmitting path must be good investigated. Except apparatus and lines impedance characteristics the transmitted signal coupling and decoupling circuits must be solved. For signal transmitted from the transmitter to the power line and back from power line to the receiver conductive (via resistors), inductive (via transformers) or capacitive (via capacitors) coupling circuits are used. This coupling circuit represents the barrier for high voltage of transmitted electric energy and transmitter output and receiver input circuits. On the other side represents low impedance for high frequency and low level data signals.

The main interest was focused on low voltage electric apparatus like miniature circuit breakers, residual current circuit breakers, time relay and over-voltage surge arresters. Theirs impedance characteristics in range 0,1 - 30 MHz has been measured and simulation model was derived.

Basic frequency range for impedance characteristics measurement is done by frequency zones for signals transmitting used. Total frequency zone is between 1,6 and 30 MHz. This broad frequency range is divided into two frequency sub-ranges. First frequency sub-range 1,6 to 13 MHz is used for outdoor communication (overhead or cable lines). The second frequency range 15 - 30 MHz is used for internal communication in the buildings.

For experimental investigation and impedance characteristics measurement following apparatus has been selected:

- 1. Current protective circuit breaker BS017101, $I_n = 1A$,
- 2. Residual current circuit breaker BD 094 110, $I_{\Delta n}$ = 100 mA
- 3. Surge arrester, AD 2, I_{SN} = 2,5 kA
- 4. Time relay ZR 368000
- 5. PC power supply EMCO JS 200, P=200 W

In accordance to international standards all low voltage installation apparatus are typically designed for 50 or 60 Hz operational frequency. Their construction is based on electromagnetic circuits and ferrites core electromagnets. They are connected in serial to the 288
power lines (circuit breakers, residual current circuit breakers, fuses). The other apparatus, connected like load, are is in parallel to power line conductors (time relays, surge arresters, all types of loads). Internal circuits of this apparatus consist of inductances (protecting HF filters), capacitances and resistances. Therefore its impedance could be very frequency dependent and will have serious impact on transmitting properties in frequency range 1,6-30 MHz.

With respect to this facts impedance measurement by HP 4285A Hewlet Packard impedance meter has been realised.

Obtained impedance characteristics of selected apparatus have very different shape.

Miniature circuit breaker, which is connected in series with the line and represents longitudinal impedance indicate significant resonant peak on frequency near 5 MHz. This resonance represents significant restriction for outdoor signals in the frequency band 4,8 MHz. Residual current circuit breaker impedance characteristic is linearly proportional to the frequency. This characteristics are more convenient for outdoor signals in the range 1,6-13 MHz.

The other apparatus impedance characteristics (surge arrester, digital time relay, PC power supply) are not suitable for their low impedance value in high frequency range. Because this apparatus are connected in parallel to the power line, high attenuation for transmitted signal will appear. Very important in this case is impedance and attenuation of connecting cables. The higher cable impedance, the higher attenuation of transmitting signal will be appearing.

Obtained results indicate that impedance of protecting apparatus, surge arresters and loads are very variable. High impedance peak of miniature circuit breaker represents frequency rejection at frequency near 5 MHz. On the other hand impedance capacitive character of digital relay, PC power supply and surge arrester behaves like short circuit on high frequencies. With respect to these characteristics spreading of high frequency signals and data transmitting via power lines could be problematic and non stable.

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The New Automated Drive Unit for Goniophotometer

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This paper describes the drive unit automatization for goniophotometer, which is placed in light laboratory T1:G1-21a. Several specialists cooperate on this project, I will describe only the drive unit and its solution.

Goniophotometer is device, which allows measuring the luminance of light source in several observation angles. It consist of the light source and around orbits the photo detector. This sensor is linked to the middle of rotation with a long shank. Goniofotometer in light laboratory is approximately 2 meters long shank with photo detector on first end and a balancing weight on the second end. In the axle of rotation it is placed a big disc, which subserves two functions. There is goniometer on its face, which indicates the angle of the shank. Its second function is that it's a segment of transmission. The motion of the shank generates the small asynchronous engine with worm-gear unit. The small wheel on the output shaft of the worm-gear unit is connected with the big wheel in the axle of rotation with the wire. This wire transmission is very troubleshooting. The wire is elastic and springing. The second big problem is that the wire spins on the wheels. The third problem is in the controlling of the engine. It's only controlled manually with two buttons. The first is for the movement left and the second is for the movement right. The engine has not some regulation of position and some start- and stop-ramp. The method is following. The operator holds the button till the pointer of goniometer show approximately the desired value. To switch the engines off is quick but the wire is elastic, hence the shank still swings about five seconds. After the stabilization the shank is either in the desire position or the operator has to correct the position, always with the swinging. This process is very lengthy and obstructs the metering. That is why it was decided the goniophotometer have to be modernized.

The modernizing of goniophotometr brings these advantages: the position accuracy and no swinging. The required accuracy is up to 0.5 degree. It is supposed the modernization allows the fully automated mode too, it mean the shank will be controlled by computer or microcontroller and it will be able to measure automatically the luminance in full range after the operator's command and from the measured values it will be able to compiled the output listing. The next important requirement is fact, that the commercial metering are always in progress on the laboratory and it is not possible that the goniophotometer is out of order for a longer time. The modernizing has to make at once (during one day) or divides in several phases, which allow that the goniophotometer will be always in progress.

The way of the solution is divided to two parts: first is mechanical part and second is electrical part. Our colleague F. Lopot solves the mechanical part, it consists from transmission and motor mounting. It was the first phase. If the resolution error was more that 0.5 degree, then the modernization has not the contribution to measure and we don't have the reason to continuing with modernization.

The electrical part consists of selection of suitable engine, the power electronic and control program. With respect to requirements to accuracy and necessity to hold the set up position, the stepping motor is the best variant. The acceptable motor has enough torque, which can move with the shank with the desired acceleration without step loss. The shank is balanced hence there is not critical the static torque. A character of stepping motor is big downtrend with increasing speed. I take the dynamic torque of the shank from the shank 290

construction especially from the geometry and material of the balancing weight. And I take the required torque of stepping motor from the probable time to moving the shank between two standard measured positions. It was necessary to choose the right motor from the available motors of the market, which has a small step, because the resolution of position has to be under 0.5 degrees after the transmission. The motor must have a sufficient torque at the same time. The acceptable motor is by company Microcon series SX34 type 6212 with static torque 12 Nm and nominal step 1.8 degree. The mechanical transmission reduces this resolution in ratio 11:1. So the theoretical resolution of position is up to 0.2 degrees to one step. The company Microcon delivers a compatible power unit with the motor too, which converts the command pulses from computer to voltage in two motor phases, and compatible source. The company Microcon produces compatible micro regulators with its stepping motor and power units too. But we use some computer equipped with input/output programmable ports in our situation in lieu of single-purpose micro regulator. This computer with respective program will be able to measure whole measuring sequence, but this computer will be so modular that it allows to measure only in partial positions of the range. On the top of it the computer can export measured data to output listing or save to next analysis.

The development system LabVIEW by company National Instruments is suitable software for this exercise. It is a graphic development system with the support for data acquisition from common measuring instrument and with great possibilities by its elaboration. It is graphic programming language. Like a data logger and the pulse generator it will be a universal unit DAQ by company National Instruments. It is a special unit with programmable input/output binary ports, digital to analog converters and analog to digital converters. This card is connected with PC via USB. The control program will cyclically send pulses through one binary port to the power unit. A shank movement will be as a result. Signal from the incremental optical sensor will be connected to another binary port. This signal will show the real shank position, because there is possible to lose the step. The shank will stop the movement in specify segments (every 5 degrees) and the controlling system will read the value from the luminance sensor.

The first phase was realized, so it means the wire transmission was dismantled and replaced by chain gear. The making a new chain gear transmission has been successfully finished. The position error is up to 0.5 degree. Now we prepare the second phase that means the small asynchronous motor will be dismantled and replaced by stepping motor. There will be the motor controlled only by basic program in this phase, which allows the movement about selected quantity of degrees. The full version of controlled program will be made by student in his graduation theses. The controlled program has to be user friendly and robust.

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Section 10

NUCLEAR ENGINEERING

Incorporation of Bones and Bone Equivalent Substitutes into Polymer Gel Phantom for Head-and-Neck Treatment Plan Verification

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In the last decade, polymer gels proved to be a very useful tool for three-dimensional visualization and measurement of absorbed dose distribution in a variety of medical applications - stereotactic radiosurgery (SRS), intensity modulated radiotherapy (IMRT), brachytherapy or breathing adapted radiotherapy (BART); i.e. [1]. All mentioned works sought to model the real world situation using appropriate shapes and dimensions of gel phantoms (e.g. pelvic phantom for prostate IMRT verification, etc...); however, the flexibility of gel dosimeters enables to manufacture even more authentic phantoms, incorporating different kinds of inhomogeneities either of natural origin simulating bones and cavities or artificial implants and clips; i.e. [2]. These kinds of heterogeneous phantoms, gel with implanted inhomogeneities, provide the only experimental way to quantify and visualize the absorbed dose with sufficient spatial resolution in regions of electronic disequilibrium. The manufacture of heterogeneous phantoms is more complicated than pure gel phantoms since the implanted heterogeneity must be chemically stable and oxygen free to eliminate fatal errors in measurement results interpretation. Moreover, when magnetic resonance imaging (MRI) is used to read-out the response of the irradiated gel, a special requirement is imposed on the MRI compatibility of the implanted heterogeneity and the gel container.

This work aims to investigate the possibility to implant real bone samples and bone substitutes into a gel sample. Special interest is paid to the head-and-neck treatment verification as it presents a complex site with irregular surface and different heterogeneous organs (e.g. spinal cord, vertebrae, larynx, etc...). A special glass phantom was designed to simulate the shape of the head-and-neck region. It can accommodate vertebrae (real or bone-like material) and thus simulate the spinal canal filled with the radiosensitive gel.

The following text summarizes practical experience and complications encountered when implanting real bones into a polymer gel.

Gel composition, preparation, irradiation, and read out

The composition of a polyacrylamide gel (PAG) used in this work can be found in [1]. The gel preparation followed our well-established procedure using a perspex nitrogen filled glove box, since the oxygen drastically reduces the sensitivity of the gel to the ionizing 294

radiation [1]. All gel containers were washed with distilled water prior to filling to avoid gel contamination.

Three samples of bones were used. Two out of the three were mechanically cleaned and washed with distilled water. The third piece was additionally cleaned with acetone and then washed with distilled water as well. Prior to the positioning into the glass flasks the bone samples were immersed in a nitrogen atmosphere (approximately 1 hour) to flush oxygen from its pores.

The PAG samples with implanted bones were homogenously irradiated with cobalt-60 irradiator Gammacell 220 (MDS Nordion, Canada) with the dose rate of 7.75 Gy/h five days from the manufacture procedure (kept in refrigerator). Two samples with bones, one cleaned mechanically and the one cleaned with acetone were homogenously irradiated with doses 11.5 Gy. The remaining sample (mechanically cleaned) was left unirradiated as a reference. The PAG response was read out 12 hours from irradiation using 1 tesla Magnetom Expert (Siemens, Germany) magnetic resonance scanner. 2D T2 weighted multiple spin echo sequence (16 echoes), with equidistant TE 22.5 ms, TR 2000 ms. T2 maps (i.e. dose maps) and dose profiles were further processed in Matlab 6.5 (The Mathworks, USA) equipped with the Image Processing Toolbox.

Results and discussion

In all samples, reduction in polymerization close to bone surface was observed, probably caused by remaining oxygen in its pores. On the other hand, our results indicate that the way of reducing oxygen levels in bone pores by sufficient nitrogen flushing can be successful when it is performed for longer time interval.

Different way how to overcome complications with real bone implants could be to coat them in some chemically resistant substance or to use bone substitutes with similar parameters as a real bone (electron density and mass density) in order to model similar interaction processes of ionizing radiation. Currently, several new materials are tested as bone substitutes – mostly plastics with higher density (1.6 - 2.5 g.cm-3), i.e. Teflon (PTFE), which can be readily shaped into various shapes.

Future work will be oriented towards improving gel manufacture procedure with inhomogeneities.

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Radiation and Temperature Resistance of Metal Hall Sensors: Optimization and Design of High Temperature Resistant Helmholtz Coil

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The construction of experimental thermonuclear reactor ITER poses several technical and physical challenges associated with its expected output fusion power ~ 500 MW. An exact plasma position determination is needed to assure its successful operation. The current plasma position diagnostic system is based upon coils with analog integration, which becomes difficult in case of steady state magnetic field measurements and pulses longer than 1000 s. Proposed complementary solution seems to be use of Hall sensors measuring directly the absolute value of magnetic field. Currently, thermal and radiation stability of Hall sensors based on semiconductors is under investigation. They still do not satisfy completely ITER requirements; therefore we decided to start testing the metal Hall sensors. Such sensors have lower sensitivity than those based on semiconductors, but higher temperature and radiation stability performance can be expected.

To measure sensors' sensitivity and thermal characteristics a new Helmholtz coil compatible with operation at temperature up to 250° C was needed. Magnetic field of several hundred millitesla was needed to be achieved due to low metal Hall sensors' sensitivity ~ 0.1 mV/T.

Helmholtz coils consist of 2 circular coils with the same radius *R* and number of turns *N*. Current *I* flows in both coils in the same direction. It produces a homogeneous magnetic field *B* in its center: $B = 8.992 \times 10^{-7} \text{ NIR}^{-1}$. In general, the stronger magnetic field *B* is created, the less space between the coils and higher *N* is needed. On the other hand, several dimensional and physical requirements of the coils construction is needed to be taken into account.

The optimal configuration of the coils was searched as a global maximum of B = B (d_w, r, a, b) with various limiting conditions, where d_w (diameter of the wire), r (radius of Helmholtz coil), a (width) and b (height of the coils winding) were set as independent variables. Other depending variables such as wire diameter with insulation d_i , inner d_{in} and outer d_{out} diameter of coils, distance between coils z, height of the coils h, I, N were expressed as functions of the independent ones. Finally, the expression for B created inside the Helmholtz coil was derived: $B = 0.08944 \mu_0 U d_w^2 \rho_{Cu}^{-1} r^{-2}$, where μ_0 is permittivity of vacuum, U is voltage and ρ_{Cu} is resistivity of copper at 250°C. Additional conditions were given by dimensional and technical limitations: $d_{in} > 50 \text{ mm}$, z > 35 mm, $d_{out} < 340 \text{ mm}$, h < 340 mm, I < 30 A, U < 120 V. The last condition showed that the optimum size of the Helmholtz coil radius is 35 mm < r < 170 mm. The smallest acceptable r was chosen. The Biot – Savart law was used to compute the magnetic field vector at net of points inside the Helmholtz coil to investigate its spatial distribution, in particular, its homogeneity. The profiles of magnetic field along

coil's central axis and in radial direction varied with homogeneity factors $f_{ax} = B_{max} / \langle B \rangle_{ax} = 1.0253$ and $f_{rad} = B_{max} / \langle B \rangle_{rad} = 1.0218$. In other words, the value of the magnetic field difference along 5 mm distance was 1.189 mT along the central axis and 0.614 mT in radial direction. The distance of 5 mm was chosen because of usual size of tested samples.

According to the results of the first optimization, a suitable copper wire was chosen. It had rectangular cross-section and Kapton insulation allowing high temperature operations. The optimized parameters of the coils for this wire are shown in Tab 1. The factors of homogeneity of magnetic field for such configuration are $f_{rad} = 1.0234$ and $f_{ax} = 1.0217$.

Size of wire	1.5 x 3.3 mm	
Height of winding	38.8 mm	
Width of winding	96.9 mm	
Radius of Helmholtz coils	74.0 mm	
Inner coil diameter	51.1 mm	
Outer coil diameter	244.9 mm	
Distance between coils	35.2 mm	
Height of the coils	112.8 mm	
Number of turns N	1232	
Resistance of winding R	3.868 Ω	
Magnetic field B	224.5 mT	

Table 1: Optimized parameters of Helmholtz coil for rectangular conductor.

Further, improvement of the homogeneity of coil's magnetic field is possible by winding deformation. A sinusoidal windings deformation would reduce the inhomogeneities of magnetic field inside the Helmholtz coils by more than 30% with less than a 5% reduction of their magnetic field [2].

The support structure for coils winding was made using 3 mm thick Aluminum plates and shaped coils centers were machined from Aluminum tubes. To improve the passive cooling of the coils twelve holes along coils' radius were made in the plates on both sides of the support structure. Unfortunately, the Kapton insulation showed a very low adhesion, which prevented proper alignment of winding layers onto the shaped support structure during manufacturing of the coils. Therefore we returned back to the simpler design with simple cylindrical support structure of the coils.

The coils were successfully manufactured and tested constituting one of the key components of experimental set-up for future study of metal Hall sensors.

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Study of the Neutron Production and Transmutation in ADTT Systems

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ADTT (Accelerator Driven Transmutation Technology, or ADS – Accelerator Driven Systems) can be a future solution for the rising amount of the high-level nuclear waste from the nuclear reactors. It is a combination of a subcritical reactor with an accelerator. The basic principle is in the production of a large number of neutrons in the spallation process (relativistic ions + heavy metal target), and their multiplication in a sub-critical blanket. Dense neutron field can be used to produce fuel from ²³²Th, and/or to transmute long-lived nuclear waste to short-lived or stable isotopes. Main advantage of this technology is its safety; switch off of the accelerator means a switch off of the whole system.

Before the first full scale demonstration ADTT unit can be built, a lot of nuclear data and properties must be well known. Details of the spallation reaction and its description in simulation codes, as well as the cross-sections of wide range of nuclear reactions are necessary to be studied. There is nowadays also another motivation - rising number of strong neutron sources based on spallation reaction, e.g. MEGAPIE.

We are members of the Energy plus Transmutation (E+T) project. It is an international project that studies the energy production and transmutation in a system of massive Pb target and uranium blanket. Lead target is in a form of cylinder half a meter long and 8.4 cm in diameter. It is surrounded with a natural uranium blanket (total weight of the uranium is over 200 kg), uranium is in a form of small rods coated with aluminum. The setup is placed in a biological shielding consisting of a wooden box with walls filled with granulated polyethylene, inner walls of the shielding are coated with Cd. This setup was irradiated on the Nuclotron accelerator in the Laboratory of High Energies, JINR Dubna. Up to now we had four proton experiments with energies 0.7 - 2 GeV and two deuteron experiments with energies 1.6 and 2.52 GeV (see for example [1], [2]). Next experiment is planned on the February 2009.

We measured produced high energy neutron field by the Neutron Activation Analyses (NAA). For each irradiation we used a set of ~100 activation detectors - foils made from Au, Al, In, Bi, Ta, Cu, Co placed in radial and longitudinal directions according to the target axis. Activated foils were measured on HPGe spectrometers, γ -spectra were evaluated in the DEIMOS32 code [3]. The products of the (n,xn) threshold reactions up to (n,11n) – threshold 78.4 MeV - were observed. Yields correspond with the neutron field in the respective place of the setup, direct unfolding and neutron spectra determining is not possible thanks to missing cross-section data. Maximum of the yield was in the centre of the setup around 12 cm from

the target beginning (depends on the beam energy). The yields in radial direction decreased rapidly.

We performed a wide range of Monte-Carlo simulations on the E+T setup. Experimental results compared with the simulated ones serve as a kind of the benchmark tests of the MCNPX and FLUKA codes (we are members of the MCNPX beta-tester team).

For most of the (n,xn) reactions observed in the E+T experiments, only a few experimentally measured values of cross-sections exist. In 2008 we got an EFNUDAT support for (n,xn) - cross-section measurements of Au, Al, Bi, In, I, and Ta. We used neutron sources at The Svedberg Laboratory (TSL) in Uppsala, Sweden (25, 50, and 100 MeV) and at Nuclear Physics Institute of the Academy of Sciences (NPI), Řež near Prague (20 and 25 MeV).

At the TSL Uppsala quasi-monoenergetic 11 - 175 MeV neutron source based on the $^{7}\text{Li}(p,n)^{7}\text{Be}$ reaction is available [4]. High energy protons from the cyclotron are directed to a thin, lithium target, the neutron flux density can be up to $5 \cdot 10^{5} \text{ cm}^{-2} \text{s}^{-1}$. The half of intensity is in the peak with FWHM = 1 MeV (corresponds to the ground state and first excited state at 0.43 MeV in ^{7}Be) and half of intensity is in continuum in lower energies (corresponds to higher excited states, multiple-particle emission etc.). Proton energy loss in the target amounts to 2 - 6 MeV depending on the incident beam energy and target thickness. Downstream the target, the proton beam is deflected by a magnet and guided onto a graphite beam dump. The neutron beam is formed by an iron collimator (50 cm in diameter and 100 cm long) with a hole of variable size and shape. At the NPI Řež protons from the cyclotron are directed also to the lithium target, passed protons are stopped in a C-layer behind the Li. Uncollimated quasi-monoenergetic neutrons are in the range of 10 - 37 MeV.

Irradiated materials in form of thin foils were measured on HPGe spectrometers. Gained γ -spectra were evaluated in the DEIMOS-32 code [3]. Yields of observed isotopes were calculated and various spectroscopic corrections were applied to lower all possible systematic errors. When evaluating the cross-sections, suitable threshold reaction has to be chosen so that the neutron continuum could be neglected. At this moment the evaluation is almost ready, we are waiting for the beam data from the TSL Uppsala. Preliminary results show we are close to known cross-section values.

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Optimizing Transmittance of Optical Filters Using Regression Analysis

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Multilayer coatings are of interest for a variety of applications where filters of electromagnetic radiation are required to have specific reflection, transmission and absorption behaviours. We use the physical quantity of transmittance in order to optimize optical filters for a suitable spectral range. We created a software solution using MATLAB to achieve these aims. The application enables us to show the trasmittances of the elements and of some compounds in units such as eV and nm. The transmittances can be calculated for wavelengths corresponding to energies from 1 eV to 20 MeV. The application allows selected filters(elements or compounds) to be added or subtracted up to three times. Additionally, the application allows us to specify the type of sources (white, rectangular pulse, lines, exponential, K-alpha, K-beta with settings of their parameters) and to select the type of detector.

Optical filter optimization for single layers and for bilayers was added to this application. The optimization solution is calculated using only the transmittance and its parameters. The transmittance is determined using the equation: $I = I_0 e^{-\rho\mu x}$, where ρ is the mass density, μ is an energy- and material-dependent mass attenuation coefficient, *x* is the thickness, *I* is the transmitted intensity and I_0 is the incident intensity. We use regression analysis based on the least squares method. We estimate the suitable thickness for optical filter design in the designated spectral range. We manually select a fixed optical filter with high transmittance in this band. We then have three options of data model to fit. The first option is the inverse model for approximation of transmittance. This model has the same values of transmittance without the filter band as the fixed filter. The values within the filter band are not included. The second option is the zero model of the algorithm tries to fit the zero transmittance model in the band of wavelengths to which the filter is applied, and unitary transmittance to all other wavelengths. It is chose the filter with the best correspondence to the model.

We now define the model of transmittance as y_i and we denote the mass attenuation coefficient as $\alpha_i = \rho \mu_i$. We then use a mathematical procedure to best fit a given set of points to the model transmittance curve. We do this by minimizing the sum of the squares of the residuals of the points from the curve of transmittance of the particular element in question.

We generally require the equation $Q = \min \sum_{i=1}^{n} (I_0 y_i - I_0 \prod_{j=1}^{k} e^{-\widehat{x_j} \alpha_{ij}})^2$ to be minimized, where

k is the number of filter, n is the number of values in the transmittance model and $\widehat{x_{z_i}}$ is the

estimation of the thickness of the layer j of the element with atomic number Z (from 1 to 92). We can then transpose the non-linear form to the linear form using a linearizing logarithmic transformation, where I_0 is substracted. Therefore, in order to estimate the composition of the filter we do not need to know I_0 of the light source or the detector absorption. In the next step we find the extremum of a function. We find the partial derivation of the equations to zero and then solve these equations and express the estimates of the thicknesses (regression coefficients). In order to design a suitable filter, we obtain the thickness estimates for a single layer filter and for a bilayer filter combination in the forms

$$\widehat{x_{Z_{1}}} = -\frac{\sum_{i=1}^{n} \alpha_{i} \ln y_{i}}{\sum_{i=1}^{n} \alpha_{i}^{2}} \text{ and } \widehat{x_{Z_{1}}} = -\frac{\sum_{i=1}^{n} \alpha_{i1} \ln y_{i} \sum_{i=1}^{n} \alpha_{i2}^{2} - \sum_{i=1}^{n} \alpha_{i1} \alpha_{i2} \sum_{i=1}^{n} \alpha_{i2} \ln y_{i}}{\sum_{i=1}^{n} \alpha_{i1}^{2} \sum_{i=1}^{n} \alpha_{i2}^{2} - \left(\sum_{i=1}^{n} \alpha_{i1} \alpha_{i2}\right)^{2}}$$
$$\widehat{x_{Z_{2}}} = \frac{-\sum_{i=1}^{n} \alpha_{i1}^{2} \sum_{i=1}^{n} \alpha_{i2} \ln y_{i} + \sum_{i=1}^{n} \alpha_{i1} \alpha_{i2} \sum_{i=1}^{n} \alpha_{i1} \ln y_{i}}{\sum_{i=1}^{n} \alpha_{i1}^{2} \sum_{i=1}^{n} \alpha_{i2}^{2} - \left(\sum_{i=1}^{n} \alpha_{i1} \alpha_{i2}\right)^{2}}$$

The combination of two layers for the filter is enough for us, because more layers rapidly decrease the transmittance. We experimented with optimization in the x-ray spectrum (in range from λ = 0.001 nm to 1.25 nm). The achieved results are good, but it is important to note that the values of the spectral filter band and the boundaries of the filter band are based on a priori information in order to calculate and select the appropriate model of transmittance. For example, we assume boundaries from 0.001 nm to 1.25 nm and a spectral filter band from 0.65 to 0.8 for fixed filter Silicon with a thickness of 2 µm (Tab. 1.).

Tal	b.	1	•

Transmittance	Best filter for fitting transmittance model		
model	Element	Thickness	Residuals
Filter inverse model	Aluminum	2.17 μm	0.0991
for single layer			
Filter inverse model	Aluminum	1.95 μm	0.0075
for bilayer	Rubidium	0.2 µm	

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Catalytic Activity of Radiation Induced Silver Nanoparticles in Hydrogen Peroxide Decomposition

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Most of the radiation-assisted methods are the photoreduction of $AgNO_3$ aqueous solution upon exposure to UV light. Some reports refer to the reduction of noble metals in aqueous solutions by gamma radiation, too. However, application of electron beam irradiation to the nanoparticles preparation is until rare. Reducing effect of Triton X-100 and subsequent stabilizing effect on the nanoparticles are also well known. The present contribution deals with the effect of fast electrons irradiation conditions on the catalytic activity of silver nanoparticles prepared by reduction of $AgNO_3$ in Triton X-100 aqueous solutions.

Influence of various molar rations of non-ionic surfactant Triton X-100 (polyoxyethylene-t-octylphenyl ether) and AgNO₃ in water on the radiolysis efficiency was studied. Concentration of Triton X-100 varied from 0,01 to 2 weight % during constant concentration of AgNO₃ (0,1 mol/l). Some reduction sensibilizers were used. Irradiation was realized in glass ampoules (20 ml volume) with fast 4 MeV electrons from linear accelerator LINAC – current of electrons, which influences resulting dose, may be controlled up to 0,35 mA.

Irradiation experiments were performed above critical micelle concentration and the temperature was below the cloud point.

Depending on applied dose (from 0 to 32 kGy), formations of yellow, brown and black coloured colloid systems are observed. Formation of well-dispersed silver nanoparticles was confirmed by electron microscopy, X-rays diffraction patterns and UV-visible spectroscopy. Radiation yield (expressed as a number of species per 100eV absorbed energy) of silver was measured by argentometric titration with potentiometric detection.

Catalytic activity of prepared systems was tested by the reaction of hydrogen peroxide decomposition. Some amount of colloid solution was injected into stirred H_2O_2 solution and rate of released oxygen was measured by recording of system pressure increase Experiments were performed in constant temperature and system volume. Catalytic activity was characterized by the hydrogen decomposition rate constant

The most interesting result of this study is the proportionality of silver nanoparticles catalytic activity, represented by rate constant, to concentration of Ag nanoparticles characterised by the value of UV absorbance, and to applied dose of ionising radiation, which is the main factor which determine the formation of these species. So, rate constant of hydrogen peroxide decomposition may be used as a characteristic factor for preparation of nano-system.

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Section 11

CHEMISTRY

Formation and control of trichloracetaldehyde in drinking water

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Chloral hydrate (the hydrated form of trichloracetaldehyde) is formed in water treatment as a by-product of the reaction between chlorine and naturally occurring organic matter. After the THM and HAAs, chloral hydrate was the next most prevalent disinfection by-product found in drinking water [1]. Chloral hydrate has not received as much attention as the THMs and HAAs but it has been shown to be present in drinking waters throughout the world up to 75 μ g.l⁻¹ [2].

The mechanism of chloral hydrate formation in water is more difficult to identify because of the complex nature of organic material. Several mechanisms of formation are possible. However the studies carried out in this area show that chloral hydrate is also subject to decay and could better be described as an intermediate by-product. The studies show that chloral hydrate will decay to give other important disinfection by-products as chloroform and trichloroacetic acid.

In general the formation of chloral hydrate is influenced by pH, contact time with the disinfectant, temperature and season, nature and concentration of natural organic matter (NOM), chlorine dose and bromide concentration. All of the factors must be considered separately when attempting to minimize its formation.

The use of chloramines as a disinfectant reduces the formation of chloral hydrate compared with chlorine. The introduction of pre-ozonation before chlorine increases chloral hydrate levels or chloral hydrate formation potential. Ozone – chloramines can result in low levels of chloral hydrate provided that the chlorine addition is well managed and there is little chlorine contact time.

Enhanced coagulation, which involves optimizing the coagulant dose, pH, mixing time and mixing conditions, can reduce chloral hydrate concentration in water.

The objective of this study is to provide information on the seasonal and spatial variations of the levels of chloral hydrate formation potential in surface water.

The source of water was the Fláje reservoir situated in Ore Mountains. The results from this study can provide a reference basis for water treatment process or high-level removal process for disinfection by-products. Chloral hydrate was quantified according to the TNV 757549 method "Determination of THM Potential".

Residual chlorine measurement was made by the colorimetric method. Chloralhydrat formation potential values (PCH) in water from Flaje reservoir range from 15,2 μ g.l⁻¹ to 99,3 μ g.l⁻¹ (\emptyset 54,4 μ g.l⁻¹) according to the DCO value between 3,9 to 9,8 mg C.l⁻¹. It was found, that seasonal variations occurs in PCH. The highest values were found on spring (\emptyset 66,0 μ g.l⁻¹) and autumn (\emptyset 56,0 μ g.l⁻¹), the smallest in summer (\emptyset 42,0 μ g.l⁻¹).

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Significance and Assessment of the Biological Stability of Water

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The objective of this study was to evaluate the necessity of measuring biodegradable organic carbon as indicator of bacterial stability of water.

The determination of biodegradable organic carbon (BDOC) in water is of particular concern to the water industry because biodegradable organic matter is almost the only limiting factor for heterotrophic bacterial growth in drinking water distribution systems, which produce changes in the water quality. The source of BDOC could be the raw water or any step of the treatment processes and it is important to determine the evolution of this parameter through the water treatment train as early as possible and to detect the steps at which BDOC appears, in order to facilitate decisions about possible treatment strategies and to give rapid responses to changes in water quality. BDOC is that portion of dissolved organic carbon DOC in water that can be mineralized by heterotrophic bacteria and has the same units (mg C.l⁻¹).

Natural organic matter (NOM) consists to a large extent of humic substances that may adversely affect the drinking water quality, as precursors to the formation of disinfection byproducts (DBP), as complexing agents for micropollutants, by biofilm formation and precipitation in the distribution system, and by giving the water an unwanted color. NOM consists of organic molecules of various sizes and with various functional groups.

Aquatic NOM can be derived from soils and plants in the terrestrial watershed (allochthonous NOM) or from the algal and bacterial growth in the water (autochthonous NOM). Frequently, NOM is a heterogeneous mixture of various organic materials, including humic substances (humic and fulvic acids) and non-humic matter (mainly proteins, amino acids, carbohydrates, etc.) Most NOM is in dissolved form, which is commonly indicated by the levels of DOC dissolved organic carbon) and UV254 (the degree of aromaticity indicated by UV absorbance at 254 nm). Specific UV₂₅₄ (SUVA₂₅₄, was a good parameter to indicate specific NOM aromaticity).

Biological stable drinking water is defined as one, which would not cause reproduction of coliforms and heterotrophic bacteria. The link between biodegradable organics and bacterial regrowth in potable water has been noted by several researchers [1, 2, 3].

The BDOC test measures the gross amount of organic matter that is biodegraded by an inoculum of suspended bacteria over a predetermined period of time. The result of the test represents the fraction of DOC that is both mineralized and assimilated by heterotrophic flora, determined as the difference between the initial DOC and the minimum DOC observed during the incubation period.

This study has been performed on the WTP Plav in southern Bohemia during the 2004 - 2008. This WTP provides settling, coagulation, flocculation, sand filtration and disinfection

with chloramines. Three places were chosen as locations for monitoring and taken samples for the analysis of the main characteristics of untreated, filtered treated and final water. The parameters in the physical and chemical analysis included temperature, turbidity, pH values, alkalinity, hardness, concentration of dissolved oxygen, iron and manganese content, phosphate, ammonium, nitrite and nitrate content, COD, DOC, free chlorine and BDOC.

BDOC was measured according to the method from Servais et al. [1], which use water sample as inoculum, after 30 days of incubation.

BDOC levels at the outlet of the water treatment plant Plav were between 0,12 mg. Γ^1 and 0,66 mg. Γ^1 (Ø 0,42 mg. Γ^1). Chlorination after filtration caused a significant decrease in BDOC.

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Radiation Preparation of Nickel Oxide and

Titanium Dioxide Nanoparticles

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Nowadays, nano-sized particles of various compounds are studied extensively, due to their possible utilization in both research and industry. Physico-chemical properties of nanoparticles may differ when compared to bulk material, e.g. they have larger specific surface area, their colour may change, etc.

The aim of this preliminary study was to prepare and to investigate nickel oxide and titanium dioxide nanoparticles obtained from aqueous (or) organic solutions using radiation energy. Both nickel oxide and titanium dioxide are semiconductors.

Redox reactions, hydrogenations and dehydrogenations are catalysed by nickel oxide. It is used as an adsorbent for some gasses such as oxygen, nitrogen, or carbon oxide. Radiation preparation of nickel oxide and formation of nanoparticles may affect the stoichiometry, specific surface area, surplus oxygen, and especially the amount of active catalytic centres.

Titanium dioxide occurs in three forms in nature – the minerals rutile, anatase and brookite. Anatase is a photocatalyst under UV light. Titanium dioxide acts as an UV absorber, efficiently transforming UV radiation energy into heat. After additional treatment, e.g. addition of nitrogen ions or doping by some metal oxides, titanium dioxide may become photocatalyst under both visible and UV light. Titanium dioxide can be also used as a hydrolysis catalyst [1].

For irradiation of the solutions, a linear particle accelerator was used. For determining changes caused by ionizing radiation, UV/VIS spectrophotometry was used, and for determination of the size of crystallites, X-ray powder diffraction was used. From other chemical methods, filtration and dispersing in ultrasound bath were used. For the comparisons and determination of instrumental resolution of RTG device, commercial NiO and TiO₂ were used [2, 3].

Five basic aqueous solutions containing nickel formate and various other compounds (hydrogen peroxide, polyvinyl alcohol (PVA), isopropyl alcohol (IPA), the mixture of PVA and IPA, and nickel formate without any other compound) were used for nickel oxide preparation. The solutions were irradiated by accelerated electrons with doses in the range of 0-40 kGy. During irradiation, the solutions gradually changed their colour from green to black, due to the formation of colloidal nickel oxide. An absorbance of solutions irradiated by various doses in the range of 190-900 nm was measured to evaluate changes caused by ionizing radiation.

Solid phase from solutions irradiated with the highest dose of 40 kGy was separated via filtration and carefully dried. The composition of solid phase and the size of crystallites were determined via X-ray powder diffraction. In all cases, pure non-stoichiometric nickel oxide was found; the size of crystallites was determined to be in the range of 10-40 nm. For the decomposition of organic admixtures, the solid phase was annealed under vacuum at 200 °C for 1 hour and at 600 °C for 2 hours. At the given dose of 40 kGy, the most solutions yield a finely dispersed solid phase; however, irradiation of the aqueous solution of nickel formate with polyvinyl alcohol leads to formation of true colloid.

Besides the commercial one, another standard of titanium dioxide was prepared by chemical hydrolysis of tetra-n-butyl orthotitanate (TBOT). $TiO_2 \cdot xH_2O$ (titanium dioxide) was obtained via titration of TBOT with deionised water. The suspension was continually dispersed in ultrasound bath.

Untreated pure TBOT was irradiated by doses in the range of 0-200 kGy. After irradiation of TBOT (colourless, transparent solution), its colour changed to black, presumably due to the formation of mixture of colloidal titanium and various (non-stoichiometric) forms of titanium oxides. As in the case of NiO, the absorbance of series of solutions irradiated by various doses was measured to evaluate radiation effects.

The irradiated solutions of TBOT were titrated by deionised water. Effects of dispersing via ultrasound during titration were evaluated. It is possible that the formed solid phase consists not only of titanium dioxide, but also of metallic titanium, which transforms to titanium dioxide rather quickly. However, further investigation is needed to support this presumption. The solid phase was treated similarly to NiO described earlier. RTG diffraction analysis showed presence of non-stoichiometric titanium dioxide and the size of crystallites was determined to be 10-40 nm.

It was observed that titanium dioxide formed under different radiation doses and under different conditions (e. g. dispersing in ultrasound bath) differs in colour and in the size of the particles.

It was shown that radiation technique is a viable and very promising method for preparation of various small-sized particles. Plans for the future are to investigate catalytic/photocatalytic activity of both nickel oxide and titanium dioxide. Detailed study of the properties of both substances using various advanced methods including electron microscopy and thermoanalysis is also needed.

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Effect of radiation on copper ions in aqueous solutions

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For several decades, the effects of radiation on various solutions containing metal ions have been studied. Radiation-induced reduction can be used for removal of some heavy metals from the industrial waste-waters or for preparation of metallic nanoparticles (colloidal metals). The most notable advantage of this method is the possibility to form nanoparticles with homogenous size distribution at normal temperature. Moreover, the size and some other physico-chemical properties could be easily controlled by changing the dose, dose rate and the composition of solutions.

The radiolysis of water leads to the formation of various unstable and very reactive intermediates, the most important being hydrogen radical H, hydroxyl radical OH and hydrated electron e_{aq} [1]. These species are classified according to their reductive or oxidative properties – the strongest oxidizing species is OH, whereas e_{aq} is the strongest reducing species. In the presence of suitable OH scavenger (e.g. secondary alcohols or formates), the reductive intermediates react with metal ions in the solution and reduce them gradually to the zero-valence state (or to the valence state, at which the metal ions form insoluble compounds – carbonates, oxides). Metal atoms and their aggregates undergo three competitive processes: aggregation or coalescence (formation of bigger particles), adsorption of metal ions on the surface (which can be consequently reduced by reductive intermediates) and corrosion by the solvent. To prevent or hinder the aggregation, another substance must be present in the solution – a surfactant or stabilizing agent, e.g. gelatine, polyvinyl alcohol or polyacrylate [1, 2]. Preparation of colloidal metal strongly depends on pH of the solution [3, 4], which can affect the efficiency of the reduction and even the composition of the final product.

In this work, we have studied the influence of γ -radiation or accelerated electrons on the aqueous solutions of 10⁻³ mol.dm⁻³ copper sulphate (CuSO₄) at natural pH in the presence of various stabilizing agents (polyvinyl alcohol PVA, ethylenediaminetetraacetic acid EDTA, sodium hexametaphosphate SHMP) and/or ·OH scavenger (propan-2-ol). To prevent reactions of dissolved oxygen with unstable products of radiolysis, yielding various strong oxidizing species, all solutions were deaerated by nitrogen prior to irradiation. Two radiation sources were used for experiments; ⁶⁰Co radionuclide source Gammacell 220 with a lower dose rate of 8 Gy.h⁻¹ and pulse linear electron accelerator LINAC 4-1200 in the possession of Tesla V. T. Mikroel s. r. o. with mean dose rate of about 10³ Gy.s⁻¹ and a mean electron energy 4,5 MeV. The formation of copper nanoparticles was observed using UV-Vis Spectrometry; for characterisation of the separated solid phase, X-ray Powder Diffraction was used; total concentration of copper ions in the solutions was determined by Atomic Absorption Spectrometry (AAS).

AAS analysis clearly showed that with the increasing dose, the concentration of copper ions in γ -irradiated solutions decreases only in the presence of ·OH scavenger. At the absorbed dose of 10 kGy, the decrease to circa 10 percent of initial concentration of copper ions was observed. The pH changed during irradiation process from circa 5,6 (natural pH) to 3,3 (at 10 kGy) and optical absorption peak at 750 nm (caused by [Cu(EDTA)]²⁺ complex) diminished, which corresponds with supposed reduction of copper ions. During irradiation with accelerated electrons, dark pink colloid was formed in studied solutions containing polyvinyl alcohol, whereas in other studied solutions, black-coloured precipitate was formed in some time after irradiation. Both precipitate and colloid were found to be extremely sensitive to oxygen and rapidly dissolved when brought into contact with air. X-Ray Powder Diffraction analysis of the precipitate proved the presence of crystalline copper Cu and cuprous oxide Cu₂O, which could be formed during the irradiation [4] or as the product of copper oxidation.

According to Mie Scattering theory, nanometre-sized copper particles exhibit absorption peak around 580 nm (depending on the particle size) – so called plasmon peak – and a weak, broad absorption band between circa 300 and 500 nm. Therefore, colloidal copper solutions are pink or violet. After irradiation with accelerated electrons, both these features have been observed in the optical absorption spectra of studied solutions, in which both ·OH scavenger and stabilizing agent (PVA or SHMP) were present. Surprisingly enough, copper nanoparticles were formed in the solutions containing propan-2-ol and EDTA after irradiation with accelerated electrons, whereas γ -irradiated solutions of the same composition did not absorb at 580 nm. Similarly, in optical absorption spectra of the solutions containing only PVA without ·OH scavenger irradiated with accelerated electrons, the absorption band between 300 and 500 nm was present, which implies that PVA acts as a rather weak ·OH scavenger. When the irradiated solutions were brought into contact with air, both plasmon peak and the broad band disappeared in an order of minutes.

To conclude, radiation-induced reduction has been successfully used for the preparation of copper nanoparticles. Further research on this subject will be focused on more detailed characterisation of copper nanoparticles separated in the absence of air; on the use of UV-light for the reduction instead of irradiation and the preparation and study of bimetallic alloyed or core-shell nanoparticles of copper and various noble metals.

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Section 12

BIOMEDICAL ENGINEERING

The Bactericidal Effect of the Corona Discharge Low Temperature Plasma at Atmospheric Pressure

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The action of plasma generated by electric discharges offers the possibility of decontamination or sterilization at ambient temperature. The bactericidal effect of the low temperature plasma generated in corona discharge at atmospheric pressure was studied on nine species of bacteria, a yeast species and bacterial spores. In an experimental arrangement resembling the testing of antibiotic sensitivity by disc diffusion technique, the growth inhibition zones area on semisolid cultivation media was measured and effects of comparable magnitude were found for all organisms. Depending on experimental conditions, the overall increase of bactericidal effect on the exposition time was apparent, whereas the dependence on the inter-electrode distance was mostly irregular. Bacterial spores were also found to be susceptible to corona discharge, but a marked effect was observed in diluted suspensions only and the efficiency on spores was found to be 4 to 8 fold less than with vegetative forms. Bacteria suspended on inert surfaces were deactivated in less than 2 min.

The low temperature plasma was generated using the previously described [1] simple apparatus of an open-air type. Briefly, the negative point-to-plane corona discharge was generated on the point electrode represented by the tip of a syringe needle, connected to the source of direct current high voltage. The plane anode, connected to the positive pole of the source, was realized by the surface of an ion-conducting semisolid cultivation medium. The distance of the point electrode from the anode surface was set by a micrometer screw.

One-ml aliquots of bacterial suspension under study were plated by pouring out onto the whole surface of the semisolid Nutrient Agar (Živný agar No. 2, Imuna Michaľany, Slovakia) culture medium in a Petri dish. For the yeast, the Sabouraud Dextrose Agar (BBL) was used. Immediately after absorption of the inoculum, the microorganisms were exposed to the corona discharge with an initial current of 0.05 mA at a variable inter-electrode distance of 2, 4, 6 and 10 mm for 1, 2, 4, 8 and 16 min. Bacterial spores were exposed at the same interelectrode distances of 2, 4, 6 and 10 mm for 2, 4, 8, 16 and 32 min. To compare bacterial spores with vegetative cells, the same exposure was used for samples of the nonsporulating *Staphylococcus epidermidis* inoculated at the same low concentration. After exposition, all plates were immediately cultivated at 37 °C overnight.

The state of the cultures was quantitatively assessed by measuring of the growth inhibition zones, where a complete growth inhibition took place. The zones were extrapolated to an elliptic shape, their two diameters were appointed and their surface area S was calculated.

The experiments on inert surfaces were performed with *Escherichia coli* suspension spread either on Teflon-laminated rubber cylinders 1 cm in diameter and 2 mm high, or on 2×2 cm cotton wool fabric squares 0.5 mm thick. These materials were placed on the plane 316

electrode represented by an aluminium plate 5 cm in diameter. A drop of the bacterial suspension was placed on the Teflon surface; it retained its compact shape due to the hydrophobic Teflon surface. The same suspension applied dropwise on the fabric was uniformly adsorbed into it, forming a spot with a diameter of about 1 cm. Immediately after dropping or adsorption of the suspension, the point electrode was positioned 1 cm above the samples, initial current was set at 0.05 mA and the samples were exposed to the discharge for 0.5, 1, 2, 4 and 8 min. After the exposure, the Teflon surface and both the upper and lower surface of the fabric were stamped onto the surface of the agar medium, which was cultivated for 18 - 20 hours at 37 °C and the resulting colonies were counted.

In general, it can be concluded that the smallest inhibition zones were observed for short exposure times and large inter-electrode distances. The largest inhibition zones were observed to occur after long exposures and the largest, or, on the other hand, smallest inter-electrode distances; in some microorganisms (e.g. vegetative *Geobacillus stearothermophilus*, *Candida albicans*), large zones were observed also at medium inter-electrode distances. These anomalies could be partly due to an error in measuring the inhibition zone diameters that could exceed the arbitrarily defined value of ± 1 mm.

The sporulating bacterium *Geobacillus stearothermophilus* is used routinely for the verification of correct performance and validation of sterilization procedures. As expected, its spores displayed a markedly lower sensitivity to the action of the corona discharge and the plasma generated by it when compared with the vegetative forms of bacteria. A significant microbicidal effect, although perceptible, was observed only after longer exposures and when lower initial spore concentration was used. The spore inhibition appeared after an 8 min exposure at the earliest. When attempting a quantitative comparison, it can be said that, for different inter-electrode distances, zones of comparable size (of the order of 10 mm²) appeared with the vegetative forms after a 2 - 16 min exposure whereas a 16 - 32 min exposure was needed with the spores. Hence, the efficiency of action of the discharge on spores can be roughly estimated to be 4 to 8 fold less than with vegetative forms. The dependence of zone size on inter-electrode distance is also different for different bacterial forms: for a 16 min exposure, it is similar in spores and in vegetative forms, while for a 32 min exposure the zone size conspicuously increases with the inter-electrode distance.

The low-temperature plasma generated by corona discharge appeared to be an efficient means of inhibition of microorganisms, but its action is limited to a small area. We aim to overcome this drawback in further experiments by use of a two-dimensional matrix of needles or sharp edges bearing the corona discharge.

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Web-based Database of Cardiac Pathology

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We built an information system providing classifications of disorders that result in cardiovascular dysfunction. The project brings the field of project management, pathology and software engineering together and results in a classification model of pathological information which is accessible via a web-based interface.

The classification model is a generic data model of predominant cardiac diseases including their aetiology, symptoms, and diagnostics. The model is augmented with diagnostic features from Electrocardiography, Echocardiography, Positron Emission Tomography, and Cardiac Magnetic Resonance [1]. A disease belongs to a category, which could be linked to other categories via associations. An association is characterized by its type. A disease can have one or several stages and could have one or several properties such as aetiology, symptoms.

Following the Software Engineering methodology recommended by the V-Model life cycle, an information system to realize the classification model was analysed, designed and implemented [3]. Starting with usage scenarios we captured the requirements, use cases and objects of the system. In the design phase we chose the Model View Controler paragdim and built the static model using the UML notation. The 'Form' objects realize the user interface of the application. The 'Entity' objects represent information which is permanently stored in the database. The 'Control' objects implement the application logic and processing.

The information system was implemented using PHP/MySQL technology. Entity objects were mapped to database tables in a MySQL database server. Control objects were implemented using PHP scripts, running on an Apache web server. The user interface (Form objects) was realized as a set of web pages using PHP, JavaScript and HTML technologies.

The realized classification is very generic. We included access control capabilities and created a super user which has rights to modify the classification model by adding or updating new categories, category associations, association types, diseases, disease properties, ... The features are automatically available via an administration menu when the super user logs in.

In this contribution we presented a web-based information system that was validated by experienced cardiologists to be a very useful tool giving easy access to pathological information. Doctors can extend the database themselves. Students and researchers can search and study pathological characteristics of diseases.

A possible future direction given to this work includes artificial networks for diagnostic assistance. The tool can be extended to support autonomic test and evaluation of the cardiovascular system such as table-tilt test, valsava manoeuvre; as diagnostic method for diseases. It would be also interesting to add features for data import and export from the database via XML ontologies for international pathological information exchange.

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Reactive ion etching of diamond thin films and realisation of nanostructures

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High mechanical strength and hardness, high thermal conductivity, thermal stability and chemical inertness, wide band gap; and thanks to other outstanding properties diamond got a persistent attention as an excellent candidate for micro-electromechanical systems or sensoric applications [1, 2], as useful material for bio-applications like implants [3], etc.

Several potential applications of diamond films require structuring, mostly known as a plasma-assisted reactive ion etching (RIE). It has been already reported about successful etching of diamond in various plasma etching systems, using various chemistries and applying different mask materials [4]. But mostly, proposed techniques includes lithography step for fabrication patterned mask structure, what makes such process less desirable for industry.

In the presented work we focus on technological realization of diamond nanorods (DNRs) and other diamond nano-structures. We use three different masking materials to realize diamond nano-structures after applying the dry plasma etching process. As masking materials are used nickel, gold and diamond powder (DP). All three material types are used in their nano-sized geometry, i.e. nano-sized particles. It is important to note that the presented technique uses only a self-assembly strategy where no lithographic steps are included. All experiments were provided on the material base of Institute of Physics, ASCR, Prague.

First, polycrystalline diamond thin films are grown by microwave plasma enhanced chemical vapor deposition (MW PECVD) from methane/hydrogen gas mixture. The continuous film consisted of grains in size up to 300 nm, as observed by SEM measurements. The final film thickness was 400 nm, as measured by ellipsometry. After then, the diamond films are coated either by 2 nm thin metal layer (Au or Ni) using an evaporation process or by diamond nano-particles using an ultrasonic treatment.

Next, samples coated with Au or Ni is treated in hydrogen plasma to form nanoparticles of it. Although the thickness of primary metal layer was the same, formed nano-320 particles and/or nano-island defers for using Au or Ni layer. Plasma-treated gold layer forms nano-particles in diameter ranging from 5 to 10 nm. For the nickel layer, plasma treatment results in formation of larger particles in diameter from 15 to 25 nm. The origin for this difference can be caused by differences in adhesion of metal layer and/or by different chemistries during the thermal treatment. It must be noticed that both metals resulted in formation of quasi-homogeneous distributed nano-particles over the diamond surface. In case of using the diamond particles as mask, the diamond film was only treated in ultrasonic bath without further plasma treatment. In this case, only nano-sized particles and/or clusters in size $5 \div 40$ nm are found which is assigned to the primary diamond particles and their clusters.

Etching and realization of diamond nano-structures was provided by dry plasma etching in CF_4/O_2 gas mixture. We found that applying a low power results in formation of nanostructures like rods (Ni mask), cauliflowers (Au mask) and isolated leaves in rods (diamond powder). The potential impact and uses of such structures in realization of electronic devices and passive chip for regenerative medicine will be highlighted.

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Doped biocompatible materials

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Over the last several years it has become apparent that a very few materials implanted in the body are truly biocompatible [1]. Therefore, there is a goal to develop thin layers to cover implant materials and by this way to improve biocompatible and mechanical properties. The main focus is to the diamond like carbon layers (DLC layers), hydroxyapatite layers (HA layers) and to the doped modifications of that materials.

Biomaterial is a material used in prostheses or in medical applications, and it is intended for contact with live tissue for a supposed time.

Our attention is paid to the synthesis and study of thin film materials using pulsed laser deposition (PLD) method. The method allows to change deposition parameters, which control Ca/P ratio of hydroxyapatite, sp³/sp² bonds in DLC, crystallinity, microstructure, and surface morphology of deposited layers.

Hydroxyapatite (HA,HAP) - is chemically defined as $Ca_{10}(PO_4)_6(OH)_2$ and forms perhaps 80% of inorganic part of bone, tooth enamel and dentine. It is heavily dissolvable in neutral pH, but on the contrary to acids, inflammatory environment his dissolubility increases. HA is biologically active material, and exhibits osteoconductivite and ossteoinductvite properties. [2]

Separate HA is a very fragile and don't bear prosthetic load. Therefore his good properties are used mainly for coating of surgical implants and not for a production of heavy-loaded implants. It employs also at setback alveolar gap and surgery spine. Presently, one form the most important use of dense HA is for uninterrupted ambulatory peritoneal dialysis, monitoring blood pressure and blood sugar, or for optical sighting inner bodily weaving. [2]

Doped HA: If we want to improve properties of HA we can dope HA with several materials as magnesium, zinc, bioactive glass of different weight percent (wt%). Using dopation we can improve surface hardness, compressive strength, biodegradation and bioresorbence. When we dope HA with silver (AgHA layer), we can improve antibacterial characteristics of HA and to support the regeneration of sufferer cells. Significant differences in bacterial adhesion between HA layer and AgHA layer were observed. It is assumed that thin AgHA layers exhibit not only better compatibility with tissue, but also support the inhibition of bacterial adhesion on surface implant [3]. It features, that the bacterial inhibition on AgHA layers can be up to 99% in comparison with pure HA.

Hydroxyapatite doped silver (AgHA) could be used everywhere, where already hydroxypatite was applied. The AgHA could have wider utilization in medicine, because the silver functions promotive at bacterial, virus and mycotic infection, and supports anti-inflammatory processes.

Diamond like carbon (DLC) – diamond like carbon (DLC) is a metastable form of amorphous carbon containing bonded carbon atoms in sp^1 , sp^2 and sp^3 hybridized orbitals. Properties of DLC layers are impressed with sp^3/sp^2 bond ratio and concentration hydrogen or other element in layers. DLC layers exhibit extreme mechanical hardness, good biocompatibility, high chemical inertness, nano-smooth surfaces and a low coefficient of friction that is lowest of all solid. [4]

DLC layers have potential applications in cardiovascular areas for coating and improving hemocompatibility of prosthetic valves, stents, artificial heart and heart-lung machines, in orthopedic areas for coating of hip and knee implants, in ophthalmic areas for improving lenses and for conformal coating of medical and surgical instruments.

Improvement of DLC properties: problem DLC layers is in the poor adhesion to biomedical alloys, such as steel, titanium alloy and cobalt alloy. This problem can be removed with the help of interlayers and doped DLC layers. [1] Among the used interlayers belongs the carbides, nitrides and metal layers and the gradient layers. Dopants in DLC layers change the sp^3/sp^2 bond ratio, their hardness, surface roughness, improve adhesion and biological properties. For example the hemocompatibility of implant can be improved with the help of doping with phosphorus, fluorine and silver. Their biocompatibility was found to be better than that of sample made of low-temperature isotropic carbon (LTIC). Silver-doped DLC have excellent antibacterial effects also. Phosphorus-doped DLC upheld growth of cortical neurons. This property was used to generation of neuronal networks. [4]

Experiment: silver doped hydroxyapatite was created by pulsed laser deposition method. The influence of deposition temperature and ambient atmosphere was studied for preparation of amorphous and nanocrystals HA/Ag doped layers. Silver islands inside of hydroxyapatite layers was observed. The size of the islands was around 10 μ m. In AgHA layers the concentration of silver under 1 wt% was measured by EDS. Silver was also good seen in optical transmission spectrum.

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Using Hierarchical Clustering for Newborn EEG Signal Classification

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This paper addresses automated classification of newborn sleep electroencephalogram (EEG) using hierarchical clustering. Newborn EEG plays an important role in determining the maturity level of neonatal brain. All recordings used in this work contain eight EEG channels (these are FP1, FP2, T3, T4, C3, C4, O1, O2), Electrooculogram (EOG), Electromyogram (EMG), Respiratory channel (PNG) and Electrocardiogram (ECG). All the data have been annotated by an expert into four classes (wake, quiet sleep, active sleep, movement artifact). Infant sleep significantly differs from adult sleep; we therefore apply methods designed for the problem of differentiation between the described states. The proportion of these states is a significant indicator of the maturity of the newborn brain in clinical practice [1]. In this study we use data provided by the Institute for the Care of Mother and Child in Prague (12 newborn polysomnographic signal; similar postconceptional age; all data are scored by an experienced neurologist). Automated classification is performed by Hidden Markov Models (HMM).

If we use signal divided to intervals of constant length for acquisition of informative attributes, non-stationeries of the signal may cause distortion of characteristics estimation. Segments defined in this way may contain mixture of waves of different frequencies and shapes. It is preferable to divide signal to segments of different interval length that are stationary. There exist several approaches to adaptive segmentation [2], [3] which divide signals to stationary segments. We used for adaptive segmentation the method using the two connected windows [3]. The two windows are sliding along the signal. The change of stationarity is indicated by local maxima of their difference measure (combined amplitude and frequency difference).

For accurate classification it is necessary to determine and/or calculate the most informative features. In our approach we use a method based on power spectral density (PSD) applied to each EEG channel. We also use features derived from EOG, EMG, ECG and PNG signals. The most informative one is the measure of regularity of respiration from PNG signal. The following methods, which have been used for feature extraction, are in detail described in [1]. EEG signal: First, we focused on computing features derived from the EEG signal. We computed Power spectral density (PSD) for common frequency ranges (delta, theta, alpha, beta, and gamma). PNG signal: One of the criteria for determining newborn behavioral states is regularity of respiration. We have used use the autocorrelation function in this case. EOG signal: We detected eye movements using the modified method developed by Värri et al.. This approach is based on applying a weighted FIR-median-hybrid (FIR-MH) filter. ECG signal: For detecting the heart rate we used modified version of Pan and Tompkins algorithm. EMG signal: In newborns, there is a major problem with movement artifacts. A large majority of these artifacts is present in the EMG channel. It was sufficient to use the standard deviation feature for this signal.
Next, we used non-parametric clustering. Two good representative examples of the non-parametric approach to clustering are the *agglomerative* and *divisive* algorithms, also called hierarchical algorithms, that produce dendograms. Both methods are based on the measure of the dissimilarities among the current cluster set in each iteration. Agglomerative algorithms merge some of the clusters, depending on how similar they are, and divisive algorithm splits them.

In the process of the classical pattern recognition we classify each segment on the basis of the features obtained from this segment and information obtained from hierarchical clustering. HMMs are a special class of stochastic processes that uniquely determine the future behaviour of the process by its present state. We use the EM algorithm for finding the maximum-likelihood estimate of the parameters of HMMs given a set of observed feature vectors. This algorithm is also known as the Baum-Welch algorithm. The Baum-Welch algorithm starts from an initial model and iteratively improves it until convergence is reached (in our case it is sufficient to use 10 interactions). Since the Baum-Welch algorithm searches for a locally optimal HMM with respect to the likelihood function, the choice of an initial model is crucial. HMMs allow to describe relations between features and hidden states and mutual relations between individual hidden states (on the Figure 4. is example of a hidden states structure for sleep or newborn data). The results of HMM are compared with standard cross validation method. Using HMM produced better results with improved generalization skills of the classifier. The purpose of this study is to facilitate the work of neurologist.

Numerous tests have been performed; only the most promising ones are mentioned. In all experiments we used recordings of eight newborns. Significant results have been obtained in the task of automated artifact removal and distinguishing active sleep from the non-active one. This paper concentrates on distinguishing all the four classes. The data (approximately 30 000 data vectors) have been randomly assigned into 10 cross-validation folds. Statistical analysis results: success rate 82%, TP rate 81%, FP rate: 6%. The resulting classification accuracy is averaged from the performance of method tested on all folds and averaged over all classes. The goal of the classifiers was to separate different classes of the PSG recording correctly (and minimize the classification error).

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Utilization of Transforms for EEG Feature Extraction

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Electroencephalogram (EEG) is a record of the electric signals generated by the cooperative action of brain cells. It provides functional brain information and has important applications in medicine and cognitive science. EEG contains a great deal of information about the state of patient's health. It has the advantage of being non-invasive and applicable over comparatively long time span. Also, it is the only widely available technology with excellent temporal resolution, sufficient to follow fast dynamical changes. The traditional and still widespread method of EEG analysis is visual inspection of signals. Neurologists use atlases and appropriate experience obtained in clinical practice for this evaluation. Such approach may not be always appropriate, for example with long-term EEG recordings (such as sleep, epileptic EEG or EEG of newborns) because it is time consuming, and in addition, more prone to mistakes due to subjective point of view. Long-term EEG recordings are very important, because they give us the possibility to follow disorders that are not permanently present but appear incidentally or under certain conditions. Aims of computer assisted processing are to simplify the work of medical doctors and to make the evaluation more objective. In most cases, the agreement of an automatic method with visual analysis is a basic criterion for its acceptance.

The method of comprehensive recording of the biophysiological changes is polysomnography. It monitors many body functions including brain (EEG), eye movements (EOG), muscle activity or skeletal muscle activation (EMG), heart rhythm (ECG), breathing function or respiratory effort (PNG), blood oxygen saturation and temperature. This contribution addresses the problem of computer analysis of neonatal polygraphic signals.

EEG also provides useful information that reflects the function of the neonatal brain. It may assist in determining brain maturation, identifying focal or generalized abnormalities, existence of potentially epileptogenic foci or ongoing seizures. EEG features are age-dependent, which means that the record rapidly changes every week after the childbirth. Experimental data for this study have been provided by the Institute for the Care of Mother and Child in Prague (8 newborn infants of similar postconceptional age). The data were scored by experienced physician. Records have eight EEG channels (FP1, FP2, T3, T4, C3, C4, O1, O2), EOG, EMG, ECG and PNG.

The main objectives of this work were the design and comparison of appropriate combination of preprocessing, feature extraction and classification methods for automatic recognition and differentiation of three behavioral states (wakefulness, quiet sleep and active sleep) in adults and newborns using EEG or polygraphic recordings. Such method should speed up the identification of described states, make it more objective, and should be used for classification and as a hint to neurologists. The proportion of these states is a significant indicator of the maturity of the newborn brain in clinical practice. Main steps of used method are segmentation, feature extraction and selection, their normalization and application of various classification methods, in order to compare the results with those determined visually

by the expert. The method is applied to records as a whole, without choosing convenient, typical or representative signal parts. Signal processing was performed off-line.

EEG is generally a nonstationary signal. For following processing methods like feature extraction and classification, it is necessary to divide signal into segments. Both segmentation to segments of equal length and adaptive segmentation were used and compared. The algorithm of adaptive segmentation divides the EEG signal into quasistationary segments of variable length. The idea was that the feature extraction from such relatively homogenous epochs would be substantially more effective than the feature extraction from epochs of fixed length. Adaptive segmentation was performed with two connected windows sliding along a signal and comparing certain data from both windows, as demonstrated in [1]. For each segment various parameters were calculated, for example statistical parameters, autocorrelation, entropy, fractal dimension. Fourier transform and wavelet transform were performed separately, such that other input data for further analysis and determination of most informative features were obtained. Various combinations of wavelets and decomposition levels were tested. Absolute/relative power in delta, theta, alpha and beta frequency bands was computed with the use of both transforms. Information obtained from other measured biological signals (EOG, EMG, ECG, PNG) was utilized [2] and the most informative features were heart rate from ECG and regularity of respiration from PNG. Feature selection is applied in order to keep those descriptors that better contribute to the classification. It was conducted with PRTools4, a Matlab toolbox [3]. Two types feature normalization were used. Finally, various classification methods were applied and compared with WEKA software [4].

Obtained results of automatic detection of sleep states were compared with those determined visually by the expert. The increase in classification accuracy and robustness was achieved by taking into account non-EEG channels of polysomnographic records. The use of adaptive segmentation also enhanced precision of the used method. In addition, classification accuracy increased by adding features obtained by applying wavelet transform.

The method was tested on real polysomnographic records of newborns with known classification. This approach is designed in such way that it can be applied not only to EEG of newborns but also to EEG records in general. Also, new features or any kind of changes can easily be incorporated and tested.

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Development of Bioelectric Impedance Analysis

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Body composition assessment is useful in a variety of clinical settings for obtaining information about nutritional condition and the status of body fluid compartments. Bioimpedance analysis is an attractive technique for this purpose because it is safe, non-invasive, low cost and easy to use. Bioelectrical impedance analysis (BIA) measures the impedance or resistance the flow of an electric current through the body fluids contained mainly in the lean and fat tissue [1]. Prediction equations, previously generated by correlating impedance measures against an independent estimate of total body water or fat-free mass, may be used consequently to convert a measured impedance to a corresponding estimate of total body water or fat-free mass indexes. Other body composition parameters are then calculated from these indexes using an assumed hydration fraction for tissues.

These prediction equations are formed from body and electrical parameters using regression modelling. For comparing are used results of other body composition measurement techniques. Dual-energy X-ray absorptiometry (DEXA) is the gold standard method for creation and comparison prediction equations [4].

One potential limitation of the BIA approach is the confidence on regression models, derived in restricted samples of testing human subjects, which restricts the usefulness of the derived model in other patients who differ from this original sample in which the model was developed. The most of BIA equations have been derived and validated against other reference body composition techniques, only a few have been cross-validated in independent target populations [2]. There is difference in body composition between Americans, Asians and Europeans, and even between Czechs and Swedes.

On the basis of this snapping, I determined fat-free mass body index for four most widely used world's prediction equations and for one Czech equation. I measured anatomical and physiognomical data of 126 women and then I used statistical Kruskal-Wallis nonparametric test for check on different results of fat-free mass. Test results confirmed significant difference between most of equations. The Czech prediction equation is significant different from all of others. It is caused by creation of others equations on the basis of measuring American people. These equations are standardly used in the bioimpedance analyzers in Czech Republic. Thanks that is the measurement error significantly heigher.

Big problem of BIA is also correct patients' parting by obese women and sportsmen. There have been special prediction equations for obese woman, but these equations aren't used in BIA analyzers [3]. I took three most frequently used analyzers on Czech market and compared the results for obese woman with the reference method DEXA. These analyzers were Bodystat 500, Omron BF 306, and Tanita TBF 410. In common use analyzers have not special prediction equations for obese woman. This comparison showed that there are big deviations between measured and real values of body indexes provided by DEXA.

I prepared two new sets of modification equations for analyzers' results correction. First set are simple modification equations for Bodystat, Omron and Tanita. Second set are complex modification equations for the same analyzers. I used statistic method linear regression for finding modification equations in the first set and I used statistic method multiple regression with forward stepping for second set. Average deviation before and after equations correction is better for second set.

Complete modification equation from second set for body fat index for Bodystat:

$$BF_{B new} = 22,06672 + 0,62763 * BF_{B old} - 0,07284 * Age + 0,06315 * Wt - 0,06434 * Ht$$

Complete modification equation from second set for body fat index for Omron:

$$BF_{\dot{O}_{new}} = 39,8628 + 0,39768 * BF_{O_{odd}} + 0,13968 * Wt - 0,17309 * Ht$$

Complete modification equation from second set for body fat index for Tanita:

$$BF_{T_{new}} = 52,27823 + 0,34613 * BF_{T_{old}} - 0,24774 * Ht + 0,16367 * Wt$$

The shortcut Wt is body weight (kg), Ht is body height (cm), Age is human age (years), BF is body fat index (kg) in these equations. B, O, and T are shortcuts for analyzers Bodystat, Omron, and Tanita.

I checked in the last point of this work, if modification equation for Bodystat is possible used for other population group than obese women. The analyzer's modification equation has significantly better result only for obese woman. The result of correction is worse or nonsignificantly better for other population groups. For men and non-obese woman aren't needed modification equations. Bodystat works with standard error for these groups. For problematic group of prepubescent girls is needed other new modification equation.

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System for acquiring and evaluation of physiological signals

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At present, there were no cheap and configurable mobile devices, which would allow continuous recording and transmission of psychosomatic signals measured by biosensors (e.g. heart rate, galvanic skin response..) as well as other important information from additional sensors (motion activity sensors, position..). Solutions available on market today are either too expensive or do not allow the measurement of several variable simultaneously. Another obstacle is often closed data format. The user almost never has the opportunity to reprogram the control unit made-to-measure for his application. Available software of control unit is generally commercial and therefore whole system is closed. Dataloggers available on the market do not allow evaluating and further processing of acquired signals. The main disadvantage, in addition to price, is impossibility of developing own modules, which would improve the functionality of such measuring system. Other expandable systems [1,2], which would suite us are not available on the market.

We developed a special hardware that allows recording, transmission and evaluation of signals from wireless sensors and is easily expandable with the other modules. Device is able to acquire continuously biological signals. Data can be wirelessly transferred for further processing. In combination with the PC is device is able to evaluate measured data and provide biofeedback.

Developed hardware is stored in separate box and does not need any wires for complete functionality. Device consists of microcontroller, LCD, Lithium Polymer battery, pressure and temperature sensor, accelerometric sensor, wireless peripherals for data transfer from sensors, vibration motor, buzzer, status leds, micro Secure Digital card and flash memory. As a microcontroller we used ARM based STM32 32-bit Flash MCU, that uses Cortex-M3 core. CPU that can run on 72 MHz frequency offers 512 Kbytes of Flash memory, 64 Kbytes of SRAM and 80 I/O ports. Low power modes, DMA capability, 60 maskable interrupt channels, 5 USARTs and USB 2.0 full speed interface make this microcontroller ideal for our application. Battery backup real-time clock timer for data time-stamping is also part of microcontroller and simplifies hardware concept of our device.

For the best comfort of measured object we decided to connect all biosensors wirelessly. Wireless solution for data transfer from sensors is based on nRF24AP1 [3] – an ultra-low power single-chip radio transceiver with embedded ANT protocol for personal area networks. Approximately 30 μ A average current consumption is ideal for sensors running on wristwatch coin cell battery. nRF24AP1 is connected through asynchronous serial interface and can communicate with independent accelerometer, galvanic skin response and breath sensors. We have successfully tested data transfers from piezoelectric respiratory effort sensor from Spes Medica. Data from sensor were AD sampled on MSP430F1611 based development board and wirelessly sent to our device, although problems with noise have to be overcome.

For measuring heart rate we used Polar hardware technology. RMCM01 receiver installed on our device can receive coded or non-coded EMF signal from commercial Polar 330

heart rate belts and user can control his heart rate on his wrist-watch at the same time. When measuring heart rate we had problems with noise from serial controlled OLED display module that uses Passive Matrix OLED technology and heart rate information could not be real-time displayed on LCD, which supports up to 65.000 colors.

Data transmitted from sensors can be evaluated directly on ARM CPU or wirelessly transferred through Bluetooth technology. SMD module from Roving Network is able of fast up to 2.0 Mbps over air data rate and can communicate with all PC, cell phones or PDA devices with integrated Bluetooth technology. USB 2.0 peripheral is also available, so device can be easily connected with the PC by wire. Acquired data can also be stored to μ SD card or Flash memory via SPI interface and evaluated later on PC with card reader.

As an additional sensor we connected GPS module that continuously sends information about position of measured object via UART. Module can be easily connected wirelessly through nRF24AP1 as well as other sensors that would be evaluated in future development. All sensors with Bluetooth or UART capability can be easily connected to our device.

Extremely light and very slim Polymer Lithium battery that outputs 2.7 V at 1900 mAh can be charged via USB interface or by external adapter. This robust power source provides energy for microcontroller, display, GPS module and wireless peripherals. LCD and GPS module can be totally powered off by microcontroller, which can also reduce power consumption by slowing down the system clocks.

The main part of work involved in this project was aimed on development universal device for recording and evaluation psychosomatic signals. Developed device is now ready to be used and is also planned to be used as a part of intelligent interface between PC and human operator in electric power station. Future work should focus on software development and evaluation of new sensors.

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Possible Biotechnology Application of Seed Mediated Grown Gold Nanorods

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Metal particles are particularly interesting nanoscale systems because they can be synthesized and chemically modified very easily. Over the past decades, there has also been deeper understanding of their optical and electronic properties which made them very interesting in many applications [1]. In contrast to semiconductor material, the metallic nanoparticles offer advantages as their dielectric constants match those of the bulk material to exceedingly small dimensions (i.e. 5 nm). Perhaps the most interesting observation is that metal nanoparticles often exhibit strong localized surface plasmon resonance bands (LSPR) in the visible spectrum and therefore they have deep colors. The gold nanorods are clearly very interesting material for future biotechnology application. The possibility of changing their absorption spectra by changing the rod lenght, and an increased sensitivity of longitudal LSPR makes them a very promising material. The seeded growth method has many advantages, i.e. growing large amounts of rods at a time, therefore preparing a large amount of material of the same characteristics for further experiments.

The interaction between light and noble-metal nanoparticles has been well-described since the last century, beginning with one of the greatest triumphs of classical physics when, in 1908, G. Mie presented a complete solution to Maxwell's equations for a spherical particle. The theory stands up to these days, but the modern generation of nanoparticles not only in spherical shapes has opened up new challenges to the theory.

One of the asymmetric structures studied in this work are gold nanorods, which are interesting because their LSPR is splitted into two modes through their non-symmetric shape: transversal and longitudal, whereas the frequency of the longitudal one is strongly dependent on the rod aspect. This gives a control over optical properties of rods: by synthesizing different lengths, one can tune the absorption spectrum of the sample. Moreover, the longitudal LSPR has a much higher oscillator strength and increased sensitivity to perturbances in the surrounding environment [2].

Nanorods samples were synthesized by seeded-growth method in the presence of silver nitrate. This method was chosen because it leads to the best possible yield of nanorods (up to 99%). Moreover by varying the amount of silver(I), one can fine tune the aspect ratio of the grown rods. This seeded growth method was refined to this point by Nikoobath and El-Sayed [3].

The adding of a controlled amount of silver nitrate to the growth solution gives a higher degree of preciseness to the fine tuning of the rods' aspect ratio. The most recent studies [4] propose an idea referring to the deposition of a metal monolayer onto a metal crystal. This deposition onto a metal surface can have a potential significantly less negative than bulk deposition.

Our samples of nanorods were produced in the form of colloidal solution. A basic characterization was performed by measuring the absorption spectra and taking TEM images. These were then used to determine size distribution and approximate particle density. A

useful information can be also read from the growth kinetics as there are number of unwanted side products in the solution (i.e. cubes and spheres) whose contribute to rising of plasmon peak around 550 nm, which corresponds with LSPR of samples of gold spheres around 40 nm in diameter. Therefore, the growth kinetics is different for samples in which were lots of spheres and cubes presents in comparison to more refined samples. Monitoring the sample spectrum during growth can then be used for fine tuning the synthesis and the reaction conditions. A method of improving of the sample growth by controlling the pH of the solution is proposed.

The importance of gold particle nanostructures in biotechnologies can be already seen as gold nanoparticles in aqueous colloidal solution are commercially available and widely used (eq. markers for TEM imaging of biological material). One of their disadvantage, however, is that 5 - 30 nm diameter gold nanoparticles has their LSPR frequency in the same region as is the blood colour, therefore they cannot be easily influenced by optical radiation – otherwise a convenient way how to affect their plasmonic behaviour. In the case of gold nanorods, one can take an advantage of their intense longitudal plasmon in the NIR region to heat up the rods by irradiating them inside the body, while still maintain safe level of energy flow through tissue. From this a number of applications arise, for example:

Targeted drug delivery consists of capping nanorods with medicament, which is passivated by the bonding to the rod surface. When injected to body, the nanorods will spread through the organism. Then, by irradiating selected positions the rods are quickly heated up releasing the medicament in localised positions therefore lowering the side effects to surrounding tissue.

Tumour hyperthermia uses the same principle of heating the rods but instead of releasing attached materials the rods are capped with antibodies selectively activated against the tumour cells so the rods injected to the organism will concentrate themselves in the tumour areas. By irradiating them with a light tuned to the rod absorption one will cause local heating of the tumour. The excess heat to the surrounding tissue caused by irradiating will quickly spread by convection.

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Evaluation of Head Position and Related Parameters in Neurology

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The head posture is considered as one of the significant indicators in neurology. It can be affected by a lot of neurological disorders. Head posture is influenced by many diseases of nervous system, visual and vestibular systems – e.g. cervical blockades and diseases of cervical spine, movement disorders (dystonias) and paralyses of eye muscles. The exact head posture measurement could be used for objectification and quantification of these disorders. There has been implemented many different methods to measure the head posture. The drawbacks of the methods used so far prevented them to be widely used in the neurological clinical practice. A method capable of measuring the actual head posture in a precise and a simple way would definitely contribute to diagnosis of these disorders. Some basic ideas that precede further work can be found here [1], [3] and [4].

The objective of the project is to develop a technique for measurement of the native position of the head in 3D space. The technique is supposed to determine differences between anatomical coordinate system and physical coordinate system. The project is focused on the extension of the existing method which uses two digital cameras. The cameras face each other, and therefore the examined subject has to change the posture during the measurement because it is necessary to acquire positions of defined anatomical coordinates for inclination, flexion/extension and rotation. The change of the posture could be a possible source of errors.

The new method tries to eliminate the drawbacks of the previous method [3]. The main difference is in the use of the digital video cameras. The original proposal expected the use of 3 digital video cameras in 3 specific positions – front, left and right profile views. The positioning of the video cameras was similar to the positioning in the previous method [3]. The assumption was that the addition of the third view (video camera) should eliminate the need to change the posture during the measurement. The experiments later proved this assumption to be too strong. It showed up that it is possible to use only two video cameras in various positions (and with various effects of course).

A special frame has been constructed. MB Building Kit System from item Industrietechnik GmbH was used for this purpose. The video cameras can be attached to the construction at different places to simulate different camera system setups. The construction served as a test bed for experiments with the positioning of the cameras. A marker based method was proposed to verify this. Three special markers were attached to the head and were tracked to determine the exact head alignment. The 3D coordinates of all three markers defines a plane and thus the orientation of the head can be expressed. However, this brought the problem with video cameras placement because not all three markers were always visible for both cameras.

The size of the area visible from both cameras is based especially on the distance between both cameras. The influence of the camera distance from the head can be neglected 334

(the greatest effect is at close distance). However, the distance between the cameras is very important. Apparently, the plane is only defined in case all three markers are in the area. In fact, the area is much smaller. It must be taken into account that the markers do not lie on one meridian-like circle. The closer the cameras are together, the bigger the area is. The further they are, the smaller it is.

The system has to be calibrated before it can start processing video sequences. This problem was solved by the use of a calibration method based on Camera Calibration toolbox for Matlab. This method requires a chessboard for the calibration purposes. The calibration is required only once after the video cameras are positioned. The calibration data are stored and are used for further data processing. The system needs to be recalibrated whenever the camera system setup has changed.

Once the system is calibrated, it is prepared to obtain video sequences of the subject. As soon as some data are available, it is necessary to synchronize both records. Some experiments showed that the most effective and the simplest solution was the utilization of a special signal LED. The LED is used to determine the first frame. When the video sequences captured by both video cameras are synchronized, all further operations are performed on the time corresponding frames.

The experiments with head posture measurement showed the ability of the method to detect the alignment of the head. It is also possible to track the motion of the markers. For more details see [2].

The results of the work supported by internal grant are expected to be used. The next work assumes the extension of the current method. The most important change is related to the markers. The version that does not require the markers is being currently worked on. It will be a marker-less head posture measurement method. This is also related to the necessity of the upgrade of the current program equipment.

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Hand Movement Analysis of Parkinsonians

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Work is focused on patients suffering with Parkinson's disease. Parkinson's disease is a degenerative disorder of the central nervous system that often impairs the sufferer's motor skills and causes specific disturbances of hand motor function [1]. Doctors created set of the hand movements test for patients with Parkinson's disease [2]. We measured the 3-dimensional hand motion trajectory of the patients, when they perform a natural manual transport task (moving an object from one place to another). The task is performed repeatedly by patients. The markers are placed on anatomical landmarks of the tracked hand and the movement of the markers is captured to 3-dimensional space by cameras. It is advantageous to use contactless system for acquisition of the movement in 3-dimensional coordinating system. The problem of acquiring and processing of the 3D motion is solved at Department of Biomedical Informatics, Faculty of Biomedical Engineering, Czech Technical University in Prague.

The patient's task is to grab small cube and move it repeatedly and regularly from one place to another. After 10 repetitions patient has to release the cube. This motion is captured by 2 independent cameras. The cameras are synchronized by remote controller. Camera calibration enables to use 3D coordinate system according to the pair of images representing the same scene. This is based on the correspondence between certain points in both images. The problem of the correspondence lies in the ambiguity of such points. Utilisation of unique points can significantly simplify the whole process. Our camera calibration method uses a chessboard and uses MATLAB calibration toolbox.

Proposal of the positioning and the colour of the markers is very important part of the system. The markers have to be well detected and their positions have to be exactly determined. The colour of the markers is very helpful for their detection. We chose the blue colour; because this colour is not included in the colour of the human skin (blue is nearly complementary colour of human skin). The shape of markers is helpful for determining position properly. The spherical shape of the markers was chosen, because their projection to the image plane has always circular. The positions of the markers are defined based on anatomical landmarks of the tracked hand. The markers are placed on wrist, forearm and forefinger knuckle.

We needed to preserve colors in the image. We implemented a color calibration. We placed 5 colors in the scene: blue, red, green, white and black and we used these colors for the color calibration in every frame. A noise was reduced by median filter. Created program finds the blue circle marker in the left and top filtered view of the camera. The position of the blue markers is remembered and in a next frame the program searches the neighborhood of its previous position. Our HD cameras get interlaced image and theirs frame rate is 50 Hz. Measurement error is ± 1 mm. The 2D positions of the markers in the top and left view are transformed to 3-dimensional coordinates system.

Captured trajectory is long broken line. The hand movement could be split to these phases: First phase: patient starts the movement (from place A) and grabs the cube (from place B). Second phase: Forward movements – set of the movements when the patient move cube from place B to place C. Third phase: backward movements with the cube – set of the movements when the patient move cube from place C to place B. The last phase: patient release the cube. The forward phase starts, when the cube starts to move and ends when the patient lay the cube down. Backward phase starts after forward phase. The hand trajectory splitting is based on the changes of the cube movement. The algorithm is described in [3].

The evaluation and classification of the hand movement of the patients with Parkinson's disease [1] need proper parameters. These parameters are extracted from the 3D-trajectories of the markers placed on anatomical landmarks. The parameters can be divided into two categories: parameters derived from the motion of each marker separately and parameters describing the pose of the whole hand (relative position of the markers). We considered parameters derived from the single marker: speed of the movement, change of the speed and change of the movement direction during the movement. Since the hand movement is repetitious an average trajectory and a variance are computed. The construction of the average trajectory and the variance of the movement trajectories in 3D space are described in [3].

We created the system for capturing of the hand movement for patients with Parkinson's disease. We captured tested 3D-movement by cameras and created the set of testing data. We focused on the variance of the trajectory of the periodic movement, timing, change of the speed and change of the movement direction. We created and tested the algorithms for the computation of the parameters. The relevancy of these parameters will be verified on the patients with the Parkinson's disease. Parameters will be used for future classification.

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Measurement and computer simulation of electromagnetic oscillations of living cells

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From experiments of Luigi Galvani in 18th century scientists became more and more interested in electric phenomena of biological systems. The most of the interest has been concentrated on the study of electric phenomena connected with specialized electroexcitable cells of higher organisms and membrane depolarization based electric processes which lie in low end of frequency spectra. Electrically polar vibrations have been postulated to generally exist in biological systems by Fröhlich [1]. Electrically polar vibrations generate electromagnetic field. This is mechanism for generation of electromagnetic field in kHz to GHz (THz) frequency region assumed to be present in all living cells and not only in eleectroexcitable cells. Mechanical oscillations of yeast cell membrane have been measured in low kHz region with atomic force microscopy and Fourier transform of the signal by Pelling et al. [2]. Cellular membrane contains proteins which are electrically polar. Thus, electrical oscillations can be expected to exist in the same part of kHz region as mechanical oscillations detected by Pelling et al. Group of Pokorný showed that there is increased electric activity in the low kHz region of synchronized yeast cells compared to the nonsynchronized yeast cells in their M-phase of the cell cycle [3]. Pohl showed that the electric field in kHz and MHz region exists in the vincinity of wide range of cell types under test: bacterial (Bacillus cereus), alga (Chlorella pyrenoidosa), yeast (Saccharomyces cerevisiae), avian (red blood cells), mammalian (mouse fibroblasts, 3 types) [4]. Pohl used dielectrophoresis. Dielectrophoresis is a phenomenon in which non uniform electric field acts by force on neutral polarizable matter. Force on the particle is proportional to the gradient of electrical field squared and the difference of permittivity of the particle and permittivity of the surrounding medium. Force also depends on the shape of the particle. Pohl customized the method to find if there is electric field around cells strong enough to act on small particles with very high dielectric constant. He found that the electrical activity of cells was observed to be highest near the mitosis.

Electrically polar structures are expected to be the source of the electromagnetic oscillations of living cells. Proteins are electrically polar. Microtubules, which compose of highly electrically polar tubulin dimers, are most probable sources of mechanical and electrical oscillations. Energy needs to be fed to the microtubules system in order to generate vibrations. Motion of motor proteins, guanosine triphosphate hydrolysis and waste energy efflux from mitochondria are possible sources of energy for excitations.

We need to realize several biophysical and technical aspects in order to measure electric oscillations directly. Point detector must be used, since the field spatial structure may be 338

rather complex. Using sensor with the tip of comparable size as the cell will cause averaging the spatial electric field structure intensity to zero. Low noise, high gain preamplifier with low input capacity needs to be used since cell is very soft electrical source. Measured cells need to be kept under physiological conditions in the solution containing mobile ions which screen the electric field especially in the lower frequency region. Impedance matching also needs to be taken into account when constructing the sensor. Knowledge of the impedance properties of the cell and cell suspension is necessary.

Using experiences of the group of Pokorný from measurements of electromagnetic oscillations of yeast cells in kHz and MHz region, the project has been undertaken to support the work on doctoral thesis of the first author. The aim of the project is to build the new sensor for measurement. Several designs of the sensor have been discussed before the start of its realization. Currently, the sensor is designed and being constructed.

Second part of the project to support the doctoral thesis of the first author was focused on the choosing and purchase of the suitable software for simulation of generation of electromagnetic field of biological system and interaction of electromagnetic field with biological systems. COMSOL Multiphysics was chosen and purchased with cooperation of other projects. Electromagnetic eigenmodes of the spherical cell have been inspected using this software recently.

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Planar applicators for hypertermia treatments

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The use of planar applicators is particularly suitable for superficial hyperthermia treatments because of their light weight and further on they offer the advantage of ease and cheapness in manufacturing when compared with other types of applicators [1]. In this project our target is to apply microwave hyperthermia on small mice with subcutaneous melanoma tumors. Since this tumors are particularly small (diameter up to 25 mm, deepness less then 10 mm), the development of an applicator able to focus the electromagnetic energy in a small volume is required as well as the necessity of a limited the penetration depth in order not to enhance the animal body temperature. In order to fulfill these requirements, we developed a planar applicator composed by a circular printed circuit board (PCB) with copper metallization layers on both sides. The two layers were then short-cut all around the board for obtaining in such a way a cylindrical cavity resonator. The microwaves are then radiated through a circular slotline ring aperture located on the top of the cavity. The power feeding is given through an Ntype connector soldered on the center of bottom of the cavity. Its inner conductor, passing through the dielectric substrate, is then soldered on the other side of the PCB board. Since the electromagnetic field excitation is produced by the current flowing on the central conductor, just the TM modes can be excited in the cavity. Thus, the TM010 will be the lower mode which can be excited. The dimensions of the applicator were chosen in order to have resonance frequency at the frequency of 2450 MHz. The choice of this ISM frequency, which is higher then the common used values in clinical hyperthermia (434-915 MHz) helped to reduce penetration depth of the microwaves in the animal allowing to keep under control its body temperature. Since the tumors were subcutaneous we challenged also with the necessity to preserve the animal skins from overheating and burn. In order to do this the applicator was manufactured with an integrated water bolus which also allowed improving the contact between the particularly critical vertically-developed tumor mass and the applicator, to guarantee an adequate impedance matching in the most of treatment conditions [2-3]. In order to optimize the applicator dimensions, evaluate the impedance matching and the specific absorption rate (SAR) inside the biological tissue, we used the computer electromagnetic field simulators SEMCAD X by Speag based on FDTD and Comsol Multyphysics based on FEM method. These second simulators also allowed to preliminary evaluate the temperature distribution in the model as function of the applied power and the cooling water bolus temperature. It also allowed considering the effect of the blood perfusion rate enhancement induced by temperature raise.

To perform the in-vivo microwave-induced hyperthermia experiments, a system mainly based on the generator Sairem GMP03 KE-D was developed. This magnetron tube generator can provide an output power within the range from 0 to 300 W, with minimal steps of 1 W at the ISM working frequency of 2450 MHz. The output power is regulated in remote mode through the connection to a Personal Computer (PC). The temperature is sensed by up to 4 K-type thermocouples connected to the digital thermometer Volcraft K204.

The thermometer communicates with the PC throughout the RS-232 serial bus where the insulating repeater ELO E0M6 was installed to guarantee a galvanic insulation between thermocouples and the rest of the system. The software installed on the PC was developed with Borland C++ Builder with the purpose of driving the generator in on-off mode, in order to keep the temperature sensed by one of the thermocouples within a settable range. The communication between the PC and the generator is done using an USB connection passing trough the interface board Velleman K8055. The temperature sampling rate is 1 s. The water bolus is connected to a water circulator composed by a micro-pump which speed can be adjusted on 6 steps, changing the rate flow from approximately 50 ml/s to 300 ml/s [4]. The preliminary tests of the applicator were conduced on homogeneous flat phantom to evaluate if the temperature penetration depth was suitable for our in vivo model. The attention was especially paid on the enhancement of the temperature in the depth, to evaluate the eventuality of possible temperature enhancement during the treatments. Also the effectiveness of the water bolus in the superficial cooling was considered, to evaluate the compatibility of a suitable skin cooling while obtaining and maintaining the set temperature value in the tumor core. Several temperature measurements during the in-vivo experiments have shown how, using the developed planar applicator together with the system described above, it is possible to maintained the temperature in tumor core during the steady state of the treatment within the set range (43-44C) having at the same time a temperature of the skin which did not produce overheating. The monitoring of the body temperature has shown in some cases an enhancement which could be compensated reducing the temperature of the water bolus. In conclusion we can assume that the studied planar applicator working with the described

In conclusion we can assume that the studied planar applicator working with the described system can guarantee a reduced microwave energy penetration depth in the tissues in-vivo, corresponded in its function to the in phantom tests. The preliminary studies on SAR, temperature distributions and impedance matching were important for assessing the main characteristics of the applicator and to guide the in vivo treatments. Efficacy of the application in the requested territory and limited increasing of temperature outside the treated area provide important insights for addressing a better development and perspective use of this type of applicators also for superficial tumors and precancerous lesions in human patients.

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HLA Explorer

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Hematopoietic stem cell transplantation (HSCT) [1] or bone marrow transplantation is a medical procedure in the field of hematology and oncology that involves transplantation of hematopoietic stem cells (HSC). It is most often performed for people with diseases of the blood or bone marrow, or certain types of cancer (e.g. leukemia). In principle intravenous infusion of stem cells collected from bone marrow, peripheral blood or umbilical cord blood could reestablish hematopoietic functions of a patient with damaged or defective bone marrow or immune systems. But HSCT is a risky procedure with many life-threatening complications (i.e. Graft-versus-host disease) and has always been reserved for patients with life threatening diseases.

Transplantation of Haematopoietic Stem Cells (HSCT) is increasingly used treating technique for patients with severe disorders of hemopoiesis, and leukemia.

HLA match is still the decisive factor affecting the prognosis of a stem cell transplant therefore a very high degree of compatibility between the HLA-tissue types of donor and recipient is required. HSCT can be successfully applied only if donor and recipient are matched for a number of important genetic markers of the transplantation antigen system HLA.

The HLA system plays a key role in self-nonself recognition is broadly divided into highly polymorphic class I (HLA-A,-B, -C) and class II (HLA-DRB1, DQB1) loci. Mismatching within class I and class II HLA antigens between recipient and donor increases the incidence and severity of an alloreactive immune response when transplanting hematopoietic stem cells.

The chance of any patient to obtain fully matched unrelated stem cells donors is dependent on possibility to match with more than 13 million donors in the bone marrow donor registry. But, up to now many HLA typing results of unrelated donors are incomplete.

The goal of the project HLA Explorer (www.hlaexplorer.net) is to develop a new internet based information system that will help physicians (transplant centers) and coordinators (stem cells donor registries) to examine Linkage Disequilibrium of HLA system in order to assist to find suitable unrelated stem cells donor.

HLA Explorer is the internet based information system that requires authorization of users. Everyone can register and use the system for free. System also monitors users and records how often they log in and what do they search. This should help to observe real needs of users and improve the system in the future.

Architecture of the system consists of several levels. Rought data are mainly collected from cooperating stem cells donor registries. The registry explains how donors are recruited and if they believe the registry database represents the whole population.

Data from stem cells donor registries are merged in to so called Population donor database. For example, data from the Czech Stem Cells Registry, the Cord Blood Bank Czech Republic and the Czech National Bone Marrow Registry are merged to Czech population Database. All these three registries have very similar parameters, i.e. allele and haplotype frequencies.

Then, we calculate haplotype frequencies from the result Population donor database and store results in special database. We use iterative EM algorithm [2] for the calculation of haplotype frequencies.

Finally, results are presented to users by easy-to-use web based application that allows comparison of haplotype frequencies between different populations, filtering by HLA criteria and sorting by allele or haplotype frequencies or Linkage Disequilibrium. User can see results by three different views - List View, Table View and Graph View.

HLA Explorer can be used in daily work by search coordinators in stem cells donor registries. Analysis of HLA typing result can include observation of patient's HLA -A, -B, -C, -DRB1, -DQB1 gene frequencies in different populations, their comparison across populations and observation of haplotype frequencies, mainly A-B, B-C, A-B-C, DRB1-DQB1 and A-B-DRB1. It helps to better understand patient's HLA typing and to define optimal search strategy.

In case two or more donors - who are potentially HLA identical - are available, coordinator can use "HLA Explorer" in order to choose donors for complementary genomic typing. The project "HLA Explorer" provides extensive information for haplotype frequencies, so it allows predicting untested HLA typing. For example HLA-C typing can be often predicted by observing B-C, A-B-C or A-B-C-DRB1-DQB1 haplotype frequencies of donor's populations.

HLA Explorer can also help to find HLA mismatched donor.

Using of modern technologies such as HLA Explorer increase the chance to find a suitable donor in the shortest term possible.

In future we would like to continue this work and include data from more populations.

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Nature Inspired Clustering Concepts in Heart Signal Processing

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Arrhythmia diagnosis and electrocardiogram (ECG) interpretation is an important noninvasive step in clinical diagnosis process. The presence of significant heart arrhythmias is an important marker of cardiac death. In this paper we compare and evaluate the following methods: Ant Colony inspired Clustering, Ant Colony inspired method for Decision Tree generation, Radial Basis Function Neural Networks with different learning algorithms and compare them to classical approaches, such as hierarchical clustering and k-means.

Radial basis function (RBF) neural networks (RBF-NN) have been introduced by Broomhead and Lowe in 1998. Using a supervised learning method, the RBF neural networks can perform as a clustering method that divides incoming data into clusters. In this paper we evaluate nature inspired learning methods: the ACO_R method [2] inspired by ant paradigm and the Particle Swarm Optimization (PSO) algorithm inspired by the behavior of bird flocks or fish schools. The nature inspired methods are compared with a deterministic learning algorithm – the k-means algorithm.

The Kohonen self-organizing network (SOM) is a single layer feed-forward network where the output neurons are arranged in low dimensional structure that can be visualized easily. The neural network is trained by unsupervised training. Note, that the number of neurons remains the same through the whole learning process.

The clustering of dead bodies by ants inspired Deneubourg et al. [1]. In their article they published biologically inspired model for clustering by a group of homogeneous agents. The ants possess only local perceptual capabilities – they can sense the objects immediately surrounding them, and they can also compare whether the objects are similar or not to the object they are carrying.

There have been some proposition on the continuous optimization methods inspired by ant behavior, but the latest approach, which was proposed by K. Socha [2], is closest to the ACO definition. Ant Colony algorithms for continuous optimization (ACO_R) use a continuous probability density function (PDF). This density function is produced (for each solution construction) from a population of solutions that the algorithm keeps at all times.

The ACO_DTree method [3] uses a hybridization of Ant Colony Optimization (ACO) with evolutionary approach to generate and optimize the population of decision trees. Using a supervised training algorithm (ACO) it can be used to perform clustering in a similar way as the RBF-NN.

For basic parameter estimation and implementation testing, the well-known UCI database has been used (the database is freely available). Real ECG signals come from widely used MIT-BIH database [4] that contains real ECG records.

Method	Accuracy
ACO_DTree	97.11±1.17
WEKA Random Tree	96.53±2.45
RBF (ACO_R)	95.85±0.42
RBF (PSO)	95.29±1.04
RBF (k-means)	91.51±0.16

 Table 1 presents a comparison of nature inspired methods with supervised learning.

 It shows the accuracy in % together with stddev.

Table 2 presents a comparison of nature inspired methods with unsupervised learning. It shows the accuracy in % together with stddev.

Method	Accuracy
Agglomerative Clustering	84.23±2.17
Ant Colony Clustering (ACC)	73.80±2.15
Kohonen SOM	72.10±1.86
K-means	70.21±3.18

The results are summarized in the Tab. 1 and Tab. 2. Corresponding results represent an average over ten independent runs. The best results have been obtained using the ACO_DTree method (97.11 \pm 1.17 %) producing an easily understandable and applicable binary tree structure. The RBF neural networks also performed well (95.85 \pm 0.42 % and 95.29 \pm 1.04 % for the ACO_R and PSO learning algorithms respectively). We have shown that the nature inspired methods increased the accuracy of the basic algorithm, and have proved to be an efficient tool for optimization in the process of ECG clustering.

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Mobile Devices for Medical e-Services

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The demands on medical doctors and nurses are continuously growing: they have to see more patients with less time, to fill in more forms, and to follow more patient data. Therefore any tool or means that allows increase efficiency without negatively affecting patient care is appreciated. Information and communication technologies can offer interesting support. According to the users' demands the whole range of mobile devices can be used, starting from laptops, tablet PCs down to small devices as personal digital assistants (PDAs). All these devices that can work as standalone assistants or wireless terminal as part of a hospital information system are becoming increasingly popular. The latest PDAs offer following features and functionalities: color screen, wireless capabilities, GSM/GPRS/EDGE, GPS, photography, voice recording and playing. Some of them are also equipped with hardware keyboard. The greatest advantage is the size. According to recent studies, medical doctors (MDs) and nurses are generally more technologically oriented. More MDs are online frequently, they are more likely to own PDAs or smart phones, have personal computers at home, have Internet connections at home (at work it is almost a must), and use computers as inherent work support tool.

The paper describes briefly an ongoing project of a pilot study and implementation of services supporting work of MDs and nurses. Since the design is rather general the final solution can be easily adapted to hospital environment, ambulatory or home care. In all these environments we can find common characteristics. Let us mention the most important ones: services are usually distributed with respect to location, function, time, institutions and professionals involved; communication among care providers is necessary; access to the latest information about the patient state is highly desirable. Usually different care providers use different information systems. Thus the application must work in a highly distributed environment using several different types of communication (e.g. LAN, WiFi, GPRS) and end-user devices (PC, laptop, PDA).

With such an integrated system, the flow of information about the updated state of the patient among the different professionals can become time-space independent. At any moment any professional implied with the patient can consult the real state of the patient and take on-line decisions, being sure that he/she accessed the last update of the patient's information. This is particularly interesting in case the patient moves from one city to another. Nowadays, when the patient moves to a different place, the professionals may have serious difficulties to obtain the clinical history of this patient. Even more, a number of specific details about the treatment are not transferred in any way to the new team. Since many of the services are performed either by nurses or other professionals who usually do not have laptops for their work we have been developing an application for PDAs that provides these care givers with all necessary data and information they need during the visit at the patient (either at home or at his hospital bed) and allows them to enter new data about the patient's health state.

The central idea of the using mobile devices in the health care domain is to automate the procedures that are nowadays paper-based. Paper lists are portable, easy to access (in one 346

location), cheap and require no training to use. However, there are many disadvantages related to limited space, inconsistent data entry among users, impossibility of remote access, difficulties in developing quick overview, e.g. of temporal course of monitored values. Keeping all information in an electronic form simplifies document processing and can save time of MDs and nurses. It is estimated that MDs and nurses spend between 25 and 40% of their time in administrative tasks. Especially nurses are using paper forms for data and information collection. These forms were developed during time and slowly grew to a big extent, which makes them hard and time-consuming to completely fill.

Our intent is to provide nurses with a device, which will ease the document handling for them and which will bring new capabilities with minimum impact on nurse's work/time. One of the new capabilities is taking photos. This idea came from our medical partners from the General University Hospital in Prague who are interested in visual checking of a development of injuries or varicose ulcers, for example. A list of photos available to a doctor during visit at a patient helps him/her to make decisions and not to completely depend on patient's description of the problem.

The PDA is well suited to medical applications because it is an electronic tool that acts at the point of care. In the current practice, nurses use paper forms. These forms grew during history and sometimes are really huge even for simple case. The purpose is to simplify and speed-up the filling. The design decision was to select only required information by the responsible doctor, who knows, which information is important. Only this information is collected, which saves the time in comparison to the situation when the nurse was required to fill unimportant data in the paper forms. The application also marks, which data was not filled so far, so the nurse cannot forget to fill the required data.

Concerning the used electronics, there are still issues which have not been sufficiently solved so far. The first issue is security. Comparing the paper-based practice, the security level is the same (based on the physical security of data holder). But the electronic device is more attractive to steal (partially because of the price of the device itself). Therefore we are investigating methods for protecting data on the PDA in case of theft. Current idea is to use the nurse's password for data encryption. The password is not stored within the PDA. An important restriction in using electronic devices is the size of display, particularly size of letters. Because of usual visual restrictions of nurses, tiny letters are unacceptable. Related to the size of display, keyboard is another issue. If the nurse opens a software keyboard, the available part of the display is small; the keys themselves are even smaller. A solution could be a hardware keyboard, but only few devices offer it together with a big display at the moment.

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Security and Data Protection in Distributed Healthcare Systems

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Medical environments use to involve highly complex structures of interacting processes and professionals where a large volume of information is managed and exchanged. With the development of technological infrastructure, the utilization of large information systems in health care has been permanently growing for several decades. The demand on data and information sharing among institutions has increased as well. Thus, the issue of data and information security becomes more and more important because most of the medical data and information is not regarded public. In our ongoing project we are developing a distributed healthcare system that is accessible through the web services. Thus security and data privacy is an important issue that must be solved properly.

In the paper we address some elements to guarantee security and privacy preserving in distributed IT applications which provide some kind of support to complex medical domains. In this kind of systems many different professional competencies, ethical and sensibility requirements as well legal frameworks coexist and, because of that, the information managed inside the system must be subject to very complex privacy restrictions. This is particularly critical in distributed systems, where additionally security in remote transmissions must be ensured.

Privacy preserving and data security is a complex field, which deals with many different problems and provides different solutions, as privacy and security can be threatened in many ways. Solutions usually lead to obstructions in normal use. Here, the most important problems are described.

A global privacy preserving and security solution has to start with a definition of a set of internal privacy and security rules, security guidelines. These rules specify how the sensitive data has to be treated, where it can appear. The rules must exactly define physical places of data in each of its life cycle. At the end, users have to be educated, they should know how the security protection work and how to resist against (often social) attacks, including safe habits regarding password.

Information security must protect information throughout the life span of the information, from the initial creation of the information on through to the final disposal of the information. The information must be protected permanently, i.e. either when stored in a file or being just processed or transmitted. The building up, layering on and overlapping of security measures is called *defense in depth* [1]. The strength of any system is no greater than its weakest part. Using a defence in depth strategy, should one defensive measure fail there are other defensive measures in place that continue to provide protection.

As we already mentioned healthcare and homecare decision support systems represent rather complex problem. Therefore to build a platform that supports a medical model of such complexity is not a trivial task and requires a careful design. One of the most critical aspects to be regarded is the one related with security and privacy preserving, which includes, for that kind of complex systems, the following issues: Identification and authentication mechanisms; authorization mechanism based on the definition of user profiles; defining personal information access rights (based on e.g. user profiles); communication using various end-user devices and different types of connections (therefore there are additional requirements laid on security); cryptography (necessary because of the requirement of secure exchange and storage of medical data); internal security leak (Technical staff has physical access to data storage (to hard disks, to backup tapes and so on) and the possibility to steal such data together with high price and with anonymity of such act can be too tempting. The more confidential information is stored in the system, the bigger is the risk. Cryptography is also offering interesting solutions for that problem.).

As mentioned before, one of the biggest problems in data protection is internal security leak. Currently available technologies offer few ways, how to improve security in this area. As an example, Oracle database offers technology called Oracle Database Vault, which hides sensitive data from unauthorized users, even database administrators. Cryptography is also used in information security to transform usable information into a form that renders it unusable by anyone other than an authorized user. This process is called encryption. Information that has been encrypted (rendered unusable) can be transformed back into its original usable form by an authorized user, who possesses the appropriate cryptographic key, through the process of decryption [1]. Cryptography is used in information security to protect information from unauthorized or accidental discloser while the information is in transit (either electronically or physically) and while information is in storage. It can be used in different ways.

A simple protection against machine data processing of stolen data is splitting administrative and medical information into two independent parts, which are linked in a nontrivial way, done by a cryptography algorithm, so that identity of the data owner cannot be easily discovered, without knowledge of the algorithm. The algorithm can be changed for a particular installation and thus makes harder to merge the two parts together. The algorithm itself is fast and has no impact on system performance.

Medical contexts are especially interesting because of the legal constraints related to privacy preserving and security. Although national legal regulations vary in certain points the main issues are solved in a very similar way. Before implementing the system in a particular country it is necessary to check corresponding legal regulations and recommendations.

Protection of sensitive data with cryptography is a key requirement valid especially for medical application. Data must be protected during all stages of its life-cycle and in every place it can appear, including server disks, transport lines, backup storage, etc. A database design for this purpose has been proposed. Finally, the access to the system must be done with the proper authentication and identification mechanisms than prevent external attackers to come into the system.

We have to realize that security is ever evolving. New technologies bring new opportunities and thus new threats. Therefore it is necessary to update the security solutions continuously.

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Automatic identification of complex fractionated atrial electrograms during catheter ablation of atrial fibrillation

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Mapping of CFAE as target sites for ablation of atrial fibrillation (AF) has shown great promise to guide AF ablation procedure. Nademanee et al. concluded that CFAE areas represent critical sites for AF perpetuation and can serve as target sites for AF ablation.

This study has been set out to develop and test a new algorithm for locating CFAE sites in A-EGM signals that are recorded during AF mapping procedures. This algorithm will be used in future studies to describe A-EGM complexity in a novel way. The aim of this approach is to have a fullyautomatic and operator-independent A-EGM complexity description that can be suggested to the operator during AF mapping procedures as a reference to locate CFAE sites. A simple and new way of describing A-EGM complexity based on the algorithm introduced here for locating CFAE sites is compared with the current algorithm for automatic search of CFAE sites and automatic A-EGM complexity description [1]. The study also shows how the proposed approach can be used in real time during AF mapping procedures.

The algorithm developed in the study was designed to describe A-EGM complexity in a new way. It performs several automatic signal preprocessing steps. Based on this preprocessing, the algorithm then automatically searches for areas of the A-EGM signal where local electrical activity is found (areas of interest – fractionated segments FSs), also described by Faes et al. as local activation waves. The level of A-EGM complexity is then derived from the characteristics of the automatically observed FSs.

The algorithm searched for local electrical activity in the A-EGM signal to find fractionated segments (FSs) in that signal. The A-EGM signal was de-noised by the algorithm shown in [2]. The de-noised signal was decomposed by discrete wavelet transform multilevel decomposition into 5 levels using the Coiflet wavelet of order four. The detailed coefficients of the signal of the given wavelet decomposition structure were reconstructed at level 3 (L3). L3 showed promising results to find FSs in previous studies. L3 was normalized with respect to the maximal absolute level of the given L3 values to obtain uniform signals across the dataset for the subsequent stages of FSs detection. The normalized L3 signal values were thresholded with threshold value 0.014. All parts of the signal where the absolute amplitude value was higher than 0 were marked as peaks with value 0.05, and the rest of the signal was set to zero. The last step of the algorithm joined all peaks that lay very close to each other and marked them as a single FS. Threshold 5 ms was used to merge the peaks together to a single FS. The individual steps of the algorithm and the algorithm itself are described detailed way in [2]. The fractionation indices of the novel algorithm were calculated as zero-crossing points found in FS in de-noised A-EGM signal.

For evaluation of algorithms for automatic detection and characterization of fibrillation potentials, a large database of fibrillation electrograms (A-EGMs) was used, recorded during AF mapping procedures using bipolar recordings in both atria during AF in 12 patients suffering persistent AF. The A-EGMs were sampled at frequency 977 Hz at recording time by CardioLab 7000, Prucka Inc., during the AF procedure and were then resampled to 1 kHz. A representative dataset (n = 113) of A-EGMs was used in this work. Although the degree of fractionation of the A-EGM signals in 350

the dataset was assumed to be naturally continuous, a four degree set of fractionation classes was chosen for the purpose of the study (1 - organized activity; 2 - mild degree of fractionation; 3 - intermediate degree of fractionation; 4 - high degree of fractionation). The design of four degree set of classes of fractionation was defined for the purpose of the study and followed a proportional distribution of degree of fractionation (regularity of signal) of pre-selected A-EGMs in dataset.

The algorithm for A-EGM complexity description was tested using non-parametric statistical analysis. Spearman's rank correlation coefficient (ρ), resp. its absolute value, was calculated for the algorithm. A correlation was performed between the fractionation classes using designed dataset and the fractionation indices of the given algorithm with result of $\rho \sim 0.89$. The results were statistically significant (p < 0.05).

This study confirmed that reconstruction of the detailed coefficients of a signal at level 3 of the wavelet transform carries information about electrical activation of the substrate during AF, and can be useful for searching FSs and especially for describing the level of complexity of an A-EGM signal. While current methods focus on dominant frequency classification or on an evaluation of A-EGM fractionation and are not fully automatic or need intervention by an operator, the newly described algorithm primarily eliminates segments of electrograms where evidently no local electric activity is present, and then describes the complexity of A-EGM based on the automatically observed fractionated segments. Because of the low computational costs, such fully automatic systems can be easily implemented into real-time mapping systems, and offer operator-independent electrogram complexity evaluation for navigation during AF substrate catheter ablation.

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Camera System for Movement Analysis

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The goal of this work is to create a functional application for 3D motion analysis by using two cameras in the MATLAB software environment. Systems for 3D motion analysis, such as those produced by the firms Vicon and Qualisys, are expensive (in comparison with ours) and use up to 10 cameras with high resolutions (up to 16 Megapixels) and reflexive markers. The camera system developed here uses two ordinary cameras with high definition (full HD) resolution. This system is sufficient for analyzing motion in clinical work, and is specifically able to analyze the hand motion of patients suffering from Parkinson's disease.

Two synchronized video sequences are obtained from the two cameras, which follow anatomically significant points that have been labeled by specific markers. These video sequences are used for off-line motion analysis. Software solutions are formed for this purpose. The application consists of a modular system, which contains preprocessing videos, color calibration, camera calibration, detection of the markers, independent measurements and visualizations of the results.

The processed video has a frequency of 25 frames per second, where interlacing is used. Every frame is split into two half frames, which causes the vertical resolution to be reduced by half, and allows us to obtain a higher frequency of 50 frames per second.

The color coordination in the Color Calibration Module automatically selects appropriate values of brightness for the image in the required standardized format (for example, sRGB). It places a calibration chart (GretagMacbeth ColorChecker chart) onto the image. This chart is designed to calibrate cameras. The image is then processed by median filtration. By using multiple regression analysis of the corresponding brightness values in the reproduced image with the reference brightness values of sRGB, we determine a 3D transfer function. Because the scene is recorded in different light conditions, we can use the acquired transformation to transpose the image from the scene into the standard values. The resulting calibration creates permanence of the colors.

Another necessary component of the modules is the Camera Calibration. In order to do this, we use the corrective functions from the Camera Calibration Toolbox. In order to reconstruct the 3D coordinates of the moving points, we need at least two views where the coordinates of the corresponding image points are visible. Before the camera system can be used to track the markers, it needs to be calibrated. This is done by placing a known calibration chessboard in front of the cameras. A Harris corner detector is used to determine the corners, which are created along with the grid of the chessboard. With the help of these corner points, the matrix can estimate the intrinsic and extrinsic parameters of the cameras, the geometric distortion of the image and the mutual positions of the cameras. It can also determine a coordinate system in mm.

The Marker Detection Module automatically detects the placement of the coordinates of the center points of the markers in the time synchronization of the video sequences. The shapes of the markers are spherical so their projection to the image plane is always circular and their position can be determined with high accuracy. In our experiments we have tried out several colors for the passive markers, but finally selected a blue color, which is also used in professional video applications, as this color does not resemble any of the colors in the human skin (blue is nearly complementary to the color of human skin). One of the markers is attached to the object being moved; the other three markers are attached to the anatomical landmark points on the patient's hand. Hand movement is recorded by two cameras (side view and top view). During the first phase of the program, the markers are selected manually on the first frame of the video sequence (side view or top view). The algorithm automatically detects the markers in the predictive region for the subsequent frames. The region for the marker detection is automatically shifted in the direction of the previous movement. The marker detection is based on RGB segmentation with fixed thresholds. If the marker is not detected, it will be ascertained using the iterative thresholding of a red color component. If the marker is hidden, it will be selected manually.

Module Movement analysis provides summarizing information about the trajectory of the tracked object. The hand velocity (the velocity of the markers) is calculated from the 3D coordinates of the reconstructed marker positions. The angle between three detected points (2, 3 and 4) on the arm is also calculated. This module allows for descriptive statistics as well. The error of the marker detection due to noise in the hand trajectory is also calculated. In our experiment this error is about 1-3 mm for hand movements. The velocity error was calculated based on measurements that were made while the marker was not moving. Since the recorded velocity of the stationary marker was around 1 mm/s, this value is the error of the marker detection. This noise was removed using moving averaging.

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The Neural Corellates of the Processing of Allocentric and Egocentric Spatial Reference Frames

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To be able to orient within our environment is crucial for everyday life. In order to keep track of the position of objects we need a stable, but at the same time flexible system to code and update the representation of space that surrounds us. It is possible to encode or represent the positions of each object in relation to oneself. At least two different frames of reference are distinguishable. It is possible to encode or represent the positions of each object in relation to oneself. This type of frame of reference is referred to as egocentric and is defined by subject-to-object relations. The locations of objects in space are represented with respect to a personal agent. Spatial positions can also be coded in object-centered coordinates that are independent of the observer's current position. This mode of representing spatial relations is referred to as allocentric. The allocentric frame of reference is constituted by object-to-object relations and therefore, it refers to a framework that is independent from the agent's position (Vogeley, 2003; Vogeley and Fink, 2003).

Based on a large amount of neuropsychological and neurophysiological studies in spatial cognition, anatomically and functionally separate neuronal circuits can be assumed for allocentric and egocentric spatial coding (Zaehle et al., 2007). The present study examines the functional and anatomical underpinnings of egocentric and allocentric coding of spatial information coordinates. Spatial processing was investigated bv analyzing electroencephalographic activity recorded while participants 'traversed' through simulated tunnels. We used the modified version of tunnels from Gramann experiment (Gramann et al., 2005). They measured only the left and right curved tunnels so we extended the experimental design to the upward and downward alternative of the tunnel shape. Tunnel routes consisted of a set of straight and curved segments, providing the navigator with visual information about translational and rotational changes solely through changes in the rate of optic flow.

Since there were no reference points at the end of the passage, the navigator could solve this task only by building up an internal spatial representation of the eccentricity of the end position. With this tunnel task, participants can be divided into two groups according to the particular reference frame they prefer to use: the first group, referred to as 'turners', use an egocentric frame, the second group, 'non-turners', an allocentric frame. The tunnel task makes it possible to distinguish between the use of ego- and allocentric reference frames during spatial navigation, while keeping the visual flow information constant.

For the experimentation were selected 14 participants (aged between 20 and 35 years). All subjects had normal or corrected-to-normal vision. In a separate session participants had to traverse tunnels with one turn of varying angle. At the end of each tunnel, two arrows were displayed representing the correct response within an ego- and an allocentric reference frame, 354

respectively. Participants had to decide which one of the displayed arrows pointed back to the origin of the traversed tunnel path. Since tunnels included only one turn, the arrows clearly differed.

Each trial started with an asterisk for 3 s, followed by presentation of the tunnel for 28 s. The speed was held constant for all segments, including turns. At the end of each tunnel participants were presented with a "three-dimensional" arrow. By pressing the left, right, up or down button, the participant chose the proper homing vector.

The electroencephalogram (EEG) was recorded continuously, at a sampling rate of 250 Hz, using the international ten-twenty system consisting of 19 electrodes. We sorted the signals according to the preferred reference frames of participant and created 4 groups. There were the turners (egocentric reference frame), the non-turners (allocentric reference frame), the mixed turners (they used egocentric reference frames for the left and right curved tunnels and the allocentric reference frames for the upward and downward tunnels) and false allocentric turners (they did not follow the instruction and turned virtually at the last segment). The last two groups were excluded from the further analysis.

We analyzed the turners and non-turners EEG signals in terms of the spectral analysis. We were interested in differences between turners and non-turners in alfa, beta, delta and theta bandwaves during the curved segment of tunnel. According to Gramann (2005) there is not difference between them in straight segments of tunnel, but at the curved segment, there is change in activity for Brodmann areas 7 and 32.

We analyzed the signals by the Wave-finder and the EEGLab software and we did not detect changes between turners and non-turners in terms of different activity in selected bandwaves. We also did not find similarities among turners or differences between turners and non-turners in average absolute amplitude values.

As we did not detect any changes in this experimental design, we would like to develop more precise measurement (more EEG channels) for further experimentation. We will try replicate this design according to Gramann tunnels (only left and right turns) and then upward and downward tunnels separately. At this stage we will analyze this data by the other methods and detect changes between members of different reference frames (turners and non-turners).

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Section 13

CIVIL ENGINEERING

Geodetic activities in monitoring the quality of the works and certification of quality management system

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Geodetic activities in monitoring the quality of construction work

This is the work of checking compliance with the technical parameters, the contractual conditions of work and casting billing for the customer buildings.

An effective tool in checking the accuracy of geometric constructions are statistical control methods. Bring savings of geodetic work in the field, saving measurement and control their use is an essential requirement for the application of quality management according to ISO standards of the 9000th.

Geometric accuracy is influenced by the applicable legislation, technical standards generally binding and carried out in accordance with generally mandatory technical standards, which are annexed to the current version of Decree Law No 31/1995 Surveying on. It is also influenced by the geometric precision of expertise, proprietary designers, singer and officially authorized geodetic engineers, as are the regulations and technical standards are respected in the construction projects. In addition, depending on the level of quality professional activities of technical supervision and site [1].

The role of surveyors in control activities

Construction supervision comes into contact with the work of surveyors of all participants of construction. The results include the verification of measurement protocols, which demonstrates compliance with the geometrical parameters transmitted buildings.

With geodetickým security building activities on the construction of related concepts such as the spatial location of objects, geometric accuracy, size, length, area, volume, tolerance, accuracy. These technical terms are expressible numerical values and a surveyor, therefore, expects its clear, clear, precise, clear and reliable observations.

Deficiencies in the geodetic activities

Surveyors work on construction sites is often unrecognized, supported by a lot of shortcomings:

A) use the lack of project documentation - a lot of problems deriving from errors in this

documentation: - use of incorrect or incomplete documentation,

- unverified marker drawings authorized surveying engineer,
- does not specify the requirements for the accuracy of identification,

B) untransparency geodetic protocols,

- C) ignorance construction terminology,
- D) non precision measurement work,
- E) unsafe levels of geodetic companies.

The effects of non-geometric parameters are different for different kinds of objects. The most negative effects are of the superstructure, construction of roads, tunnels and bridge facilities, which added the impact on security with economic implications. The consequences of non-geometric parameters may affect only the aesthetic but also may affect the durability and functionality of the object to the security threats [2]. 358

Integrated management system

A) ISO 9001:2000 - the quality management system certification to meet the needs of customers

Customers more and more give emphasis on quality and require their partners to meet the highest requirements for the quality of their services. Quality management system certification according to ISO 9000 allowing demonstrate a commitment to quality and customer satisfaction. Quality management system certificate is recognized by international guarantees to ensure confirmation of the level of quality and to new customers.

B) ISO 14001 - demonstrates your commitment to protecting the environment

ISO 14001 is an internationally recognized standard for environmental management systems (EMS). Provides a guide to how to effectively manage the environmental aspects of services, taking into account environmental protection, pollution prevention and socioeconomic needs. Demonstrate a commitment to environmental protection and sustainable development, ensuring compliance with environmental legislation, improves the quality of work and morale of employees.

C) OHSAS 18001 - demonstrates the ability to achieve sustainable development

OHSAS (Occupational Health and Safety Assessment Specification) is an international standard relating to the management system for safety and health of workers, which allows organizations to manage their risks and constantly improve in this area. Demonstrating a commitment to issues of safety and health of workers increases efficiency and, consequently, reduces accidents and downtime at work, reduced financial costs through appropriate management strategies, compensation for loss of time in the manufacture of cleaning organizations or pay fines for violations of rules and also ensures compliance with the legislation.

Conclusion

Compliance with the prescribed geometric parameters of construction is a basic requirement for the control of buildings. Their failure is often linked to geodetic activities. Non-precision and errors in the location, shape and dimensions of buildings and parts to the technical implications, the solution has extensive economic consequences. The use of modern technologies in the analysis of the spatial relationships and consistent application of controls geometrical parameters and integrated management systems can bring significant savings to investors.

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Reliability-based Analysis of Geotechnical Structures Using FEM

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The finite element method is increasingly used in the design of geotechnical systems. It can provide information on stability and displacements over time and, in many respects, is the most general method in geotechnical analysis and design. The finite element method currently used in practice is, however, largely a deterministic method that does not deal with the stochastic nature of design parameters. In reality, uncertainties of many types pervade the practice of geotechnical engineering, and estimation of geotechnical design parameters inevitably involves treatment of these substantial uncertainties and assessment of their implications on performance. Natural subsurface conditions may vary in space and time. Site characterisation is often based on limited information from sampling or boreholes. Models and methods used to predict the performance of geotechnical systems are simplified representations of reality. Due to these uncertainties, one cannot guarantee that a design based on deterministic analysis using averaged values of the design parameters will perform successfully. While a sensitivity analysis provides valuable information, more insight is desirable. Increasingly, geotechnical engineers are being asked to quantify their degree of uncertainty by estimating a probability of failure.

Probabilistic methods are not new to geotechnical engineering. Because of the significant amount of additional computational effort involved in combining stochastic approaches with advanced numerical methods, it is, however, not until very recently that these methods have emerged as a new tool for geotechnical engineering. They provide not only a systematic evaluation of the uncertainties, but also a means for assessing the impact of these uncertainties on the likelihood of satisfactory performance of an engineering system. In the limited published research on probabilistic finite element methods, most applications have used simple soil models with typically one random parameter. Real geotechnical problems are characterised by complex soil behaviour, with large number of soil parameters, and by coupled physical processes like consolidation.

The above mentioned inaccuracy in the geotechnical modelling (especially in the input data) is solved by stochastic simulation. Monte Carlo Simulation is generally used stochastic method. In the Monte Carlo simulation, a the random problem is transformed into several deterministic problems that are much easier to solve – sample inputs are used to generate sample outputs with statistical or probabilistic information about the random output quantity. But for the geotechnical tasks Monte Carlo method is not appropriate due to that this simple random sampling scheme requires many samples for good accuracy and repeatability – in practice, generating a probability distribution of the safety factor of a rock slopes requires a minimum of 200 up to 2000 selections.

The Latin Hypercube Sampling method – LHS is incomparably less time consuming when compared to the Monte Carlo method and that makes it a hot candidate for its application within the finite element method. This method is therefore implemented in the program GEO 360
FEM /2/ and GEO5 /1/ (within the solution of the grant). While the Monte Carlo method is a classical example of sampling from an infinite population as we may perform as many simulations as necessary, the LHS method represents sampling from a finite population with replacement.

The project was aimed at the development of complex software tools providing the possibility of a probability-based evaluation of geotechnical structures with the emphasis on dump slopes and underground structures. The attention was devoted mainly to the formulation and verification of a reliable material model suitable for the description of the behavior of assumed structures and its implementation within the framework of stochastic simulation techniques and the finite element method. The primary output of the project is the procedures allowing improved prediction of failure probability of geotechnical structures with reference to evident uncertainties in input parameters, both material and topological /3/. The methods of stochastic simulation together with genetic algorithms was also utilized for identification of parameters of the proposed model using the inverse approach. We coupled the rapid improvement of computer performance with our developed efficient numerical algorithms that's why we can provide probabilistic finite element methods with more realistic soil and physical models. Development approaches are implemented in the software environment of the company FINE Ltd. - in particular the programs GEO 5 /1/ and GEO FEM /2/.

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An Examination of Deposits in a Distribution System and their Effects on Water Quality

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The distribution of treated water of good quality can generate in many cases the formation of unwanted deposits in the reservoirs and pipe work of distribution systems. Disturbances in water distribution system can detach these deposits and biofilms and thus deteriorate the drinking water quality.

There are a number of origins for the formation or deposition of particulate matter in distribution systems: incomplete removal of particles from raw water, release of fine materials from treatment filters, precipitation of metal oxides or calcium carbonates, post-flocculation, biological growth, or corrosion. External contamination in reservoirs or pipes, for example fractures or replacement of pipes, can also lead to the introduction of particles into the system. Nevertheless, such a large number of possible sources of particles, and the pipe work complexity, prevent in most cases a direct identification of the origin of particles found in distributed water.

Suspended particles generate at last two types of problem for distributed water quality: firstly, they can carry bacteria fixed on their surface, which protect them from disinfection, secondly, they contribute to the formation of loose deposits in reservoirs and pipe work, which are resuspended into the water phase when a change occurs in the hydraulic properties of the system. Organic matter is suspected to greatly influence the activity of bacteria located inside these loose deposits, even if it is not known to what extent these bacteria grow on dissolved carbon diffusing from the water phase or from accumulated material.

Next to the sources and growth of particles, it is important to understand the hydraulic behaviour of these particles to determine the fate of the particles in the network. Boxall et al [1] presented results for the distribution of particle sizes found in discoloured water samples, suggesting a repeatable distribution of particle sizes irrespective of network conditions, source water ets. They suggested that the size range of the particles was predominantly less than 0,050 mm, with an average size of around 0,01 mm and a significant number of particles in the sub 0,005 mm range.

While the composition of suspended particles is seldom detailed due to their very low concentration, the composition of loose deposits has been determined and shown varying proportions of iron and manganese oxides, sand, zinc flocs, algae siliceous skeleton, detrital organic particles and organic micropolutants [2]. Quantitative data regarding particulate organic matter in drinking water systems is given only by Sly et al. [3] who found 23% of volatile solids in deposits (after combustion at 550°C) and 21 - 32% in suspended particles.

Deposits and biofilms in drinking water pipelines have been found to consist mostly of bacteria, including pathogenic microbes, which can also be present in drinking water distribution system.

This study concentrates on changes of water quality in the pipeline that take their drinking water from the WTP Plav to the city of Tábor and to the cities and the villages which lies on route during its transport. The length of the pipelines is about 80 km. The material of the pipelines is steal without any type of coating. They carry about 285 $1.s^{-1}$ from WTP Plav. There are six reservoirs along the pipelines, at various intervals, with a total capacity of about 48000 m³.

Previous research on the south Bohemia transport pipeline has shown that deposits formed from particles of different origin and size can deteriorate under specific conditions the quality of distributed drinking water. As a consequence of the resuspension of these deposits rise the consumption of active chlorine and disinfection by-products formation in the bulk flow [3].

In our research few deposits were sampled from different sampling points along the transport pipeline.

The content of suspended solids varied between 33 and 911 mg.¹⁻¹, the content of volatile solids was rather low (1, 2 - 17, 8% of suspended solids). Prevailing part of suspended solids was constituted by iron. Its content (Fe₂O₃) ranged between 442 and 933,4 mg.g⁻¹ (44,2 - 93,3\%). The content of other metals like manganese (0, 28 - 0, 67%), nickel (0, 01 - 0, 04%) and zinc (0, 05 - 0, 007%) was much lower.

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Innovation of Water Treatment Process and Provision of High Quality Drinking Water Quality

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Water treatment consists of a sequence of complex physical and chemical processes. In many water treatment plants, process control is generally accomplished through examining the quality of the drinking water and adjusting the process through an operator's own experience and jar tests. This practice is inefficient and slow in controlling responses. With more stringent requirements being placed on water treatment performance, operators needed a reliable tool to optimise the process controlling in water treatment plant. One such tool is the artificial neural network model, which is capable of assisting treatment plant operators with determining real-time coagulant dosage for WTP [1]. The WTP in our study is a conventional treatment facility consisting of coagulation, flocculation, sedimentation, filtration and disinfection.

The chemical quality of the water entering the distribution system always has some impact on the system. Waters with appropriate qualities have minimal impact and the systems have long life expectation. Waters with inappropriate qualities can have a major impact and reduce expectation of the lives of systems substantially. The water may cause e.g. extensive precipitation of calcium and iron minerals on the walls of the conduits, so extensive that carrying capacity of the conduit may be reduced severely (fouling). The water may dissolve away cement material comprising the conduits and retaining structures, causing destruction of the integrity of the material. Corrosivity of particular water depends on its chemical properties as well as the nature of the pipe material [2]. Corrosion of pipe materials may be affected also by bacterial growth.

The distribution system of treated water of good quality can generate in many cases the formation of unwanted deposits [3]. Suspended particles generate at last two types of problem for distributed water quality. Firstly, they can carry bacteria fixed on their surface, which protect them from disinfection. Secondly, they contribute to the formation of loose deposits, which are resuspended into the water phase when a change occurs in the hydraulic properties of the system. Organic matter is suspected to greatly influence the activity of bacteria located inside these loose deposits. The different studies agree to conclude that the control of biodegradable organic carbon (BDOC) remains one of the prime objectives to achieve biologically stable water.

This study concentrates on changes of water quality in the pipeline that take their drinking water from the WTP Plav to the city of Tábor and to the cities and the villages which lies on route during its transport (El-Shafy et al. 2000).

Specific objectives of the study were:

- 1. The principal concepts of using the artificial neural network (ANN) in the water treatment modelling and process control were introduced.
- 2. Evaluation of current corrosion control program applied to a full-scale conventional treatment plant.
- 3. Developing of a new method of corrosion rate calculation and differentiation between uniform and pitting corrosion.
- 4. Study of iron release in the distribution system.
- 5. Modelling of chlorine content in distributed drinking water.
- 6. Deposits formation in drinking water distribution network.
- 7. A possible formation of different by-products from deposits by reaction with chlorine.
- Study of BDOC in raw water and drinking water and the effect of coagulation process on the residual concentration of this parameter. Relation between BDOC and biological stability of water.
- 9. Study of water losses in a distribution system

Outcome of the project was a complex evaluation of variable problems affecting drinking water quality and proposal of actions for its improvement.

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Evaluation of Iron Corrosion Control in Water Treatment System

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Iron corrosion is one of the most complicated and costly problems facing drinking water utilities. Corrosion of iron pipes can cause three distinct but related problems. First, pipe mass is lost through oxidation to soluble iron species or iron-bearing scale. Second, the scale can accumulate as large tubercles that increase head loss and decrease water capacity. Finally, the release of soluble or particulate iron corrosion-byproducts to the water decreases its aesthetic quality and often leads to consumer complaints of "red water" at the tap. The water industry must be concerned with all three of these aspects of corrosion.

Iron corrosion is an extremely complex process. Because if the large variability in distribution system conditions, a particular factor may be critical in one system but relatively unimportant in another system. Moreover, corrosion itself has several different manifestations and can be evaluated in many ways.

Previous studies on iron pipe corrosion have focused on different aspects of iron corrosion: pipe degradation (measured by weight loss, oxygen consumption or corrosion current), scale formation (measured by head loss or scale deposition) and by-products release (measured by iron concentration, color, turbidity, or number of customer complaints). Thus, it can be difficult to compare conclusions or theories from different studies. For example, one study found that head loss increased with increasing pH [1], whereas another study saw decreased iron by-product release at higher pH [2].

Corrosivity of a particular water depends on its chemical properties (e.g. pH, alkalinity, dissolved oxygen content, dissolved solids etc) and physical characteristics (temperature, flow, velocity), as well as the nature of the pipe material. In addition to general corrosion, localized pitting corrosion may also occur if there are imperfections in the metal, oxide film or scale. Pitting is localized corrosion which results in pits in the metal surface. This type of corrosion generally takes place in corrosion cells with clearly separated anode and cathode surface.

Pitting is accelerated by high levels of chloride and sulfate. Microorganisms can also promote corrosion by creating areas with different concentrations in oxygen, minerals and metals. Some microorganisms also catalyze reactions associated with corrosion process. Corrosion products of iron pipe provide habitats for microbial growth and react with disinfectant residuals, preventing the disinfectant from penetrating the biofilm [3,4].

What sets uniform corrosion apart is that it proceeds at about the same rate over the whole surface of the metal exposed to the corrosive environment. The extent can be given as a mass loss per unit area or by the average penetration, which is the average of the corrosion depth.

Corrosion monitoring is an integral part of any water treatment program. It is used to determine treatment effectiveness and to establish the optimum level of chemical treatment that is most cost effective, not necessarily the cheapest. The purpose of corrosion monitoring is to assess or predict corrosion behavior of the system.

The most obvious method of assessing the corrosivity of a water treatment system to a specific material is to expose a specimen or coupon made of the material for a given time in the flowing water. Coupons are made from specific alloys, which have been cleaned and preweighed with a known surface area. Coupons vary widely in size and shape. At selected time intervals, the coupons are removed, cleaned, and reweighed to determine the metal loss.

The goal of our work was to define the new method of corrosion rate calculation and differentiation between two types of corrosion: uniform and pitting corrosion. The investigation was performed in the WTP Plav which provides potable water to many municipalities in South Bohemia. Three places were chosen as locations for corrosion monitoring and taken samples for the analysis of the main characteristics of the treated water from WTP Plav in South Bohemia.

Temperature, pH, alkalinity levels, iron, manganese, calcium and magnesium concentration, disinfectant residual were measured at the inlet of WTP, in water after coagulation and filtration and at the outlet of WTP.

Corrosion rates were measured using removable steel coupons. The coupons were removed from the cradles after a 35 and 70 days incubation period. After this period the coupons were analyzed using mass loss and a new scanner method as well. A software simulation study was carried out using Matlab program.

Corrosion rate measured in crude water from Římov reservoir after 35 resp. 70 days exposition was between 32,6 and 243,3 μ m.year⁻¹(\emptyset 83,1 μ m.year⁻¹) resp. 51 and 212,4 μ m.year⁻¹ (\emptyset 89,0 μ m.year⁻¹) and in final drinking water after 35 resp. 70 days exposition was between 45,9 and 135,8 μ m.year⁻¹(\emptyset 73,9 μ m.year⁻¹) resp. 26,6 and 102,3 μ m.year⁻¹(\emptyset 51,3 μ m.year⁻¹).

Corrosion rate showed a typical seasonal pattern with the maximum value in summer and a minimum in winter.

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Water Regime of Unreclaimed Post Mining Sites.

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Open post mining causes massive disturbance or complete destruction of ecosystems. A large amount of spoil material overlaying coal layers was excavated and deposited on vast spoil heaps, just in Sokolov coal mining district the amount of the excavated material vary between 30-50 mil m³ annually and more than 9000 ha are affected.

The study sites were located on spoil heaps in a post mining landscape in the Sokolov coal mining district. The aim of the project was to study succession changes in hydrophysical soil properties and water regime in the condition of unreclaimed post mining soil owegrown by natural vegetation. The spoils were formed from the cypris clay material of different age and overgrowth by spontaneous vegetation [1]. The experimental plot I was 12 years old, covered by sparse herb vegetation, experimental plot II was 20years old, covered by dense shrubs, including also small trees. The experimental plot III was 45 years old. Vegetation cover is represented by birch and poplar.

A dielectric soil moisture meter [2,3] was used for the long time undisturbed soil moisture measurements. An access tubes were permanently installed in the soil profiles to the depth of about 70 cm, one tube in the top of wave and second in the depression between waves. The data was read manually in the time increments of about 2 weeks during vegetation periods. For the transformation into moisture content a simplified calibration based on a gravimetrical method has been used [2].

Undisturbed samples in four replicates of volume of 100 cm³ have been taken and the basic hydrophysical properties including the retention curves have been analyzed in the laboratory conditions.

Two different methods were used for evaluation of hydraulic conductivity: laboratory measurement of undisturbed soil samples using the standard falling head method and field measurement applying so called Guelph permeameter method. The Guelph permeameter provides simultaneous in situ measurement in the surface horizon so called field saturated hydraulic conductivity.

The differences of moisture content for the youngest (I) and oldest (III) plots show more stable moisture water regime in the bottom parts, than surface layers. Comparison of individual sites reveals no significant differences between sites in 10-15 cm layer. In 25-30 cm and 60-70 cm site (I) had significantly higher moisture than remaining two sites. Site (II) is significantly drier than site (III). In all sites depressions were significantly more wet than elevation. There was significant interaction between depth and sites as concern moisture caused by fact that in site (I) surface layer was dried than deeper layers but in site (II, III) intermediate layer was drier than surface layers.

Water holding capacity decreased with succession age. Field capacity and wilting point was significantly higher in the youngest site than in two others. Also differences between field capacity and wilting point decreased with succession age. The values of the hydraulic conductivity obtained in the laboratory on undisturbed soil samples were significantly smaller,

than the values measured in the field conditions. Due to the high variability of soil properties, no significant differences between sites were found.

We have presupposed, that the reason for lower soil moisture in older sites may be higher uptake of water by plants, which corresponds to higher plant cover and root biomass. The effect of roots on moisture decrease is also supported by observation, that the largest water decrease was observed in rooting zone. However this decrease in soil moisture can be partly also connected with decreasing ability of soil maintain available water.

Decrease of water holding capacity in our study may correspond with higher value of macropores indicated by decreasing bulk density and the differences among the values of hydraulic conductivity measure in laboratory condition and in situ. Other studies show, that soil water holding capacity may increase abandoned areas overgrown by natural vegetation. Results of our study show that the vegetation development and soil development occur with different speed which may cause shortage of available water for plants. During the succession the herbs are gradually replaced by shrubs and trees, this shift is likely to cause deeper rooting zone which may partly compensate for shortage of available water. The question is how much this shortage of available water may contribute to species replacement during succession [1].

The presented results prove the important differences in the time and profile soil moisture distribution in the comparison of top and depression parts of experimental plots. The influence of the age of the heaps and the vegetation cover is possible to recognize in both the soil moisture distribution and the transport parameters. The physical properties and soil moisture distribution are also influenced by the degree of the development of the root system. No basic differences have been obtained in the shape of retention curves, neither from the

point of view of terrain configuration, neither the age of heaps. The soil forming process is very slow in those conditions, so it could not be possible to find any differences; the heterogeneity on the other side has greater importance.

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Measurement of bridge body across the river Labe in Mělník

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Long-span concrete prestressed bridges are sensitive for long-term deflections growing. Bridge over the river Labe near Mělník is a typical example of this structural type. 15 years after bridge opening, midspan deflection still increases. Detail surveying of the superstructure was made to identify possible structure failure.

Long-term deformations are measured in fixed points on the structure (above supportings for analysis of their long-term settlement and in the intermediate points of the end span and middle span for observing long-term deformations of the prestrained concrete structure caused both by reological signs of concrete - creeping and shrinkage, and by other possible effects (e.g. decreases in prestress etc.).

The result of such measuring is time development of the real shape of the structure – comprising both the starting shape and the deflection line – in the analyzed points.

So as to find out an exact shape of the deflection line, a detailed measurement of the deformed shape of the supporting structure in large amount of points was designed. Possible found "anomalies" in the course of the deflection line might point to failures of the structure causing enormous long-term increase in deflections of this bridge structure.

The Trimble S6 Robotic instrument with a relevant omnidirectional reflection prism was used for the measuring. It is a total station with automatic targeting and measurement on prism and it also allows using reflective foils as targets.

The bridge structure was measured by the space polar method. The measuring technology was determined in dependence on time change of the bridge structure shape and on accuracy requirements. The precise leveling technology, which would determine height of points with higher accuracy, could not be used for reason of extremely higher measurement time, which would cause a significantly bigger movement of the structure owing to temperature change and thereby a significantly higher measuring inaccuracies (the measuring would not be continual and a correction by means of a time sample would be infeasible).

The standpoint was placed in the middle of the focused section of the bridge, because then all the 492 points could be focused from one standpoint. Eventual using of two or more standpoints would lower the total accuracy owing to connections errors. The bridge structure shape was changing during the measurement. When designing the configuration of measuring it was supposed that this systematic influence will be sufficiently suppressed by the "time sample" method. The standpoint could be placed in a more stable place, but in this case it would not be possible to measure everything from one standpoint, the structure shape would also change systematically and therefore it would be necessary to implement a correction.

Determination of heights of such a large number of points cannot be at present carried out from the technological point of view with standard deviation cca. 1 mm - 2 mm in such a 370

short time, so that the shape of the structure does not change owing to temperature changes in time during focusing the first and the last point. So as to minimize these undesirable changes, the measuring was carried out at night, in spite of the fact that there appeared a change in vertical direction by values of approximately 3 mm. That is why approximately 1/5 points (each fifth point) were re-measured for check reasons in a significantly shorter time (cca. 45 min) after finishing the first measurements. Changes between height determination of the first and the last point can be taken here for significantly smaller and the sample of points determined in this way can be used to determine a correction curve, by means of which it is possible to bring the measured points into the correct position and to suppress systematic errors.

A detailed measurement of the supporting structure surface with using large number of points was therefore carried out. The result is a "smooth and continuous" line approaching the current shape of the supporting structure, the detailed mathematical analysis of which, amended for example by visual check of state of the supporting structure, can reveal eventual failures of the supporting structure leading to excessive deflections that grow in time. When adopting assumption of linear creeping (level of pressure tensions is supposed to be e.g. according to ČSN ENV 1992-1-1 smaller than $0.45f_{ck}$) and constant tension must be a found shape of deflection line "similar" to shape of deformation gained by calculation when considering building procedure, changes in static system and development of deformations owing to concrete creeping.

The eventual found differences can therefore indicate places on the construction for example with reduced solidity caused by fissures in the structure. It is necessary to remind that if the real shape of deformation does not correspond to presumptions of the calculation, then even the lay-out of the inner forces defined by the calculation is not correct.

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Selected Factors Affecting Resultant Stresses in Cement Concrete Pavement Slabs and their Modelling

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Finite-element method

The finite-element method (FEM) has a great potential in concrete pavement studies; this is supported by the fact that three-dimensional models were developed in the past (e.g. 3DPAVE) to analyze some of the many factors affecting the behaviour of concrete pavements. Examples: the base course effect (modulus of the road base "k" reaction), interaction of pavement layers and friction, slab twisting and deplanation due to temperature and moisture; dowels and anchors and transfer of loads in joints. A 3D model easily overcomes numerous persistent limitations of two-dimensional (2D) FEM models, which provide reduced precision of results. The correctness of 3D models has even been confirmed by comparison with measured deformations and stresses induced by traffic volumes and temperatures in some tests and experiments. In each comparison, a good accord of measured and computed values was reached.

3D model potential

Including some factors into the 3D model of the cement concrete (CC) pavement will allow a precise specification of actual deformations and stresses, even in not very typical compositions of concrete pavements. This fact may lead to considerable financial savings in the construction of concrete pavements and surfaces. The model naturally need not be focused only on monitoring stresses and deformations in CC slabs and may also study e.g. crack development, specification of stresses and deformations in dowels and anchors, appearance of unfavourable "hollows" due to so-called "pumping" of slabs and other problems. One of potential alternatives for the 3D model creation is the ABAQUS programme. The text below mentions only selected factors which are of principal importance for the determination of resulting stresses.

Wheel load and Temperature

The problems of determining tensile stresses due to wheel loading using FEM are already well known and so they are not treated in more detail here. It is known that stresses arising due to temperature (particularly in CC pavements) may, under certain conditions, reach and sometimes even exceed the values of stresses induced by traffic volumes. Temperature induced stresses in the CC slab may act undesirably together with the traffic volume, or, on the contrary, against the traffic volume. It is a common fact these days that the temperature gradient along the slab thickness is of non-linear nature and depends on numerous conditions of the outside environment. To simplify the computation, however, this gradient may be considered as linear. Unlike models dealing only with the effect of wheel loading, the temperature analysis requires the usage of elements with temperature characteristics for the CC slab. The optimum solution, however, consists in using combined elements of C3D8T type (8-node trilinear displacement and temperature), because of a future potential joint application of temperature and traffic volume effects. The outputs from the analysis of

temperature loads simulated on the CC slab in the ABAQUS programme indicate the correctness of assumptions and computations.

Definition of interaction behaviour (mutual interaction of layers)

The transfer of stresses between individual pavement layers in the ABAQUS programme is allowed in numerous ways, both in relation to the type of transferred stresses (normal, tangential), and dependence on the material characteristics of neighbouring layers and e.g. actual stress state of the layer. The essential interaction is between the concrete slab and the base course (e.g. unbound grainy). This is where discontinuous deformations across the interface of surfaces arise. In terms of computations, the existence of the interaction has a great impact on numerical results, but a change in the friction coefficient between the slab and the road base produces only slight changes in the global response of the pavement system.

Non-linear behaviour of unbound materials

The recently most used and modeled dependence in FEM is the relationship between the behaviour of a grainy base course and the stress and deformation state. Stresses and deformations are, therefore, increasingly used for the determination of mutual relations of pavement layers. The need for considering non-linear material behaviour is becoming quite important. Linearly elastic approximations of unbound materials are no longer acceptable for pavement analysis. Various non-linearly elastic models, derived from the repeated triaxial test (RLT -Repeated Load Triaxial), describe the response of grainy materials exposed to loading (K-0, UZAN, UT-AUSTIN, UT-EL PASO, BOYCE, DRESDEN).

Slab connection by dowels and anchors (interaction of slabs in joints)

The problems of load transfer onto neighbouring slabs are of importance also for the computation of maximum tensile stresses. If, for example, the maximum tensile stress in the slab's loose corner has some value, the stress at the same point of the slab connected by dowels to the neighbouring slab is considerably lower and mostly not crucial. These problems have become the subject of numerous studies abroad. ABAQUS programme allows the modeling of load transfer onto neighbouring slabs through dowels and anchors.

Results of analyses

The results of analyses indicate possibilities of modeling temperature and other factors, which is definitely a contribution in terms of precision in the specification of resultant tensile stresses in the CC slab. Although the computed values of tensile stresses approach to real ones, the model must still be improved by including other effects, and computed results must be experimentally verified.

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Energy Intensity Recycling of External Thermal Insulation Composite Systems from Eps

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Currently, most of prefabricated buildings are insulated by external thermal insulation composite system (ETICS). Its thermal insulating layer is consisted of expanded polystyrene, mineral or glass wall. It is the structure, which is used for short periods, so their faults and weaknesses show up at this time. Viability of this structure takes about 25 years, while the energy intensity is recovered for 1/10 useful life. If we talk about buildings with high energy needs, so there is about 1/1000 useful life.

In the Czech Republic are 3.8 million apartments. About a quarter of flats from 700 000 oldest was not rebuild. With ETICS is possible to save up to 40 percents of energy. Most prefabricated houses have been built in Prague, Usti and Moravia-Silesia region. The total consumption of EPS in the Czech Republic is 48 400 tons. Compared to the previous year, when the consumption of 40 000 tons, is therefore to increase by 21 %. This is one of the highest annual increases in consumption in Europe where the European average is only an increase of 10%. A similar situation as in the Czech Republic is in Slovak, where consumption of polystyrene has increased over last year by 12% from 20 000 tons to 22 400 tones. The total consumption of polystyrene in Europe is around 1 430 000 tones.

Around 80% of the total consumption of EPS is intended for construction, rest the EPS is processed into wraps. About 70% of polystyrene used in the construction industry are polystyrene plates. The remaining 10% attributable is for the fittings.

Recyclability EPS applies in particular to the materials, which are ready for recycling (material is relatively clean and free of impurities. To obtain such material is very difficult to find the source of such EPS either in municipal waste, where constitute the most protection function or a waste material in the manufacture of the new EPS. However, the majority of EPS for recycling is associated with the other structures, such as ETICS. This material is linked to the surrounding structures so that their separation is very difficult. For this reason nearly all waste materials of ETICS are in a landfill waiting for a recycling process.

The main objective of the proposed project was to determine the energy efficiency of separation EPS from ETICS. The project was divided into two phases. In the first phase was carried out to separate its own structure and the second phase was to evaluate the recycling process in terms of usefulness in practice and energy.

Construction, which was conducted experiment, had two species composition, which varies in thickness reinforcement layer. Supporting construction consisted fiber cement board with the thickness of 8 mm. On this supporting construction was stuck thermal insulation layer from polystyrene, a thickness of 60 mm, adhesive cement with a thickness of 3 mm. Adhesive glue was applied in 60% of bonded are. On the layer of thermal insulation was attached glue with reinforcement material forming strengthening layer. Finishing layer formed silicate plaster with the thickness of 1,5mm.

Machine base solder formed on the special machine for cutting of EPS with unlimited period of use and length meter (tape measure, digital caliper).

During the experiment, there were two problems. The first problem was with a lot of fume, which arose during the cutting of thermal insulation layer. For this reason it is possible to carry out the separation of either outdoors or in rooms with appropriate air change. The second problem was the cutting knife. This element has a thickness of 0.5 mm, and after heating to the necessary temperature began to deform due to the large temperature differences. This had a significant impact on the quality of separation. This deformation was up to 4 mm to knife length with 200 mm. Therefore the final element of separate had external imbalances. Excluding those effects is the impact of the human factor. For the process of separating is very important flow of cut, which is affected by many factors such as exercise cutters, the quality of the citing knife, cutting equipment operator.

The resulting element had the relatively large size variations. Inequality has been cut about 4 mm, which in the test sample of thickness of 60 mm a final dimension of 56 \pm 4 mm. Therefore the resulting yield is around 91.5%. This yield changes depending on the thickness of thermal insulation layer. For example, for the insulation thickness of 50 mm is yield 90.2%, but for the thickness of 100 mm is yield 94.1%. This means that with the increasing thickness of the separated layers grow yield and efficiency of the recycling method. Speed of this separating process was 65 mm / s for the width of cutting 200 mm.

The proposed separation method is appropriate to use for the energy assessment as equation that expresses the conductions of economical use of energy in building as follows:

• EN R	$_{\text{DZR}} = \bullet \text{ EN }_{\text{D}}$	$OPR + \bullet EN ZPRAC \bullet \bullet EN NÁVR$
		40, 6 kJ • 28 290 kJ
Where:	EN DOPR	energy for transporting and cleaning
	EN ZPRAC	energy consumed cutters machine for separation layers on the internal and external side thermal insulating layers
	EN _{návr}	energy produced material to return to the cycle, is equivalent of primary energy, which to be supplied to the production of building elements of the same amount of volume

This equation shows that the energy required for the creation of recycle the same volume is 670 times smaller then the energy required for the creation of a new building element. Therefore from the energy aspect has the way of recycling in the future the door open and is possible to say that incomparably more environmentally friendly, unlike the current landfill. For this reason I would like suggest studied this issue in further.

For these reasons suggest that this method is not ready to use on practice. The problem is the speed of separation and quantity of building structures, which are waiting for recycling. In the future part of the solution might be to improve the instrument base (for example the length of knife).

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Analysis and geothermal energy simulations for usage of heat pumps

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Summary

Nowadays, when the big requirement for saving energy and ecological operations of heating and cooling systems is in need, there is a tendency for using the alternatives sources of energy. The borehole introduces a very interesting alternative source of energy which has a very good possibility for using not only in residential buildings in future.

Nowadays, the ground heat exchangers are very extended sources of energy. For the appropriate heat pump design and operation, with the ground as a source of energy, it is always necessary to know the temperature history in the ground, minimal and maximal temperature of working medium.

The main goal of this work was to determine the distribution of the heat flux in the ground for the next usage with the ground to water heat pump systems for heating and cooling in the civil engineering objects. It is based on the usage of renewable sources of energy for operation in low energy buildings. With the exact definition of boundary conditions in the ground it is possible to save a big quantity of energy for heating or cooling.

Methods

In the dependence of the soil type its properties are changing during the system operation time. These properties can sorely influence the operation parameters of the heat pump. With the mathematical model of the system it is possible to predict the soil thermal behavior. With the new program EED (Earth Energy Designer) it is possible to see the minimal and maximal fluid temperatures dependences of the borehole depth, boreholes distance and its configuration. The optimization of the boreholes is possible to make as well.

As the first model a single family house was simulated, only with heating operation. It was a two storey family house with 8kW heat loss and the annual heating demand 17,5MWh. The operation of the heat pump was supposed from September to April. Two boreholes were simulated with the different depth. The system was calculated with the depth from 80m to 150m. As the best depth of the borehole 105m was determine from the results. As subsoil the sand, gravel and granite was thought. The whole system was simulated for 50 years of the heat pump operation. The energy potential decrease is phenomenal during the first 15-20 years of system operation and it makes about 4° C. The maximal working medium temperature reaches 10° C, the minimum fluid temperature makes 3° C.

After this model, the simulation of commercial offices was made. As variable parameters two boreholes distance and subsoil type were thought. The whole system was simulated for boreholes spacing 10m, 15m, 20m, 25m, 30m, 40m, 45m and 50m, the subsoil type the saturated sand, saturated gravel, moist clay, dry clay, granite, basalt, sandstone and peat was consider. The administration building has a 40kW heat loss, the annual heating demand makes 98 MWh. Two single U-tube boreholes were supposed, each of them with the depth

300m. The working medium flow was 0,35 l/s for each ground heat exchanger. The borehole configuration was used typical for central Europe. The maximal soil temperature reaches dry clay, almost 22° C in summer after 50 years of system operation. During the winter period the soil temperature falls down below the fluid freezing point, when the borehole distance is smaller than 30m. The peat has a very similar behavior like dry clay. The rest of the simulated types of subsoil do not make a radical temperature variation, their temperature during the year makes about 5°C. The maximal working medium temperature reaches with the maximal borehole distance 50m. In this interval the ground heat exchangers does not influence each other. The temperature difference between system installation year and the last year of operation embody all types of subsoil is almost constant. It is 2,46°C in a maximal value for 50m borehole distance.

When the ground heat exchangers distance is higher, the energy potential increases. These results were obtain from a numerous simulation made in EED program.

The last simulations were made for a single family house with heating mode operation of the heat pump. It is a family house with 15kW heat loss where the real system of ground to water heat pump is installed. There are two boreholes, depth of each of them is 75m, the boreholes are single U-tubes, the soil temperature sensor is placed 30m under the terrain. Other measuring sensors are placed on the inlet and outlet from evaporator, inlet and outlet from condenser. The ground heat exchangers are situated in the peat subsoil. For these real conditions the simulation in EED was made. The optimization for this system was done in EED program. From the result follows, that the installed boreholes are sufficient for the building. The aim of these simulations was to verify the EED program in comparison with real measured system. The outputs of EED program are concurrent with the available measurements.

Conclusions

In EED program a lot of simulations were made. From these, how the fluid temperature is influenced by the soil composition is clear. It was determine which subsoil types are suitable for borehole installation and utilization with the heat pump systems. In all cases the exact subsoil constitution is necessary to know for appropriate design and operation of the heat pump.

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Timber space structures with semi-rigid joints with glued-in rods

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The energy need for the civil engineering materials is in contrast with the problems due to the air pollution and warming of the atmosphere. The wood is one of oldest structural materials that grows naturally and don't produce any air pollution. The structural sizes and carrying capacity is limited by the wood material properties. The cost of timber structures is competitive to the steel and to the concrete or brick structural systems. Several structural timber systems are possible to be used for the civic buildings and dwelling houses. The critical part of any timber system is in connections where the concentrations of stresses in several directions are. The wood properties are entirely different at the grain direction and at the direction perpendicular to grain. The connection can be easily destroyed because of the exceeded strength in one direction. At the timber is usually critical the direction perpendicular to the grain. The connections of timber structures are usually acting as pinned joints transferring axial and shear forces only. One of the possible solutions is the application of glued-in-rods, that are long time known technique. This technique is still subjected to the further development as is realized for example in contribution [1]. The glued-in rods are used often for the strengthening of some overstressed part, but the possibility to use it for the semirigid connection in bending is obvious idea. The problem is the realization of joints in situ because of the technology of gluing needs some special conditions. Therefore the combination with the steel part in joint allows the dry process of the structure and assembly should be used. The behavior of such a joint is semi-rigid and the analysis needs complex approach with experiments and e.g. finite element solution. Some description of results from our continuing research is published at [2] and [3]. However the space structures need the connection of more members under different angles. Usually the rotationally symmetric joints are used. The glued-in rods offer similar type of the end connection of bar member in space structure as some other well known systems, that is threaded rod or bolt that can be assembled by tightening of nuts in-situ. In this contribution is described a part of the research on semi-rigid joints for space spherical or cylindrical domes. This joint is rotationally symmetric and his behavior has to be checked with respect to all the six general forces in 3D space. The work that deals with semi-rigidity in space is [4].

For the space dome the rotationally symmetric steel body was developed. This steel part developed for the system made from timber bars with glued-in rods at the end is following previously investigated joint for steel space roof. This joint was prepared and tested at [4]. The sector was tested in the scale 1:1, vertical load was applied on the joint and we examine behavior under tension and compression. The horizontal load was also applied for certain specimens to simulate complex situation in the real dome. The glued-in rods are connected to the body of joint by nuts with special threaded washer to provide transfer of the forces between joint and glued-in rod directly through the washer to avoid compression of the front wood of the member. The arrangement without these washers led to the development of mechanism at joint due to the geometric imperfections that could cause collapse of the joint by the rotation of the part of structure tangentially with respect to the spherical surface.

The timber profiles were laminated from Czech timber. For the laminated Czech spruce timber the Swedish glue either Cascomin 1242 or Cascomin 1240 produced by AZKO NOBEL was used. The steel threaded rods, zinc coated is made from steel S235, but the threads are cold formed; therefore the yield point is 95% of the ultimate strength. Steel were tested informatively for the tension, modulus of elasticity was used nominally guaranteed by the steel and rods producer. The steel used for the tubular section is S355. Threaded rods properties were tested and the yield point fu = 400 MPa, was found. Young's modulus of elasticity was taken as E = 210 GPa, Poisson ratio = 0.3. Threaded rods are glued into the timber by epoxy resin with small viscosity less then 5 Pa.s. to obtain good filling by the glue in 200 mm deep holes. Epoxy resin 455 was used with the hardener Telalit 0252. All these materials are available in the market. The properties of laminated wood are varying also over the cross section according to lamellas. Therefore to evaluate general wood properties over the beam is for the practical reason almost impossible. The strength of the cut out lamella parallel to the grain and perpendicular to the grain was tested for the each set of specimens. This allows us to classify the wood roughly. The set of material properties is needed for the FE analysis.

The models of joint steel body use elements SHELL181. The evaluation of experiments is still in progress. The three-dimensional system offers very complex semi rigidity and also non-linear behavior. The designed joint itself shows good performance, no big yielding and acceptable deformations. Evaluation of M- ϕ curves with respect to bending moments in two directions is under progress.

The presented results of research on semi rigid frame with joints based on glued –in rods proved the possibility of the realization of heavy timber skeleton with the joint that allows assembly insitu. Further development of the structural system for different sizes of timber columns and beams are prepared. The good correspondence of experiments and FEM analysis predict the possibility of verification based mainly on the FEM analysis and will not need so many experiments. The problem of space dome that use glued-in rods in joint is far more complex and need detail evaluation of experimental results and also the complex solution of whole experimental specimen and non linear analysis of space frame with semi-rigid joint. The known danger of big influence of geometric imperfections was verified and the concept of design that transfer forces from the body of joint through glued–in rod directly was proved to be good. The detail numerical study of the forces between the body of joint and ends of timber bars is under progress by simple analytical and FE solution.

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Semi - Rigid Joints of Timber Structures

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Wood is s unique structural material. It stands alone in many characteristics when compared with man-made materials such as steel, concrete, stone, brick, and most synthetics. It is multicomponent, hygroscopic, inhomogeneous, inelastic, fibrous, porous, biodegradable and renewable. Wood is also cellular organic material from which timber is cut for construction purposes. The tubular cells of timber have an orientation that gives different properties, depending on the direction of the grain, and produce a highly anisotropic material (i.e. having different properties in different directions). This explains why timber is subject to different permissible stresses depending upon whether the direction of loading is parallel or perpendicular to the grain [3]. Timber is one of the oldest structural material but its deformation and failure processes are poorly understood compared to information about other materials like steel or concrete.

Timber frameworks and roofs are one of the most important and widespread patrimonial structures and they represent one of the most important ancient engineering works spanning over considerable distances. They involve not only an evidence of structural knowledge and creativity of their makers but also a good deal of structural beauty. The roofing frameworks have passed a long way of development of their structural schemes and improvements of their layout [2]. The development of roofing frameworks and also building frames was accompanied by changes in joints and their structural behaviour. Unfortunately, these structures are vulnerable, and damaged joints can lead to some modifications of the global behaviour of the structure.

Timber joints are often less effective than corresponding joints in steel, for instance, because of the relatively low embedding strength and low strength in shear, and particularly in tension, perpendicular to grain. Relatively large spacing and distances to end and edge are therefore needed to avoid splitting. This means that the necessary load transfer areas are quite large, and may often determinate the size of timber framework members [4]. This shows that great attention must be paid to the design of joints. In some cases, the joints are quite complicated, especially where there are tension forces. These designs have remained out of use for a period, but due to the introduction of CNC wood-working machines, some carpentry joints may again be of interest because of their fire resistance, or for use in structures with many similar compression members.

Carpentry joints are of course the oldest kind of joints. In many cases the internal forces are passed on by contact and friction in the joint areas, without any fasteners. Because of important sections used in old timber structures, in many cases only the serviceability limit states are restrictive. In this case, taking into account the rotational stiffness of the joint can be useful but the modelisation of timber framework is not so easy throught lake of informations about carpentry joints. Traditional timber joints behaviour remains badly known. Recent studies have shown that some kind of carpentry joints can be considered as semi-rigid connections. Their rigidity (bending stiffness) in general sense plays an important role in 380

computation of the global deformations and force distribution of roofing frames. Developments in computer-controlled manufacture of timber members enable a revival of traditional timber connections without steel fasteners. This study will focus on deformation, failure processes and bending stiffness of rafter-tie beam connection and modern tenon (dovetail) joint as secondary beam-main beam connection (both joints are made by CNC wood-working machine). To characterize the behavior of the frameworks, different types of joints and geometries will be studied. In order to validate the results, it will be made comparison of analytical, numerical and of course experimental approaches. Comparison should bring out some new knowledge of understanding carpentry joints behaviour which is most important in the field of structural design and timber repair and their retention for next generation.

The analytical method is based on the component method, frequently used in steel construction. This method consists in associating stiffness to each couple of surfaces in contact. The joint is decomposed into components, which are represented by force – deformation diagram. It provides quick results according to geometrical parameters and elastic properties.

3D finite models (by ANSYS) will be used for numerical solution of these connections. These models will take into account contact and orthotropic elasticity. Contact will be introduced by non linear springs or contact "surface to surface"

All these results will be compared to the laboratory tests. Pilot experiments of raftertie beam connection (hand-made) were performed by Institute of Theoretical and Applied Mechanics in Prague [1]. We will use these data for calibration of our own experiments. Our own experimental research is currently being conducted. These experiments will observe deformation, failure processes and bending stiffness of rafter-tie beam connection and modern tenon joint as secondary beam-main beam connection, both connections are made by CNC wood-working machine.

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Column Web in Shear at Elevated Temperatures

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Reliability of steel structures exposed to fire conditions has been increased by developments of prediction models which are based on experiments at elevated temperature. To predict the behaviour of the structure during the fire, the gas temperature in the compartment, the transfer of temperature into the structure the mechanical loading during the fire and the mechanical resistance of the structure is calculated. The structural joints are exposed to the elevated temperature during the fire and forces from thermal expansion during heating and contraction during cooling. The behaviour of the joint can be predicted by the Component method which is well-established as an analytical technique for rotational properties of joints at ambient temperature cases. The joint decomposes into its components of which behaviour describes in terms of initial stiffness, resistance and deformation capacity by force-deformation curves $F - \delta$. In general the components in tension, in compression and in shear can be recognized. Based on mechanical/spring model and the loading history is the behaviour assembled into the behaviour of the joint, which may be described by a moment-rotational curve $M - \phi$. Widen usage of this method for fire design of joints prevents poor description of some components at elevated temperature and appropriate methodology of components assembling into the spring model. The behaviour of components in tension and compression at elevated temperature was investigated at University of Sheffield. The beam web loaded by combination of shear force and compression force due to the thermal restraint is described in doctoral thesis of Qian Zhenhai from Nanyang Technological University in Singapore. One of the last studied components in the steel structure joints exposed to the fire conditions is the column web which is loaded, except for pure shear, also by an axial force [1].

At the Czech Technical University in Prague two sets of tests were prepared to study the behaviour of the component "column web in shear". The first set was tested under ambient temperature, the second under elevated temperature. The test specimen consisted of two columns HEB200 cross-section and short I-cross-section beam, which was connected to columns by the end-plate connections with six hand tightened bolts M24-10.9. The beam web was stiffened in the compressed part by a channel section. The column was stiffened locally in the position of the applied load. The transversal forces generated in the joint the bending moment and the normal force, which simulate force from thermal expansion during the fire. The guiding component, which was expected to fail, was the "column web in shear". Resistance of this component was designed for ambient temperature case by the bending moment 95 kNm and the normal force 58 kN. Resistance of other components was quantified about 50% more.

Experiment at elevated temperature was realized in the test furnace in PAVUS a.s. laboratory in Veselí nad Lužnicí. Two specimens were suspended from the ceiling of the furnace to expose by heating only the part with joints. The mechanical load was introduced by weight unit through the rope tackle. The different loading for each specimen were generated by 15 kN and 20 kN. The heating in the furnace was realized by oil burners which followed the gas temperature curve which was measured during the Cardington fire tests. Two linear transducers were used for measuring deformations of the joint. Due to high temperature the 382

deformation of the column web panel was observed by photogrammetry only. The visibility in the furnace during the fire was not good enough to reach an applicable result. The deformation was derived from chamfering of the whole joint on the basis of ambient temperature result which is described below. Due to the mechanical loading and high temperature the deformation of the shear panels was observed during the test. The fast grow of the joint rotation was reached between the 26^{th} and 27^{th} minute of the test, which comply to the temperatures $625 \text{ }^{\circ}\text{C} - 695 \text{ }^{\circ}\text{C}$, see [2]. This corresponds to the drop on the material reduction curve of the structural steel when the yield strength decreases to 1/3 at this temperature.

By ambient temperature test which was realized in laboratory of Institute of theoretical and applied mechanics has been observed the linear dependency between the shear component deformation and the whole joint deformation. The same dependency was applied to derive moment – rotation relationship of the component "column web in shear" at elevated temperature. The analytical prediction of the component was carried out by the Component method described in EN 1993-1-8: 2005. The influence of elevated temperature on steel structure was introduced by reduction factors for modulus of elasticity and yield strength. The moment-rotational diagram was calculated for the height of the shear deformation zone 350 mm. The height of the deformed panel zone was confirmed by measurements after the test. The comparison with experimental results shows a reasonable prediction till 600°C. The application of the derived function at elevated temperature was verified by the final deformation measured after the test. Total difference between the deformation, measured at the point, where the contact of columns were reached, and calculated final deformation is 4,6 mrad only, see [3].

The results obtained by this research work confirmed good prediction of the initial stiffness and resistance of the component "column web in shear" by the analytical model with using reduction factors of modulus of elasticity and yield strength at elevated temperature.

In January 2009 will be tested another set-up to find the deformation of the column web panel during the loading by elevated temperature. The specimen will be consisted of short beam HEB cross-section connected to short column of HEA cross-section by the end-plate connection using six hand tightened bolts M22-8.8. Mechanical loading will be applied by the angle of 45° to generate the bending moment and normal internal force in the connection. Incasdescent heating will allow to measure the deformation of the column web panel optically during the loading. Shear stress in the component will be verified by the high-temperature strain gages.

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Quantification of values differences of noise level from measuring and from software LimA

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Software for noise prediction are focused on calculation of industry noise, noise from roads traffic and railway traffic. There is not the foreign software for tramway traffic to calculate separately that is why the calculation of tramway traffic is most often included in railway traffic. That is why there are few input parameters to describe tramway traffic which are entering to calculation in the software LimA and they can influence calculation of noise level from tramway traffic. Especially types of tram track structure are not more closely specify in the software LimA.

The main study of the project is to compare measuring values of equivalent noise level and values calculated in the software LimA on different types of tram tracks structures of tramway traffic in Prague. Measuring places were chosen so that they can be use for results of acoustics measuring from Department of railway structures since 1997 [1], on different types of tram track structures. In the same tine selected measuring places were modelled in the software LimA and the noise level calculations were icluded too.

It was necessary to find an equivalent noise level (with weight filter A) to compare measuring values and software calculations from the transit of one tramway per hour.

Calculation of this equivalent noise level from measuring values in situ was taken from an average temporal developed noise level from the transit of one tramway car. Temporal develop noise level was achieved on the basis of multispectrum which was obtained by measuring three identical tramway cars. Formula for individual logarithmic sum was used for caunting noise levels in time [2].

$$L_{Aeq,Nt} = 10 \cdot \log \frac{1}{N} \sum_{i}^{N} 10^{0.1 \cdot L_{Aeq,h}}$$

 $\begin{array}{lll} N & [-] & number \ of \ time \ periods \ in \ interval \ temporal, \\ L_{Aeq,Nt} & [dB] & equivalent \ noise \ level \ per \ time. \end{array}$

After obtaining equivalent noise level value from measuring in situ was approached to model the same area in the software LimA. Cartographic data which were used for modeling of landscape and surrounding built-up area were obtained from the Czech office surveying and cadastral in Prague. Aftewards there was modelled the tram track and there were associated inputs parameters to tram track. Among input parameters for tram track belong:

- the track is model like a line surce of noise,
- max. allowed speed on the track,
- the type of track structure,
- quality of the track and discontinuous rails.

The tramway car was associated with following input parameters for the track which was described by:

- tramway car was modeled as a point source of noise,
- intensity of tramway traffic,
- speed of tramway car,
- category of the car by a moving system.

Calculation in software LimA was effected by Dutch methodics for calculation and measuring noise from railway traffic RLM II [3].

All areas were modelled and their measurings were made up by the same process. Parameters detailing a tramway car were used for all areas by the same way. There were used different parameters for the tramway track especially parameter detailing the type of track structure and quality of the track.

It is not uniquely possible to determine about correlational coefficients from calculated values gained by software LimA and values gained from measuring in situ. There were successfully modelled an acoustic situation which were corresponding with measurings in situ in some areas. Another areas were differented from two decibeles and more. This difference can be included to the measuring errors. Other errors which could have be the cause of the difference between measuring and modeling noise levels values we could find in setting parameters for tram tracks structures. There are not possible describe a tram track cover by the parameters for describing tram tracks structure in software LimA.

Today the software LimA is not prepare for noise prediction of tramaway traffic as a cause of little input parameters entering to calculation in software LimA which are not included for the tram track structure description. I would like to follow this problematic in the future in my thesis.

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Essential Deformation Properties Testing of New Developed Railway Structure

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For the cost reduction of the railway track maintenance is necessary to install the continuously welded rail (CWR) in a small radius of curvature, where Y-steel sleepers support higher robustness of superstructure construction in comparison with lateral movement. The vertical and horizontal profile and their degradation is monitored in test section of the railway track. The vertical settlements of the railway construction are measured and subsequently determinate the real C value which is compared with foundation of the railway structure.

Y-steel sleeper as well as other types of sleepers has to ensure appropriate load transfer and distribution from the rails to the ballast, constant rail spacing – track gauge, stability of whole track grid and provide resistance against the horizontal movement. One of the other requirements for railway superstructure is to ensure its elasticity and homogeneity along the track line. This is important mostly in places where the classical track with concrete sleepers is changed to the track with Y-steel sleepers.

The main object of this project was measuring of vertical deformation of railway structure with Y-steel sleepers and its comparison with the classical construction with concrete sleepers. The measurement was evaluated at the short parts of the railway tracks in the Czech Republic where Y-steel sleepers were experimentally used. As load for measuring was mostly used the traffic load of each part of the track. Y-steel sleepers were also used at one part of the tram track Liberec – Jablonec nad Nisou, where no measurements were evaluated.

There are a lot of differences between the railway track superstructure with Y-steel sleepers and with concrete sleepers. Y-steel sleeper is made by two main curved beams and two secondary beams. All beams are cut at their ends in angle of 32° because of the material saving. Hence the length of the sleeper is different in the part of sleeper-ballast contact (2300 mm) and in the part of rail-sleeper contact (2000 mm). The distance between main beam and secondary beam is 190 mm. The shape of main beams can be easily changed. Hence Y-steel sleepers are made in two different distances of fastening – 600 mm and 650 mm. The connection of two neighboring beams is provided by lateral bracings. Upper bracings are used for rail fastenings, ensure track gauge and transfer loads from rails to sleepers. Lower bracings transfer most part of horizontal loads from sleepers to ballast. These bracings are made of steel angle with dimensions 100 x 50 x 1100 mm at the wider part of sleeper and 100 x 50 x 300 mm at the narrow part of the sleeper (in case of high horizontal load, it is possible to use the angle with higher vertical part).

There is also a possibility to reduce the dimensions of ballast for different kind of reasons. Due to higher elasticity of Y-steel sleepers in comparison with concrete sleepers, the thickness of ballast under the sleeper can be reduced from 350 mm to 300 mm (values for international tracks). The other reason for reduction of the ballast thickness is the sleeper's

high. Y-steel sleeper is only 95 mm high while the concrete sleeper 210 mm. It is possible to save huge amount of gravel which is needed for covering the spaces between sleepers.

Considering that the structure with Y-steel sleepers has a lot of differences in mechanical properties in comparison with the structure with concrete sleepers, it is necessary to confront these properties and the structure behaviour under load. To make this comparison it was decided to measure the maximal subsidence under the loads of moving vehicle and than calculate the real C value for each part of the track. For calculation the real C value, the load per axle, static characteristics of beams (rails) and the maximal subsidence under the loads must be known. The results of calculation were compared with values that are specified in Czech technical standard – CD S3 "Railway Superstructure"– Part Four.

The measurement of maximal subsidence at the track with Y-steel sleepers is nowadays made on three test sections of the different railway tracks in the Czech Republic – Popelín, Liberec and Rozsochatec. Each section has its own characteristics, which have to be included in calculation of C value (sleeper spacing, rail profile used in that part of the track, type of Y-steel sleeper (loading area) and mainly the different types of railway substructure).

The measurement of maximal subsidence was carried out by two different methods. First method was based on measuring with digital beam calipers, whilst the second one on digital camera recording. Two different methods were used to have a chance to compare the results from each of them and to be sure, that there is no error in the method of measurement. At the part of the track in Popelín, 106 subsidences were measured, in Rozsochatec the number of subsidences was 172 and in Liberec 211. In all cases, the load per axle was known and after that the C value was calculated. The average value in Popelín was 103 MPa.m⁻¹, in Liberec 109 MPa.m⁻¹ and in Rozsochatec 188 MPa.m⁻¹. The C value of the track with concrete sleepers listed in Czech technical standard ČD S3 "Railway Superstructure" – Part Four is 100 MPa.m⁻¹.

From the results of above mentioned measurements it is clear that the structure with Ysteel sleepers is comparable with classical structure with concrete sleepers. The basic characteristics of the track with Y-steel sleepers (characterized by C value) measured at the track with normal traffic loads are mostly the same as these at the classical track.

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Preparation Enters Climatic Data for Analysis Climatic Change Impacts on Water Management in the Czech Republic

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Climate change as a modern phenomon is not only a subject of research but also that of political debate, conversations between friends, as well as strangers. Climate change affects everyone, but not everyone understands this. Water management is a very important element of the ecology and the economy of a nation, and also the area in which we can most clearly see climate change. We have yet to understand, however, how deeply we will be affected by this change. The world's climatic system is multi-faceted and difficult to understand in full, and there are many different factors which influence it. It is possible to see how this system behaves, and Global Circulation Models can help us to do so. The support of the Global Circulation Models allow us to estimate how the climate will change within the atmosphere as a whole. If we want to know more precisely what is going to occur in our region, we need to use a regional model, such as EC HAM1, which is used in Europe.

These regional models, however, do not work precisely enough to enable us to see what is occuring in the varied Czech landscape. Not only the orography, but also the conflict of the continental and oceanic climates in our longitudes and latitudes do not permit such a regional model to work. For this reason, this project is exactly what is needed for researching climate change in several river basins in the Czech Republic. Detailed data were bought from the Czech Hydrometeorological Institute that described the conditions in four different small river basins (average daily runoff, average daily rainfall, average daily temperature), these four being Dědina (General map of water manamegent 1:50000: 14-11 Nové město n. Metují, 14-12 Deštné v Orlických horách, Number of river basin: 1-02-03-008, 1-02-03-009, 1-02-03-010, 1-02-03-011, 1-02-03-012, 1-02-03-013, 1-02-03-014, 1-02-03-015, 1-02-03-016, 1-02-03-019, Number of gauging station: 0380); Křetínka (Number of river basin: 4-15-02-020,4-15-02-021, 4-15-02-022, 4-15-02-023, 4-15-02-024, 4-15-02-025, 4-15-02-026, 4-15-02-027, 034, Number of gauging station 4530, General map of water management 1:50000: 24-11 Nové město na Moravě, 24-12 Letovice, 24-14 Boskovice); Liběchovka (General map of water management 1:50000: 02-42 Česká Lípa, 02-44 Štětí, Number of river bassin: 1-12-03-020, 1-12-03-021, 1-12-03-022, 1-12-03-023, 1-12-03-024, 1-12-03-025, 1-12-03-026, 1-12-03-027, 1-12-03-028, 1-12-03-029, 1-12-03-030, 1-12-03-031, 1-12-03-032, 1-12-03-033, 1-12-03-034, Number of gauging station: 4050); Rusava (General map of water management 1:50000: 25-14 Valašské Meziříčí, 25-31 Kroměříž, 25-32 Zlín, 25-13 Přerov, Number of river basin: 4-12-02-122, 4-12-02-123, 4-12-02-124, 4-12-02-125, 4-12-02-126, Number of gauging station: 4050). All these data had to be transfered into an identical format so that more detailed analysis could be carried out.

The method of researching the elemental change of the water balance of the long-observed hydro-climatic changes included at first, the monitoring of the zero hypotheses in relation to: the consistency of the order of obversation with the assistance of the Pitman criteria π and the

utilization of the linear model equation Y=aT+b, where Y is the research data; T is the calendar year; a and b are the empirical constants; 2) the uniformity of the research data with the assistance of of the criteria of W. Wilcoxon, T. Student and F. Fisher. The result of the uniform changes or breaks from the uniform order was made on the level of significance α =5% in the case when the estimated statistics (π , t, F) of the module exceeded the corresponding critical significance (π kp, tkp, Fkp) or (for W) exceeded the assumed limits (W1, W2). The additional coefficients of the autocorrelation r(l) were calculated with the frequency of 1 year and the error of their calculation was (δ r(1)=(1-r2)/(N-1)0,5. The more detailed method of hydrometeorological statistical analysis utilized can be found in [1,2]. A mathematical model of the river basin runoff will be made on the basis of this analysis, which will then serve in estimating the change in average runoff, rainfall and temperature. I will write my doctoral thesis based on these data.

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The Effect of Initial Saturation on Dynamics of Infiltration

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A major part of soils in the Czech Republic expresses unstable hydraulic characteristics caused by heterogeneity of solid phase in a micro scale. These soils exhibit preferential flow [1] [2]. The water regime is often mathematically described by dualpermeability approach, which considers two interacting flow domains (matrix domain and preferential flow domain) each governed, by Richards equation [3].

The saturated hydraulic conductivity is commonly measured by laboratory infiltrationoutflow experiments on undisturbed soil samples. Císlerová et al. [2] observed saturated hydraulic conductivity deviations during recurrent ponded infiltrations. The aim of this project is to study the instability of hydraulic characteristics and the effect of initial moisture content on water infiltration to heterogeneous soils.

The recurrent infiltration–outflow experiments were carried out on five undisturbed soil samples. Each run had different initial saturation. The purpose of the study was to investigate the sensitivity of measured steady infiltration rates on the initial moisture contents.

The soil samples were taken of three locations in the Czech Republic. Two soil samples were taken at the experimental site Korkusova Huť in Šumava Mountains, two samples were taken at Předměřice in Central Bohemia and one sample was taken at Uhlířská in Jizera Mountains. The diameter of column samples is 120 mm, the height is 180 mm. The disturbed soil samples for determination of particle-size distributions and samples for measurement of retention curves were also collected. The particle-size distributions curves shows composition of the soils. The soil at the experimental site Předměřice consists of 8 % clay, 10 % silt and 82% sand, the soil at the site Jizera Mountains consist of 12 % clay, 40 % silt and 48 % sand.

To investigate the spatial arrangement of the solid matter in the samples we carried out a CT imaging on each soil column before the laboratory experiments. The semi-automatic setup (designed by Sněhota et al. [4]) was used to conduct the infiltration-outflow experiments. The set-up consists of tensiometers with pressure transducers, data logger, scale, turn-over flow meter with weight sensor, metal frame (to fix the soil sample) and computer. Three tensiometers were arranged in different depths to monitor the pressure heads during each experiment. The positions of tensiometers were selected according to CT images to avoid stones. The calibration of the pressure transducers was carried out before the start of the measurement. The soil samples were fixed in the metal frame which stands on scale.

The constant water level of 1 cm was being kept at the top of the samples during the experiments. The scale records correspond with immediate water content in the samples. The outflow is measured with the turn-over flow meter which is fixed on weight sensor. Because distilled water may cause unwanted chemical reactions, we decided to use weak solution of $CaSO_4$.

The soil hydraulic characteristics and evolutions of water content, evolutions of outflow and inflow were evaluated from the measured data. The time which infiltration takes is determined by reaching the steady state flow. It means that the value of infiltration rate and outflow rate are the same. Next run of infiltration experiment was repeated after several hours. The steady state was reached after two to three hours for samples taken at the experimental site Předměřice, the volume of infiltrated water was one to three liters. Although the experiments on samples taken at the experimental site Korkusova Huť were in progress for more than 11 hours, the steady state was not reached and the volume of infiltrated water was only 0.7 liter. These results are in agreement with particle-size distributions of the soils which have a higher ratio of clay particles.

The steady-state infiltration rates for particular runs changed significantly with different initial moisture contents. Lower values were obtained in recurrent infiltration runs when the initial moisture contents were higher. This finding contradicts the standard Richards' theory of movement of water in unsaturated soils.

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Research of methods of geodetic and geotechnical measuring of vertical networks at the Prague Castle

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The issue of evaluation of all results of the geodetic and geotechnical measuring of the basic vertical network at the Prague Castle was explored within solving this project. The final result of this research should be the objective determination of the stability of related points in periodical instant measurements. The vertical network was created by seven depth geotechnical boreholes and by chosen levelling marks. Besides the basic stage, which was carried out at October 2007, other two stages were subsequently measured in six months intervals.

For geodetic measurements, a precise levelling from the centre between rods was used. The vertical network was measured with two different level instruments. The optical contact level instrument Zeiss - Jena Ni007 and the digital automatic level instrument Trimble Zeiss DiNi T12. Geodetic levelling points were stabilized with bench marks. In case of geotechnical boreholes, the measurement was connected to the metal preparation which was put into the lined borehole. The levelling lines between related points were always measured in both directions.

For geotechnical measurements a gliding micrometer was used. This instrument enables measuring of differences in elevation between the free measurement mark on the top of the borehole and the fixed mark at the bottom of the borehole with accuracy of 0,003 mm/m. The exception was the point number 1012, where the borehole was only the depth stabilization of height geodetic point.

Geodetic and geotechnical measurements were connected to each other by a special metal preparation, which was developed with a help of the Faculty of Machinery of the Czech Technical University. After removing the cover and putting the preparation into the lined borehole, the preparation bears on the free mark to which the geotechnical measurements are connected. The preparation was also used as a related point for levelling measurements.

All calculations were carried out in Matlab programme (language for technical computing).

For heights calculations of related points an adjustment of observation equations with condition equations was used. Normal equations for calculations of differential increments were set together from the condition that sum of squares must be minimal value (as small as possible). The other condition for an adjustment was chosen such, that the average height calculated from all points before and after adjustment is the same.

$$\sum_{i=1}^{n} H_i = konst.$$

The solution of an adjustment of observation equations with condition equations is formulated by block matrix.

$$\begin{pmatrix} A^T P A & B \\ B^T & 0 \end{pmatrix} \cdot \begin{pmatrix} dH \\ k \end{pmatrix} + \begin{pmatrix} A^T P l \\ b \end{pmatrix} = 0, \qquad \qquad \begin{pmatrix} dH \\ k \end{pmatrix} = - \begin{pmatrix} A^T P A & B \\ B^T & 0 \end{pmatrix}^{-1} \cdot \begin{pmatrix} A^T P l \\ b \end{pmatrix}$$

To judge accuracy it was also necessary to determine values of standard deviations of the levelled unknowns, which were calculated from unit standard deviation.

$$N^{-1} = \begin{pmatrix} A^T P A & B \\ B^T & 0 \end{pmatrix}^{-1} = \begin{pmatrix} Q_{HH} & Q_{kH}^T \\ Q_{kH} & Q_{kk} \end{pmatrix} \qquad \sigma_{Hi} = \sigma_0 \sqrt{\sigma_{HHii}} \qquad \sigma_0 = \sqrt{\frac{v^T p v}{r}}$$

For other calculations only points measured in all three stages were used. In each stage an average height was calculated. The heights in n-stage were reduced by difference of average heights between basic stage and n-stage. At the end the vertical shifts were calculated from reduced heights.

$$p_{i}^{n} = H_{i}^{n0} - H_{i}^{0}$$

Measured differences can be within a real change of the position caused also by an influence of errors of observation. So it is necessary to know the critical value of vertical shifts which depend on the accuracy of the measurement. If the absolute value of calculated differences exceeds the critical value, vertical shifts can be taken for proved.

$$\Delta_{Mp} = u_p \cdot \sigma_{n^n}$$

The confidence coefficient u_p determines the risk of a bad decission.

At the end, it is possible to state, that the vertical shifts can be taken for proved, if they exceed the critical value (0.6 mm) in both calculations. Size of the vertical shift of levelling point 206 was calculated -1.1 mm. The vertical shift of geotechnical point 1011 reached the value -1.5 mm. Other points in the vertical network at the Prague Castle can be taken for stable. It is necessary to measure other stages to confirm the reached results. Next measurements should also help to enable the elimination of season influences.

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3D Scanning system with virtual binary targets

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A functional prototype of a fotogrammetric scanning system [3] using virtual targets with a binary code was created. The system is designed for laboratory scanning of small objects as e.g. archaeological objects with point accuracy in a position up to 1 mm. An advantage of the system is especially its low purchase price and its modularity.

The whole system is based on using a data projector with which virtual targets on the scanned object are realized and on the digital camera serving as a data collecting unit. Virtual targets on the objects are interconnected with a starting system of coordinates by means of photogrammetric points. A key part of the scanner is generation and then identification of codes contained in targets. With respect to the fact that the scanned object is a generally irregular form, a unique numeric code is created for each point; this numeric code converted to binary system creates a sequence of ones and zeros. If a certain colour is assigned to one and another colour is assigned to zero, it is possible to create a sequence of pictures definitely identifying selected points in the figure screened from the data projector. Decoding goes in the following way: values one and zero are assigned to each pixel in sequence of pictures according to the accomplished calibration; these values are then converted to a number in decimal system.

An experiment for testing prototype accuracy was conducted. There were selected thirty virtual binary targets, which were screened on the back wall of the calibration frame and focused by the Topcon GPT-2006 instrument. Virtual targets created a square picture (4×4 pixels), the proportions of which were in fact approximately 5×5 mm. Scanning by the system was carried out afterwards from six various standpoints.

Conclusion of the efficiency test is that increasing number of pictures is almost irrelevant for accuracy of the whole system. It is therefore possible to judge that the system moves on the frontier of achievable accuracy that the used set of instruments and aids can offer.

Deviations in coordinate axes can be reduced by the average values of deviations for purposes of evaluation of relative accuracy of the scanning object. Reduction theoretically suppresses effect of systematic errors that is the same for the whole scanned object.

The system achieved the following accuracy parameters in the experiment:

Standard deviation of the scanner	0,61 mm
Standard deviation of the scanner after reduction	0,15 mm

The Canon EOS 450D digital camera with resolution of 12 megapixels is available for realization of the scanning system. This camera is connected to PC through USB 2.0 port. The efficient Umax Lumens LM136 data projector, luminous intensity 3600 ANSI lumens with contrast ratio 400:1 is used as well. The set is used with notebook.

The main topic of the research in 2008 was lens distortion [4]. Growing resolution of cameras brings several complications as well – many various defects of objective influencing

accuracy of the whole system. Three calculation models were chosen to suppress distortion of objective. These models were mutually compared by means of an experiment. The result of the experiment shows possibility of the individual models to suppress lens distortion.

The first model [2] uses 16 coefficients theoretically derived from the mathematical model of all mathematically definable distortions of lens. The second (simpler) used model [1] uses only 5 coefficients. The third model uses Tschebyschev's multinomials using up to 15 coefficients for each component of the coordinates so as to suppress distortions. The goal was to test using of an orthogonal multinomial as a possible procedure without necessity to define the individual components of distortion.

The experiment was conducted for 194 points. The first half of the points served for calculation of distortion coefficients and collinear transformation and the second half served for application of distortion terms for determination of correctness of the distortion model.

The experiment showed various methods of suppression of lens distortion. The distortion method [1] turned out to be very good according to expectations. Although its relations are the simplest ones, it achieves very good results with respect to the distortion [2], which is more general and more accurate. Implementing distortions is certainly simpler and the calculation is more stable for the second (simpler) method [1].

If the demand on elimination of defects of the lens were considerably higher, it would by profitable to use the Tschebyschev's multinomials as they are not dependent on the geometry of the used optics and the calculation can be adjusted according to the needed accuracy. According to the results of the experiment it is possible to apply the multinomials already from the third grade.

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Expressing Relations Among Several Material Parameters Using Fuzzy Logic

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In the construction industry, the emphasis is put on reliability. Therefore, any material or construction technology is verified with numerical simulations at the design stage. In order to obtain acceptable results with the numerical simulations, such as those based on the finite element method, the material models need to describe the material behavior as close to the real behavior as possible. As most of the material models are derived theoretically, they often focus on expressing the general behavior and lack the capability of covering the detailed features, which is mostly caused by the mathematical apparatus commonly applied. However, the detailed features decide the result of the numerical simulation and thus the ultimate reliability of the structure. An example can be represented by the transition from elastic to plastic region in multi-dimensional analyses, when it is necessary to evaluate the exact direction of the plastic deformation, but the Chen model of plasticity [1], due to its definition, cannot provide this information for some stress distributions.

Recently, several papers were published which used the fuzzy logic, e.g. [2], for definition of the relations among several material parameters, such as the definition of the relation among stress, strain and amount of reinforcing fibers in [3] or the evolution of the stress-strain curve with respect to the progressing hydration of concrete. In all cases, the fuzzy logic processed only triangular fuzzy sets, which are on the one hand very easy to work with, but on the other hand the triangular fuzzy sets cannot provide a differentiable curve, unless an almost infinite number of the fuzzy sets is used.

This work focuses on an alternative approach for obtaining a relation among material parameters. The method makes use of various non-linear shapes of membership functions of fuzzy set and the Sugeno definition of fuzzy relations to provide a differentiable curve. The proposed method is demonstrated on the Chen model of plasticity, [1], which is a useful material model for analyses of heavily loaded concrete structures. The advantage of the original Chen model of plasticity is viewed in its simple mathematical definition, when in the compression-compression zone it is represented by a parabola and the other zones by a hyperbolic function. The parabolic function describes the behavior of concrete quite realistically. But, in the various combinations of tensile stress the hyperbolic function cannot express the real behavior, moreover, on the contrary, it increases the compressive strength when tension is applied in the lateral direction, which is truly impossible, [4]. Also, the transition from the parabola to hyperbola does not provide the continuous first derivative, which may cause considerable difficulties during numerical simulations. These drawbacks represented the motivation for this study.

The input data for setting up of the fuzzy material model representing the Chen model of plasticity contained 23 values obtained from testing of real concrete specimens, [4]. Since the experimental data proved insufficient during setting of the fuzzy sets, 8 more values were added by an expert opinion. This feature, adding the expert knowledge to the material model, is also highly appreciated. The location, where the expert values were added, coincided with the largest errors of the material model. Further extension of the experimental and expert data was not necessary. As the next step, these data were transformed into the polar coordinates. 396
Results of a transformation were entered to a specialized software tool, developed specifically for design of a fuzzy sets system. The software was developed as a part of this project.

Two methods for setting up the fuzzy sets were selected: the Sugeno-based method and the combined method. The Sugeno-based method is using the second order polynomial only, because polynomials of higher orders are giving unsatisfying results. The combined method means a combination of Sugeno-based method and the method of non-linear shapes of the membership functions of fuzzy sets. The most accurate of them is the combined method. The resulting fuzzy material model for the combined method obtained by the fully automated procedure consisted of 23 fuzzy sets. If the peaks of the input fuzzy sets were sets manually, because as of now it is difficult to generalize the criteria for optimal location of the peaks, the number was further lowered to 17 fuzzy sets with yet increased accuracy. This feature needs to be automated in order to ensure objectivity. The Sugeno-based method is the fastest when the computational requirements are considered. Regarding the ultimate accuracy, only the Sugeno type and the combination of the two proposed methods were compared as the method based on redefinition of membership function shapes does not satisfy the requirement of the continuous first derivative.

The relative error of the Sugeno-type method was 3.2% while the combined method was even more accurate with 2.9%. Regarding the effectiveness of the methods, the Sugeno-type method needed 21 fuzzy sets to provide this accuracy while the combined method needed only 17 fuzzy sets. However, the combined method requires more time for setting of the number of fuzzy sets and their distribution, which on the other hand does not constitute any serious drawback, as the setting up of the model is done only once at the beginning of the numerical analysis, while the iterations which are run at each loading step process a lower number of fuzzy sets, which represents the real computational efficiency.

The resulting fuzzy model set up by the combined method was compared with the experimental data and the original Chen model of plasticity. The comparison showed that all disadvantages of the Chen model (discontinuity of the first derivative and unreal behavior of concrete in compression-tension parts of the curve) were remedied.

It should be also noted that the proposed approach allows definition of an arbitrary material law, as this approach essentially represents an approximation method which works with experimental data and experts' opinions. Therefore, it does not require any analytical model, however, this approach can be used for improvement of analytical solution by modifying the analytical curves in order to include the very particular phenomena in behavior of specific materials.

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Fatigue of Reinforced Concrete Bridges with Influence of Deterioration of Concrete

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Fatigue is a process of permanent progressive changes in the structure of a material exposed to cyclic loading. High stress ranges in these structures can cause crack propagation, consequently reduce stiffness and can lead to fatigue failure. Also, exposing the material to aggressive environment can result in material deterioration, which accelerates the decrease of fatigue performance of the construction.

Cyclic loading acts on a material with a slightly changed structure in every new load cycle. The cracks do not close during the unloading phases. Stress concentrations at crack tips cause damage in every load cycle. The cyclic load causes further development of existing cracks, which propagate, unite and finally they develop in the whole specimen section. Finally they cause the element to fail. Process of fatigue of concrete consists of three phases:

Phase 1 – Phase of initiation of cracks: During this phase microcracks develop in the weaker parts of the cement paste. It lasts the first $5 \sim 10\%$ of all load cycles.

Phase 2 – Phase of stable propagating of cracks: In this phase strain increases linearly with the number of load cycles. Microcracks propagate slowly further until they reach their critical length. This phase lasts about 80% of all load cycles.

Phase 3 – Phase of instable propagating of cracks: This phase starts when in the structure there are enough instable cracks – cracks which have reached their critical length. These microcracks unite to one macrocrack. The macrocrack rapidly decreases strength of structural element and causes fatigue failure. The third phase lasts last $10\sim15\%$ of all load cycles.

The prediction of deflections, and thus serviceability, of concrete bridges subjected to cyclic loading can be calculated by using a fatigue damage function [1]. This function expresses reduced structural stiffness by decreasing of the modulus of elasticity depending on the number of load cycles. For calculation it is needed to know only the number of all load cycles, which the structural element can resist during its service life, furthermore the number of load cycles which the structural element has already resisted and the value of the load level.

Exposing the material to aggressive environment can result in material deterioration which accelerates the decrease of fatigue performance of the construction. Deterioration of concrete is caused by many factors, which can be of physical, chemical or mechanical character. Physical factors of damage are the effects of high temperature, differences in thermal expansion of the aggregate and the hardened cement paste and freezing and thawing processes. Chemical attack is mainly caused by sulphates, chlorides, de-icing salts and acids. Mechanical damage can be caused by one isolated effect. It is usually a combination of physical, mechanical and chemical processes. But sulphates and chlorides can be considered as the most significant agents deteriorating the concrete microstructure.

Sulphate, when present in solution, can react with hydrated cement paste. The most common sulphates are sulphates of sodium, potassium, magnesium and calcium. Calcium sulphate occurs in soil or in groundwater. Calcium sulphate attacks calcium aluminate hydrate

and forms calcium sulfoaluminate ($3CaO.Al_2O3.3CaSO_4.32H_2O$), known as ettringite. The formation of ettringite causes expansion and it causes stress, which results in cracking.

Chloride attack causes corrosion of steel reinforcement. The products of corrosion occupy much more larger volume than undamaged steel reinforcement and that results in stress, which causes cracking [2]. Chloride ingress into concrete element is related to permeability of concrete. The coefficient of permeability of ordinary undamaged concrete is about 10^{-13} m/s. But when structure is exposed to cyclic loading, cracks arise. After unloading phase cracks do not close down completely which causes increase of permeability. It is obvious that rate of permeability depends on how much the structure is damaged. The value of damage can be determined by the fatigue damage function [1]. Experiments show that uniaxial compressive load at 90% of the ultimate strength can increase the axial permeability by about one order of magnitude after unloading. It was compared to the undamaged samples of the same concrete [3]. But the effect of higher permeability increases the speed of chloride ingress into concrete and it results in faster formation of cracks and enlarging the existing cracks. And this again and again increases permeability and allows ingress of aggressive chemicals and more rapidly decreases residual durability of the concrete structure.

Due to exposing the structure to aggressive environment, the value of the fatigue damage function increases more rapidly and the curve expressing decreasing of the modulus of elasticity has also a faster descent. Effect of permeability and its influence on the durability of concrete structure is included in relation fatigue damage function as other parameters.

The fatigue damage function, which describes directly the impact of cyclic loading on the reduced stiffness of a structural element. The emphasis in the mathematical definition of the fatigue damage function was put on simplicity and a small number of input parameters, which need to be calibrated with help of experimental results or literature. The fatigue damage function is used as a multiplier of the modulus of elasticity in the case of a one-dimensional analysis or of the stiffness matrix in the case of a multidimensional analysis. Since the reinforced concrete structures are placed in an environment containing various aggressive agents, the fatigue damage function also needs to take into account these effects, which can be included in the fatigue damage function as either simple multipliers of additional functions of concentration of the agent and exposure period. It is estimated that the aggressive environment can reduce the service life of a structure by several tens of percents. This value is based on the relation between permeability and accumulated damage given in [4].

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Paper presentation: Stochastic Process Influence on the Yearly Total Energy Need - The 11th International Conference on Indoor Air Quality and Climate

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Summary [1, 2, 3]

This paper deals with assessment of people activity on the object total energy need. Currently dynamic simulation are used for object energy need calculation where given problem is formulated by set of input variables and their each other connected structures. Some input values are not possible to describe only by one value or by one load profile. Those are random character magnitudes which depend on one variable – time. These magnitudes are called stochastic process and are linked with user activity and behaviour in the interior. This simulation input values are currently described like static (constant) loads profiles during the time but in the most cases it is not true. The main aim of this paper is to create probability model of presence user in one single office and by the help of energy simulation to determine dispersion of yearly energy need of this office and compare it with simulation result with static presence profile.

User presence probability model in one office room is processed like set of Matlab scripts. Model works on base of empiric probability functions and pseudo-random numbers. It will ensure non-repetitive one generated profile from each other like it is in real life. The energy simulations with the presence profile will be made by help TRNSYS simulation software.

Result is model of probability presence in single office validation which will create input user profile for energy simulations. By help the multiple simulations in energy simulation tool will be determined energy need dispersion in dependence on user human factor presence in office and these simulations will be compared with currently used static profile for office facilities.

Model inputs data

Inputs data for model are from monitoring single office during one year. Measured data was obtained during study stay at university TU Delft – Netherlands. People presence data was measured like by–product at adjudicates usage natural lighting of office spaces during the day. Measure equipment was given by firm the Watt Stopper. Resulting input presence profile is built from several dates files from several decade measured offices in various time intervals. Always work days and weekend days were respected and they are separated in model. Intervals are in quarter time–step and every day has 96 intervals. Model is universal, it is possible to generate profiles for different building types on the base of measured values. In measured dates was observed absence divided to the two categories – short term (less than 24 hour interval) and long term (bigger than 24 hour interval) where vacation and sickness days are calculated. Model within frame of long term absence generates 30 vacation days and 5 sickness days yearly. There are observed first arrivals and last departures in the office.

absence interval we calculate for every quarter interval total time where is person present or absent at workplace and bigger value from this two values determines the interval state. We have two states in this profile 1 - present 0 - absent. In interval except short term absence is state 0.

Algorithm realization [4]

User presence probability model in one office room is processed like set of each other scripts in Matlab program. Model works on base of pseudo-random numbers, probability distribution function and empiric probability functions. Algorithm connects computational Matlab core with excel file from where data are taken for own calculation and there is place for saving profile results. Excel provides easy access to results and their processing.

Energy simulation [5]

Energy simulation was created by connection three parts: generated profile presence model, TRNBuildu where are described individual model parts (engineering construction and boundary condition) and TRNSYS program which calculate own energy simulation. Structural model for next energy simulations is single office space oriented to the outdoor space with two windows on the southern side.

Conclusion

Model was created like universal which will generate user profile presence for one person after input presence of typical building and its processing. If we have more than one person in the interior then the algorithm will calculate so often how many times people is in the interior and total result will sum. Primary algorithm aim is to create input user profiles for energy simulations where by multiple simulations dispersion and improvement total yearly energy need in dependence on human factor user presence in typical building type will be determined. Next aim was creation this model like base for next continues in more demanding stochastic process modeling like hot water consumption, ventilation, lightings operation, heating a cooling systems user operation etc. How it was mentioned stochastic process are from big measure depended on random number during the time which we cannot influence and is not possible these processes describe by constant profiles from this reason.

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BuHu 8th International Postgraduate Research Conference: Eco-efficiency Modelling of the Building

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In a global change context, as a result of new international research, it is necessary to reduce the CO2 emissions and other industry effects on all human activities. The risk posed by global warming is significant. Buildings and the building industry generally is a sector with a high share of total energy consumption. CO2 emission growth has a direct causality with the growing energy consumption. Eco-efficiency modelling assists in solving the problem of energy demands, CO2 and other effects. At present, there exists, new instruments for energy demands, CO2 and other effects, monitoring. This paper is occupied with the application of software in real buildings. The model works with data from the building project and evaluates them over time. The main aim is the creation of an energy demand model for the life-cycle of the building, which includes: design; use; recycling; and demolition. The outputs of the model are data relating to total energy consumption and other Eco-effects during the life-cycle, which are useful for development strategies, state politics and investment.

Ecological assessment of buildings creates many categories, in which energy efficiency modelling is only one. Other impacts relate mainly to the broader environment. Eco-efficiency offers the comparison of the different construction variants and different types of houses. Eco-efficiency can quantify the energy demands and other impacts for the environment.

For Eco–efficiency modelling it is necessary to have plentiful data relating to the construction. These information resources create the base for the model. Typically needed are project details of the building, thermal losses computations, bill of quantities and other information. A second requirement is data about generic building materials and construction. These data are important mainly for the formulation of energy demands. In this case study two building projects are used. The first was a family house for four persons with non-traditional steel frame construction and timber walls. The second was a block of flats with standard ceramic walls in combination with a light facade and deep foundations. Both buildings had a high standard of equipment [4].

The database of the model is created from the project details of the buildings and a database of the Eco-Quantum software. This model predicts energy demands and emissions of buildings during different periods, and also predicts total energy demands of the building. The model does not currently include the processes of transport, construction site material operations, local intrinsic building influences and the processes of demolition and recycling. To create a data model at a particular point of time, it is necessary to fix the first duration of the Whole-life-cycle. The age of the building is very important for the final values of the building sachieve this age? There are many differences between countries, but most countries have the biggest group between 32 and 62 years of age. These numbers are very important for the selection of time periods of the building. The main processes of application for energy and emissions (eco-efficiency) modelling are comparable with software used in the bill of quantities and cost model of the building, but each material needs a few typical specifications.

Outputs of the model are cubature of the material, emissions produced by the building, energy consumption, and the amount of waste produced by the building. In both cases the chosen durability of the building was set at 75 years. By this choice, a higher proportion of the energy consumption is use related in comparison with material consumption demands.

The total quantity in each category depends on the shape and measurements of the building, construction system and materials, heating systems, cooling system, and equipment of the building. The family house has a complicated frame construction, which makes for a high emission proportion from the roof and exterior walls materials. The positive influence for emissions is largely by using wood in the construction. The graph displays different categories: of the ecological assessment. Material demands have the highest share in the categories: antimony substances; smog creating; sediment toxicity; phosphate emissions; and general waste. Energy demands have the highest share in the categories: global warming; ozone layer - mainly in toxicities; acid gas emissions; and energy consumption. Water demands are important only in the categories: ozone layer; and soil toxicity. Total energy demands of the building are 6213133 MJ during 75 years [3].

By using different time periods it is possible to determine the energy demand trends of the particular groups, in this case divided into the three groups. The first group presents energy demands during the use of the building. These are demands for heating, lighting, airconditioning and other electrical appliances. The second group presents mainly demands during the construction phase. These are demands for construction materials and maintaining the building. This category does not include cycles of reconstruction and modernization.

Eco-Quantum software works with the large database of building material parameters in many categories. It is a good choice for Civil Engineering. However aggregation of the building materials to the construction causes inaccuracies in computing.

The possibilities of building structures modeling from the sustainable development aspect offers much information for the future decision making of developers, information for planning engineers and architects and for the decision making of the state, which have to support energy efficiency and ecologically suitable buildings. Comparing the data from different construction variants, or comparing different modes of habitation from different periods can be used to estimate which ecological impacts and impacts for material recycling need to be solved in next few years. Eco-efficiency analysis shows strong points and weaknesses of structures from the perspective of sustainable development.

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Innovation of soil chemistry laboratory classes

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Soil science related courses are currently offered in bachelor and master programs at the Czech Technical University in Prague, Faculty of Civil Engineering. Important parts of the courses are laboratory classes of soil chemistry, which have been reintroduced in year 2008 as a part of the educational doctoral project no. FRVS 2400/2008/G1. In newly created laboratory classes students can gain practical skills in the area of soil chemistry.

In past years, the soil chemistry laboratory classes were not exercised in Soil Science (Pedologie) and Soil science and soil physics (Hydropedologie) courses. The reason was mainly that the basic analytical equipment and other reliable laboratory instrumentation were not present. Basic instruments for measurements of soil acidity, redox potential and electrical conductivity were acquired as a part of the current educational project in year 2008. The instruments were purchased in the agreement with the project proposal. The equipment allowed introducing selected methods of chemical analysis in Soil Science related classes. Important task of the project was to provide lab class instructions to the methods. These instructions were prepared in Czech and English and are accessible on-line.

Essential soil chemistry analysis methods such as measurements of active and reserved soil acidity, electrical conductivity and oxidation-reduction potential [1] were practiced by students in the laboratory classes of the "Pedologie" and "Hydropedologie", which are the courses in Environmental engineering and Water management bachelor study programs. A demonstration of the total organic carbon analysis method was performed in the course "Soil Contamination and Remediation", which is taught in English.

Following instrumentation has been acquired from the project resources:

a) laboratory pH meter Orion 4 Star KIT, type 1115002 (Thermo Scientific) supplied with pH electrode

b) portable conductivity meter Orion 3 Star KIT, type 1217501 (Thermo Scientific) supplied with conductivity cell

c) compatibile ORP elecrode Orion Redox (ORP Triode Reffilable), type 9180 BNMD (Thermo Scientific)

d) automatic pipete Cole Parmer (Fisher Scientific)

e) automatic feeder Pipet Helper, type 24549-00 (Eppendorf)

f) holder of electrodes, type 090043 (Thermo Scientific)

In year 2008 the laboratory soil chemistry classes were given as a part of the following courses:

in Czech:

143 PEDO "Pedologie" (Soil Science)

143 HYPE "Hydropedologie" (Soil Science and Soil Physics)

143 RLVP "Rizikové látky v půdě" (Soil Contaminaton and Remediation)

143 IHP "Inženýrská hydropedologie" (Soil Science for Masters)

in English

143 SSSP "Soil Science and Soil Physics"

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Laboratory for the Studies of Transport Processes in Soil Environment

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The aim of the project no. FRVŠ 1945/2008/A/a was to establish modern student laboratories for the studies of transport processes in soils, as a part of reconstructed laboratory facilities of soil physics and soil chemistry at the Dept. of Drainage, Irrigation and Landscape Engineering, Faculty of Civil Engineering, CTU in Prague.

New laboratories supplement education of recently accredited study module Transport Processes in Soil (MSc. level). The courses are focused on modern approaches of numerical modeling of water and transport of contaminants in the subsurface. Students are being prepared to solve engineering tasks regarding water sources quality protection, remediation of contaminated sites and emerging problems of quality of water in the subsurface in general.

Based on theoretical knowledge the laboratories are employed for practical training of students taking courses of Soil Science, Soil Science and Soil Physics, Soil Contamination and Remediation, Automated hydropedological measurements and Training in Field.

The aim was to build an open laboratory facility to be used by students during projects and diploma theses elaboration in water management and environmental engineering in general. This goal was achieved.

State-of-the art equipment is used to support the student laboratory assignments which are closely related to the solution of real-life problems. Innovated courses help students to reach the up-to- date knowledge base. Diploma students don't need to rely on literature derived parameter estimates or costly commercial analyses, any more. They are able to analyze their samples themselves, raising the quality of their theses. By opening this laboratory the capability of the CTU in Prague to offer a high quality program comparable with the others good European universities has increased.

Foreign students are attracted by the courses based on modern approaches complemented with practical training on professional devices. This state also motivates students to continue in their education when finishing MSc program.

In agreement with the project proposal, following instrumentation has been acquired:

a) Total organic carbon analyzer multi N/C 2100 (ChD) in combination with the solid module - furnace HT1300, Analytik Jena, Germany

b) Automatic geoelectrical system ARES with standard setting of two multi-electrode cables with intelligent electrodes and adaptor for passive cables. GF Instruments, Czech Republic
c) System for detection of soil moisture TDR100 with accessories, Campbell Scientific, UK
d) Multimeter ORION5 Star for electrochemical detection of pH/mV/ORP/ISE/Cond/DO Br-,

incl. electrodes, Thermo Scientific, supplied by Neotec.

e) Fraction collector Retriever 500, TELEDYNE ISCO, supplied by Amedis s.r.o.

f) Laboratory centrifuge MPW 251, programmable, incl. two rotors 10x10ml and 36x1,5/2,2
 ml, MPW MED. Instruments, Poland supplied by Unimed.
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g) Peristaltic pump ECOLINE VC360, Ismatec, supplied by Donau Lab

h) Device for preparation of demineralized water AQUAL 29, supplied by Vitrum Praha s.r.o.

Detailed list of equipment exploitation in courses (courses listed in Czech with translation in brackets):

Bachelor programmes:

K143 Pedologie (Soil Science) 5.sem, (TOC, ORION5 Star, AQUAL29, MPW251) K143 Výuka v terénu V (Training in Field, Water Management) 5. sem. (TDR100, ARES) K143 Hydropedologie (Soil Science and Soil Physics) 5. sem. (TOC, ORION5 Star,

AQUAL29, MPW251)

K143 Výuka v terénu Z (Training in Field, Environmental Engineering) 5. sem. (TDR100, ARES)

Master programmes:

K143 Transportní procesy (Transport processes) 1. sem. (ARES)

K143 Transportní procesy I (Transport processes I), 9. sem. (ARES)

K143 Rizikové látky v půdě (Soil contamination and remediation) 10. sem. (AQUAL29, MPW251, ORION5 Star).

K143 Automatizace hydropedologických měření (Automated hydropedological measurements) (ECOLINE, MPW251)

Courses taught in English

143 Soil Contamination and Remediation, (ECOLINE, MPW251, ORION5 Star).

Bachelor Theses:

Olga Haladejová (Determination of TOC in soils at Liz catchment) TOC + AQUAL29 (will defend in June 2009)

Jiří Mikule (Determination of TOC in soils at Uhlířská catchment) TOC + AQUAL29 (will defend in June 2009)

Vladimír Klípa (Measurement of soil water content in sandy loam by TDR100 system (will defend in June 2009)

Master Theses:

Bc. Pavel Potsch (Study of erosion and transport processes in the catchment of Olešnice using Erosion 3D model) TOC analyzer + AQUAL29 (will defend in January 2009)

Bc. Jan Kasper (Evaluation of water regime of drained wetlands in Jizera Mountains) – ARES (will defend in January 2010)

Bc. Veronika Benešová (Evaluation of hydrological impact on gravimetric measurements at Pecný observatory) – ARES (will defend in January 2010)

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Software for Evaluation of Properties E-Real

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The contribution presents educational software for evaluation of properties called E-Real. The educational software is the subject of authors work on the basis of accepted grant from FRVS Fund 2008.

The software is primarily designed for students of Faculty of Civil Engineering Czech Technical University in Prague. The software and manual were created for improving the quality of education of study subject called "Appraisal of properties" that is destined to students of master degree study programme "Civil Engineering".

It was realized a detailed analysis of economical and technical literature relating to the questions of evaluation of properties. The software was programmed in Borland® Delphi® for Microsoft® WindowsTM EnterpriseTM, whose trade license have project employees for the disposal. It is necessary to have installed operating system Microsoft Windows for the utilization of this tutorial software.

When the tutorial software for evaluation of properties is started, user is due to set the input data of assessed real property. The input data are segmented into following groups: Identification of real property evaluation, Description of assessed real property, Estimative methods and Recapitulation.

After fulfilment of input data the tutorial software for evaluation of properties compiles a report about evaluation of property. It is possible to export the report into text file in rich text format (RTF).

For easy utilization of the tutorial software it was created interactive menu by the help of whose it is possible to simply walk up and down among particular modules of the tutorial software.

It is possible to load semi finished project and carry on the work. The input data are recorded by the data file with filename extension "pos". The data file is also easily editable using common text editors.

The tutorial software includes two basic modules. It makes possible to determine administrative property price of housing unit and market property price with using of certain evaluation methods.

It is usually used one of mentioned basic access (but more often their combination) in determination of property market price: A/ the access on basis of comparison (comparison method), B/ the access on basis of expended costs (cost method), C/ the access on basis of expected revenues (income method). The tutorial software for evaluation of properties E-Real makes it possible to evaluate real properties by means of all above mentioned basic access.

The comparison method is based on principle of market value comparison of estimated property with prices of similar real properties that were realized in recent period (sold, purchased, still in reality market). It is necessary to look at external factors that impact the value of property. These are external influences of general character (such as economic growth and economic depression), regional influences, externalities, traffic accessibility, 408

human living environment, viewpoint, infrastructure and facilities, safety factor, protection, state or municipal regulations.

It is possible to use the income method in the event that exist future benefits that are expressed as number of expected future incomes. The calculation of the revenue method is based on the time value of money and scope of risk of investment.

The cost method is based on the calculation of purchase construction costs reduced with degradation (devaluation). The purchase construction costs derivate on comparison with costs construction of new building that has similar technical and functional parameters.

The administrative property price of housing unit is the price realized according to law No. 151/1997. The administrative property price is used for example at tax assessment from property transmission (assessment base), gift tax (assessment base), quittances for notaries and personal representatives, in some cases of construction and pieces of land expropriation procedure.

The software E-Real includes modulus for administrative evaluation of properties for housing units.

The tutorial software for evaluation of properties E-Real is designated for continuous study and preparation of evaluations of properties. The tutorial software contributes to improvement of education process of economical and technical subjects on Faculty of Civil Engineering, Czech Technical University in Prague. It makes possible better understanding of subject matter and better explanation of mutual dependences among economic quantities.

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Innovation of the Subject "New Constructions of Railway Structures"

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The subject "New Construction of Railway Structure", which was taught at the department of Railway Structures, Faculty of Civil Engineering, CTU in Prague, was complete remade during academic year (summer semester) 2007/2008. The subject includes the specialized lecture about modernization of build-up of railway structures by using current advanced technologies into substructure and superstructure of the railway construction. In the course of innovation of this subject ware considered modern pedagogic approach to teaching.

Within the project which was supported by Ministry of Education, Youth and Sports was complexly remade the subject "New Construction of Railway Structure"(NCRS). The curricula of this subject were completely renovated. This renovation had a basic reason: changes of study programs at CTU in Prague from 5.5 years of master studies to 4 years of bachelor studies with 1.5 years of continuing master study.

Before beginning of remaking the curricula of the subject "New Construction of Railway Structure", the subject was analyzed. Also the schedules of other subjects which the students already attended at the Department of Railway Structures were collected. These analyses was made to be sure, that the topics of the new subject would be completely new and wouldn't be thought also in other subject at the department during the same semester.

After the materials of other subject were collected, the main topics of the new subject were discussed. After this discussion were chosen the names of the all lectures and this topics were after that discussed with specialists from the Department of Railway Structures and also the extern workers were asked for cooperation. After that each specialist made his own lecture and all lectures were consulted with the head of the Department of Railway Structures doc. Ing. Hanou Krejčiříkovou, CSc. After consultation the lectures could be thought during the subject NCRS.

Into this subject was included mainly the topics about modernization and the way of construction of specific railway structures. The modern and perspective technologies were shown and the new structure elements for railway structures were presented.

After the timetables for the summer semester 2007/08 was obtained, the exact timetable of subject NCRS for this semester was created.

During innovation of the subject the modern pedagogical way of teaching was one of the most important things. This way supposed creating of electronically materials for study and also audiovisual materials and photography.

From asked specialists we had a lot of precious theoretical materials which could be used for making the lectures.

During the summer semester of academic year 2007/08 new photography materials were made. These photographies were given to the lectures and with cementers were given to

the DVD with other materials for students. Making this photography material is still continuing and the new photographies can be used in the next academic year.

The main outcomes of the project are the lectures in form of presentations made in PowerPoint. This presentations are used like study materials which are divided to several chapters and given to PDF format.

Thanks to contacts with companies we could have a lot of new materials and elements used in modern railway structures. These elements were also put to the showcase of the Department of Railway Structures in the atrium of the CTU in Prague. In the same showcase we can see also the poster publicize the subject NCRS. Thanks to this poster, other students of the faculty can be informed about this subject. The important part of the outcomes of this project is also DVD with short video records from different parts of railways.

The results of the project "Innovation of the Subject New Constructions of Railway Structures" are verifiable and we can find the CD with lectures and other materials at the Department of Railway Structures. Most of these materials are also on the web sites of this department.

The result of this project was that the teaching of the subject NCRS was much more effective, which is mainly good for students of this subject. Thanks to this project we made the subject also more interesting for them and that's why the students from all Faculty of Civil Engineering are more interested in this subject.

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Determination of residual load-bearing capacity of existing masonry structures

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A precondition for the determination of residual mechanical characteristics of historical masonry and its load capacity is a detailed description, mapping and analysis of all mechanical failures, cracks, the state of surface layers, masonry non-homogeneity, thickness and quality of the binder in bed joints, the type and dimensions of walling units and masonry bonds.

Special emphasis must be put on the determination of load capacity of stone or mixed masonry composed of irregular walling units (of freestone) or of various types of natural stone (arenaceous marl, fine-grained sandstone, coarse-grained sandstone, limestone, granite etc.) and multi-layer masonry (so-called emplecton). The predominantly positive effect of the triaxial compressive stress state of mortar, which applies in classic brick masonry, cannot be applied to masonry where there are chips and sharp-edge walling units of freestone. The points of appearance of vertical tensile cracks subdividing a masonry element into individual parts ("columns") are most frequently cross sections with ineffective bonding of masonry on several layers. Local stress states characterized by a tensile component arise in the vicinity of masonry elements with a relatively higher elasticity modulus, as compared to the surrounding elements, may unfavourably manifest only at higher values of stone or mixed masonry.

The decreasing reliability in the determination of physical and mechanical properties of historical masonry must be accompanied by a growing ratio of the ultimate strength set by experiments and the actual stress of a masonry structure. The issue of limit or admissible load-bearing capacity is usually asked in the cases of occurrence of more extensive masonry damage, or during a reconstruction implying a change in loading or extensive interventions in the existing masonry. The principle on which each reconstruction should be based is the preservation of the original structural concept and solution of the whole structure, or removal of all earlier insensitive interventions and heterogeneous structural elements. This principle, at the same time, also limits the design concept of prepared reconstructions. Each dramatic increase in the loading of the existing historical masonry structure, or interventions and adaptations, must be subject to a detailed qualitative, or if there are enough precise input values, numerical assessment in order to preventatively avoid a potential successive appearance of cracks and disintegration of masonry.

In relation to reconstruction projects of historical buildings, the present practice in numerous cases applies models of homogenized masonry. A numerical analysis based, on the one hand, on mathematical models, and on insufficiently precise material and physical models, on the other, may lead not only to erroneous conclusions, but it may also be the cause of a faulty reconstruction concept and subsequent appearance of structural failures and damage.

Insufficiently precise boundary conditions and input parameters describing physical and mechanical properties of masonry and its individual components cannot be substituted by the application of "the most demanding" numerical model.

Research of physical and mechanical characteristics of porous masonry units

Research of the effect of moisture on the strength value of masonry units in compression fb has manifested a major effect of moisture on the compressive strength and elasticity modulus of porous building materials.

Experiments were aimed at the determination of the dependency of the compressive strength f_b , the elasticity modulus E for bricks determined from core samples taken from historical masonry, on the pore saturation degree, pore distribution and size for individual types of bricks by means of mercury porosimetry.

Based on the analysis of the results of experimental research we may, with regard to the limited number of samples, state that the effect of moisture expressed by the saturation degree of the porous system on the compressive strength of bricks f_b and the elasticity modulus E in the saturation interval from 0% to 100% is variable and, apart from the saturation degree, the size and proportion of individual pores is also relevant. The results of research indicate that the effect of moisture on investigated properties of bricks (f_b, E) is more prominent in bricks with a porous system with a significant proportion of pores with sizes $\delta \in (0,01-1)$ µm as compared to bricks with a porous system containing a significant proportion of pores with sizes $\delta \in (1.0 - 10) \mu m$. In the case of sandstone, the dependencies above show that sandstones with a larger proportion of pores with sizes $\delta \in (10-100)$ mm react more dramatically, there is a more progressive drop in the compressive strength fb and the elasticity modulus E with a growing degree of pore saturation, as compared to sandstone with a larger proportion of pores with sizes $\delta \in (0, 1-1)$ mm. This different effect of the pore saturation degree by the liquid phase of moisture in bricks and sandstone is, among others, given by a different structure of both masonry units. While the structure of a brick, which is formed by fired brick clay, is relatively compact, the structure of sandstone is mostly formed by two phases - individual grain types which form a matrix whose voids are filled by a binder as the second phase. The liquid phase of moisture, together with the original structure, forms a multi-phase structure (system) where mutual interaction of individual phases affects the resulting compressive strength and elasticity modulus (compressibility). Learning this mechanism of mutual interaction of a multi-phase structure with sudden changes in characteristics on the boundary of individual phases requires relatively demanding mathematical modelling.

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Probabilistic verification of structures for durability

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Probabilistic approach to verification of structural durability is applied to various types of deterioration processes affecting structures made of different materials. General principles of probabilistic approach are also provided in a new international standard ISO 13822 "General Principles on the Design of Structures for Durability". The developed ISO document is partly based on the results of the described research project, partly on the commonly accepted concept of limit states. In addition to the ultimate and serviceability limit states, the durability (initiation) limit states are recognised.

It appears, however, that an operational use of the proposed principles in practice would require additional data and investigations [1,2]. In particular the target reliability level related to various limit states considered when predicting service life needs to be specified. No particular recommendations concerning the target reliability levels are provided in the the new ISO document. The research project illustrates the significance of the target reliability level for prediction of the service life and presents a proposal for informative values of the reliability levels associated with individual limit states of structural durability.

It is further shown [3,4] that the methods of probabilistic optimisation may provide valuable background information enabling rational decision concerning the target reliability levels. The optimisation procedure assumes that in common cases of structural durability the economic aspects are decisive. The objective function representing the total cost is formulated as a sum of initial costs, marginal costs (dependent e.g. on concrete cover) and expected costs due to protection failure (dependent on the design service life and discount rate). The analysis shows that for a given discount rate and design service life the target reliability levels should be differentiated taking into account expected costs of failure consequences and relative costs of foreseen durability measures.

General procedure is illustrated by an example of a durability limit state describing protection of reinforcement of concrete members by concrete cover [2,3]. It is well known that the protection failure due to chemical attacks may considerably affect the service life of the members. It is shown that the predicted service life is significantly dependent on theoretical models of basic variables and specified reliability level. Furthermore, the optimum thickness of the concrete cover and the corresponding reliability level increases with increasing cost of consequences and increasing the design service life, decreases with the increasing discount rate.

Methods of probabilistic optimisation may provide rational background information for a specification of the target reliability level [4]. In case of carbonation of a concrete cover the total costs depend on the thickness of the concrete cover, design service life and discount rate. The optimum concrete cover increases with increasing the costs due to durability failure, and decreases with increasing the discount rate.

The following particular conclusions may be drawn from the optimization study of a concrete cover.

- The optimum thickness of a concrete cover of reinforced concrete structures is significantly dependent on the cost ratio $C_{\rm f}/C_{\rm 1}$, specified design life and discount rate.
- Commonly used concrete covers of reinforced concrete structures correspond to relatively low cost ratios $C_{\rm f}/C_{\rm l}$ and, seem to be uneconomical.
- For the required design life of 50 years, discount rate 0,03 and the low cost ratio $C_f/C_1 = 200$, the optimum concrete cover is about 18 mm. However, for the cost ratio $C_f/C_1 = 1000$ the optimum cover is about 35 mm and for $C_f/C_1 = 5000$ more than 50 mm.
- Further experimental data and appropriate theoretical models for the carbonation process including the description of wetting and drying effects in outdoor conditions are needed. And, for more realistic reliability conditions it is necessary to take into account expected corrosion of reinforcement.
- Further studies on all the components of expected costs including marginal and costs due to protection failure are needed in order to formulate more realistic objective functions.

Practical conclusions concerning the optimum target reliability level [4] may be drawn from the optimization study of a concrete cover exposed to carbonation. In particular the optimum thickness of a concrete cover of reinforced concrete structures is significantly dependent on the cost ratio C_f/C_1 , the time of intervention and discount rate. Commonly used concrete covers of reinforced concrete structures correspond to relatively low cost ratios C_f / C_1 . For the time of intervention 50 years, discount rate 0,03 and the low cost ratio $C_f/C_1 =$ 250, the optimum concrete cover is about 20 mm (the minimum acceptable thickness of the cover), and the corresponding reliability index for the durability limit state is $\beta \sim 1,1$. However, for the cost ratio $C_f/C_1 = 1000$ the optimum cover is about 34 mm, for $C_f/C_1 =$ 5000 more than 53 mm, corresponding reliability indices are $\beta \sim 1,3$ and $\beta \sim 1,9$. Thus, in the example of durability limit state due to neutralisation of concrete cover the reliability index should not be less than 1,1.

In design of structures for durability, the following reliability indices can be considered in general [4]: for durability (initiation) limit states the values from 0.8 to 1.3, for the serviceability limit states from 1,3 to 2,3 and ultimate limit states around 3,7. Additional optimisation studies of structural durability concerning different limit states would be needed in order to develop more specific recommendations concerning reliability of structures in particular conditions.

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Probabilistic Analysis of Time-Variant Structural Reliability

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A great number of efficient structural reliability methods has been developed to analyze time-invariant cases where basic variables are considered as random time-invariant quantities. However, actions on structures are often of a time-variant nature. Various approximations are then accepted in the reliability analysis to estimate the failure probability related to a given reference period. Special attention is required when a combination of timevariant loads needs to be considered. It has been indicated in several studies that development of methods for the so-called time-variant reliability analysis is still a challenging task of researchers focused on the theory of structural reliability.

Thus the research project Probabilistic Analysis of Time-Variant Structural Reliability was supported by the Czech Science Foundation in the period 2006 to 2008. The project was primarily aimed at the development of probabilistic reliability analysis applied to structures exposed to time-variant actions. These actions have been described mostly by rectangular wave renewal processes. In comparative studies other available approximations such as the transformation of time-variant case into the time-invariant one have also been used.

The most significant scientific achievements of the project include:

(1) Improved upper bound on the failure probability related to a given referenced period, considering several renewal processes. The improved upper bound has been derived using the outcrossing approach. It has been indicated by numerical studies that in general, the bound yields estimates sufficiently accurate for civil engineering applications [1].

(2) Lower bounds on the failure. Simple lower bound on the failure probability has been derived. However, numerical studies have indicated that available lower bounds as well as the new lower bound often lead to rather crude estimates. However, sufficiently accurate lower bound may be obtained using the so-called Turkstra's rule if applied strictly as originally proposed [2].

(3) Correlations among the processes. It has been shown in several studies that statistical correlation among intensities of the processes and between intensity and duration of load pulses influences the failure probability insignificantly. Within the project, simplified approximations that enable to consider correlations among occurrences of the processes have been proposed and applied in the case study of imposed loads in garages [3].

(4) Evaluation of experimental data. To facilitate practical applications of the developed probabilistic methods for time-variant reliability analysis, characteristics of processes (load intensity, duration between renewals and duration of load pulses) have been derived considering available data for snow loads on the ground and wind velocity (several locations in the Czech Republic). The results are provided in the final report of the project and will be published in scientific literature. 416

Other outcomes include optimization of partial safety factors for time-variant actions γ_Q and combination factors ψ used in Eurocodes, critical appraisal of models for time-variant actions used in the SBRA method, method for application of Turkstra's rule for intermittent actions and determination of process characteristics for different initial conditions using Markov processes [4].

Project achievements have been published in 4 papers in the reviewed journals, 3 contributions in ISI Proceedings, 4 contributions in international conferences and 5 contributions in national conferences. Additional information on the project can be found at the project web sites www.ctn-eurocodes.cvut.cz/cas.

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Oxygen Isotopes and Silica in Catchment Hydrology. Monitoring and Modeling

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Experimental catchment Uhlířská (1.78 km^2) is situated altitude range 777 - 895 m a.s.l of Jizera Mountains, Czech Republic in the humid temperate mountainous region of Nisa and Labe headwaters. Here soils are shallow and highly permeable with preferential pathways. This areas are typically formed on the the paleozoic crystalline bedrock overlaid by shallow highly permeable shallow cambisols, and filled by thick saturated glacial deposits in the valley, overlaid by histosols. These properties allow for quick communication of the vadose zone and the fractured granitic bedrock underlying the whole catchment. As a result of the instant water pressure transformation throughout these structures, outflow caused by storms is regularly of a quick response and high magnitude, although surface runoff occurs very rarely.

Data collection of the water regime in the soil profile, subsurface, surface flow and groundwater regime is accompanied with the standard climatic and hydrological monitoring for more than a decade. Since 2006, quantitative measurements are supplemented by the additional techniques of natural element tracing. During the formation of the outflow of water from the catchment, the content of the oxygen isotope ¹⁸O and composition of silicon dioxide (SiO₂) are monitored in the water. Both of the natural elements are sampled at selected spots in the catchment [1]. These activities cover the sample collection of rainfall, snowmelt, snowcover, subsurface stormflow, groundwater, soil water from soil suction cups and the stream outflow at two gauging stations. Samples were acquired in liquid rainfall, snowfall, snowcover, soil subsurface stormflow, snowmelt, streamflow at two gauging profiles, soil pore water and shallow groundwater. Analyses of samples for ¹⁸O concentration were performed by mass spectrometry and laser spectroscopy [2]. Analyses of silica were performed using induced couple plasma coupled with mass spectrometry.

The mutual variation of oxygen isotope in form of ¹⁸O and silica is described using the end-member analysis. For selected rainfall-runoff episodes, the evaluation using isotopic and hydrochemical parameters provides varying contribution of event and pre-event water in the outflow. On the catchment scale, the seasonal fluctuation of the ¹⁸O in rainfall and stream outflow is fitted by sine function [4] and by lumped dispersion function model [3] to evaluate mean residence time of water in the catchment. Both of the approaches bring evidence that significant portion of the outflow resides approximately 7 months in the subsurface in average. Dispersion function modeling indicates significant contribution of the groundwater aquifer in the overall outflow (approximately 50%).

A steady-state, one layer numerical groundwater model was designed to assess the spatial variability of groundwater mean residence time across various aquifer depths. Aquifer thickness was evaluated by means of the electrical resistivity tomography [1]. Water table observations in the shallow wells were performed in last decade within the catchment. Detailed mapping by means of GPS gives the distributed water drainage network data. Based on the analysis of the outflow hydrograph, multiple approaches towards the standard baseflow separation analysis results in a baseflow amount of 36% of the precipitation and of 46% of the

streamflow, i.e. streamflow forms approximately 80% of the precipitation. The residence times within the aquifer is in the range of approximately from 5 months to about a decade. Significant transformation effect of the subsurface was concluded, supporting the initially hypothesized major role of the quick groundwater recharge through permeable soils and storage within the glacial valley sediments. On the soil profile scale, the detailed modeling focuses on the evaluation of the water regime of the shallow hillslope soils. Transport of ¹⁸O was evaluated in the variably saturated soil profile by means of a one-dimensional numerical model adopting dual domain approach for taking behaviour of water in preferential pathways into account. This model is based on Richards' equation for water flow and advection-dispersion equation for tracer transport. Vegetation season 2007 was analyzed with respect to tensiometric data and tracer content in the soil pore water sampled by suction cups. Magnitude of outflow from the subsurface sampling trench with the isotopic content of the subsurface stormflow is compared with the outputs of the model's preferential domain. A good agreement with observed values was achieved supporting the hypothesis of significant role on runoff formation by the soil profile.

Hypothesis of a relatively low portion of quick surface-near runoff combined with rather quick recharge and mixing in the lower soil horizons and the upper less consolidated bedrock, was confirmed. This quick subsurface mixing is assumed to be the principal runoff generation process in the catchment. A runoff component with uniform isotopic composition and modelled residence in the order of one decade suggest the existence of a periodically stagnant subsurface water pool in deeper sediments below peatlands, supplying the streamflow under pronounced dry conditions. Approaches used in this study demonstrate the need for their conjunctive application, in particular when interpreting the origin and pathways of the slower runoff components. The obtained results are of importance for water and landscape management of the temperate humid regions of Central Europe in view of future changes of climate and water regime and the role of the mountainous headwaters for the water supply of the adjacent lowland.

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Research of Ageing of Underground Infrastructures with the Help of Micro-Measurements and Monitoring Systems

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Ageing of structures represents a general problem and have a little bit different undertone for individual types of structures. At present day there are millions of civil engineering and building structures, where design serviceable life is usually defined in the range of 70 - 120 years. However at the same time we are speaking about structures, for which serviceable life should be much longer.

Symptoms of underground structures ageing can be observed by monitoring of deformation in time or using physical methods of monitoring for local spots, where concrete degradation is reaching above standard values that have been up to now observed visually.

Grant No 103/06/1257 of the Czech Grant Agency being solved between 2006 and 2008 has been devoted to the different aspects of possible monitoring of all above mentioned changes of the concrete lining in the Prague's metro. However this project has been also solved in the frame of the international research project - Eurocores Programme – Smart Structural Technologies (S3T) "Micro-Measurement and Monitoring System for Ageing Underground Infrastructures (Underground M³)", where the project leader is the University of Cambridge and the project partners are Universidad Politechnica de Catalunya, Consiglio Nazionale delle Richerce Bologna and Czech Technical University in Prague. Research activities were supported also by associate partners, from the firms taking care about metro systems in London, Barcelona, Madrid and Prague as Tube Lines Ltd., Trans4m, Transport Metropolitans de Barcelona, Metro de Madrid a Dopravní podnik hl. m. Prahy.

During the first phase of the project background research regarding geology environment in which metro was constructed and as well with technology of construction was performed. On the base of this information and subsequent site inspections it was possible together with representatives of Dopravní podnik hl. m. Prahy to select metro sections with different geology and construction technology and where some signs of ageing were clearly visible. Finally the section between the stations Vltavská and Nadraží Holešovice on the line C was selected as a basic one. Next one was section on line A close to the station Můstek in the vicinity of the so called Prague fault, the place where geological properties are abruptly changed. In the case of line C the lining is composed from reinforced concrete prefabricates. The section selected on line A is composed from mass concrete but applied as press concrete – concrete lining constructed directly behind tunnelling shield.

For the specification of changes in lining the following methods were applied as basic ones:

- changes in deformation;

- changes inside of concrete with the help of non-destructive physical methods.

Changes in deformation can be observed by different methods in accordance with length of section or according to demanded preciseness. Generally it is valid that for longer sections the methods with lower preciseness are used, as are able to inform about prevailing character of deformation, about deformation development in longer time interval. They can be used also for the evaluation of abrupt changes in loading. Therefore the following methods were used and the results were compared and evaluated:

- classical methods, based on dilatometers, inclinometers, tiltmeters;

- methods using **scanning system** for measurement of displacement and deformation, which seems to be very useful for longer sections;
- photographic methods based on comparison of pictures (camera) or picture sequences (video camera) inscribed as "**Computer Vision**", where pictures taken in the different time periods are compared, whereas cannot be taken from the same position. The methods are proposed for sections with the length in order of m or tens of m.
- methods enabling very precise measurement, whether for observation of the deformation of the whole tunnel profile or for deformation in micro scale, capable to measure the deformation changes in the order of 1×10^{-4} mm, so called **MEMS systems micro electrical mechanical systems**, which are able to observe the deformation of micro cracks in time.

A great attention was devoted not only to the measurement but also to the data recording. **Wireless technology**, finally successfully applied, represents last advanced phase, when measured values are collected by wireless network directly in the tunnel and subsequently send again using wireless technology to the server for further processing and evaluation. This system makes possible the continuous control of measured data on computer.

As was mentioned before ageing can have different symptoms, for constant loading it is question of creep. Similarly it is valid for cyclic loading. The question of metro tunnel lining is therefore more connected with creep of concrete and with question of deterioration of concrete on the surface, on the surface of cracks, microcracks and finally on the weakening of the internal bonds of the whole profile of concrete structure, when this weakening is not observable by another methods on the surface.

To be able to react on these problems, **numerical method** was elaborated which makes it possible not only to solve the deformation of the tunnel lining as a function of loading change but also to include the creep factor and deterioration of concrete in general.

Non-destructive physical methods, as spreading of resilient waves or dynamic response, were able not only to measure the deformation of micro cracks, but also the weakening of the bonds inside of the concrete structure.

Finally all types of measurements were evaluated, compared not only among themselves but also with numerical models. Brief conclusion is as follows:

- all used methods proved to be useful, however from the point of view of ageing the MEMS systems, non-destructive physical methods and wireless technology of data transfer seem to be the new step forward;
- measurements proved that the deformation of lining for observed period of 1-3 years are very small and were affected by temperature changes and indicate small nonlinearity.

The results are continuously confronted with results from measurements which are realized by our co-partners, namely for metro in London, Barcelona and Madrid and the experiences from this phase will be evaluated in the next period.

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Reliability and Risk Assessment of Structures in Extreme Conditions

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The described project of the Czech science foundation GACR is focused on the development of procedures for the design and verification of structural reliability and risk assessment in accidental design situations due to the impact of heavy road vehicles and trains, gas explosions, seismic actions and extreme climatic actions. The probabilistic methods of the theory of structural reliability and methods for risk assessment are applied for the evaluation of extreme actions and assessment of structural resistance. The partial aim of the project is the preparation of background materials and guidance for application of selected results in construction practice. The solution of the project is carried out in several phases in 2006 to 2008.

For the preparation of background materials, the search for information and data was carried out on the basis of national documents of selected countries, analyses of European and international prescriptive documents, research reports and recommendations of research organisations (JCSS, CIB, IABSE, JRC) and standardisation committees (CEN, ISO). The collection of data of accidental actions was made also in co-operation with the World Road Association PIARC and the Road and Motorway Directorate of the Czech Republic. New data of snow actions on ground was obtained in co-operation with the Czech Hydrometeorological Institute. The extreme snow actions caused serious damages to roof structures in the Czech Republic as well as in other European countries during winter 2005/2006. New assessment of snow data and research on the effect of snow on the reliability of structures was needed and therefore, included also within the research activities of the project.

The probabilistic verification of structural reliability under extreme actions is based on the inequality

$$P_{\rm F} < P_{\rm Ft} , \, \text{resp. } \beta > \beta_{\rm t}. \tag{1}$$

where $P_{\rm F}$ denotes the determined probability of failure, β the corresponding reliability index of analysed structure, $P_{\rm Ft}$ and β_t denote their target values. Numerical integration methods and approximate analytical methods (FORM, SORM) as well as simulation methods (Monte Carlo, importance sampling) are applied in the project to determine the reliability measures $P_{\rm F}$ and β .

The target values of reliability indices P_{Ft} or β_{f} are proposed for individual categories of consequences of failure for structures in accidental design situations using methods of probabilistic optimisation.

The rules for combinations of accidental action with other types of actions introduced in various international documents were analysed and subjected to probabilistic calibrations [1]. For analysing structural reliability in selected accidental situations, the dynamic response of structures is in relevant cases carried out, too.

For the reliability analysis and risk assessment of structures in extreme conditions, the methods of Bayesian casual networks are applied to determine the optimum reliability level and mitigation measures. These methods are used for decision about optimal distance of a

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bridge piers or other supporting substructure from the railway [2].

The project outcomes include development of theoretical models of extreme actions (impacts of traffic, gas explosions, extreme climatic and seismic events) and procedures for the probabilistic analysis of structural reliability and risk assessment of structures in accidental design situations. Selected project achievements were presented in seminars for designers, technicians and other people working in construction in co-operation with the Czech Chambre of Civil Engineers and Technicians Engaged in Construction ČKAIT and the Czech Concrete Society ČBS in last two years. The vocational training materials developed within the project solution are also focused on the clarification of procedures for determination of models for extreme actions, including examples of application in reliability analysis and risk assessment of structures [3].

Selected project outcomes were also applied as background materials for the development of Czech National annex to EN Eurocode EN 1991-1-7 Accidental actions [4].

It is foreseen that selected project findings will be used in further research activities of the project team and in prenormative research in the period of maintenance of Eurocodes in co-operation with the Technical Committee CEN/TC 250.

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Reliability, Optimization and Durability of Building Materials and Structures

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Research carried out within the research plan includes theoretical and numerical analyses, experimental laboratory and in-situ research of models of constructions, laboratory research of test specimens and samples taken from monitored structures, laboratory research on models, in-situ investigations, evaluation and statistical processing of obtained data, longterm surveys (monitoring) of structures, comparative analyses, formulation of conclusions, elaboration of methodologies and design procedures.

Topic 1: Reliability approaches, optimization, time-related phenomena and processes, safety, risk management methods, quality, durability and controlled service life of structures.

Topic 2: Reliability of structures in terms of extreme effects and loads, variable and cyclical loads, extreme loads of emergency type, resistance of structures in fire and at high temperatures.

Topic 3: Problems of "structure – environment" interaction, chemical and biochemical degradation processes, interaction of primarily non-load-bearing constructions with the bearing system, "footing bottom – foundations – superstructure" interaction, interaction of composite and multi-layer materials and constructions.

Topic 4: Sustainable development, reconstructions, renovation and maintenance of structures, prediction of residual life, material recycling, health-risk free structures, rehabilitation and strengthening of structures, problems of revitalization and restoration of historical structures.

Partial results achieved within RP1:

Boundary research:

- Effect of soil bacteria and radiation on the degradation of damp proofing systems and foundations of structures
- Effect of residual strengths and fracture geometry on the selection of a material model
- Convergence criteria for iterative aggregation methods solving problems in reliability theory
- Solving problems of parametric programming with parameters set in intervals for calculating ultimate strengths
- Effect of oscillations on a drop in residual rigidity of prefabricated wallboard systems
- Effect of microbial corrosion on the stability of sedimentary rock structure
- Heterogeneous materials structures, composite multi-layer materials

Quasi-applied research:

- Time-related reliability of earth slopes and dumps
- Reliability of structures under extreme loading conditions of emergency type explosion, fire, flood
- Stability and durability of biocides in timber
- Interaction of extrusion masonry constructions with planar and discrete strengthening systems

- Biodegradation and chemical degradation of historical structures
- Kinetics and dynamics of degradation processes of historical structures using nonstress effects and effects
- Transport phenomena in soils, suffosis
- · Failure theory and criteria of masonry vault and extruded constructions
- Computational models of vault bridge constructions
- Failure theory of thin-walled flat trapezoidal arches with low cambers
- Design theory of thin-walled girders with undulated webs for loading by mobile local loads
- Failure mechanism of coupled trusses

Applied research:

- Risk factors of contact padding systems
- Risk factors of infusion and crystalline rehabilitation methods
- Risk factors of flat and padded inclined roof constructions
- Interaction of historical stone bridge constructions with breast walls and bridge body layers
- Strengthening of masonry and concrete constructions by FRP reinforcement
- Decision-making methodology on rehabilitation methods of masonry and concrete constructions
- Methodology of diagnostics, evaluation and monitoring of structures
- Degradation of rail constructions in time
- Specification of noise emissions and disintegration of geometric rail position
- Discontinuities in the field of pre-stressing cable anchorage
- New coupling members for steel-concrete constructions
- Global reliability coefficients for designing lean concrete constructions
- Optimization of superstructure construction for different type localities
- Application of stainless steels for load-bearing building constructions
- Modifications and applications of new coupling members
- Reliability of multi-storey pre-cast panel buildings exposed to the effects of technical seismicity

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Design Specificities of a Pavement for Lovosice Container Transship Point

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Introduction

To minimize the costs connected with the transport of goods from manufacturer to end users combined transport has presently been increasingly used, which combines the advantages of all modes of transport. Railway lines and water ways are used for cheap longdistance transport, while roads serve for shorter distances. One of the conditions of successful operation of combined transport, therefore, is the construction of a sufficient number of logistics centres, which necessarily need transship points with adequate capacities – container terminals - for their activity. Therefore, we can witness an unprecedented boom in the construction of these transship points even in the Czech Republic, where transshipment of goods containers from ships, but most frequently railways, is executed by handling (transshipping) mechanisms – portal cranes or wheel container transshipment vehicles.

One of completed facilities is the Lovosice – South Container Transship Point, which is situated at the Lovosice railway station near the Lovosice Logistics Centre. The reasons justifying the necessity of this structure included mainly reduced costs for goods transport for enterprises in the region, mitigation of the ecological burden on the environment (transfer of part of traffic from the road to the railway), extension of logistics services in the region and creation of new jobs.

Transship point pavement construction

The handling mechanisms for the transshipment of containers from railway carriages onto the transship point surface and successively onto trucks used are Kalmar wheel transshipment vehicles, type DRF450-60C5X. These vehicles have two axles; the front axle has 2 dual wheels and the rear axle 2 single wheels. The tyres of all wheels are inflated to a pressure of ca 1 MPa.

In terms of road pavement design requirements, the following parameters are known:

- □ self-weight of 81.1 t,
- □ max. loading capacity of 45 t (corresponding to max. shipped "sea container"),
- □ most frequently shipped containers are of type 40' with a max. total weight of 30.5 t, or type 20' with a max. total weight of 24 t,
- □ max. loading while handling the container is 45 t, for shorter distances 126.1 t with axle load distribution in a ratio of 107.3 t (front) to 18.8 t (rear),
- unloaded transhipment vehicle with a weight of 81.1 t and axle load distribution ratio of 47.3 t (front) to 33.8 t (rear).

The greatest design problem involved the specification of the design traffic load, which includes the following:

□ specification of the critical (dimensioning) profile of the traffic surface,

- □ specification of the number of passings of transshipment vehicles along this profile with further specification of the number of passings for individual loading versions (full x empty container, loaded by 24 t, 30.5 t and/or 45 t, empty transshipment vehicle),
- □ specification of the effects of passings in individual versions of transshipment vehicles loading,
- □ specification of transfer between the front and rear axle load.

The traffic surface specifications further included static loading by max. four stacked containers with a weight of 24 t, i.e. the total container weight was 96 t. For 4 contact areas, this means each of them loaded by 24 t, and for their dimensions of 0.203×0.178 m, the equivalent contact pressure acting on the pavement amounts to ca 6.5 MPa. It is clear that such load may be supported only by a pavement with a cement concrete cover.

The results of engineering geological survey showed that the pavement underbed is mostly formed by sandy loams and medium-settled sands with loamy substances, which locally pass into strongly clayey loams of solid to stiff consistency. A geotechnical engineer designed the underbed treatment ensuring the load-bearing capacity of the underbed corresponding to the obtained modulus of deformation Edef.2 min. 60 MPa.

The pavement construction designed for these design conditions has the composition as follows:

Cement concrete	CB I	350 mm	ČSN 73 6123-1
Aggregates strengthened by cement	KSC I	250 mm	ČSN 73 6124
Crushed stone mixture 0-63	ŠD	300 mm	ČSN 73 6126-1
Total		900 mm	

The transship point pavement cover is composed of square slabs of plain cement concrete with dimensions of $4.0 \times 4.0 \text{ m}$, transverse joints were reinforced by sliding dowels ca 0.25 m apart, longitudinal joints were treated by toothing.

Conclusion

Due to the input investor's requirement for placing containers straight onto the pavement (i.e. without using weight distribution plates) the static loading of the pavement by stacked containers also needed computational assessment of the CC slab in terms of resistance to pushing-through (to shear). This requirement was met by the CC slab with a thickness of. 350 mm for max. loading by four full containers 24.0 t in weight, i.e. the total weight of 96 t.

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Specificities of Dimensioning Floor Constructions of Aircraft Hangars

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Requirements for hangar floors

Aircraft hangars currently represent a facility serving for maintaining and repairing aircraft rather than for parking them. The plan dimensions of hangar halls vary according to the size of aircraft for which they were designed. The hanger floor area may, therefore, with a view to the aircraft size and their presumed number in the hangar at one moment, amount to considerably high dimensions (for large transport aircraft the hangar depth is up to 60 m). The previous makes it clear that investment costs spent on such floors are significant, and thus the characteristics of the designed floor construction must be carefully considered. Today's requirements for floor constructions (or rather hangar pavements) are summed up in the text below.

Depending on the type and way of loading, one of specific demands for the hangar floor is its high load-bearing capacity. The loads which may occur here may be classified as loads exerted by aircraft wheels (aircraft wheel undercarriage), aircraft loads transferred by jacks (during wheel undercarriage repairs), loads exerted by assembly tripods (during wheel undercarriage repairs), loads exerted by high-lift trucks or other machinery, loads due to storage racks (with different arrangements and numbers of legs).

Due to their high load-bearing capacity and resistance to permanent deformations, therefore, the most convenient solution for hangar floors seem (and most frequently are) constructions with cement concrete (CC) wearing courses.

Another specific requirement for the hangar floor construction currently becomes its thermal insulating ability. Energy savings, comfort and protection of the building require the use of reliable thermal insulation of floor constructions. The thermally insulating layer, however, may be installed over or under the cement concrete floor slab. In most cases, the designs put insulation under the floor slab as perimeter horizontal thermal insulation. Thermal insulation must permanently resist high loads exerted by operating loads (trucks, storage racks, high-lift trucks, machinery, aircraft), dynamic loads (take-off runs / braking) and mechanical loads during the construction phase of the building. The material most frequently used for thermal insulation in the last years is extruded polystyrene (such as ROOFMATETM, FLOORMATETM, IZOL).

As a result of its placement under the CC floor slab, important characteristics are, in particular, the strength and resistance of insulation plates, which participate in the transfer of loads. This type of material is frequently applied mainly because of its very good properties (high compressive strength, elasticity modulus of 20 - 25MPa, permanently high thermal insulation ability, simple composition with minimal thicknesses, simple handling and thus favourable cost-effective installation, minimum moisture absorption thanks to enclosed cell structure, resistance to freeze-thaw cycles, resistance to rotting).

Dimensioning of hangar floors

These atypical loads and atypical compositions of hangar floors (pavements) are not considered in the Catalogue of Pavements or standard calculation methods. A correct specification of maximum stresses in the floor construction due to these loads may, therefore, be considerably complicated. Although the sought tensile stresses in the CC slab may be calculated, classic calculations must apply numerous idealizations, such as conversions of any of the loads above onto a substitute circular loading area, calculations of the equivalent elasticity modulus for all base courses (subbase system) under the CC floor slab, an estimate of the mutual interaction of CC slabs, or an estimate of the interaction rate of the CC slab with the base course. In these classic calculations, the applied procedures mostly rely on outputs from computational programmes like Laymed, EQUIV and OPMEKO with a subsequent assessment of the floor (pavement) construction by means of the respective design instruction. The design of pavements of roads and other traffic areas in the Czech Republic is currently regulated by technical conditions of the Ministry of Transport of the Czech Republic, TP 170 "Design of Road Pavements". To assess (atypical) road pavement constructions with cement concrete wearing courses loaded by non-standard loads, however, the use of these technical conditions is rather problematic. For this reason, their assessment seems relatively convenient by using a modified designed methodology ON 73 6440 "Design of reconstructions of cement concrete airport runways and surfaces by their strengthening".

A potential offered solution to this problem is based on the finite-element method (abbreviated as MKP in Czech or FEM in English). Today's so-called large MKP programmes (ANSYS, ABAQUS and others) allow creating 3D models based solely on the graphic determination of the dimensions of the element (of a part) of the model, assignment of material properties, determination of mutual interactions of individual parts of the model and boundary conditions and by defining loads. A model designed in this way undergoes a subsequent analysis. Thus, in this way, we may specify (with a high level of precision and without simplifying assumptions) the necessary magnitudes of stresses and deformations for a correct specification of the behaviour of a pavement.

Conclusion

The dimensioning of atypically loaded constructions in combination with new structural materials, which is definitely the case of aircraft hangar surfaces, is a challenging and important problem whose solution may save considerable financial resources. Here, the instructions and design methods commonly applied in road practice cannot adequately fast react to the material development of the past years or cover by calculations all types and magnitudes of loads, which may occur during the service life of the floor or pavement construction. Therefore, it is more than convenient to invest in the finite-element method, model creation and its exploitation in these specific cases.

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Sustainable construction 4

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Solution of the research project "Sustainable construction" MSM 6840770005 in 2008 continued in fourth year. Interest connect with sustainable construction has increasing tendency even in enterpriser sphere – Matyáš (2008). Basic fact is respected that technical and economical solutions should be supplemented by environmental, sociological and architectonical ones that particular structure should be competitive. Presented review for the year 2008 is based on the publication "Sustainable construction 4" which has been published in publishing company CTU and which has a connection to the Workshop of this research project which was arranged in December 2008. However, only brief review can be presented here.

WP1 **Construction on brownfields** continued in defining basic principles, above all in connection with 5 main strategic documents of the Czech Republic, which have connection to brownfields:

- Strategy of sustainable development of the CR
- Strategy of economic growth of the CR
- Strategy of regional development of the CR
- Politics of regional development of the CR
- State policy of environment protection of the CR.

Mansfeldova (2008) defines connection of individual strategies including National strategy of brownfields regeneration in which research workers were involved. At the same time she gives overview of Operational programmes for years 2007-2013 which have some relation to brownfields.

Simultaneously continues solution of sectional problems as for example possibility of utilization of old building (in the frame of cultural and industrial heritage) with respect to capillarity movement out of foundation or with respect to utilization of old foundations for new buildings. In the area of old ecological burdens very difficult task is connected with remediation of subsoil after uranium excavation by leaching method – Vacek (2008). The experiences in the field of landfills were presented at the int. conference in Budapest in the form of Keynote Lecture – Vaniček (2008).

WP 2 **Sustainable construction of buildings** is getting wider acceptance not only between technicians but also generally between public, because this problem is strongly connected with energy savings and with improvement of the building interior. Measurements continue on experimental buildings, where instead of energy demand the possibility of energy and heat gains from solar radiation are observed. But the tendency is to observe overall demands, on one side a great attention is devoted to extra wall (window) insulation but in some cases the demands for energy for hot water is significantly higher (as e.g. for hotels). Significant attention is also devoted to the different exchanger – for air and water. A meaningful output is publication Low energetic houses 2 – Tywoniak et al (2008). Ongoing development is connected with radon detection and protection and with higher application of green vegetation as in small scale (green roofs) so in larger scale (green pedestrian zone).

Work package WP 3 is concentrated on **Utilization of waste and recycled material** in building industry. Highest attention is concentrated on the utilization of old bricks, concrete, ceramics. New structural material was developed – brick-fibre-concrete – where final properties can be modified with the help of synthetic fibres and change in density of the final product. The application is very wide, last year the concentration was on the application in dikes where numerical and laboratory modelling started to prove the positive impact on limit states of dikes failures – Vodička et al (2008). Additional step was performed in the field of the evaluation of application of flying ash in earth structures of railway engineering as well the laboratory investigation of ash reinforced with scattered synthetic fibres. Also important step forward was done for general support of waste utilization, especially from the economic point of view – Commodity market and building waste management - Gazda et al. (2008).

Significant progress was achieved also in the last WP 4 **Natural hazards (natural disaster or accident).** Very complex in this direction was fire test in real scale on structure with different structural materials and details. This fire test make possible to verify the behaviour of structures during increasing temperature, verification of models of temperature development during fire and also different monitoring of whole structure during fire (e.g. deformation with the help of geodetic methods) – Wald et al (2008), Štroner and Pospišil (2008). In the field of flood protection systems our experiences leads to invited lectures in abroad – Vaníček (2008,a,b). Methodology developed – Fošumpaur (2008) - for evaluation of projects connected with flood protection system is used by Ministry of agriculture. To limit risk of landslides new model was developed for unsaturated soils taking into account of heavy rainfall. In situ tests are in progress for landslides monitoring of spoil heaps. Our attention was also devoted to seismic risk.

Very sensitive is problem connected with potential risk, our investigation is taking into account not only economic aspect, but also aspect of responsibility – acceptance of the risk during design of structures, especially with respect to earth structures – Vaníček and Vaníček (2008).

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Measurement of Properties Utility

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The perception of property as a commodity is beginning to change. Market participants aware of the benefits and risks associated with the ownership and occupation of property. It means challenge for the development of methodological approaches and supporting decision tools. The identification of performance and sustainability indicators is not only academic task. A new combination of knowledge and experience is needed – property economic with technical experience, with knowledge about environmental and social issues.

The utility (performance) of property is a very broad concept and can mean very different things to different people. In a very general sense, utility of property may be defined as behaviour in use. More precisely, utility can be understood as a degree of compliance of user or owner requirements with building characteristics and attributes. This approach is useful for describing and assessing the fulfilment of functional requirements. On an international and European level, there are a lot of efforts to define criteria and indicators for property performance measurement, for example HOPE (Health Optimizing Protocol for Energy-efficient Buildings), PeBBu (Performance Based Building), CRISP (Construction and City-related sustainability Indicators). There are an unwieldy number of criteria and indicators that represent various ways of measurement of various aspects of building performance and sustainable development.

Property utility has to be viewed in a wider context including issues of process, design and technical quality. A building designed with strong emphasis on sustainability issues may not reach these targets because of bad operation and management. The description and assessment of a property economics, environmental and social utility can be based on these methodical basics:

- Life cycle costing (LCC),
- Life cycle assessment (LCA),
- Post-occupancy evaluation (POE).

Life cycle costing technique considers all relevant costs and revenues associated with the acquisition and ownership of a property. Well founded prognosis of life cycle costs are seen an indispensable for investment decisions. Very difficult is to estimate future maintenance and operation costs. LCC calculations consist of the following items:

- Initial capital cost for design and construction or acquisition,
- Management and operational costs,
- Maintenance and renovation costs,
- Building's disposal costs.
Life cycle assessment technique examines energy and mass flows in order to provide information on resource consumption and determine the origin of environmental loads, which have potential effects on global warming, acidification, ozone depletion, biodiversity, toxicity and living health.

The goal of Post-occupancy evaluation is to provide information on what kind of building solutions work best in practise and why. Assessments take the issue of occupant satisfaction, functional fit and productivity.

Possible utility indicators for property are following:

- Technical utility of building heat insulation class, sound insulation class, fire safety class, load carrying capacity, ease of maintenance, servicing,
- Functional utility of building functionality, serviceability, adaptability, suitability, accessibility,
- Economic utility LCC, income, value and worth,
- Environmental utility primary energy demand during use, use of fossil fuels, land use, impact on environment (CO2-equivalent, ozone depletion potential, SO2-equivalent), waste production during construction and use, impacts on soil and ground water,
- Social utility appearance of Sick Building Syndromes, appearance of black mould, occupant and user satisfaction, olfactory freshness, concentration of radon, disturbance through building and use and occupation, cultural value – monumental protection.

The simultaneous consideration of economic, environmental and social issues can provide a more complex knowledge about property characteristics and associated utility. It is important to have tools to show assessments results about property in various levels. The process of properties utility measurement is continual process during the all life cycle.

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Section 14

ARCHITECTURE, TOWN PLANNING, GEODESY, CARTOGRAPHY

Medieval rural church in Central Bohemia

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Romanesque Architecture in Central Bohemia

This doctoral project deals with the phenomenon of the architecture of buildings of rural Christian churches in Central Bohemia in the Romanesque epoch. In the Middle Ages, the church served not only for worship. Apart from religious purposes, it was also the center of social and cultural life, especially in rural areas. It is a living witness of ancient past, a history that differs so much from the picture provided to us by documentary sources. The prime focus of this project is on research of relationship between the architecture of Romanesque church in Bohemia and the adjacent settlements.

Architectonic form of a church is to be understood not only as a mere construction type of buildings of the historical period concerned; rather, it is a resultant of different formation forces. Among the most important influences that shaped the architecture of church buildings was long the church ownership. As of the end of the twelfth century, two distinct types of sacred buildings prevailed. The first group was composed of churches that were remodeled from existing sacred buildings of castle types. The second one comprised of new buildings falling under the church or the secular power. Starting with the thirteenth century, a gradual establishing of parish churches under the jurisdiction of the church took place. These buildings involved existing old sacred buildings which remained untransformed and subsequently stagnated, churches that were remodeled along with "modern architectural trends," mostly in developing regions, and entirely new buildings that slowly arose as a result of expanding of settlements. With respect to urban changes that took place in later periods it is possible to distinguish between churches that ceased to function and subsequently perished and churches that were completely rebuilt and the medieval origin of which can be documented by written sources or by archeological research only.

Other factors that were decisive for the architecture of church buildings to take shape and further develop included the natural conditions in the construction area, such as rainfall, average annual temperature, site altitude, and availability of construction materials. The location of the church and its distance from and connection to the then important towns or monasteries was of no less significance.

The reflection of changes of the religious cult in architecture throughout centuries is yet another interesting factor that has not been thus far sufficiently analyzed. Generally speaking, a pronounced emphasis on the predominant position of the church institutor was characteristic for early medieval churches that had a temporal institutor. Thus, so-called tribune churches emerged where the privileged followed the worship services from elevated tribunes that were inaccessible to the serfs. In contrast, church institutors from the Catholic Church initially preferred the construction of rotundas to other types of church buildings. With the establishment of parish churches, the expansion of their network and the process of transferring of church buildings from secular jurisdiction to the church, the architectonic form of church buildings in Central Bohemia transformed as well. Other changes in the architectonic form of churches were caused by changes of the religious cult; the priest, who previously stood en face to the altar and with his back to the followers, now stands behind the altar, facing the followers.

This project aims at providing an analysis of the step-by-step architectural changes of church buildings in Central Bohemia in Middle Ages. It is intended to demonstrate how the adjacent settlements contributed to the development (or to the lack thereof) of churches. The modern approaches in history and art do not often go far beyond the medieval architecture of buildings, thus neglecting causes and consequences of this development. This project seeks to make a contribution to the research of development and character of medieval settlements on the territory of today's Czech Republic.

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The Manueline Architecture in Portugal

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The Manueline architectonic style is part of Portuguese late gothic architecture. This unique Portuguese style was able to develop due to the special conditions which existed during the famous era of the Portuguese "Age of discovery", when Portuguese voyagers traveled the world. The possibility to take part in overseas expansions brought an exceptional chance to this small country. New territories were gained on three continents – Africa, Asia and South America. The colonization of new domains was connected with the economical growth of Portugal. There was a large potential for investment, which at least the king used for the construction of new buildings, imposing monasteries and churches.

The Portuguese late gothic style is named after King Manuel I, because it was chronologically connected with the time of his reign (1495 - 1521). Architectural monuments from this period mirror the extent of the Portuguese territory in Portugal and in its colonies. They also show the period when the Portuguese touched the top of their historical mission – economically, culturally and politically.

The Manueline style is characterized by late gothic forms with the influence of other styles – Flamajentes, Platarescos and Mudejares together with elements from the Arabic culture and impulses from the African, Asian and American areas.

Its high decorativeness of the windows, portals, arcades and columns symbolizes the King's power and his place in a historical context and also declares the strength of Portuguese Christianity. Another symbolic line shows the ancient conflict between good and evil. Manueline style contains some typical elements: the armillary sphere as a symbol of the cosmos and also a personal symbol of King Manuel, ropes, anchors and cables. "Sea" elements include shells and pearls, amongst the botanical elements are typical oak leaves, laurel branches, artichoke, poppy capsules and corncobs.

Between the most important Manueline architects belonged Diogo Boytac, Francisco de Arruda, Diogode Arruda, Mateus Fernandes and Joao de Castilho.

The main goal of this project was the development of knowledge about Manueline architecture and photographic documentation of the most important monuments of this style in Portugal, and the formulation of a theory about the influence of the late gothic style in Central Europe on the Manueline style. The subject of the project included local research and photographic documentation in Lisbon, Batalha, Sintra, Évora, Setúbal, Coimbra, Vila do Condé and Montemor-o-Velho. Moreover some important books were purchased, which are unavailable in the Czech Republic, for example: *Igreja de Santa Cruz de Coimbra – história, conservacao e restauro da fachada e arco triunfal, Mosteiro dos Jerónimos* a *Pacos medievais portugueses*, published by Instituto Portugues do Património Arquitectónico (IPAR).

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Web information system for a visualization and comparison of old city maps and views using map server and databases

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Old maps are important part of human heritage. They bring interesting information about history of cartography, landscape and human settlement in addition. Huge development can be seen all above in urban areas. Prague, the ancient capital of the Czech Kingdom was a subject of interest of many cartographers. Comparison of their works can show us changes which had influenced face of Prague. The project is focused on a creation of the web information system for a visualization and comparison of old city maps and views of Prague. The important part of the project is the research of significant Jüttner's plan of Prague, which is the main map layer of the map server.

The web information system about old city plans is based on popular open source UMN MapServer and its JavaScript interface. This application allows: publish georeferenced old map raster images, connect data published through the Web Map Services by other institutions, query of layers, etc. Georeferencing significantly improves possibilities of comparing a map with other one or with the present situation. As a base old map layer was chosen Jüttner's plan of Prague (see below). Data from geoportals of the Czech Environmental Information Agency and the Czech Office for Surveying, Mapping and Cadastre were joined through WMS. Semi-transparent layers of present orthophotomap and cadastral map offer very easy comparison of the historical and present situation on maps. For example dramatic urban changes behind the city borders can be seen. Jüttner's plan was probable pattern for the older Pinases' plan. This plan was researched and georeferenced earlier, but it was added to the application as well. Comparison of map drawing of both plans proves their dependence. There are many of old views of Prague. Several of them were added to the application. Their relation data are saved in a database. The new queryable layer displaying location and orientation of views was created and added to the mapserver. Views and information about them can be displayed. Present photo made from similar place as view allows see differences between historic and present appearance of Prague.

Jüttner's map is famous and revolutionary map of Prague. It is the first plan of the Czech capital based on trigonometric frame and geodetic survey. Plan of scale of 1 : 4,320 is a very detailed depiction of town from 1816. Thanks to the year of its creation the map depicts image of the town short time before the vehement expansion changed its face forever. The plan was chosen as main old map for web map application due to its importance and accuracy. Digitizing, processing, georeferencing and cartometric analysis of Jüttner's map was a part of this project. Two map sheets of black-white print of plan were scanned with resolution of 400 DPI and 24 bit colour depth. Both map sheets were merged together into the one raster image. Spatial localization is necessary for map publication. Method of georeferencing using network of identical points was chosen because map doesn't have any frame corner coordinates or exact geographical grid. Identical points were represented by well

recognizable corners of important buildings which have preserved up to the present days. Some Prague districts have been preserved without large changes. There was no problem to find out enough identical points. On the other hand there are some areas, especially behind the city walls, which have been totally changed. It was almost impossible to find there any point. About 80 points were taken and some problematic points were locked out. Final set of 69 identical points was used for a transformation into the S-JTSK. Affine transformation, the most suitable one for this purpose was used and its RMS error was 7.21 m. The map scale was determined by three various methods. First one, simple count from text scale description resulted to the map scale of 1: 4.320. Next method of a measuring of the graphic map scale resulted to the value of 1: 4,400. Last method based on measurement of 20 distances between well indicated points of topographical content of the map concluded to mean value of map scale of 1: 4,426. The Jüttner's map displays all important topographic objects of Prague city. All buildings are displayed and completed by house numbers. Differently oriented hatches of buildings were used for a distinction of city boroughs. Different hatches were used for various land types as well. Terrain was depicted using hachuring. Map drawing is ended very closely behind city borders. The Prague's fortification was displayed just schematicly. Most of the streets are entitled. Gates in fortification, main roads outside the city and all city districts are entitled as well. With no doubt Jüttner's map is exceptional work of Prague cartography.

Modern digital methods bring new possibilities of cartographic analyses and processing of old maps. Publishing of maps on the Internet makes them accessible to academics and to the general public. Moreover, georeferencing allows synoptic comparison of the map with the present situation. The project will be developed onward in the future. Works will be focused on improvement of information system functionality and on its enrichment by more old maps and views.

Works on this project are based on the successful cooperation with the Historical Institute of the Czech Academy of Sciences, which will continue.

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Industrial Heritage in the Ústí nad Labem Region -Maping and Revitalizing Heritage

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The books *Pražský industriál. Technické stavby a průmyslová architektura* (Czech editions, 2005, 2007), *Industrial Prague* (English edition, 2006), and *Industriál Libereckého kraje* (in Czech, 2007) summarized the results of systematic research mapping the industrial heritage of these localities, and that heritage is elaborated in detail in the on-line Industrial Heritage Register. In 2008 the Research Centre for Industrial Heritage (VCPD) at CTU in Prague began research on the Ústí nad Labem region.

This region is difficult to apprehend for various reasons, such as the rapid devastation of factories (including archives), the demise of entire communities as a result of opencast brown-coal mining, and the typological diversity of industrial structures, and a diversity of industry that derives from the historical specifics of all seven of the region's districts (Ústí nad Labem, Děčín, Teplice, Most, Chomutov, Louny, Litoměřice).

It is not the usual practice to organize a conference at the start of a research project. However, it is more than just the past of industrial heritage structures that requires our attention; we need also to be interested in their future use - revitalization - and that objective requires a multidimensional approach from the very outset. For the conference we selected several questions from a range of relevant of issues with a view to the location in which the conference was held - one of the two main factories in the city of Ústí nad Labem. These issues focused on the questions of what is to happen with industrial zones at the centre of the city when production ceases (urbanism of the city of Ústí nad Labem - past and future of the industrial zones), why do industrial brownfields deserve revitalization (problems of brownfields in the Ústí nad Labem region), what kind of geotechnical problems does revitalization involve (strategies for assessment, cleanup and redevelopment) and how can industrial heritage be incorporated within the network of pre-industrial monuments or the oremining project in Montanregion Erzgebirge / Krušnohoří? This project running in cooperation with TU Bergakademie Freiberg will continue with the participation of Research Centre for Industrial Heritage within The International Committee for Conservation of Industrial Heritage congress of in September 2009.

The search for answers continued at the conference in a debate over themes from the past and the present (changes in the ownership of industrial heritage and the consequences of these changes, the 'museuming' of industrial heritage, the issue of memory, the story of the industrial armour company Severočeská armaturka, the role of urbanism and heritage conservation as disciplines and institutions, etc.). The conference signified – we hope – the start of a discussion of the values of this heritage and a challenge for cooperation with everyone dealing with industrial heritage, especially experts and professionals tied to this region. The examples from abroad were also mentioned, the *Working Heritage* international exhibition and the greatest landscape building site, lake land in Lusatia, developed at the former brown-coal mining area.

The conference was held on 19 June 2008 on the premises of the company Setuza in Ústí nad Labem. The conference proceedings also include an itinerary of an excursion that was organized to the grounds of Spolchemie and Setuza on the day of the conference, and of a

bus trip the following day to visit other types of industrial structures: the silo in Lovosice (warehouse type), the Masaryk lock (waterworks type), the Moldavská Railroad (transportation), textile plants in Bystřany and Šumná (textile industry), the Pokrušnohorské Mining Museum / Julius III Mine (underground mining), and a number of opencast mining structures, a typical industry in this region, using mining machines and massive earth removal machinery.

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Innovation of Study Subject Cartographic Printing and Reprography

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The study subject Cartographic printing and reprography is included in educational program Geodesy and Cartography at Faculty of Civil Engineering, the Czech Technical University in Prague. Main content of the subject composes procedures used at processing printing basis, proof-sheet and map printing including reproduction of text and graphic documents. This subject is attended by about one hundred students every year.

Past ten years, area of cartographic printing and reprography was affected by a great progress in using digital methods that were enabled by development of new hardware and software equipment [1]. The project "Innovation of Study Subject Cartographic Printing and Reprography" has been focused on the implementation of these changes into education.

The main goals of subject innovation were summarized into these points:

1. To update the content of the subject by including new lecture topics and by creation of new practical tasks.

2. To make the study more accessible by creating the educational course available via internet for students and entire community in order to support interest in this subject and branch of study.

3. To establish tighter cooperation in field of experience and to use acquired knowledge to update the subject of education.

Lecture topics were updated and extended namely in these areas:

1. Theory of color – lights, color systems, additive and subtractive color mixing, color gamut, ICC profiles.

2. Digital reprography – digitalization of graphical and text-edited copies, scanners and digital cameras, OCR programs, digital archives, data formats.

3. Map publishing on the internet – marked languages, static, dynamic and interactive maps, software solutions on client and server side, web map servers.

4. Presentation of technical work – computer typography, Desktop Publishing (DTP), support of elaboration of semester works, printed publications, web pages, oral presentations, practical examples.

5. Copyright – copyright protection for reprographic products, publisher contracts.

The main changes were made in the content of practical tasks of the innovated subject. Into the education were included three new tasks:

1. Text reproduction – applying principles of computer typography and digital reprography; technical text (script from mathematical cartography) was scanned; the task is to

convert two pages by OCR software into edited format and to make desired typography correction by Latex system.

2. Creation of an information brochure – application of DTP; the task is to create information brochure on topic according to one's own selection (formal requirements on contents and format are determined) using Scribus software.

3. Map publishing on the web - application of electronic publication of digital maps; set of maps were taken by camera; the task is to handle geometric and color adjustment and to place the results on the web as static picture, interactive map and data for web map service.

Created web pages are an integral part of the project results and will support education. They are conceived as educational course that offers more convenience for students. The pages are available for all interested people without any time restriction. The course extends presentation of our education to public.

We use Moodle system for e-learning course creation. This system is developed under the terms of noncommercial license. It is free and provides us with all functions needed. We service the installations and maintenance of this educational system for department of Mapping and cartography. We already cannot imagine education without Moodle system [2-4]. Web page http://geo2.fsv.cvut.cz/kurzy/ contains our current installation of Moodle. Anonymous access into courses is enabled also for guest user (without password).

Financial resources of the project allow us to innovate our technical equipment that is used by students in frame of subject education "Cartographic printing and reprography". Thanks to enhanced theoretical knowledge extracted from purchased books and thanks to additional skills gained in practice were updated lecture topics and tasks. Overall, mentioned subject is now modernized and more attractive.

In our opinion are students getting more actual view of situation in area of pre-press and map print and they are better prepared for practice.

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Müller's Map of Bohemia and its Detailed Analysis

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Müller's map of Bohemia is one of the most important maps in Czech history. It is not just beautifully and well made, but it shows many characteristics of historical landscape in surprising detail. This map was created and finished in 1720 by Johann Christopher Müller and is the last piece of "one-man cartography era" in Czech lands. J. Ch. Müller was outstanding cartographer. During his works, he used instruments which he named "instrumenta matematica". Distances were measured by viatorium (measuring wheel) behind a chariot, directions by compass, and astronomical measuring was made by a big astronomical quadrant. His greatest work Map of Bohemia was finished in 1720, but originally printed in 1723, after author's death in 1721.

Müller's map of Bohemia is printed on 25 sections in the scale approx. 1 : 132,000. The size of one map section is 473 x 557 mm and the entire map size is 2,403 x 2,822 mm. Map content can be interpreted by very wide legend. Towns and villages are represented by many point symbols characterizing additional information about settlements (e.g. churches, monasteries, mines, spas). With line symbols there are depicted rivers and streams, administrative boundaries and some roads. The scales of geographical grid are displayed on the map frame. The map has two graphic scale bars (Czech miles and hours of march). The whole map is decorated with allegorical scenes in the corners.

In [1] authors made basic cartometric analysis of this map. All 25 map sections were scanned and digitally merged together. Due to map material distortion, every map section was transformed into its original size 473 x 557 mm. Resulting image displays the whole map without gaps between sections. The size of the image is 2194 MB. The aim of cartometric analysis was to get more precise values of the map scale. There were used several methods (measuring scale bars, measuring geographical grid, getting the scale from transformation of identical points). The updated scale has value approx. 1: 134,000. The most precise method of scale determination is undoubtedly getting the value from transformation of identical points. Unfortunately, authors in [1] used only a few identical points. Different types of transformation were not used also.

The research on Müller's map of Bohemia is now funded by Czech Science Foundation for following three years. Now it is enough time to make more precise analyses of this map. The aim of this research project is to make cartometric analysis, to create vector database model of the map and to make these data more accessible for public.

In the first phase of the project, all 25 scanned sections were transformed into real paper coordinates in ArcGIS software (size 473 x 557 mm). For later thorough analysis it is necessary to create vector model of the map. ArcGIS geodatabase was designed to store this data. After cleaning and revising all 25 databases, they were merged into complete vector geodatabase of Müller's map of Bohemia. Once we have this data, we are able to test many types of transformation with different structure of identical points. After this we will be able 446

to choose the best method for georeferencing the map into some well defined coordinate system (e.g. national S-JTSK). The scale of the map will be computed more precisely. The other method of map scale determining is described in [2, 3]. On the map can be displayed isolines of the map scale using MapAnalyst software.

From the vector database we can derive very interesting data. We can count numbers of churches, monasteries, spas, mines. We can find disbanded villages; we can compare lines of rivers flowing with contemporary state. Many landscape analyses will be very easily accessible. After georeferencing the data into well defined coordinate system, we will be able to compare the state of 300-years old landscape with current situation. Very easily can be analyzed the relation between Müller's mapping and later First military mapping of Austria-Hungary discussed in [4].

The aim of the project is also to make the data of Müller's map of Bohemia more accessible. Merged image of the whole map will be available in the web application based on Zoomify software. This application is running already for image created as the result of [1]. As the data will be georeferenced, they can be also distributed in real coordinates. The raster image will be served as WMS service; the vector database will be served as WFS service. Using these web map services the data will be very easily accessible from any GIS software keeping the standard of Open Geospatial Consortium for web map services.

The project of detailed analysis of Müller's map of Bohemia is standing at the beginning. After creating the geodatabase and deriving analyses outputs, detailed workflow process will be described for possible other old maps analyzing. Old maps are full of interesting information about the environment and this project can show how to get them.

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Section 15

TRANSPORTATION, LOGISTICS, ECONOMY, MANAGEMENT

The Effects of Foreign Direct Investment Spillovers and Property Rights Protection

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Foreign direct investment is a carrier of technology transfer. The intensity of spillovers is interpreted as an indicator of the strenght of intellectual property rights protection. We highlight two effets of foreign direct investment spillovers. The presence of spillovers reduces the unit costs asymmetry between firms. Foreign direct investment spillovers might stimulate the growth of the sector output and create income that becomes a source of the market demand. In this context we tallk about the wealth effect of foreign direct investment. In this respect, when the wealth effect of foreign direct investment spillovers is sufficiently strong, the congruence of interests between firms is a possible state of affairs.

There is widespread recognition that foreign direct investment entails significant long – term welfare gains for the host cauntry. The potential gains from foreign direct investment také diverce forms. Foreign subsidiaries may serve as an effective competetive force, which reduces the (excess) profits of domestic competitors and improves their allocative efficiency. The competitive pressure exerted by the foreign affiliates may force local firms to speed up their innovative activity and increase technical efficiency. Foreign direct investment generates technological and affect productivity of local firms.

There may exist backward and forward linkages between foreign affilates and local firms that occur when foreign firms provide technical assistance or train the workers of their local suppliers and customers, thus resulting in inter-industry spillowers.

The beneficial effects of foreign effects direct investment on the economy of the host country have been empirically established not only on the micro level, but also on the macro level. Foreign direct investment is found to positively affect economic growth in developing countries, contributing to growth in larger measure than domestic investment. The beneficial effects of foreign direct investment on economic growth come through higher efficiency, productivity and higher capital accumulation. Thus, foreign direct investment plays a central role in the process of economic development, promotes economic growth of the host cuontry, and, consequently, stimulates the creation of new wealth in the society.

The scope for productivity spillowers from foreign subsidiaries to local firms depends on technological factors (promotion or suppression of spillovers by investors the ability of potential recipient local firms to absorb and effectively deploy spillable knowleedge, etc.), but it also has the intellectual property, rights constraint. Thus, even when it is relatively easy to obtain relevant information about new products and process (that is, when the technological constraint is not binding), it still remains a question whether these pieces of information can be legally exploited by recipients.

The institucion and enforcement of property rights has been an important policy isue for developing countries, transition economies, and developed countries in the 1990s.

Extension of intellectual property rights has been argued in terms of preventing piracy, broadening the rewards for inventive activity, and providing a good international business climate in general developing countries in turn resist such pressure, seeing extension of intellectual property rights as a channel through which firms possessing domestic 450

monopoly power in the use of a particular idea might extend monopoly power overseas and transfer rents to the high – income developed countries.

Foreign direct investment spillovers are defined as the leakage of technological information which can be used by the recipient at zero or small marginal costs. While the technological factor of foreign direct investment spillovers (the scope of information leakage and the ability of the recipient unit to absorb spillable knowledge) is treated as given, the intellectual property rights factor is treated as a policy instrument of some gowernment. Thus, the intensity of spillovers is determined by the strenght of intellectual property rights protection.

The presence of spillovers has a generally negative effect on the spilling firm profit, since increase the productivity of its competitors. However, the negative effect of spillovers on the spilling firm profit might be reversed if foreign direct investment stimulates the growth of sector output and creates income that becomes a source of the market demand. In this context we use term: the wealth effect of foreign direct investment. Thus, the wealth effect is a channel through which foreign direct investment generates demand spillovers that benefit profits of both the spilling and spilled-upon firms. Taking this feature into account, the wealfare and profit impacts of intellectual property rights protection are reconsidered.

The major insights providet by this foreign directs investment spillover approach can be summarized as follows:

- 1. We highlight two effects of foreign direct spillovers. The presence of spillovers reduces the unit cost asymmetry between firms, but also has the wealth effect, which is reflected in the size of the market. There is no (to the best of our knowledge) related theoretical analysis which considers and models this feature of foreign direct investment.
- Using this approach we show generall benefits in social welfare terms through the lac of intellectual property rights protection, while the standard result that some countries are always worse off in terms of profitability does not necessarily carry over in our framework.
- 3. The speed of imitation is shown to be an imortant factor influencing the nature of countries market interaction, whith significant impact on social welfare and profit of firms.
- 4. Finally, when the wealth effect OF foreign direct investment is sufficiently strong, the congruence interests between countries with respects to intellectual property rights protection is a possible state of affairs and both sides then prefer relaxing intellectual property rights protection. However, if the speed of imitation is low and the unit cost asymmetry between firms leads to monopolization of the market until the firms deploy spillable technological information, the kongruence OF interests in regard to intellectual property rights protection is never achived

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Approaches leading to correction of the negative transport externalities

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The main drives of permanently and increasingly growing mobility are modern, global connected markets as well as growing population and welfare. The various means of transport have been developed to fulfill the requirements for mobility. Mainly road, rail, marine and air transport can be used everywhere according to the personal preferences.

Sharp growth of transport performance results in higher infrastructural costs, lower noisiness and lower number of accidents. Based on this development public can hear more often that there is the need to evaluate all these costs – all cost submission and compensation caused by the transport. The costs are not compensated by the producer, they are transferred to the public – we are speaking about externalities. All the producers in the economy market tend to transfer losses to the whole society but the profits to their own bank accounts, we can say they socialize costs and privatize their profits. This holds truth for the positive externalities as education as well as negative externalities where air pollution, global, regional or local ecological problems, greenhouse effect, ozonosphere destroying, temperature increase and so on can be found.

As externality we understand the part of social costs, that are not paid by the producers and that are transferred to the other subjects. The third subjects (inhabitants) or the whole society have to bear these typical social costs as the traffic noise, air pollution and time losses, but they are not fully or partially compensated by the traffic participants.

The transport externalities in the Czech Republic are about 3,25 % GDP i.e. 88,1 billion CZK. Individual car transport causes significantly higher externalities compared to the public transport in relation with the car accidents, traffic noise, greenhouse gas pollution and other impacts on global ecology.

Negative externalities can be solved by two approaches. First one comes from the application of Pigou tax the second approach is based on Coase theorem.

According to the Pigou approach can be the negative externalities suppressed by tax that increases the private costs to the level social costs. According to Coase approach is the reason for the existence of externalities imperfectly defined ownership rights. Validity condition of Coase theorem is the fact that negotiation costs are very low or equal to zero. It is question that this condition can be fulfilled in real situations.

We can shortly say that Pigou requires the government intervention in form of regulation, the Coase prefers private agreements were can market subjects with the similar intention join together that leads to the "Cluster" formation. The private agreements can significantly help in decreasing of negative externality effects mainly in cases where there are not many agreement participants which can be simply identified. Pigou tax is not universal tool for externalities solutions. The government can use other tools:

- Prohibitions/sanctions the externality limitation
- Limit permissions this tool uses the market principle
- Government regulation e.g. car with the catalytic converter equipment obligation
- One time financial support/subsidy motivation instrument
- Own government activity very often used in case of positive externalities

The government enters to the market mechanisms because of these main reasons:

- Public goods existence
- Transaction costs existence
- Imperfectly defined ownership rights

Another way how to minimize the externalities without the government intervention is their internalization. Externality internalization is also supported by the fact that prerequisites for Pigou tax (the knowledge how high external costs are and the reasons of their establishment) are not in reality often fulfilled. The agreement negotiations are not also always successful. How it is described above, the negative externalities can be found in cases where the ownership rights are not settled or where the sources are limited. Everybody can use them without necessity to pay for them. Extreme source exhausting as a result of that can lead finally to their devastation.

The thought of internalization is based on the fact that the environment quality or the amount of transport will be given by the government policy. Internalization of external costs will have the effect that the traffic participants will change their behavior based on traffic limitations and environment protection. Internalization should lead to the social optimum in which the drivers will use charged infrastructure only in cases when the utility from the transport will be higher than the costs. Then we can speak about the allocation optimum.

The general rule is that the market amount of goods that are the reasons for negative externalities is higher than social optimum for amount of goods. That means in case of road transport that the amount transport performance is high about social optimum. The whole social ineffectiveness results in welfare loss and the limited sources are decreasing.

Finally we can say that the charging of selected traffic infrastructure segments is the social need for the future more effective sources allocation and to the future decrease of external costs through their internalization towards the subjects that are the producers of these external costs.

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The Influence of the Batch Size Dimension on the Work in Process and the Fluent Material Flow in Internal Logistics

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Logistics is seen as a process capable to increase organization efficiency through operational costs reduction and also improve the goods movements within all supply chain. The area of transport, storage and manipulation occupies up to 25% of workers, needs 55% of total company's space and 87% of time which product spend in the plant. All those activities can create 15-70% of total product costs and it can significantly influence the quality of the product. Therefore the effective and well-working internal material flow is very important and indivisible part of the supply chain. The batch size dimension, Work in Process, Lead Time and the usage of the capacity are the main factors of the internal logistics, which need to be respected.

The material flow has to be organized in such a way, that the fluent run of the production of the component or the group of components is ensured. On of the important factors mentioned is the batch size - it is the major characteristics of the repeatable production processes, which has an influence on the basic technical-economic indicators. For gaining the highest rhythmicity in the production process it is necessary to set the optimal batch size dimension (for that particular case) not only for the movement of the final products but also for the movement of the semi finished parts. The costs for ordering the material and setup costs are decreasing with increasing batch size; on the contrary the holding costs are increasing in this case – therefore it is necessary to find a compromise.

The main characteristics of bigger and smaller batch sizes follow:

Bigger batch sizes:

Positive – lower number of setups, better usage of the capacities, easier control and direction, quantity discounts when buying the material.

Negative – higher Work in Process (WIP), waiting of the product for the processing, long lead times, slow reaction, postponing of the moment of detecting the problem.

Smaller batch sizes:

Positive – more flexible reaction to the customer's demands, flow speedup of the sales incomes, lower WIP and holding costs, shortening of the time needed for finding the problem in the process.

Negative (new problems) - it is necessary to ensure shorten setup times, manage higher requirements for the coordination, solve the numerous interoperation manipulations, there are small reserves for eliminating the unperfect product.

The superfluously big batch sizes are almost not used anymore, on the contrary extremely small batch sizes is also not possible to implement everywhere. In the company working within the automobile industry, where the production is very complicated, it is impossible to implement One Piece Flow (to use as a batch size 1 product). To change the production line from product A to B takes around 30 min, therefore is it not convenient to change it after few products produced.

The kanban system works in this production area very well. Firstly, Value Stream Mapping and Value Stream Design have to be done in order to understand to the material flow. Than follow the kanban calculations and calculations of number of pieces for one kanban card. By these calculations the optimal WIP is controlled.

WIP is determined by the batch size dimension; however another important factor is the suitable organization of the processes. It is necessary to respect the bottleneck in the process and adjust the volume produced exactly to this problem. Too high WIP binds too much of finances, which can be used more efficiently in another place. However, it is not the problem only of finances bound; important is also the space occupied by the big amount of products and damaged material on the grounds of too long storage in the production area. Than the decision about the batch size becomes crucial.

The requirement of the smooth material flow, which brings us to the shorter lead time, is possible to fulfil owing to the synchronization of the processes. In complicated production as usually is in the automobile industry the solutions is: smaller batch sizes together with setup time reduction, keeping the capacity reserves and mainly working with the bottlenecks. Any savings of time or finances in the process, which is not bottleneck, cannot bring the higher productivity or efficiency as far as neither more products are produced nor process is faster – this all is determined by the bottleneck. All mentioned principles are in accord with the project "5 DAY CAR", which is a big challenge for the automotive companies and all their suppliers.

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Automatic Car Parking System

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Abstract

This papers describes the application of intelligent transportation systems, which solves the problem about parking in cities. In Asia, American and Europe has some encountered problems with city streets that are historic cities where there are narrow streets and congestion problem due to the parking of cars. The static traffic work hasn't enough space for parking. Nowadays, some cities in the world selected modern solution for parking to solve these problems and has installed an automated, underground parking system or parking in steel structure... Automatic parking system support for car parking system in area.

To find safety and comfortable parks which is the pressing and necessary requirements of cities? The flow of vehicles in the road never has stopped and which is creasing with speeds very fast. Previously times, traditional park was builded but nowadays it's not fit for investors because the prices of land were creased.

In the 20 Th century, to build car parking garage with some floors is method to solve this problem but it has some limits. The solving requites space to reserve for elevators, uphill grapes and escape hatch. The space for use is limited and sometime that is place very dangerously for drivers. Some people flinch to car parking garage with some floors because where is the location of robberies...

Nowadays, the solve to build automatic car parking satisfies requirements of drivers (safety and comfortable) and investors (economy and takes effect). The driver doesn't must to do anything because robots replace roles of human and they carry cars to location in garage exactly and very fast. This model is called: "store of car" because the technology applies for garage is store productions system in factory.

Automated car parking is a method of automatically parking and retrieving cars typically using a computerised system of pallets, lifts and carriers. The drivers park their car at an entrance point then leave the vehicle. From there, the car is automatically moved through the parking system. It's returned to the driver in the same fashion using a signalling device or for a public car park a ticket and payment system in a designated waiting zone. The interpark automated car parking system has all the advantages of any other automated parking system; reduced use of space, increased security, less environmental impact and cost effective installation and operation.

We have some kind of model automatic car parking system. Depend on conditionals of place in cities, we can choose the solve and principles to assembly and

to build automatic car parking. We can classify three main groups automatic car parking system:

- underground automatic car parking system
- Automatic car parking system in building
- Parking uses steeling structure.

There are over hundreds of million cars on the road worldwide, and this number is increasing at a rate of more than 5% annually. As the number of drivers grows, so does the demand for convenient and safe parking. Car parking is the bane of any property developer's life. The requirement that new car-parking spaces must be provided on a fixed ratio basis for every development or redevelopment in these islands has halted many a deal. Even a simple 4 or 6 unit apartment development must also provide parking for up to 12 cars. Add a few retail units and perhaps a doctor's surgery to that development and the car-parking issue becomes untenable. Even with the possibility of basement parking, the cost rises exponentially, and the problems, including geological, archaeological and hydro-logical, are myriad.

Automatic car parking systems are particularly suited for use in commercial and private parking lots, car dealerships, hospitals, universities, government buildings and especially in apartment buildings. They are economical to install and operate. They are safe, dependable and robust, conforming to strict EU and US safety codes. Euro Automatic Car Parking Systems will help you to park more vehicles in your car park space while maximizing your parking profits. Many users have effectively doubled or even tripled their parking capacity without using any additional property.

Dependable, low maintenance, free standing units fit easily into your existing space and usually require little or no special foundation preparations or additional services. They cost a fraction of traditional concrete car-parks to build and install and once erected, need little maintenance to function perfectly for decades. They are user-friendly, are built to last and have excellent safety and reliability records.

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Key factors for Model of Enterprise specification

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Introduction

A model enterprise specification based on the critical factors is essential for choosing suitable managerial tools which will possibly be further integrated.

The critical key factors have to be perceived as a complex – it is not possible to be focusing only on quantification of one particular key factor without considering its connection with other key factors.

Critical factors

The following key factors are crucial for a model enterprise specification in terms of managerial tools determination.

Sphere of activity and type of enterprise in terms of production and business orientation

These are important factors for economic and sales matters (currency, transport costs, traditions, etc.). The type of enterprise stands for the fact whether the enterprise develops its own products that are consequently sold, whether a cooperative enterprise is considered, etc. This fact naturally influences the whole enterprise organization structure.

Number of employees

This key factor is crucial for determination of economic and production indicators. It is necessary to determine the number of overhead employees who do not create the value in the production process itself, thus so-called overhead workers belong there, too.

Turnover, proportion of export and added value in the turnover

Accounting turnover – representing financial value created and received by the enterprise in a particular period including semi-finished products and finished stock room - is considered. The proportion of export in the turnover is crucial for the company characterization in terms of regional influence, exchange rate risks, etc. The proportion of added value enables the idea of productivity of labour and is crucial for enterprise specification in terms of business or production orientation.

Property characteristics

This factor is related to property structure transparency particularly in connection with the extent of decision-making and investment competence of the enterprise executive management.

Customer segments

This factor represents the fact to what degree the enterprise is dependent on individual industries (automotive, heating, power industry etc.). This influences the degree of dependence upon seasonal and also global variations in demand.

Production technology specification

The factor stands for the complexity of production demands in terms of technology dependence on exterior suppliers as well as for the proportion of competitive advantage in case of the enterprise high quality production equipment for possible products with high quality and technology needs (=high added value).

Input materials

This factor gives answer to the following question: "What materials enter the production process, what is the availability, durability, etc. of these materials, including delivery dates?" All this significantly influences flexibility, needs of supplies and planning in the enterprise, which means that particularly overhead costs are influenced.

Enquiry processing system

The following process is considered:

Sales department: Receipt of enquiry by email/fax, reply to a customer within 24 hours – information concerning the date and terms of the offer, filing in the sales department information system.

Technical preparation of production: price calculation

Sales department: price offer, successfulness evaluation (proportion of obtained orders to the overall number of offers).

It is necessary to specify possible differences in the system.

Standard order processing

The following process is considered:

Sales department: Receipt of an order (fax, email, internet customer planned demand), filing into the system (appropriateness control – price, date, etc.)

Technical preparation of production department: Making the order available for production, technology procedure

Production department/Production planning: Starting of production, progressive processing (productivity and quality monitoring)

Warehouse/Sales department: Dispatch (EXW(DDU)

Sales department: Invoicing

It is necessary to specify possible differences in the system.

Quality system

The certification type of an enterprise represents not only the (supposed) standard of quality but it also represents the process control degree. The quality system influences all the processes in the enterprise – labour productivity is highly increased by the right use of the system.

Type of planning

The factor covers the description of operational and strategic planning. It is necessary to specify which areas do particular planning types refer to and with what time outlook the plans are created. The factor also covers the description of so called feedback, which means continuous evaluation with relevant possible interventions.

Costing

Calculation of costs per a production unit or a performance volume, most frequently depending upon a time unit, stands for costing. Sales and in-house output price in the structure of individual price constituents of a calculation unit is the basic subject of costing. The factor defines the way costing is calculated for particular sections, departments, etc. – it means the price of work per person, time unit, product etc.

Work productivity monitoring (= wage bonus component)

Labour productivity signifies work efficiency in creation of utility value. Labour productivity monitoring represents a necessary tool for its increase (e.g. learning curve application). The factor should describe how the labour productivity and the follow-up wage motivation is measured in particular sections and departments.

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Method MDA Used for The Evaluation of The Suitability of Individual Crash Barrier Types

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Viewpoints about the suitability of use of individual types of crash barriers are often different. The complex of problems therefore required a mapping out of the issues while also adding in viewpoints accessible from the media.

In the circumstances of design preparation and subsequent implementation of orders for highways and expressways of the first class the purchasing agent the Road and Motorway Directorate of the CR mostly prefers the use of steel crash barriers, and only rarely cable crash barriers. The decision regarding choice of crash barrier type on any respective section however belongs to the designer. He is responsible for a project. A building contractor is only responsible for making a construction. The investor – the Road and Motorway Directorate of the CR is among other roles obliged to check that quality is in harmony with regulations.

It is obvious that with any choice of a particular crash barrier type on a respective section it is necessary to make an individual judgment. The right decision for use of a crash barrier type must be preceded by a decision process, the formulation of initial principles, setting down principles which will serve to determine the benefits for any crash barrier type so judged. An initial basis is the setting of assessment criteria along a wide spectrum of viewpoints and proceeding with their analysis. Different views will emerge- that of the building owner, that of the operator, that of the general public, that of the users. The latter the users will also differ in their individual viewpoints.

These wide enumeration of viewpoints were portioned out into blocks and into any subsequent judgement there were included additional standpoints: living cycle costs , winter maintenance, width of a communication, universality of use, impact on living environment, recycling, aesthetic influence, security, material damage, psychological aspects, visibility, longevity, the challenges of assembly, vandalism, contractor's reinsurance, experience from abroad, restraint. The criteria had the aim of an objective viewpoint judged and evaluated by a number of respondents (during the course of the conducted inquiry) – experts working within the framework of the Czech Technical University in Prague. The data thus gained were subsequently evaluated by a multi-dimensional analysis (MDA).

MDA carries out a choice of project solutions on the basis of a collection of criteria, which can be divided into hierarchic levels. Their creation is specific for each individual technical project. They are differentiated by significance (relative weight). The programme product MDA enables a finalisation of options. The evaluation itself is carried out on the basis of an evaluation enabling the introduction of technical or economic risks and developing trends. The resulting solution i.e. an evaluation of individual variants is also provided with a statement on the assumed spread (variability) and the assumed developing tendencies. The rather demanding information given is not included in a majority of the common decision methods.

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The use of steel crash barriers is routine. In the Czech Republic they are used to almost 100%. A partly damaged steel crash barrier continues to discharge its function. Steel crash barriers point the direction more visibly. The condition of steel crash barriers may be monitored visually. Steel crash barriers are used among other things around bridge piers to avoid hard impact.

Cable crash barriers were initiated for use by the Road and Motorway Directorate of the CR. Application was accompanied by the need for approval. Cable crash barriers have not been tested and used world-wide. The use of cable crash barriers was banned in Norway in 2006. A cable crash barrier with a fallen wire rope or also at a loosened tension does not perform its restraint function until the time of its repair and return to normal tension. It allows the passage of snow more. As an important standpoint there has also been considered the monopoly position of a cable crash barriers producer.

In general it is necessary to re-evaluate the use of places for installing crash barriers and possibly place them elsewhere e.g. also next to toll gates.

A mid-lane with an asphalt surface for a provisional override in an opposite direction will release more easily with a steel crash barrier than with a cable crash barrier, where a long section is put out of traffic.

From the opinions of professional respondents (from a number of work centres – Department of Road Structures, Department of Mechanics, Department of Steel and Timber Structures, Department of Concrete and Masonry Structures, Department of Landscape Engineering, Department of Social Sciences, Department of Construction Technology, Department of Economics and Management in Civil Engineering, etc.) there emerged a recommended order of applicability: as the most appropriate solution, from the viewpoint of the benefit and risk of crash barriers at highway constructions, is the variant using steel crash barriers. Gaining the opinions of respondents and those derived from their specialist standpoint may be appraised as very valuable.

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Development of the Primary Road System in Prague

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The modern history of the Prague's new primary (freeway) road system dates back into the 60' of the 20th cent. That time new housing estates have been developed at the edge of the existing city and the number of privately owned personal cars increased. The average length of transportation got longer and the requirements on comfort, speed, reliability, safety, environmentally qualities gained in importance.

This situation and tendencies were reflected in activities on system wide proposal of the development of the Prague Integrated Transportation System, which included the City Public Transportation System (subway and tram system), road transportation and redevelopment of the Prague railway junction.

First ideas of a new road system in Prague dealt with freeways in a chessboard pattern including three North – South freeways and two East – West freeways. The system was completed by a outer ring freeway situated on the edge of the city. In 1967 construction of the first North – South freeway started together with the development of the first subway line (Metro C line) and modernization of the Prague Main Railway Station.

In following years the basic concept of the city freeway system has been changed. The reasons were firstly to obtain higher capacity of the system, together with the accent on the environmental qualities and impact of traffic on the city and its inhabitants, protection of nature and protection of historic values of the city. The chessboard pattern of the freeways was changed into a Ring-Radial system.

The complex transport development and prognosis is based on the valid City Development Plan of Prague[1-4], including the chapter Transportation with coordination of all transportation aspects with the city's overall development. and with developments in areas around the city and in the country.

The newly developed ring – radial pattern of the city freeways creates a network whose total length will be about 180 km. The pattern is formed by 2 rings and 7 radials. The network of freeway roads guarantees not only sufficient capacity and smooth traffic flow, but also good traffic safety and minimum negative influence on the population. The main idea of the new freeway system is to concentrate as much as possible the traffic flows on this corridors and reduce the traffic volumes in the city centre and in residential and protected city areas.

The City Ring is the main strategic communication for the city's traffic. The City Ring is approx. 35 km in length and half of its length is in use –i.e. the southern and western part. The City Ring is situated on the edge of the densely built up central city area and serves mainly for personal and delivery cars. On the existing western section there are two tunnels (2000 and 1800 m long). The first part of the northern section, which is under construction, will be situated in tunnels of total length more then 6000 m.

The outer freeway ring, s. c. Prague Ring is a part of the state freeway system and is an investment of the state. In use is its western section and a part of the eastern section. Today's length of the Prague Ring in use is almost 20 km. Under construction is over 12 km 462

of the southern part, including two tunnels and a long bridge/flyover crossing two rivers. Prague Ring with its total proposed length of 80 km approx. serves mainly for heavy trucks, cargo, regional and through traffic.

The seven Radial freeways are continuation of the rural freeways and speedways on the territory of the city and create a connecting link between the Prague Ring and the City Ring. Four of the radials are completed and in use. The total length of all radials, when completed, will be approx. 65 km.

Development of the primary road transportation system in Prague requites both a longterm urban planning and transportation concept and massive financial investment. Additional special aspect for Prague Transport: appearance, infrastructure, legislative, financial frame, local economy, construction technologies, organization and good field of decision making, planning, Public-Private-Partnerships (structure of owners), historic protection, ecology, protection of nature and last but not least public participation.

Rural freeways in the Czech Republic - freeways connect the most important political, economic, industrial and recreational centers. They connect the state communication system with the neighboring countries. Freeways carry the largest proportion of transport and therefore are strategically important.

Czech Republic ranks among the leading European countries concerning road densities – there are 0,70 km of roads/square km.

Basic data - in the Czech Republic are: 633 km freeways 329 km speedway (dual carriage ways) 5 843 km class I roads, 11 % 14 660 km class II roads, 26 % 34 118 km class III roads, 62 % total 55 583 km (100 %)

Development in freeways and road is in compliance with the aims of the Transportation Policy of the Czech Republic for years 2005 – 2013 and consequential General Plan of Development of the transportation Infrastructure.

Both Documents result major questions of international and domestic road transport, questions for development of particular regions, questions to increase road safety and environmental protection of their surroundings.

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Research of Mechanisms of Non-Market Interventions

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Major point of this project was to design and create a simulation model, which could be used as a simulation of the housing market. Model, with options of setting input parameters and watching characterizations of the simulation during the simulation itself. Another possibility of the model should be simulation of market and non-market interventions too.

System versus Model

First of all was necessary to identify the market as the system or more precisely to find a complex of subsystems and design the model, which would reflect any housing market. The housing market is influenced by wide range of factors. It means that the system has many relative subsystems, which are mutually linked. Main part of the work was to find parameters which are really important for this system and eliminating those unnecessary.

Model

The basic structural elements of the model are created by stocks, flows and complimentary elements. Model is open with a constant time step. Length of the time step is one year and model is adapted to it. Model contains three types of housing - owning, renting (regulated rent, open-market rent).

As mentioned earlier, the system is large. Model can be divided into sub-models as well as the system, where every part performs one task and together create complete model.

Main Parts of the Model:

- The main part of the model contains elements and relations which are simulating people and housing "moving" over the market. These entities are recorded all time during they are in the market (system). Their statuses are watched: at housing - building-up, occupied/unoccupied, demolition, etc. and at people: moving-in, accommodate/homeless, moving-out, etc. But this main part is functional only with the other parts:

- Decisive part for people is attempted to simply simulate making decision as people in the housing market. People's decisions are based on these factors - types of housing, its value, its quality, etc. These factors are crucial for decisions how and where they want to live or if they want to leave the system. Process of people entering the system can be deterministic or randomized by Poisson distribution. Entrance/exit of people can be affected by natural reproduction/mortality, immigration/emigration, level of unemployment, economic growth, quality of life, and so on. These are additional conditions, which could have an effect on housing market.

- Decisive part for development is making decision about building - what types, how many. Everything is consistent with supply and demand. Other option could be demolition or reconstruction.

- Decisive part for setting an open-market rent. Calculation is based on usual price from housing market. It enables to calculate a business loss from regulated rent (if it is switched on).

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- Decisive part for regulator. It is possible to input political intervention to the housing market. Regulation can be applied as for the number of housing and as for the price of rent (percentage value, constant value).

- There are a lot of smaller and supporting sub-models, which help to complete the model. For example: watching a relation between financial investment/recovery, quality standard in the different types of housing, financial indicators - average salary, average open-market rent, average regulated rent, average mortgage, inflation, economic growth.

Software for Simulation

For building and using the model was chosen simulation software Vensim DSS from The Ventana Systems, Inc. This software was chosen for its wide range of using options mainly processing of the outcomes (graphs, tables, file processing), modeling modes (simulation, simulate on change, game, sensitivity simulation) and selection of mathematics simulation methods. Model is built on the system dynamics methods. Next advantage is that the program can take as an input a data-set instead of a single constant, which is other plus in using it.

Using of the Model

Input values could be modified. It could change running of the simulation and the change could be very distinct. It is a way how we could move between one housing market to another (for example: from a market with open-market rent to a market with regulated rent and other way round). The model was build to enable it.

Many inputs can be set in this model. As mentioned earlier as input can be used constant or data-set. For improving outputs is good to take real tested data or assessment data or do research between people. It is always necessary to consider a local situation.

Changing of the many output parameters can be watched during the simulation. They are changing according to input parameters. Functionality of the model and suitability of the input values can be verified by historical data with known outcomes. This can give us knowhow to change the input parameters.

Examples of an output characteristics: percentage of people living in housing with regulated rent, percentage of empty housing, relation between regulated rent and open-market rent, relations between regulated rent and average salary, etc. Outputs can be as data in table or data in graphs.

Conclusion

Results from this simulation model are applicable for a decision making at state administration or in the business sphere. Knowledge of presumable future gives us a chance to change our decision or the way of deciding. We can influence the market or we can find a potential of the market. We could say that we have learnt from "future". We know where we want to go and we want to find good inputs for final required effects, which could be implemented to the real world by us.

At the present we need quality simulation models, the world is looking for the way to get out of the financial crisis, which is starting to influence us as well. The crisis makes people careful to invest and this creates the market saturated, including the housing market as well. Simulation models can help us with this problem.

SWOT analysis of entering small and medium industrial companies to B2B markets

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Present is the age of information. The development of a usage of computers, from a tool that could only solve mathematical operations to nowadays global computer systems, has enabled reaching important competitive advantages. The application of information systems (IS) and a usage of new information technologies (IT) are many – sided and are intervening in the main functions of value – forming network of a company on one side and in the adjacent functions on the other.

The grant that has been granted by a commission from CVUT to help solving the project has been established to apply the SWOT analysis of entering small and medium industrial companies to B2B markets. The fundamental of the project has been to create a checklist, that should have been used as internal analyse of companies and to identify the derivates of electronical markets, that should have gained the processes of a companies. On a fundamental of activities connected with recherché and using Czech [2,3] and foreign special literature [1,4] was made an external analysis of surrounding from internet markets.

The internal analysis of small and medium companies had to detect the strong and weak sites of these companies due to their preparedness of entering abroad markets using B2B internet markets. With this context were formulated the questions, that should have brought the answers from a domain such as:

- qualification of a manpower (computer knowledge of employees);
- financial situation of a company;
- integration of user system with system of a market;
- possibilities of customization of products;
- levels of information system (SW a HW) the highest potential for companies offers network connection of companies and application of miscellaneous forms of electronical trading;
- web pages own web pages brings continuous propagation of a company, because the web page is accessible from whole world and open 24 hours a day;
- access to innovation processes impatience to changes in a company system can have different origin – psychological or cultural;
- motivation of employees the creativity and effort of employees is motivated by objective, collective success, approbation and of course financial award;
- supply network (storage reserve) internet markets give companies competitive advantage due to growth of efficiency of their storage networks by automating process of supply of products;
- quality of service;
- research and development the technology of Internet initiate the producer and the supplier to change their entrepreneurial process by making it easier and by bringing near particular activities and its participants or whole new processes are implemented.

The external analysis of a company implemented on a basic of recherché activities of special literature has provided identification of opportunities and threats connected with entering internet B2B markets, for example possibility of entering the international markets, outsourcing of services connected with electronic trading, possibility of finding suppliers and customers, getting new contacts, automating the processes, security of web pages, competition, progress of IT and qualification of a nation.

The last part that this project targeted was to identify convenient functions of B2B markets from a view of using them by companies. For the needs of companies has been suggested following functions of B2B markets:

- informative portals a place, where can customers, suppliers, distributors and sellers find information about news in a branch or specific branch information;
- on-line catalogues it associates catalogues from a lot of suppliers at one place and in a standardized format;
- automate requests and quotation a mechanism of automated requisition for quotation (RFQ) provides the customers to get the quotations from greater amount of potential suppliers;
- e-auction concentrates a lot of customers or sellers at one place in one time;
- function of management of suppliers networks markets B2B are able to connect the producer with suppliers and create a process that generates greater efficiency of development of new products, save time and lower cost of production;
- communication central interprets information in between various parts of internet network;
- web services with added value;
- trading in stocks (futures contracts such as forwards, futures and swaps).

Proposed checklist should have been filled up in cooperation with managers from chosen industrial companies. Due to the change of my type of study this activity hasn't been realized. Although the internal analysis haven't been done, the outputs gained from external analysis discovered opportunities and threats connected with entering B2B markets and recherché activity of special literature identified the most significant functions of B2B markets from the view of small and medium companies and their users. Obtained conclusion will be used as a file of decision-making information attached with proposal of strategy entering small and medium companies to B2B markets.

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Analysis of traffic information provided to vehicle drivers and determination of their priority

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The main aim of this project was analysis of possible influence of traffic information displaying via VMS (variable message signs). The literature review was elaborated as well as questionnaire survey.

Literature review – main findings

From the results of different studies related to evaluation of VMS follows:

- Drivers are more willing to change the route (divert) in the case of occasional incident when the alternative route is confidentially known,
- young, unmarried drivers, predominately men, were also more willing to divert to alternative route,
- drivers' behaviour is influenced with currency and detail of provided information (about TT and alternative route) and knowledge of incident characteristics, traffic conditions, etc.,
- VMS have the greater effect on drivers during morning traffic peak than in afternoon traffic peak and also when the queue length on the VMS is longer,
- Drivers' characteristics as age, education, earnings, don' t considerably effect the driver final position and decision.

Current situation in CR

The situation in road monitoring and control in Czech Republic is improving slowly. There are number of automatic counters /detectors, weather stations, small number of VMS, etc. Traffic information is mostly provided on specialized internet information portals (incidents, road closures, road works, etc) but there is one problem that the drivers don't check their planned routes before trip whether they have no free time or chance (internet access). Currently drivers mostly get knowledge only from radio and they have no certainty that the information is accurate and verified (except of specialized radio broadcasting). Often drivers in the cars not even find out that traffic problem on concrete section of highway pass away. Limited data quantity is available from partial systems of RSD: about closures, weather and winter news service.

As a suitable place where is possible to practically analyse the situation with VMS in Czech Republic was chosen the part of highway D8 where ITS applications were implemented. It was a pilot project in which the part of highway D8 was equipped with automatic traffic detectors, equipments for traffic information (VMS – display of travel times and other traffic information) and also software for collection, process and dissemination of travel times. Providing of actual information about traffic situation on VMS should prevent traffic accidents and congestion due to the fact that drivers can change their behaviour to new traffic situation (e.g. slow down in unexpected weather change, traffic line closure, etc.) or where is possible can divert to alternative route.

Individual messages displayed could be summarized to following areas- seven thematic groups (source of data from April 2007-January 2008 / RSD)

- Traffic information "radiožurnál 90,9 FM"
- Meteorological information
- Accident information
- TT information
- Road maintenance information
- Information about colony
- Testing operation of the system
- Information contain note about highway D1 it is evaluated as error message. It should be mentioned D8 instead of D1.

Almost in 50% of the time when the VMS were in operation the information about frequency of radio providing traffic information was displayed. The second most displayed message contained information about travel time remained to the border of the main city of Prague. In the 13% of the time there was displayed weather information – warning of unfavorable weather. Only 1 % of messages were classified as error message.

Questionnaire survey

There were also realized questionnaire interview surveys to find out drivers' opinions on the system of displaying actual traffic information on the highway via VMS with the aims:

> establishment of user satisfaction rate.

Main survey results

- The most frequent way how the drivers gather information is radio-broadcasting, the second way is internet information portals. As other source mostly the walkie-talkie was mentioned. The same results were reached also in analysis of specific group only women up 50 years old gather information more from TV than from internet. Also the truck drivers prefer radio, walkie-talkie or information from satellite navigation. Paucity (only 1%) of all drivers don't gather traffic information either.
- The interest of actual traffic information transmission to satellite navigation was stated by majority of respondents (100% truck drivers and drivers transporting the goods).
- Almost 51% of drivers assessed the VMS as useful, about actuality of the messages are confident only 30% of respondents and about reliability of messages only 25%. Majority of drivers who assessed the VMS as reliable and actual were women.
- The text of message was evaluated as readable and understandable.
- In the case that there is a blank sign almost 68% of all drivers think that the sign is out of order.
- The most preferred text of message in the case of normal traffic condition is "free flow". In the case of congestion the recommendation on exit is required (mostly commuter drivers).
- The drivers were also asked if the information displayed on VMS influenced their behaviour. There wasn' t demonstrate effect on majority of the drivers. Not more than 50% of the drivers were influenced according to their answers. More inclined were women.

Conclusion

From the questionnaires follows that the drivers are interested in providing traffic information via VMS nevertheless there is necessary to increase higher awareness about VMS, increase reliability and actuality of messages displayed on VMS.

Also the small rate of interaction – influence on drivers' behaviour. This could be caused by insufficient confidence to displayed information or prevalent good traffic conditions (on highway D8 the intensity is not so high and traffic congestions sporadic).

From the answers results it should be better to let the VMS switch on and displayed any information than let them blank.

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Creation of Discount Rate of Investment Rating in Transportation

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The discount rate is the main instrument for evaluating investment project in private and public sector of economy. The basic and mostly used mathematic instruments are Net Present Value (NPV), Internal Rate of Return (IRR) and Index of Profitability (IP). These instruments can count on discounted cash flows thanks using the discount rate and they evaluate projects without the influence of time.

Evaluating of investment projects in public sector

The method CBA (Cost-Benefit Analysis) is the most common tool for evaluating in public sector. Cost-Benefit Analysis is systematic and structural procedure which can be used for any public project and it focuses on more subjects than just an investor and its income of investment. It takes into account the social effects of the project, their impact on the people, society, landscape and nature. These bring a lot of problems with evaluating of projects because most of them it is difficult to express exactly. Many parameters are non-financial or even intangible. In many cases, there is no market price because inputs and outputs are not trading on any market. Otherwise it is market failure in setting the prices of benefits. But for comparing and evaluating, it is necessary to convert all the parameters to the financial value. That is problem of externalities, because users do not pay for the negative or positive benefits flowing from the project.

Many theories focus on evaluating of the price of time, the price of life and injuries, the cost of damaging the environment or the noise and thus to damage caused to health or impact on climate. Some of them are solved like the price of time or the price of injuries, some of them can be solved with several methods like the price of life and the rest is currently difficulty expressed. The price of time is determined as the lost wages of typical user of that type of traffic caused by waiting in the congestion. The price of injuries is defined as the social costs necessary to threat. The rest of costs are evaluated by the shadow prices. Shadow prices are the prices at which there is no real market, but they are the real social cost, which are only imperfectly reflected in market prices. It brings some problems and incorrectness.

All these Cost and Benefits have to be discounted for using economic tools for comparing and valuating (NPV, IRR...). All projects are discounted with time discount rate and with risk discount rate. Risk discount rate indicates the percentage of how much the project must be more profitable than risk-free project. Real time discount rate for projects awarded of government is 5%.

Creation of discount rate in private sector

Evaluation of investment projects in private sector in transport or in the other parts of economy contingents on other parameters than in public sector. Private companies use also the discount rate but the amount of discount rate has to be determined from the economic 470

indicators of project. In public sector there is discount rate fixed for each area. In private sector there is discount rate intended chiefly of WACC (Weighted Average Cost of Capital). WACC is constituted by equity and borrowed capital. The cost of equity is defined as the sum required risk-free return on investment (corresponding interest rate of government bonds) and the risk premium, which corresponds to the risk of the project. Riskiness of the project is determined by several expert methods. The cost of borrowed capital represents the interest rate of loans. It is necessary to remember that capital structure of companies is not constant in all circumstances but in the case of a significant deflection ratio of equity and borrowed capital from original value will change both rates of capital. Discount rate is reported either as a nominal discount rate or real rate. Real discount rate is used in cases of cash flows are processed in constant prices (prices of starting period). If cash flows are treated in the prices of each year, the used discount rate is nominal. Using wrong discount rate can make mistakes during evaluation of projects and it can cause that good project could be rejected.

Discount rates for European countries

The size of the discount rates in the public sector is dependent on the discount rate from European Commission regulation No. 271/2008 of 30. January 2008. It is the discount rate for each country and it expresses the amount of investment risk in different countries. For countries of EU-15 is discount rate in the range from 5,36% to 5,66% p.a. For the whole EU-15, these values can be considered equivalent. Discount rate for the EU-15 countries can be considered as a reference value for low level of investment risk. This value is then compared with discount rates of new member states (EU-27). The countries with discount rate smaller than 6% can be called as the low-risk countries for investment projects. Those are Czech Republic (4,2%), Slovak Republic (5%), Slovenia (5,36%), Cyprus (5,36%) and Malta (5,36%). The countries with higher rate are Estonia (6,43%), Lithuania (6,1%), Poland (6,42%), Hungary (8,58%) and Latvia (9,44%). These values mean December of 2008.

Discount rates in transport

Investment in transport must be divided into two areas. At first that are investments in infrastructure and other investments in the transport itself. Investments in infrastructure are ensured by the government, or more precisely Ministry of Transport. In recent years have seen a united methodological evaluation process of investment in each type of traffic and therefore are currently projects in road, rail and waterway transport very good comparable. Discount rate as a fundamental tool for calculation of economic indicators in all areas is the same, 5% p.a. Value is based on the background of Czech National Bank which provides discount rate for the whole of the Czech Republic. CNB is subject to the decision of European Commission. Investments in transportation are treated as separate projects whose parameters are created the same like in other economic projects outside of transportation. The biggest problem of evaluation every projects in transport is the difficulty of establishing all costs, especially externalities.

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Modernization of Projection System of Car Simulator

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A Common Laboratory of Systems Reliability of Faculty of Transportation Sciences CTU and Academy of Sciences of Czech Republic (LSR) work many years on research in the field of reliability of operator-machine interaction. Driving simulators are successfully used for experiments dealing with investigation in driver's behaviour under normal and marginal conditions. We have been developing and using the driving simulators for many years mostly for the research purposes. During this years of work we have done plenty of experiments concerning investigations in so called "driver-car interaction"[1][2].

Most of the information which the driver's brain needs for driving are visual ones. The driver from the observed virtual scenery gathers information primarily about shape and color of the surrounding objects (including the road), distance of the objects and self motion (eventually the relative movements of other objects). From those primer cues driver derives majority of secondary information used for driving[3]. That is why, it is necessary to provide the driver with as forceable visual perception as possible (wide angle of view, resolution, stereoscopic projection...). However the primary information which the driver perceives via visual input is what he/she sees on a frontal projection screen (in fact this information can be satisfactory for majority of experiments) the simulator of Skoda Superb (which is continuously developed by the Driving Simulation Research Group and was used for this project) is accompanied with four side projection screens (placed under angle with the frontal one) which simulate a peripheral vision and is useful mainly for self-speed perception and for tasks where driver should look around his/her car. Although, the side projection significantly increases the overall fidelity of the simulation, during development it was decided that the stereoscopic projection will be useful an will even more increases the fidelity of simulation. There are several ways to present a stereoscopic motion picture. In this project approach of passive stereoprojection is used. Two images are projected onto the same screen through polarizing filters. The viewer wears low-cost eyeglasses which also contain a pair of polarizing filters. As each filter only passes light which is similarly polarized and blocks the other polarized light, each eye only sees one of the images, and the effect is achieved. Linear or circular polarisation are the two main alternatives for passive stereo, they have their own relative advantages. Linear polarization means that light is polarized in a single direction. When one changes the orientation of linear-polarized glasses by tilting his or her head, so that the resulting orientation of polarization does not match that of the polarization filter mounted on a projector, there will be a loss of stereo information as perceived by the viewer[4]. Although linear polarization is a cost-effective technology that can produce excellent image separation, for this project the second approach was used. With circular polarization, the viewer can tilt his head and change his viewing angle relative to the stereoscopic projection display, because the light is not polarized in a single direction.

As mentioned earlier stereoscopic projection using polarized glasses generally involves two projectors and the two projected images need to be overlaid precisely. There is a number of ways this can be achieved. The cheapest way was used in this project. The two projectors are

normally stacked one above the other, the top projector is rotated slightly downwards and the bottom projector rotated slightly upwards so that the two images overlap. Because this introduces a degree of keystone distortion digital keystone correction must be used. The other difficulty that had to be solved arises because light reflected from a screen lose its polarization. This problem was eliminated by use of silver screen. Instead of previously mentioned problems, that were mainly solved during the design and installation of hardware of the projection system, we had to do some software changes. That included changes in visual engine setup and simulation system setup itself.

To approve quality of the solution we built, an experiment utilizing was performed. The pilot set of experiments was performed with six testing drivers and was based on filling questionary. Drivers had to drive twice different simulation scenario (first without stereoscopic projection, second with it) and then answer questions and describe their subjective feeling from each drive.

Conclusion

We approved need of implementation of stereoscopic projection for specific experiments. Although this solution can't be use in all experiments run in our laboratory it appeared to be valuable enhancement of one of our driving simulators. The results and experiences from this project gave a valuable background for future series of experiments.

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The Quality Effect to Rating of Traffic Services

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Finding solutions of problems in passanger railway transport in competitors fight on the transporation market is needed to assert principes of process engineering. One of the modern neccessity is quality transport system represented e.g. by norm ISO 9001. But before using of quality methods is neccessary to defineted backround of service quality, requirements for the service, roles of participations and after that is possible to determine main processes in passenger railway transport. It is way to optimalize current operations within process engineering of product or service.

Satisfaction of customer and backround of the service, role in participation, definition of main processes, indicators of service and of course customer requirements determine final level of service quality. Knowledges each of these inputs have key role and they have to be clearly describe. Main objective of this article is acquaintance with conditions in public railway transport in focused on quality within transport service and desribe main processes and links within commitment of public service.

In general surroundings of services is created by many external and internal influences. These influences take important place within quality of engineered services. Backround of quality is illustrated in the article.

Quality feelings of customer shaped final proposal of service. But not every requirements are sensed. Costs invested to "redundats requirements" creat lost output. So the first problem of quality management is determinated by relevant equipmentss of customers/passengers.

The most important thing to operate public transport systems is a support in law. Actually the law of public transport systems is still missing in Czech Republic. But in general these systems already have the support. The mobility of workpeople closely relate with the state growth economy. Other item is in modification of technical norms to modern transport systems. Approach to growth and improving public transport is in formation streight conditions.

Role of public transport is like alternative – creat copable of compating service for travellers. In Czech Republic is builted three-level client system: client for long-distances (state), client for regional-distances (regional government) and client for local-distances (municipality government). In regions have been established integrated transport systems.

Most of outputs in public transport are realized within contract of public transport service.

Regional authority has an unsubstitutable role in funding, ordering and in generating offer of public transport. Regional authority has to ensure funding of compulsory traffic service by their funds and role of municipalities is in ordering and funding of added traffic service. It means that regional government and authorities of municipalities has to decide about range of regional transport servicies. The duty of regional authority is to approve timetables. The production of timetables make independent subject – coordinator of PTS or department of PTS of regional authority. So the region has many tools to influence extent of lines, intervals during day and other parametres. Order party has to focus to financial efficiency of money expended on servicies, e. g. prevent to operation in parallel lines. Various participants can suggest formation of timetables by submit offers. However by submission of order part or by knowledge of agglomerations. During formation of timetable is necessary to result from needs of inhabitans, employers, keepers of services and schools. But the most important elements of system are travellers. They have to know what to do in case they want to travell, change for other mode of transportation, don't like something or if they have some needs.

Determination of quality requirements is neccessary for right view to transport service.

Who is who in Czech's rail transport service is discribed by the author – role of Client/Provider (regional government), Supplier/Operator of transportation service (mainly Czech Raiways) and customers.

For right function of processes in railway public transport is neccessary to improve legislation in transport market and definate main participations in the market, their roles, needs and responsibilities. Each of participants has to know his main processes and mainly their customers and their needs. Quality of management in these processes are determinated in final quality of transport service.

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Pedagogical Project "Fundamentals of entrepreneurship"

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Introduction

Entrepreneurship plays an important role as a driving force for the region's competitiveness, for the job creation and for the economic growth of the state. Technically well educated students often do not have a positive relationship with the entrepreneurship, are not willing to take a risk and personal responsibility. That is why they can not fully use their competences of innovative engineering approach.

To encourage the future graduates of Faculty of Mechanical Engineering in innovative way of thinking, in active approach to professional life and in motivation for being en entrepreneur, the Department of Enterprise Management and Economics, Faculty of Mechanical Engineering, CTU in Prague has started to work on the project "Fundamentals of entrepreneurship" and gained the support for it from European Social Fund, city of Prague and the Czech Republic budgets.

Project Justification

The importance of this project "Fundamentals of entrepreneurship" results from a number of different analysis, studies, surveys, interviews that deal with the current state of knowledge and skills of graduates of technical universities in the Czech Republic. For example:

- regularly conducted surveys of graduates of Faculty of Mechanical Engineering, CTU in Prague
- the survey of the opinions of graduates of the programme Enterprise Management and Economics, Faculty of Mechanical Engineering, CTU in Prague and in-depth interviews with employers of graduates of the same program (2006, project DEQU, supported by Leonardo da Vinci)
- the national report within Global Entrepreneurship Monitor 2006 that describes the entrepreneurship activity in the Czech Republic (this report has drawn the attention to the relatively low level of new business activities of students over 18 years)
- the interview with the director of the Scientific incubator CTU, which focuses mainly on students and fresh graduates of CTU in Prague, and which shows a lack of basic economic knowledge of candidates to participate in the incubator.
- The inspiration for this project was also experience of foreign universities with educational programs focusing on entrepreneurship and management.

Project Description

The main aim of the project consist of the support and the development of ability of technical oriented students to be an entrepreneurs

Particular aims:

- 1. to bring the subjects relevant for daily management of small innovative business near to technical oriented students
- 2. to prepare future graduates for the most frequent appeared economic challenges
- 3. to encourage graduates to start their own business

4. to establish and promote the cooperation with institutions providing the support and administrative facilities to those who start their own business

To fulfil these aims the new course is being prepared. Course will develop the competencies of graduates needed to succeed in future business careers: ability to make decisions, self assertion and assertion of ideas, skill of teamwork and team leading. The objective of this course is to improve students' managerial-economics knowledge so they are able to apply them in practical business life.

Key activities of project are following:

- Organizational support of project
- Data assembly for e-learning
- Preparation of e-learning application
- Preparation of case-studies
- Preparation of videos
- Workshop organization
- Entrepreneurship support presentation
- · Publicity of project among students and professors before course
- First course at Faculty of Mechanical Engineering
- Final revision of course

Pedagogical methods

Newly prepared subject will be in form of blended learning and it will be based on

- the e-learning application in modular form which summarizes the essential knowledge of the business practice
- a set of case studies created in cooperation with business representatives
- thematic workshops which combine knowledge of e-learning part and solving of complex case study in teams
- short motivation videos with so-called "success stories" of successful young "innovators", former graduates of CTU in Prague

What does course bring is an integration of distance and presence educational forms complemented with strong accent to motivation factor. Students who pass the course will obtain not only in business needed knowledge and skills, but also appetite to try to get their chances as entrepreneurs.

The course will be realized for the first time in the summer semester of 2010.

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Organizational Action Achievement

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A prevailing myth of management is that most top managers are masters at developing a carefully thought out strategy, for future success of the firm. Actually, the facts indicate that most managers, who get promoted into top positions, simply accept the goals and objectives, which have been handed down from their predecessors. The ultimate result is that they become administrative baby sitters, rather than managers concerned with planning and strategy. Strategy is different from planning, in that it takes into account the plans of competitors. Strategy implies that the top management must constantly keep in mind what competitors are doing, and then try to beat them in the market place. This kind of strategy is not limited to business and industry. It concerns all organizations, because their future survival and growth depend upon an overall strategy being developed, to insure success under permanently changing conditions. The trouble is that most top managers work hard at daily administration, rather than developing strategies to apply to emerging problems and opportunities. Thus, the reality is that few managers do this successfully, even though this is their prime responsibility. Managers can create their organization's success by developing appropriate plans and strategies. This applies to all organizations, but it requires that managers find the right interstice for their organization's resources. Strategies vary with environmental conditions and with the positions of the firm or organization in terms of those conditions. Naturally, any strategy for success works better when the company is already successful. This is when managers have an optimistic outlook and the financial resources to work out a new future. On the other hand, companies which are losing money, or fighting for survival, usually develop a pessimistic outlook and simply turn to cost reduction as a way to survive. They have no financial substance or personal resolve, left to develop new opportunities. The managers of these firms fail because they refuse to recognize an opportunity, or are fearful to size it. Loss companies have difficult time raising money, getting good executives, or even carrying on the normal operations of the business. One of their best strategies, therefore, should be to avoid getting to the point where an adequate strategy can no longer be entertained. The key element is whether the management of an organization knows when it is getting sick, so that it can take appropriate action to insure the organization's survival and growth. All basic strategies take certain elements into account:

1. The organization must know its inherent SWOT analysis.

- The need to develop a workable strategy should be uppermost in management's mind, and such a strategy should receive periodic review.
- 3. The firm or organization must maintain a constant surveillance of its market position, to keep abreast of problems and opportunities as they unfold.
- 4. Any corporate strategy should maximize entrepreneurship in the market place along with efficiency of production and aggressive marketing. All must be exploited.
- 5. The master strategy for an organization or a company should encompass all elements in its future growth and success financial resources, its products and services, manpower complement and future needs, marketing capabilities, the possibilities of merger, financial leverage as a way of developing better profits, and so on.

Too often, management people are so concerned about their own problems and competitive conditions, that they do not spend enough time examining, what competitors are doing in new fields of endeavour. These items of intelligence provide a management with good clues as to how they can maximize their position. Thus, an important element in strategy is the development of information about what competitors are doing, so that you can plan a better strategy for your own organization.

There are many managers, who believe, that past forms of organization structure can be transferred to modern organizations, by simply adopting the classical principles of unity of direction by authority, accountability through job classifications, chain of command, specialization of functions, and limited spans of control. Managers who apply these principles as eternal truths are assuming, that all organizations are essentially the same simply because people must organize together to accomplish a given mission. The major problem is to balance organization order with individual initiative. A manager who is too concerned about rigid organizational approaches like authority, coordination, accountability, and control tends to make organizational structure more important than organizational results. He worries about how a thing is done, rather than what is done. That's why the last act of a dying organization is to get out a new organization chart or new procedure manual. Most successful firms started from a good entrepreneurial idea, with usually one man responsible for the initial success of the firm. As a rule this man brought entrepreneurial flair to the firm-not organizational ability.

The best antidote is to motivate the people who make up an organization, by keying their individual results into the organization's performance. Rather than controlling people, we must release their energy and capabilities by permitting them to make a contribution. We must, if we are effective managers, get the full people power which an organization has to offer. Obviously, you don't get this by sheer organizational control. Don't do it by drawing neat boundary lines of authority and accountability. Look for the strengths your people have. Build on those strengths, and then develop people to contribute according to goals and objectives which are clear, meaningful, relevant, and inspiring.

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Life Cycle Cost Analysis Models for Solid and Non-solid Road Constructios

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In practice, the selection process of road infrastructure projects is often based only on finding the alternative with the lowest purchase costs, but this kind of selection falsifies the benefits of the other alternatives and seems to be insufficient. Repair, reconstruction and maintenance costs during their life cycles make a significant part of the total costs and that is why they have to be considered in a proposal or a selection of construction alternatives. This means that the optimum proposal of the road constructions' life cycle could significantly help to decrease construction, operation and time costs [1].

Several computer models can be used for the life cycle cost analysis of solid or nonsolid pavements. All these models usually work on the same principle. They enable to compare purchase, maintenance, repair and reconstruction costs of selected constructions, considering various factors. The number of factors and the level of analysis details divide the programs into simple and complex ones. The suitable computer model selection depends on project purpose and entry data accessibility.

The simple computer programs are less time-consuming, require less financial resources and simpler computer systems, and so they are easily accessible to the wide range of users, but they do not give such a precise analysis of the solved problem. Such programs provide a quick, but simplified comparison of two or more construction alternatives. They can be applied only for smaller projects, where a low level of the analysis details is for the given purpose sufficient.

AB-CB is one of the simpler computer programs, which can be used for comparing asphalt, concrete or asphalt and concrete pavements during their life cycles [2]. The number of alternatives under consideration is basically unlimited. This program was developed by a team of Czech experts, using European and American sources as well, for the Road and Highway Directorate of the Czech Republic. This user-friendly program consists of several interconnected spreadsheets. It enables to carry out a quick and simplified life cycle cost analysis. The result correctness depends on the data input accuracy, primarily on the future cost estimation. The simplicity of the model determines its application mainly for the lower size and importance projects. Life cycle cost analysis of larger projects would require program corrections or other model usage.

The more sophisticated programs bring a complex analysis of the road construction alternatives. However, they require a high precision of input data; it means that they can be applied only if all the input data are available. These programs provide relatively correct results and could be used as a decision making instrument for large road infrastructure projects. On the other hand, such models are usually very time-, labour-, capital- and technological-intensive.

HDM-4 (Highway Design and Maintenance Model) is one of the most sophisticated programs for comparing road constructions. HDM-4, developed by the World Bank, has been used for over two decades to combine technical and economic appraisals of road projects, to 480

prepare road investment programs and to analyze road network strategies. The HDM-4 analytical framework is based on the concept of life cycle analysis. This is applied to predict road deterioration, road work effects, road user effects, socio-economic and environmental effects over the life cycle of a road pavement [3]. This model requires a high quality and also quantity of input data, but enables to carry out a complex road management analysis. HDM-4 method has been acknowledged by important grant organizations and governments in many countries and could become one of the main decision making instruments of road infrastructure investments. Nowadays, especially Project analysis - one of the main program levels – is used in the Czech Republic to appraise road infrastructure projects from the economical and technical point of view. In principle, the other levels (Program analysis, Strategy analysis, Studies) have not been used in our country yet [4].

A suitable instrument for setting up the life cycle cost analysis could also be the "Pavement Management System". This model was developed more than 15 years ago to determine the pavement deterioration course during the life cycle and to select suitable maintenance, repair and reconstruction strategies. Its goal is to put the pavement to the desired technical condition, to maintain and repair the construction with minimal capital and material budget and maximal road user effects. In order to assess the pavement condition properly and choose an appropriate maintenance technique, it is necessary to consider especially the following parameters – skid resistance, longitudinal and transverse unevenness, bearing capacity and interruptions. Pavement management system helps investors and road providers to manage the existing road and highway network as well as to propose new road infrastructure projects.

In order to propose an optimum road construction, it is necessary to consider the whole life cycle of the construction. Suitable model selection enables to evaluate and predict life cycle costs; that could lead to benefit maximization from the investors', road users' and affected regions inhabitants' points of view.

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Model Assessment of Indirect Benefits of D11 Motorway for Socioeconomic Development

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Introduction

Based on the methodology applied for the D8 motorway [1], the D11 motorway (Praha – Hradec Králové) [2] was analogically developed in 2008, and the D5 motorway (Praha – Rozvadov) is being prepared.

For municipalities situated up to 15 minutes of car travel from the D11 motorway, the following characteristics were surveyed:

- proportion of commuters to Prague
- number of job opportunities in the municipality
- unemployment rate in the municipality (4/2008)
- transport accessibility (time needed) from the municipality to Prague or to a district town

On contrary to the D8 motorway, the survey included the following extra issues:

- · transport accessibility (time needed) to the nearest exit
- theoretical (determined by a model) location potential of the municipality in relation to Prague and to a district town (the power of Prague or a district town expressed by the formula: the number of inhabitants divided by the distance from the town to the surveyed municipality)
- total location potential (the sum of both partial location potentials)
- municipality potential (total location potential related to the surveyed municipality power, i.e. the number of inhabitants in the municipality)

Results

The analysis of the data above produced several fundamental, statistically relevant correlation relations among the surveyed characteristics.

The location potential of Prague shows the closest correlation relations. A correlation with 5 other characteristics was proved on the 99% significance level.

Based on the relationships thus obtained, we may judge that the potential of Prague has a much higher weight for the surveyed municipalities than the potential of Hradec Králové, and therefore the location in relation to the capital city is much more significant for the municipalities than their location in relation to Hradec Králové.

A significant positive relation (correlation coefficient of 0.835) of mobility (i.e. the proportion of inhabitants commuting to Prague) to the location potential of Prague was logically manifested. It implies that the proportion of commuters to the capital city grows with the decreasing distance from Prague. The greatest proportion of economically active commuters to Prague is from eastern surrounding districts.

The number of jobs is not in any way influenced by the distance from Prague or from Hradec Králové, and the total potential of the respective municipality does not play any role in it either. Therefore, the number of job opportunities solely depends on the size of the municipality, i.e. also on the municipality potential derived from the population size of the municipality. The correlation coefficient of this relation is 0.711.

The unemployment rate significantly relies only on the location potential in relation to Hradec Králové (-0.308). The unemployment rate decreases with the growing location potential of Hradec Králové, i.e. with the decreasing distance to this district town.

The comparison also involved the accessibility values to Prague and Hradec Králové, and the intensities of car travels to Prague which results in the finding that Prague is the destination of commuters travelling even from municipalities with a better transport accessibility to Hradec Králové, who should, considering the minimization of both the time and financial demands for commuting, rather commute to work to the district town, Hradec Králové. The potential of Prague and its attractiveness, however, is higher and, therefore, the capital city is the destination of even such economically active commuters who live closer to Hradec Králové.

The motorway effect on the unemployment rate in the surveyed municipalities was not statistically proved, but the fact is that unemployment is reduced particularly by a higher level of commuting. In terms of timesavings and reduced transport costs, however, it would be better to work in the place of residence or in its close vicinity. The survey proved that municipalities with larger numbers of inhabitants offer more jobs, regardless of their location in relation to the motorway. The size of the motorway effect on the growth of the number of job opportunities is difficult to prove (among others, because of the "shading" of the general economic development etc.). A kind of solution is offered by intensive research of selected settlements, even though the conclusions drawn from a limited number of case studies cannot be generalized.

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Economic Tools in Brownfield Redevelopment and EU Structural Funds

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Redevelopment of brownfields is strongly connected with the changes of socialeconomic structures of regions and with strategic, regional and municipal planning. Resolution of these problems is a challenge to national and regional policy makers in terms of bringing the derelict land and abandoned buildings back into beneficial use.

Successful brownfield redevelopment policies and strategies need a combination of environmental, spatial and urban planning approaches. The regeneration policies and strategies concerning brownfield redevelopment are defined in the Czech Republic in many strategic documents, such as the State Policy of the Environment, the Strategy of Sustainable Development, the National Strategy of Brownfield Regeneration or the National Development Plan. The key objective of the proposed brownfield regeneration strategies is the economic, social and environmental development of regions and cities. The indispensable element of the strategies is availability of the public financial sources and in particular EU sources. Since the accession of the Czech Republic to the European Union there have been sufficient possibilities to draw out the financial means from the Structural Funds or the Cohesion Fund. The financial means for the Czech Republic will be differentiated in the following period.

The sector operational programs relating to brownfield redevelopment for the period of 2007-2013 are connected to the previous plans from the period of 2004-2006. Being connected to the development strategy and the cohesion policy objectives, they are defined in the National Development Plan. The operational programs convert individual priorities of the NDP into the actual spheres of supports, which are precisely defined and separated. The executive authority responsible for the proper implementation of the sector operational programs is the appropriate ministry. The recipients of supports may be according to the operational program character, for example, non-profit-making organizations, civic societies, entrepreneurial subjects, natural entity, legal entity, contributory organizations, state organizations, state enterprises, voluntary unions of municipalities, environmental agencies, regional self-governing authorities, etc. The most important programs dealing with the brownfield regeneration are the operational programs of the environment, the regional operational programs and the development programs in the rural areas.

The operational programs of the environment deal with disposal of wastes and removal of old ecological burdens. The part concerning removal of old ecological burdens include their inventarization and risk analyses, remediation of seriously contaminated localities, such as industrial objects, military and agricultural grounds endangering the environment and the human health. The other important supported area is a support of regeneration of urbanized landscape, most of all revitalization of major urban greenery, foundation and renovation of parks in housing estates, plantation of vegetation on the places of the formerly removed, small and from the economic point of view barely usable brownfields.

The regional operational programs aim their support at the actual region in the Czech Republic. The global target of the regional operational programs is acceleration of regional

development, increase of competitiveness and attractiveness and improving the quality of life, while respecting the balanced and sustainable development of regions. The other significant goal is stimulation of economy in regions and creation of new employment opportunities as well as increasing the regional prosperity by creating the environment for development of small and medium enterprises.

One of the chief priorities of the regional operational programs is revitalization of urban agglomerations. The supported activities are regeneration of brownfields, i.e. abandoned grounds earlier used for industry, transport, army or administrative purposes in cities for their next function. Decontamination of the affected areas and modernization of the transport and technical infrastructure as a part of a broader concept of the certain region regeneration must be carried out, too. Funding should be also concentrated on the renewal of inner-city industrial sites, initially with a preference for industrial reuse, but more recently with increased focus on housing development. The preservation of the architectural heritage of the industrial revolution by finding a new usage for historic buildings is also a meaningful priority. The important area of support is investments into the improvement of physical infrastructure with supported activities for revitalization and restoration of municipalities.

The development programs in the rural areas include investments into reconstruction of agricultural brownfields, dilapidated buildings and into technologies or, for example, rehabilitation of the former areas after mining activities. A support is also directed to investments to the techniques for creation and maintenance of the landscape.

All these programs may draw out the financial sources from the European Regional Development Fund. The other financial mechanism that may contribute to the brownfield redevelopment is a financial source from the European Economic Area and from the bilateral, so-called special Norwegian financial tool.

Economic redevelopment matched with environmental cleanup will definitely result in the rebirth of many industrial and commercial properties and surrounding neighborhoods. Besides the administrative-legal tools (e.g. Local Agenda 21, Ecological Action Programs, Governmental Directives, etc.), the economic tools having a character of support operational programs funded from the EU Structural Funds are definitely crucial instruments for redevelopment of decayed areas.

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Integrated Approach to Evaluation Utility LLC Product

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Determination of the Term "Product"

The product here presents a process of realization single subprocesses that give a range of externalities.

The product of a common consumption brings utility resulting of its consumption. A good like a manufactured product, a part of a capital equipment, is a source of an only narrow kind of externalities (servising, liquidation) and complementary goods. This product won't be a subject of the concerning research. We concentrate here entirely on a product with a long – life-cycle. For the farther step we're expressed undermentioned thesis about a product of a long-life cycle:

The realization of a long-life cycle product is however a source of many (broad-spectrum) heterogeneous externalities (a positive and negative environmental impact, decrease of unemployment, development of regions ...)

A manufacturing enterprise manufacturing products is in itself a product, which contributions is necessary to be inquired, quantified and regulated. A manufacturing plant is a product with a long-life cycle. Its products – goods - we consider as consumer subjects - then products of a with short-life cycle.

Life Cycle Periods of a Product

Under the concept of a product life cycle we understand the way the product follows from its proposed design and feature in a development department, following manufacturing, distribution, consumer usage, as far as recycling materials and storage of unused parts of the product after the end of its life time on a scrap heap his service life on tip or deactivation in an incinerator. (For the completeness' sake we have introduced the typical life cycle period of a product of common consumption).

The product life cycle from the point of time differs according to the type of a product: it can be very short, e. g. foodstuffs will currently not exceed 14 days, is can last several years (e.g. home electric appliances), but also several decenniums (buildings, infrastructure).

With respect to the function we distinguish these basic periods of product life cycle:

Development period: This period proceeds in development departments, where the product is designed (on the basis of ascertained needs of consumers) and proposed ways of its manufacturing. Manufacturing period: In this period the imaginations of designers and production engineers are realized ("materialisation") in form of a real product, whose function is comprehensibly tested for a set of specified operational conditions and handed over to the users (consumers). Operational period: In this life cycle period the product is routinely exploited, maintained. in some case restored (inclusive servicing bv the manufacturer). Liquidation period: After the end of the technical life of a product (generally life, or long - term life cycle) the technical liquidation comes to word, so that the moral or

physically worn out product threatens at least as possible the environment. Lays stress on maximum measure on recycling of used material.

For a long life cycle engineering product we have efficiently defined the so called partial cycle phase, characterised by acting of so called relevant factors of partial utilities.

Partial phase TF – phase of defining the technological levels in broader sense, Partial phase PHUT – phase space - temporal specifications, Partial phase DF – phase configuration.

Partial phase LOT ... coupling circuit phase, (includes activities before - production),

Partial phase FLESH - GLOVES ... user – implementation phase, (includes manufacturing and working operations),

Partial phase WT ... run-out phase (includes maintenance activities).Definition, Implementation and Realization Products with Long - Term Life Cycle

This part of the study will deal with determinating characteristics and the meaning of specific above standard needs on preparation and running of engineering products with a long life cycle.

The main aim of this part of research will be the creation of a model for calculating externalities contributions in a quantitative formulation that will be used by other subjects than the stakeholder and will not influence the rate of return of the investment towards the stakeholder.

On the basis of the made background research and the following comparison with consumer goods the resulting procedural characteristics concerning products with long life cycle were stated: Set of Projects Resulting from the Initiatory Project

Projects Implicated in Single Partial Phase of Long Life Cycle Products

Production project (concept, construction, technology),Project of diagnostics, Management project (including all acts, leading to the full functioning system),Projects of examinations, debugging, starting operational sets, before - complex and complex check - out (establishment that the reservation function defined in contracting relation are ensured),Project of guarantee measurement, Technological projects, System of project metrology, Project of the testing type running technology and her diagnostics.Partial phase DF – phase configuration: System, following and documentation of depreciations, repairs and service lifetime of components, Long-term following of complex quality works, Description of the feedback processes towards to producers – learning organization. Partial phase temporal – space specifications: Bought subdeliveries, Projects of realization coordination of supplies, assembly management, cleansing operation, tests, debugging, starting of operational sets and after their tuning initiation and setting of the whole technology.

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Dynamic Model for Maintenance Management and Investment Decision in Buildings

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Description of problem. Maintenance management is an important task during the whole life cycle of the building. It is a complex problem with many points of views reflecting concerns of a building owner, a building user, employees, suppliers of services, suppliers of construction works and components, a local government etc.

Contemporary planning tools deal with day-to-day maintenance planning and do not cover complexity of the system. Methods and programs deal mainly with resources allocation and can be considered as the scheduling tools. These tools are also focused on keeping conditions of the buildings but not on the development. This development (functionality changes) is evoked by the changes of the external environment – e.g. energy price changes, laws and standards changes, construction works price changes. Another category is a variation coming from an internal environment, e.g. building usage change, decreasing the budget for the maintenance, human resources changes. All described problems reflect the need for the development of the model dealing with these aspects - the model including all relevant elements for the simulation of the dynamic behaviour of the system and testing the suitable strategy.

Method. The main used methodology is system dynamics [1-3]. This method is focused on the structure and the processes in the investigated objects. The models describe the dynamic behaviour of the systems that are derived from the objects. The elements of the model include a hard part of the system (e.g. technology) as well as a soft part of the system (e.g. human resources behaviour). The method integrates these aspects into one model. The field where system dynamics is widely used is the simulation of the behaviour of the socio-economic systems. The model is designed by means of stocks (the stock represents the important variable in the model), flows that influence the stocks and auxiliary elements for the calculation of the variable values. The models allow us to test the designed solution before the implementation in the real world. It saves time and financial resources. In large-scale system it is possible to test the policy for achieving strategy goals. The described problem has all aspects for introducing this method.

Model. The dynamic model has been developed. The model is divided to three main parts.

The first part is focused on the conservation of the system. The goal is to keep the system in stable level, it means this subsystem is about maintenance. The main stock is number of defects (or troubles, failures) in the building. These failures can be decreased by ad-hoc repairs (the evident problems) or by planned maintenance (the latent problems).

Another subsystem is the financial subsystem. The building owner has revenues (lease revenues) and expences (services, maintenance etc.). The cash can be used for both kinds of maintenance. The simulation model can test the situation when more money is used for the planned maintenance or for ad-hoc solving problems. The structure includes back loops - the most important is the connection to the element of defect creation that is influenced by level of maintenance. The amount of the problems depends also on the complexity of the building,

the design and conception failures, the construction failures and the quality of the maintenance works. The financial elements are connected to the functionality subsystem.

This subsystem is focused on the system improvement. The goal is to change (to improve) the functionality of the building. The main stock is the functionality that is increased by investments to the building and decreased by the damages caused by the defects. The decision making process is based on the evaluation of the investments (functionality improvement can increase revenues). This is only one approach. The evaluation of investments is difficult problem because the question is - who is a beneficial owner.

Conclusions. The designed model has been developed in the simulation environment Stella. The next stage in the modeling process is model testing for different situation. The future work will be focused on the application of the model for the evaluation of the energy saving projects during the life cycle of the building. The issue is – the implementation of the projects decreases the expenses for the energy but also can increase the demand for the maintenance in case of the complicated active elements.

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