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Dear readers,

the 6th International scientific conference TRANSCOM 2005, organised with the support of the European Commission within the framework of FP6 European Project SurfTran (CETRA project, Centre for Transportation Research, University of Žilina, Slovak Republic), was held in the University of Žilina, Slovak Republic, in June 2005. The conference was also under activities included in the state programme of research and development "Improvement of social recognition of the young in research".

The main purpose of the conferences TRANSCOM organised regularly every other year since 1994 is a presentation of scientific works (from the fields of transportation, telecommunications, mechanical, electrical, civil, security, forensic engineering and social sciences) of young research workers incl. PhD. students up to the age of 35 from universities, scientific institutions and industry.

More than 489 contributions were published in 10 proceedings of the conference TRANSCOM 2005 (247 contributions were from abroad, Austria, Czech Republic, Finland, Germany, Great Britain, Hungary, Italy, Lithuania, Poland, Romania, Russia, 39 were from the universities of the Slovak Republic and 203 contributions were from the University of Žilina).

I should express my gratitude to all participants for contributing to the TRANSCOM 2005 and to the TRANSCOM 2005 scientific committee incl. organizing committee members for cooperative spirit, motivation and enthusiasm.

This volume of the Communications is devoted to the selected contributions (recommended by the scientific committee) of the 6th International scientific conference TRANSCOM 2005, Žilina, Slovak Republic.

Prof. Ing. Otakar Bokůvka, PhD.

Robert Bešťák *

ARQ MECHANISM IN HSDPA

Two principal features of the MAC-hs protocol include retransmissions of erroneous blocks and in-sequence data delivery to the upper layer. The first function is provided through a HARQ mechanism. The second function is achieved with the help of sliding transmission/receiving window and by using a specific numbering. In this paper, the MAC-hs performance for different sliding window sizes, timer values and number of retransmission attempts are investigated. Simulations show that values of these parameters have to be carefully set up in order to prevent incorrect block discards at the receiver side.

1. Introduction

The HSDPA concept (High Speed Downlink Packet Access, e.g., [1], [2]) of UMTS (Universal Mobile Telecommunication system) was introduced in Release 5 of 3GPP. The HSDPA includes several enhanced techniques such as fast link adaptation, Hybrid ARQ (HARQ) or higher order modulation (16QAM). The enhancements make it possible to increase downlink data rates up to 10 Mbit/s on the air interface.

The HSDPA introduces a new transport channel and three physical channels (see Fig. 1). The transport channel, High Speed Downlink Shared Channel (HS-DoShCH), is shared among several users. The HSDPA scheduler reallocates radio resources, i.e. channelization codes, with a period called HS-DoShCH TTI (Transmission Time Interval). For the UMTS FDD mode, the HS-DoShCH TTI is set to 2 ms ([2]). Within a HS-DoShCH TTI, radio resources can be allocated to one or several users.

At the physical level, data of HS-DoShCH (i.e. MAC-hs PDUs) is mapped into a frame structure of HS-Physical Downlink Shared Channel (HS-PDoShCH). Three consecutive HS-PDoShCH slots form a radio unit for traffic. We denote this three-slot unit as T-slot. The T-slot duration corresponds to the HS-DoShCH TTI duration. One HS-PDoShCH equals one channelization code. Up to 15 channelization codes ([3]) can be employed, i.e. up to 15 HS-PDoShCHs can be assigned in one T-slot. The signaling is carried by a downlink HS-Shared Control Channel (HS-ShCoCH).

HSDPA signaling information (downlink/uplink) is conveyed via control channels. The downlink signaling informs a mobile how to decode transmitted data on the HS-PDoShCHs (type of modulation and coding, transport format, HARQ information).

The downlink signaling is transported by HS-Shared Control Channel (HS-ShCoCH), whereas the uplink signaling (HARQ Ack/NAck and Channel Quality Indication) is carried by HS-Dedicated Physical Control Channel (HS-DePCoCH). The transmission of HS-ShCoCH precedes HS-PDoShCH by 1.33 ms (or 2 slots, [1]).

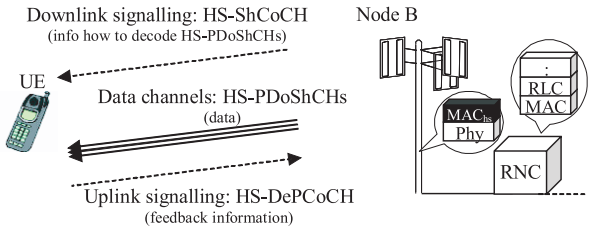

Fig. 1 HSDPA physical channels: HS-PDoShCHs (High Speed Physical Downlink Shared Ch.), HS-ShCoCH (HS Shared Control Ch.), HS-DePCoCH (HS Dedicated Physical Control Ch.).

The uplink signalling (HARQ Ack/NAck and Channel Quality Indication, or CQI) is carried by HS-Dedicated Physical Control Channel (HS-DePCoCH).

The scheduling and HARQ functions are implemented in a new MAC entity (Medium Access Control) called MAC-hs (MAC-high speed, e.g., [4]). The MAC-hs is located in the Node B (Fig. 1). The MAC-hs layer (or entity) can be regarded as a layer composed of two sub-layers: the upper one and the lower one.

The lower MAC-hs sub-layer handles data (re)transmissions between the Node B and UE (User Equipment). The HARQ mechanism is based on an ARQ method: Stop and Wait. Up to 8 independent HARQ processes or instances can be simultaneously activated per UE ([4]), i.e. up to 8 MAC-hs PDUs can be handled at the same time. We denote MAC-hs PDUs as d-Blocks in the rest of paper. At most one HARQ process per UE can be activated in a T-slot.

The upper MAC-hs sub-layer manages flow control, reassembling/segmentation, numeration, and in-sequence data delivery to

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the upper layer. The in-sequence function is fulfilled by using a specific numbering and by using sliding transmission/receiving window. This paper investigates the MAC-hs performance for different window sizes and for different values of reordering release window timer (designated in 3GPP specification as timer T1).

The rest of the paper is organized as follows. The next section describes the MAC-hs protocol with the focus on the in-sequence data delivery function. The simulation model is presented in section III. Section IV describes simulation scenarios and results. The last section presents our conclusions.

2. MAC-hs protocol

The HSDPA can activate up to 8 priority queues per MAC-hs entity (per UE). The pot of HARQ processes is shared by all active queues. Each time a new d-Block is sent, the MAC-hs scheduler determines: UE, priority queue and a suitable d-Block size. The d-Block size selection is important since the size cannot be modified during retransmission attempt(s). A proposal dealing with this issue can be found in [5].

A d-Block is assigned a Transmission Sequence Number (TSN, modulo 64), Queue Id (3 bits) and HARQ Id (3 bits). The TSN and QId are carried in the MAC-hs PDU header, whereas HARQId is carried by HS-ShCoCH. Each priority queue manages numbering of d-Blocks (i.e. TSN) independently to other priority queues.

The assigned HARQ process controls d-Block (re)transmissions. If a retransmission occurs, the original d-Block size is kept constant and different MCSs (Modulation Coding Scheme) may be used. Different MCSs lead to different coded block sizes. We denote coded blocks as c-Blocks; a c-Block corresponds to a d-Block after applying channel coding.

The sorting of received d-Blocks is provided in a MAC-hs reordering entity. The scheduler may only send d-Blocks with TSN that lie within the sliding MAC-hs transmission window.

Notice that due to the multi-instance ARQ feature together with the specific numbering of d-Blocks, the MAC-hs retransmission mechanism behaves as if the ARQ scheme Selective Repeat were used.

D-Blocks that become out-of-date are discarded from the transmission buffer. No explicit signaling is done between the Node and UE when discarding data. The receiver is informed about a discard event implicitly: either (i) by expiration of the re-ordering release timer or (ii) by receiving a d-Block above the upper edge of the receiving window. We denote the first discard as timer discard and the second one as window discard.

The re-ordering release timer is called timer T1. The timer controls stall avoidance events in the UE reordering buffer. There is one timer per receiving priority queue. The T1 is initialized for a d-Block that cannot be delivered to the upper layer due to previous missing d-Block(s) in the MAC-hs reordering entity (e.g.; d-Block with TSN = x, d-Block$_x$). The T1 is stopped as soon as the d-Blockx is delivered to the upper layer.

If the T1 expires, the receiving window is advanced in such a way that: a) all correctly received data up to d-Blockx (inclusive) and b) all correctly in-sequence received data above d-Block$_x$ are delivered to the upper layer. If there is still a d-Block in the reordering entity that cannot be delivered to the upper layer, the T1 is restarted for that d-Block.

The receiving window is also updated and data discarded if a d-Block above the upper edge of the receiving window is obtained (i.e. the window discard occurs). The received d-Block forms a new upper edge of the window. If necessary, the T1 is activated in the same way as in case the of timer discard.

3. Model of simulation

A fixed number of UEs (= 10) is considered in the cell. The simulation model and layer architecture are illustrated in the figure below (Fig. 2).

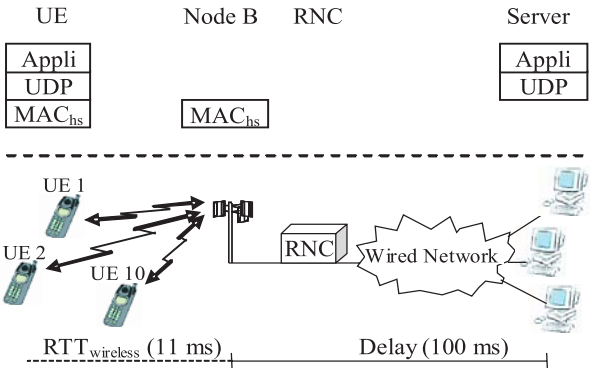

Fig. 2 Model of simulation.

MAC-hs scheduler. The scheduler is based on the Round Robin algorithm. The maximum number of HSDPA channelization codes that can be assigned in one T-slot is 12.

Radio conditions and MCSs. The variation of radio channel conditions is simulated via a variable SIR (Signal to Interference Ratio). The SIR follows a normal distribution N(μ, δ^2), where the mean μ = 0 and the standard deviation δ = 4 dB. The memory of the random process indicates a parameter T_v, $T_v \in$ (20 ms; 50 ms; 100 ms, 400 ms; 1.5 s). Table 1 shows the used MCSs and d-Blocks sizes.

ARQ. A MCS is selected in such way that SIR(MCS) $<$ $<$ SIR$_{NodeB}$', where SIR$_{NodeB}$' is the last known value of SIR in Node B for the given UE. The SIR(MCS) threshold values are given in Table 2 ([6]).

MCSs and size of d-Blocks. Tab. 1

	Size of MAC-hs PDU (data rates), MCSs					
Chann. codes	480 bits (240kb/s)	720 bits (360kb/s)	960 bits (480kb/s)	1440 bits (720kb/s)	1920 bits (960kb/s)	2880 bits (1,44Mb/s)
2	QPSK 1/4 (MCS4)	QPSK 1/3 (MCS5)	QPSK 1/2 (MCS6)	QPSK 3/4 (MCS7)	16QAM1/2 (MCS8)	16QAM 3/4 (MCS9)
4	QPSK 1/8 (MCS2)	QPSK 0,18 (MCS3)	QPSK 1/4 (MCS4)	QPSK 1/3 (MCS5)	QPSK 1/2 (MCS6)	QPSK 3/4 (MCS7)
6	QPSK 0,08 (MCS1)	QPSK 1/8 (MCS2)	QPSK 1/8 (MCS2)	QPSK 1/4 (MCS4)	QPSK 1/3 (MCS5)	QPSK 1/2 (MCS6)

SIR thresholds for different MCSs. Tab. 2

	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8	MCS9
SIR [dB]	−12	−7	−5	−4	−1	1	3	5	9

Due to feedback delay and scheduling, there is delay between the fresh SIRNodeB value and the moment of selecting MCS. The minimum (maximum) delay is set to be 6 ms (20 ms). When transmitting a new d-Block, the selected MCS can correspond to several d-Block sizes and the lowest one is chosen. The chosen MCS and d-Block size determine the number of channelisation codes that need to be used. Within retransmissions, MCSs are chosen from the column of corresponding d-Block size.

A HARQ instance in UE processes a c-Block according to the following procedure:

if $\mathrm{SIR(MCS)} < \mathrm{SIR_{UE}}$ then erroneous c-Block
else correctly decoded c-Block,

where $\mathrm{SIR_{UE}}$ gives the current value of SIR measured in the UE. The maximum number of retransmissions per c-Block is delimited by a parameter denoted in our paper as MaxDat; MaxDat = 2. The downlink and uplink signaling is assumed to be error free.

Traffic model. Every UE uses web-browsing running over UDP (User Data Protocol). A web-browsing session comprises of several packet calls or web pages. A packet call is followed by a reading time interval to view the download contents. The packet call size is modeled by Pareto random variable, with cutoff ($\alpha = 1.6$; min = 1.8 kB; max = 40kB, *mean* = 4.4kB [7]). The reading time follows an exponential random variable (*mean* = 5s).

4. Simulation

Simulation experiments are carried out for two MAC-hs sliding window sizes (4 and 16). In the Node B, a d-Block is discarded whenever a retransmission counter associated with c-Block reaches the value of MaxDat. In a UE, a d-Block is discarded either due to the timer discard or due to the window discards. Fig. 3 and Fig. 4 show a ratio of discarded d-Blocks in the Node B versus discarded d-Blocks in UEs (1).

For small values of T1 (20, 50, 100 ms), a UE discards more d-Blocks than the Node B does. A missing d-Block in a UE is discarded before the erroneous c-Block can be corrected through the retransmission mechanism. For higher values of T1 (400, 500 ms), the number of discarded d-Blocks in the Node B and UEs is the same. As the variation of channel conditions slows down (values of T_v increase), the ratio (1) gets smaller for the $T1 = 20$ ms. For higher values of $T1$ (50, 100 ms), the ratio (1) increases.

Larger MAC-hs window size has little impact on the number of discarded d-Blocks (Fig. 4); graphs in Fig. 3 and Fig. 4 are about the same.

Let's now investigate which of the UE's discard mechanisms dominates: timer discard or window discard. The ratio of discarded d-Blocks due to the window discard versus all discarded d-Blocks in UEs is shown in Fig. 5 and Fig. 6 (2).

$$\frac{\sum_{NodeB} \textit{discarded blocks duet to the Max Dat discard}}{\sum_{UE} \textit{discarded blocks due to the timer discard} + \sum_{UE} \textit{discarded blocks due to the window discard}} \tag{1}$$

$$\frac{\sum_{UE} \textit{discarded blocks due to the window discard}}{\sum_{UE} \textit{discarded blocks due to the timer discard} + \sum_{UE} \textit{discarded blocks due to the window discard}} \tag{2}$$

Fig. 5 shows that for $T1 = 20$ ms, the timer discard dominates, no matter how fast the channel conditions change. Just a few d-Blocks are discarded due to the window discard; the value of $T1$ is so small that missing d-Blocks in UEs are discarded before the MAC-hs retransmission mechanism can take steps. For other values of $T1$, the window discard becomes more and more important as the variation of channel conditions slow down (values of T_v increase). The discarded d-Blocks in the Node B are detected in UEs by receiving d-Blocks above the upper edge of the receiving window. When setting the window to larger size, more d-Blocks are processed at the same time. The transmission delay of d-Blocks increases and the timer discard becomes more important (Fig.6).

4. Conclusions

The paper studies performance of the MAC-hs protocol for different window sizes and for different values of the release window timer T1.

Simulations show that values of T1 and MaxDat have to be adequately set up. Setting up values of T1 too small, compared to values of MaxDat, results in more discarded d-Blocks in UEs than the Node B discards. D-Blocks are discarded in the UE due to the timer discard. In other words, unnecessary discarded d-Blocks at the MAC-hs level deteriorates received data from the user's point of view. For example, the discarded data can degrade a received audio/video signal. If a reliable data transfer is required, the unnecessary discarded data at the MAC-hs level has to be retransmitted through retransmission mechanisms of a higher layer (e.g., RLC or TCP). However, this results in an increase in transmission delay as well as in higher user cost.

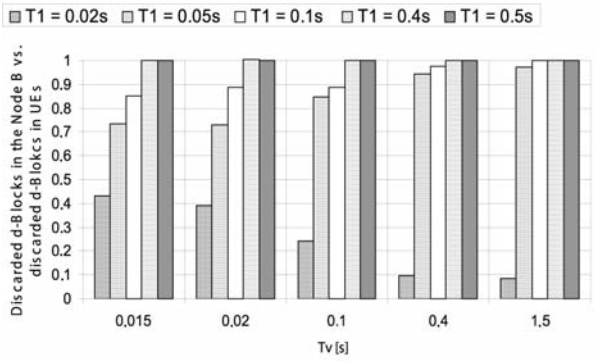

Fig. 3

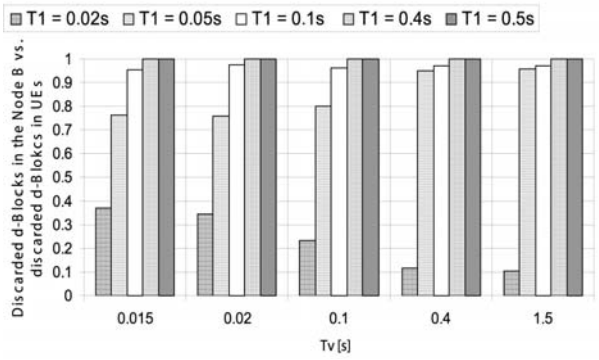

Fig. 4

Fig. 3, Fig. 4 Ratio of discarded d-Blocks in the Node B versus discarded d-Blocks in UEs, window size = 4 (Fig. 3) or window size = 16 (Fig.4).

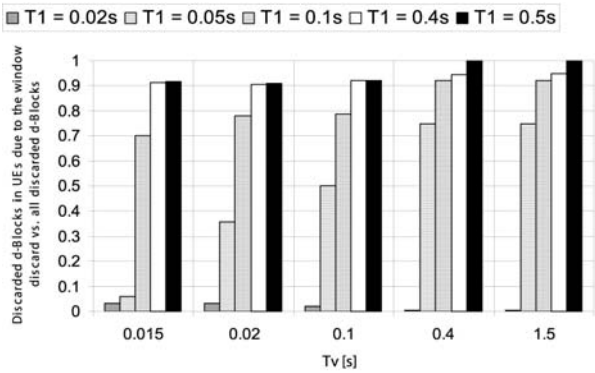

Fig. 5

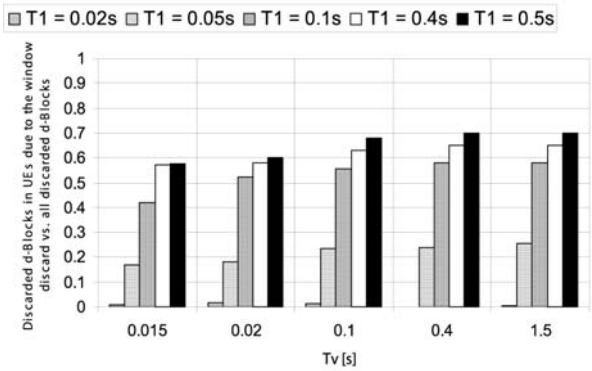

Fig. 6

Fig. 5, Fig. 6 Ratio of discarded d-Blocks in a UE due to the window discard versus all discarded d-Blocks; window size = 4 (Fig. 5) or window size = 16 (Fig.6).

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SIGNIFICATION OF DEPTH OF PENETRATION IN EDDY CURRENT NON-DESTRUCTIVE TESTING

Eddy currents are utilized for non-destructive testing of conductive materials. The depth of penetration is a very important parameter as it defines the propagation of the electromagnetic wave as well as of the electromagnetic energy in conductive materials. Limitations of the non-destructive testing using eddy currents are therefore given by the parameter. The paper highlights the signification of the depth of penetration in eddy current non-destructive testing using numerical simulations. A tubular specimen with a defect of a variable depth is inspected using a bobbin type probe and the crack signals are calculated for the purpose. The finite element method is used for the numerical study.

1. Introduction

Non-destructive testing (NDT) is utilized to examine structural components because of localization and characterization of material properties' degradation (i.e. crack) that might cause malfunction of a component (e.g. reactors to fail, trains to derail, pipelines to burst, etc.) with economical and ecological impacts. The NDT is performed to assure consequent faultless operation of an inspected object without any mechanical damage. Recently, NDT methods are used not only for localization of a crack, but also for characterization of its size, shape, and orientation [1].

The number of NDT methods continuously grows as there are increasing demands for the inspection of structural components in different applications. However, six major NDT methods are mostly utilized, namely penetrant testing, magnetic particle testing, electromagnetic or eddy current testing (ECT), radiography, and ultrasonic testing.

This paper concentrates on the eddy current non-destructive testing. Numerical simulations of electromagnetic field distribution using the finite element method are done to simulate inspection of a tubular specimen with a defect of a variable depth. A bobbin type probe is used for the testing. Different frequencies of an excitation current are considered to highlight the signification of the depth of penetration in eddy current non-destructive testing.

2. Eddy current non-destructive testing

An inductance coil driven by an alternating current generates an alternating electromagnetic field [1]. When a conductive material is placed in proximity of the coil, the electromotive force is induced in the material and eddy currents (EC) flow there according to the electromotive force. The primary, exciting, electromagnetic field produced by the exciting coil is attenuated by a secondary, reaction, magnetic field generated by eddy currents. If the flow pattern of eddy currents is changed by a presence of an anomaly, it influences the reaction field and, therefore, also the exciting electromagnetic field. This change can be measured as a variation in the coil impedance. In a case of a transmitter – receiver probe, the field fluctuation is sensed through the change of induced voltage in a pick-up coil. Exact location of a defect can be evaluated by tracking of the measured signal when the probe is moved over the surface of a material.

There are several possible configurations of eddy current testing probes. The probe consists of at least one exciting coil and one detecting coil to pick-up the signal. Although, only one coil is used for both purposes in absolute probe [2]. The design of the probe has to allow surface testing of an examined material. The measured values of the impedance or the induced voltage are gathered to a computer or they are displayed and visually evaluated on a scope. It is common to plot the eddy current signals in the complex plane as not only the amplitude but also the phase of the signal carries important information about any change in material properties.

One of the major advantages of ECT is the variety of inspections and measurements that can be performed. ECT can be used for:

- crack detection,
- material thickness measurements,
- coating thickness measurements,
- conductivity measurements [3].

ECT is sensitive to small cracks and it is used for detection of surface and near surface defects. There is no need for physical contact between the probe and an inspected material and the inspection gives immediate results. Despite all the mentioned advantages there are several drawbacks. Only conductive materials can be inspected while the volumetric inspection is limited by the depth of penetration.

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3. Electromagnetic waves propagation and the depth of penetration

The theory of quasi-stationary electromagnetic field is used for theoretical description of eddy currents in conductive media. The simplified Maxwell equations [4], [5] well define the problem as the displacement current $\partial\mathbf{D}/\partial t$ is eliminated from the equations because conductive currents are dominant in ECT as the problem is solved in conductive materials.

Propagation of the electromagnetic waves in the air and in the material can be described by wave equations [4]. It is possible to write a wave equation for any properly defined vector or scalar function (e.g. **E**, **H**, **B**, **D**, **A**, **V**, etc.) in general [4]. By using time-harmonic domain, the equations can be simplified using only one element of a vector function. Consecutively, the wave equation, which is described a wave propagated along the z direction in Cartesian coordinate system, is given

$$\frac{d^2 E_x}{dx^2} + \omega^2 \mu\varepsilon E_x, \tag{1}$$

where ω is an angle frequency [rad/s], μ is a permeability [H/m] and ε is a permittivity [F/m]. As it can be seen, this equation is without right side that means there are no sources. In general (for all material types), the permittivity is considered as a complex number where the real part is the permittivity of a material and the imaginary part consists of two elements, the first one represents the conduction current and the second one describes the polarization losses. The complex permittivity is substituted into the equation (1) and then it can be written

$$\frac{d^2 E_x}{dx^2} - \gamma^2 E_x = 0, \text{ where } \gamma^2 = -\omega^2 \mu\varepsilon \left(1 - \frac{\mathrm{j}\sigma}{\omega\varepsilon}\right). \tag{2}$$

The propagation constant γ can then be expressed in a following way

$$\gamma = \mathrm{j}\omega\sqrt{\mu\varepsilon}\sqrt{\left(1 - \frac{\mathrm{j}\sigma}{\omega\varepsilon}\right)} = \alpha + \mathrm{j}\beta, \tag{3}$$

where α is an attenuation constant [1/m], β is a phase constant [rad/m] and σ is an electric conductivity [S/m].

The losses are large ($\sigma >> \omega\varepsilon$) in highly conductive materials and, therefore, the equation (3) can be simplified and it defines the depth of penetration δ [m]

$$\delta = \frac{1}{\sqrt{\pi f \mu\sigma}} = \frac{1}{\alpha} = \frac{1}{\beta}, \tag{4}$$

where f is a frequency [Hz]. Equation

$$E_x(z) = E_0^+ e^{-\gamma} = E_0^+ e^{-z/\delta} e^{-\mathrm{j}z/\delta} \tag{5}$$

is a solution of the wave equation (2) for a propagating wave along the positive z direction. It is possible to write an equation for the x component of current density J_x in the similar way. It means that electromagnetic wave or induced eddy currents are attenuated in the highly conductive material by $e^{-\alpha z}$ and the phase lag is changed by $e^{-\mathrm{j}\beta z}$ (Fig. 1). The wave is attenuated to the $1/e$ of its original amplitude in the depth δ inside the material.

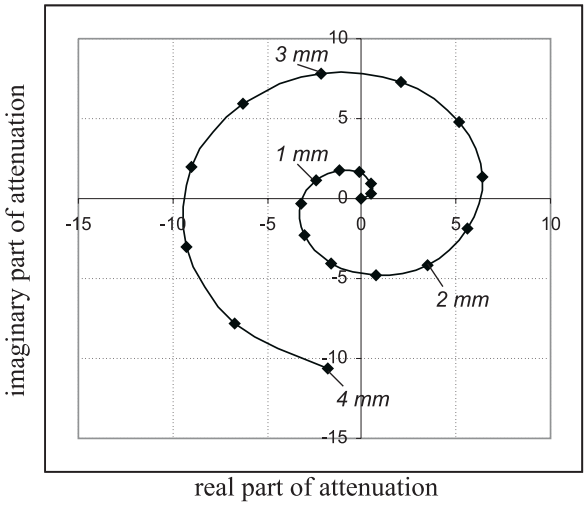

Fig. 1 Attenuation spiral of field value in the material with δ = 0.37 mm

4. Measurement of frequency influence to the crack detection

The depth of penetration and hence the rate of the electromagnetic wave attenuation significantly depend on the exciting frequency, the permeability and the conductivity of an inspected material. As the electromagnetic parameters, μ and σ, of the inspected material are fixed, it is not possible to vary any of them. Thus, it is necessary to choose the appropriate frequency of the exciting electromagnetic field for the inspection. The influence of variation in the excitation frequency to the field distribution during the inner tube inspection is presented in this part of the paper. An axisymmetric excitation coil is located inside a tube. A defect (crack) is positioned under the exciter on the inner surface of the tube and its depth is changed from 0 to 100 % of a tube wall thickness in a step of 20 %. The total exciting current is 10 A. The electromagnetic properties of a tube are defined as $\mu_r = 1$ and $\sigma = 5.8e7$ S/m (pure copper), Fig. 2.

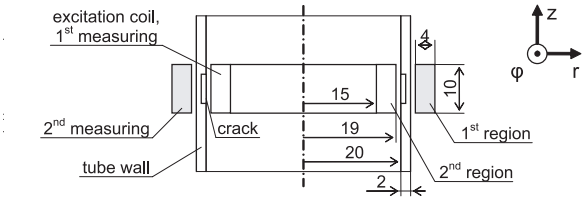

Fig. 2 Simulation model (all descriebed regions are axially symmetrical and defined in cylindric coordinate system)

A 2D axisymmetric program based on the finite element method is used for calculating the electromagnetic field distribution. The simulations are done for frequencies of 1, 2, 4, 8, 16 and 32 kHz. The φ component of the vector of electrical intensity (in cylindric coordinate system) is calculated in two regions to inter-

pret the field. The first one is a region of the excitation coil. The second region is a symmetric one to the first region but it is placed on the opposite site of the tube wall (Fig. 2). The results from the simulations are given as the integration of E_φ in the regions. The mean value of the electrical intensity E can be calculated using equation (6)

$$E = \frac{1}{S}\int_S E_\varphi \, dS, \tag{6}$$

where S is the cross-section of region and its value is $S = 4e{-}5$ m^2 for both the regions. The result from the first region is denoted as E1 and from the second one as E_2.

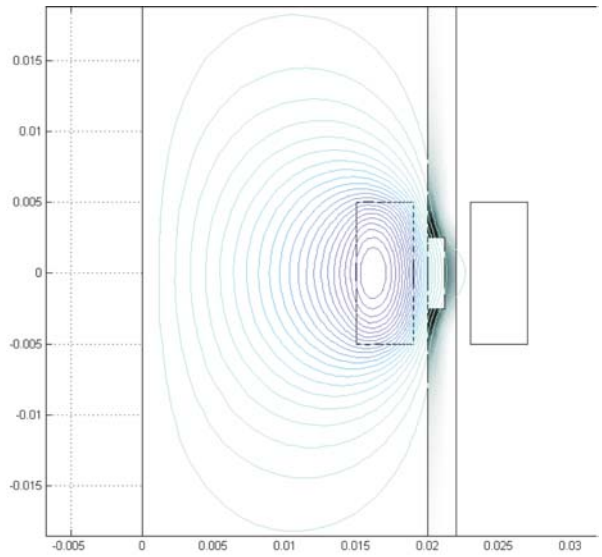

Fig. 3. Absolute values of the electric field intensity (contours) and the induced current density (grey scale, max = black)

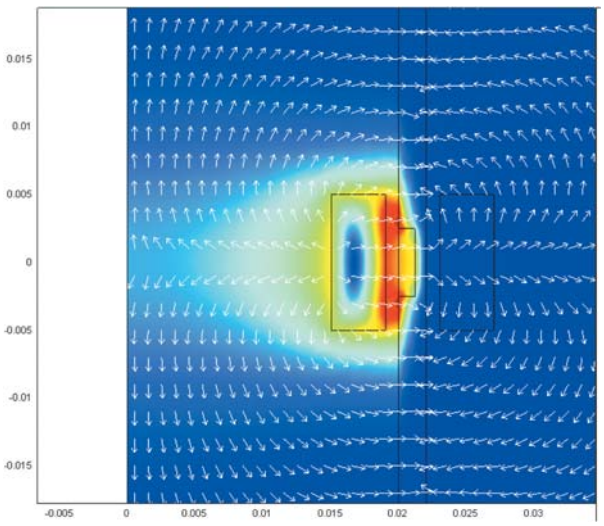

Fig. 4. Absolute values of the magnetic flux density (colour scale, max = red) and the power flow density (normalized arrows)

The simulated components of the electromagnetic field for $f = 8$ kHz and crack of 60 % in depth can be seen in Figs. 3 and 4. Because the problem is an axisymmetric one it is sufficient to simulate only one half of it.

The relationship between the depth of penetration and the chosen frequencies, counted for the material which is used in simulations (pure copper), shows Fig. 5.

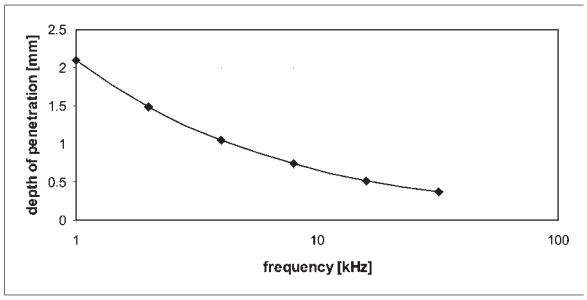

Fig. 5. Relationship between the depth of penetration parameter and the frequency for the constant parameters of material (pure copper)

Fig. 6 shows how the penetration of the field through the tube wall given by E_1/E_2 ratio depends on the depth of the crack. The depth of penetration is only 0.37 mm for the frequency of 32 kHz which is the reason for the maximal E_1/E_2 ratios difference between 0 % and 100 % cracks. The difference for 1 kHz (where $\delta = 2.09$ mm) is a minimal one.

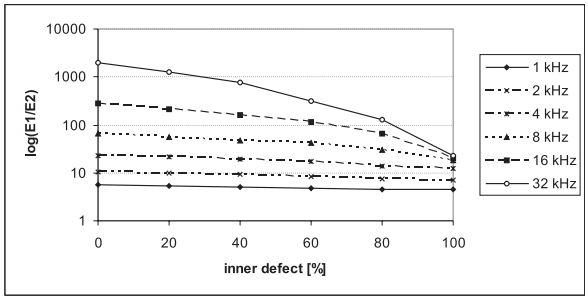

Fig. 6. Rate of penetration of the field throught the tube wall depending up to depth of inner defect (% of the wall thickness)

In the graphs shown in Figs. 7 and 8 only the results for the first region (inside tube) are shown because that is the side of the exciting coil. The value of E_1 for 0 % crack is taken as a reference value and this reference is subtracted from the signals of deeper cracks. Therefore, such defined relative values are given in the plots. As it can be seen in Fig. 7, the higher relative values of field intensities are obtained for the higher frequencies that mean better sensitivity to the crack using higher frequencies (32 kHz). On the other hand, Fig. 8 shows that the probe is not very sensitive for deeper cracks recognition using the high frequency (32 kHz) however using the low frequency excitation (1 kHz) it is

almost equally sensitive to all the depths of the crack, which is an issue of the depth of penetration.

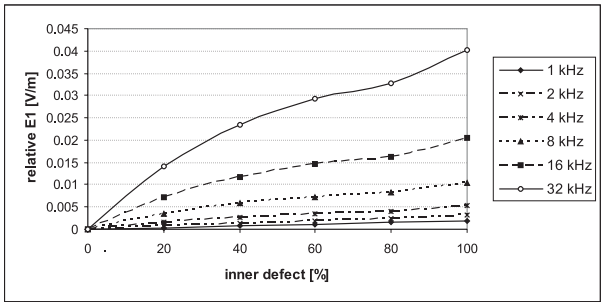

Fig. 7. Relative value of E1

5. Conclusion

Based on the simulation results presented in the paper it can be concluded that the selection of the appropriate inspection frequency depends on the material properties as well as on the expected character of a defect. It is necessary to make a compromise between an intensity of the measured signal (high frequency) and sensitivity to an increasing depth of a defect (low frequency). The depth of penetration can help with this choice and hence it is one of the most important parameters in EC method of NDT. Accordingly, it is possible to allege that the depth of penetration shows limitations of the method e.g. maximum accessible depth of material.

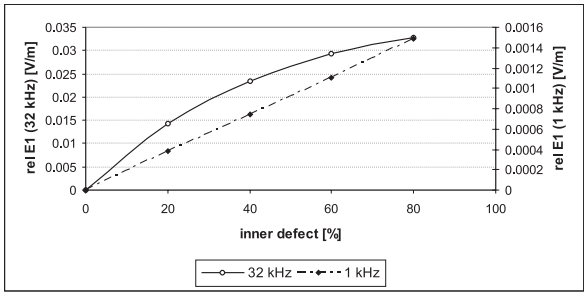

Fig. 8. Relative value of E1 calculated for 1 and 32 kHz

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Jacek Chałupczak – Tomasz Miłek *

COMPARISON OF SIMULATION AND EXPERIMENTAL AXIAL LOADINGS FOR HYDROMECHANICAL BULGE FORMING OF COPPER CROSS-JOINTS

Hydromechanical bulging is applied mainly to the series production of hydraulic installation and sanitary facilities including tubes with a changeable diameter, T-pipes and cross-joints. The process consists in placing a tube segment in a die-cavity, pouring some liquid over it and sealing the faces. As a result the liquid pressure rises and the pipe is upset. The basic parameters of the hydromechanical process of bulge forming are: liquid pressure and axial loading. The simulations of hydromechanical bulge forming were performed using MSC Marc software based on the finite element method. The calculation results were compared with the experimental data especially to study axial loading for different ratios d/D, s_o/D and for different variations of internal pressure. The results of numerical simulations of axial loading are in good agreement with the experimental data for established μ = 0,15.

1. Introduction

The method of hydromechanical bulging of cross-joints was patented in 1973 [1]. Since then many research teams have been investigating the problem especially for steel *T*-pipes and cross-joints [2-8]. The technology involves placing a tube segment in a die-cavity, pouring some liquid over it, and sealing the faces. As can be seen from Fig. 1, the rising pressure of the liquid upsets the pipe.

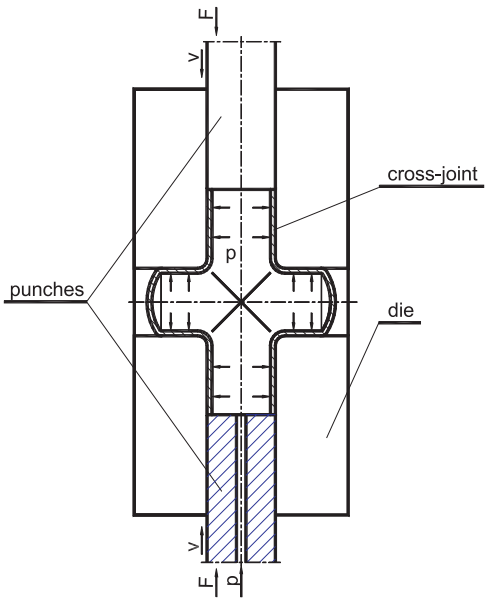

Fig. 1. Bulge forming of a cross-joint

As a result, we obtain bulged cross-joints with identical or different branch and outer diameters, the shape and dimensions being presented in Fig. 2.

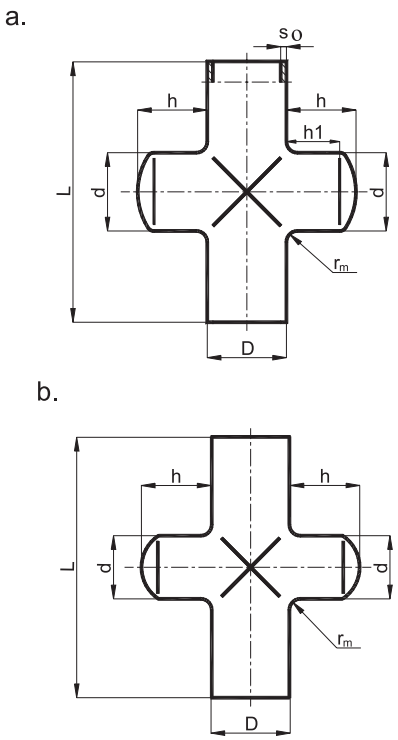

Fig. 2. Shapes and dimensions of cross-joints: a) with d/D=1; b) with d/D<1.

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Except for the liquid pressure, the upsetting force is also responsible for hydromechanical bulge forming. As the stub pipe bulge on two sides, the lengths can be considerable. By applying appropriate pressure, it is possible to obtain a cross-joint with exactly the same dimensions – radius and diameter – as those of the die-cavity.

The paper discusses the significance of the upsetting forces in the hydromechanical bulge forming of copper cross-joints with the same and different branch and outer diameters. The forces values obtained by computer modelling were compared with the experimental data. The analysis takes into account various d/D and s_o/D ratios and pressure changes.

2. Methodology

MacNeal-Schwendler software was used for modelling. The basic calculation package was the general-purpose MSC. Marc program [4-7]. As the analysis concerned plastic working, it was required to apply MES program as well. The model was developed and analysed with the aid of MSC/MENTAT presented in [6]. A simulation of the hydromechanical bulge forming process was conducted for copper cross-joints with a relative wall thickness $s_o/D = 0.05$.

Table 1 presents the dimensions and mechanical properties of the samples of copper pipe sections used both in the modelling and testing of the bulged pipes. The properties were determined experimentally by static tensile testing (columns 4–7) and using the Heyer method of stepped specimens (columns 8–9).

The calculations and the experiment aimed at the following final geometry: length of the tubular blank section after bulging $l = 70$ mm, diameters of the stub pipes $d = 20$ mm and $d = 22$ mm if all diameters are identical ($d/D = 1$) and $d = 18$ mm and $d = 16$ mm if the diameters are different ($d/D = 0.9$ and $d/D = 0.8$ respectively).

The pipe was covered with a square mesh consisting of 7800 coating type elements, the thickness of which was established to be 1 mm. It was assumed that the matrix and dies/ were stiff rigid enough and could not be affected by any deformations [4-7]. The physical and mechanical properties of the deformed elements were compared with those of a model of a uniform material with good elasticity and plasticity. Thus, we had $\sigma_p = 524\ \varphi^{0.33}$ for pipes with $s_o/D = 0.05$, and $\sigma_p = 517\ \varphi^{0.27}$ for pipes with $s_o/D = 0.068$. In the simulation, the changes in pressure p, which were dependent on the relative pipe bulging $\Delta l/l_o$, were assumed from the experimental data [3, 7, 8] obtained with a test facility described in [8]. The values of the coefficients of friction, $\mu = 0.1$ and 0.15, were assumed to be the same as in [2].

3. Simulations and experimental results

The graph in Fig. 3 shows selected values of the upsetting forces obtained in the simulation and experiment. In this case, the cross-joints were hydromechanically bulged for a selected change in pressure (Fig. 3b) and the ratios $d/D = 1$; $s_o/D = 0.05$ assuming that the coefficient of friction μ was equal to 0.1 and 0.15 in the simulation.

As can be seen from Fig. 4, a decrease in the d/D ratio causes an increase in the pressure force of the stub pipes. While bulging at $\Delta l/l_o = 0.42$ the difference between the maximum values for $d/D = 0.8$ (55kN), and $d/D = 1$ (46kN) is 16.3%. The difference between the minimum values, on the other hand, $d/D = 0.9$ (48.6%), and $d/D = 1$ (46kN) amounts to approximately 5.3%.

In cross-joints with the relative wall thickness $s_0/D = 0.068$, the changes in the upsetting forces for various d/D are similar to those with $s_0/D = 0.05$; the values of the upsetting forces, however, turn out to be greater not only due to greater pressures but also due to thicker wall at the ends and in the centre of the cross-joints. The difference in the values of the forces for cross-joints with $s_0/D = 0.068$ ($d/D = 1 - 73$kN and $d/D = 0.9 - 81$kN) at $\Delta l/l_o = 0.42$ was 9.8%.

As the maximum values of the forces had to be assessed, the following tabulation was made (Table 2).

The greatest coincidence of the maximum values of upsetting forces obtained in the simulation and the experiment was reported for the assumed coefficient of friction μ equal to 0.15. The difference ranged 4.54–16.85%. The simulation results were almost always smaller than the experimental data. The only exception concerned the modelling of a cross-joint with $s_o/D = 0.05$ and $d/D = 1$, where the maximum force was 4.54% greater than that in the experiment. This was the case when the smallest difference between the force values was established for $\Delta l/l_o = 0.42$.

4. Conclusions

1. The values of the forces responsible for the bulge forming process calculated by computer modelling were reported to

Dimensions and mechanical properties of copper tubes — Table 1

D_0 x s_0 [mm]	l_0 [mm]	s_0/D_0	R_m [MPa]	A [%]	$A11.3$ [%]	Z [%]	n	C [MPa]
1	2	3	4	5	6	7	8	9
∅ 20 × 1	120	0.05	268	31.4	29.7	49.7	0.33	524
∅ 22 × 1.5	120	0.068	283.2	44.25	33	53.9	0.27	516.8

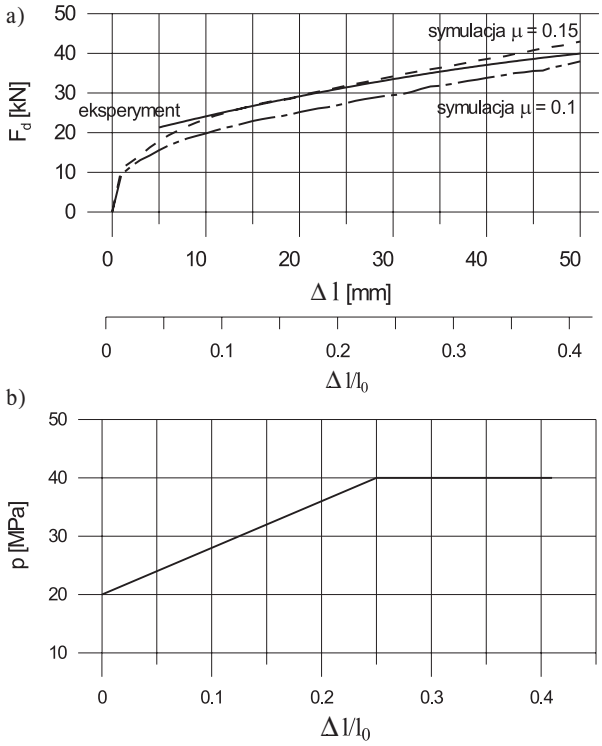

Fig 3. Comparison of the force waveforms (a) obtained by simulation and experimentally for copper cross joints at $s_o/D = 0.05$ and $d/D = 1$ hydro-mechanically bulged due to pressure changes, b) at the assumed coefficient of friction $\mu = 0.1$ and $\mu = 0.15$,

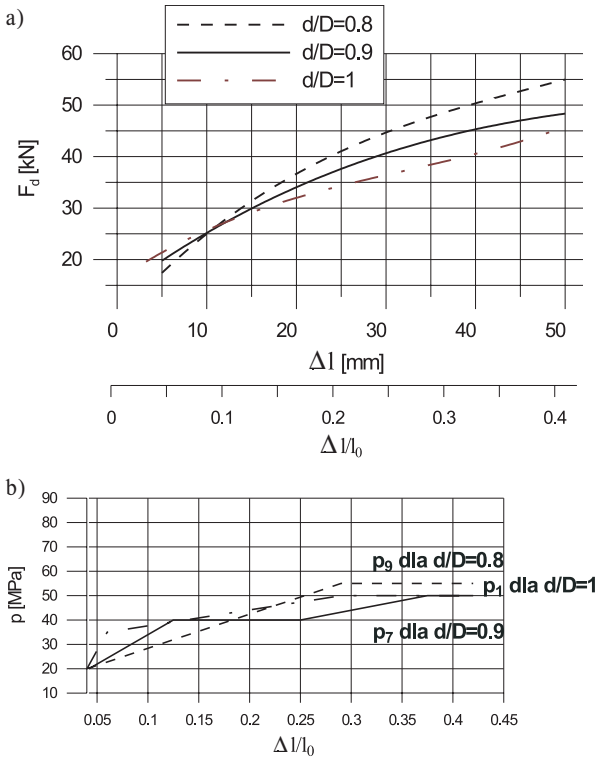

Fig. 4 Comparison of the force waveforms obtained experimentally for a) copper cross joints at $s_o/D = 0.05$ and $d/D = 1$, $d/D = 0.9$, $d/D = 0.8$ hydro-mechanically bulged by means of pressure changes, b) at the assumed coefficient of friction $\mu = 0.1$

A summary of maximum values of upsetting forces obtained by simulation and experiments performed for selected pressure changes

Table 2

Outer diameter of the tubular blank	Tube wall thickness	Relative wall thickness	Pipe branch diameter	Ratio of the pipe branch diameter to the outer diameter of body	Established course of pressure	Maximum values of the axial loading for $\Delta l/l_0 = 0.42$	
D [mm]	s_o [mm]	s_o/D	d [mm]	d/D	p [MPa]	Simulation [kN]	Experiment [kN]
1	2	3	4	5	6	7	8
20	1	0.05	20	1	20–50	39.65 ($\mu = 0.1$)	46
					20–40	37.97 ($\mu = 0.1$) 42.95 ($\mu = 0.15$)	40
			18	0.9	20–50	42.19 ($\mu = 0.1$)	48.6
			16	0.8	20–55	46.69 ($\mu = 0.1$)	55
22	1.5	0.068	22	1	30–80	60.7 ($\mu = 0.15$)	73
			20	0.9	40–80	75 ($\mu = 0.15$)	81

be highly dependent on the assumed values of the friction coefficient. The greatest agreement of the simulation and experimental data was reported for $\mu = 0.15$.

2. The value of the upsetting force in the bulge forming of cross-joints increases:
   - if there is a rise in the pressure used for the bulging; this is due to the fact that the greater the pressure, the greater the loads of the liquid on the swelling dies faces; moreover, this causes an increase in unit loads [2] in the contact area of the cross-joint and the die cavity,

- if there is a rise in the relative bulging ratio $\Delta l/l_o$, caused by an increase in the wall thickness in body area of the cross-joint [7] and in the material strength [4],
- if there is a decrease in the d/D ratio caused for example by greater plastifying stresses [4] in body area near the faces.

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Árpád Veress – József Rohács – Imre Sánta – Tamás Gausz *

DIRECT NUMERICAL OPTIMISATION OF A FUEL JET PUMP BASED ON A PSEUDO-COMPRESSIBILITY METHOD USING CHARACTERISTIC BOUNDARY CONDITIONS

The paper tries to give an overview of the latest industrial development of the Department of Aircraft and Ships at the Budapest University of Technology and Economics.

The numerical investigation presented below based on Chorin's pseudo-compressibility method is used to make the incompressible Euler equations artificially hyperbolic [1]. A less dissipative flux difference splitting method is evolved to solve governing equations. A low cost 4th order Runge-Kutta method is applied for time marching in pseudo space. Both extrapolated and characteristic type boundary conditions are examined and compared with each other in qualitative accuracy and convergence point of view. Using the described computational tool a direct numerical optimisation of a fuel jet pump is performed.

Notation

Arabian

A	Jacobian of flux F
$a_{i,j}$	Element of A matrix
a	Pseudo sound speed
c	Dumping coefficient
e	Unit vector
F	x com. of convective flux vec.
G	y com. of convective flux vec.
$\vec{H}$	Total flux vector
k	Stiffness coefficient
L	Left eigenvector matrix
$\dot{m}$	Mass flow
N_p	Number of points in comp. domain
N_f	Number of faces over the cell
$\vec{n}$	Outside pointing unit normal vector
P	Pseudo-compressibility parameter
p	Static pressure
t	Time
v	y direction velocity
W	Vector of characteristic variables
x,y,z	Cartesian space
U	Vector of conservative variables
u	x direction velocity
$\vec{V}$	Velocity vector
$\dot{V}$	Volume flow

Greek

α_k	Runge-Kutta coefficient
α	Damping coefficient
β	Compressibility parameter
ε	Volume flow rate
Γ	Boundary of control surface
λ_i	Eigenvalues of matrix A
τ	Weighting parameter
Ω	Control surface

1. Numerical method

1.1 Governing equations

The Euler equations can be derived from Newton's second law applied to a cubic fluid element only considering pressure forces and external forces. 2D incompressible Euler equations with the extension of the pseudo-incompressible term in dimensional form are given by [1]

$$\frac{\partial U}{\partial t} + \frac{\partial F(U)}{\partial x} + \frac{\partial G(U)}{\partial y} = 0, \tag{1}$$

where

$$U = [P/\beta^2, u, v]^T, F(U) = [u, u^2 + P, uv]^T \text{ and}$$

$$G(U) = [v, uv, v^2 + P]^T. \tag{2}$$

In this context p is the static pressure, ρ is the density, u and v is the Cartesian components of velocity vector, β is the compressibility factor with the typical value of 3 and $P = p/\rho$. In order to satisfy consistency, when the steady state condition is reached, the first term of the continuity equation is vanished so the original form of the incompressible Euler equations is recovered. Introduction of total flux vector, $\vec{H}$, system (1) in compact form becomes

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$$\frac{\partial U}{\partial t} + \vec{\nabla} \cdot \vec{H}(U) = 0. \tag{3}$$

Integrating system (3) over a control volume Ω, which is bounded by interface Γ and applying the Gauss divergence theorem, one gets

$$\frac{\partial}{\partial t} \iint_{\Omega} U d\Omega + \int_{\Gamma} \vec{H}\vec{n} d\Gamma = 0, \tag{4}$$

where $\vec{n} = (n_x, n_y)$ is the local outside pointing unit vector and so

$$H_n = \vec{H}\vec{n} = \begin{pmatrix} V_n \beta^2 \\ uV_n + Pn_x \\ vV_n + Pn_y \end{pmatrix}, \tag{5}$$

where $V_n (V_n = \vec{V}\vec{n} = (u\vec{e}_x + v\vec{e}_y)(n_x\vec{e}_x + n_y\vec{e}_y) = un_x + vn_y)$ is the normal component of velocity vector.

1.2 Discretization

Concerning the system (4), in order to pass from continuous to a discrete form, a choice about the type of representation of the solution vector over the cell centered finite volume has to be made:

$$U_j = \frac{1}{\Omega_j} \iint_{\Omega_j} U \, d\Omega \,. \tag{6}$$

By substituting (6) into the first integral in equation (4), and replacing the second integral by a summation over the number of faces N_f of the chosen control volume Ω_j, equation (4) can be written in the following semi-discrete form for the point *j*:

$$\frac{\partial}{\partial t} U_j = -\frac{1}{\Omega_j} \sum_{k=1}^{N_j} [H_n]_{j,k} \, \Gamma_{j,k} \,. \tag{7}$$

For a higher order reconstruction κ-class of a higher order scheme approach is used for determining the cell face flux function using flow variables at left and right states [2].

In case of spatial discretisation, flux difference splitting methods have the lowest level of indispensable dissipation compared with the other type of splitting or artificial dissipation methods. This feature is also important in the extension of the code for accurate modeling of shear layers in viscous flow. Hence, the total flux functions (5) at the interface of two adjacent cells are written in following form

$$H_n = \frac{1}{2}(H_{n,i} + H_{n,i+1}) + \frac{1}{2}(\hat{R}\hat{\Lambda}^{-}\hat{L} + \hat{R}\hat{\Lambda}^{+}\hat{L})\Delta U, \tag{8}$$

where $\hat{R}$, $\hat{L} = \hat{R}^{-1}$ are the right and left eigenvector-matrixes composed by an average of right an left states:

$$\hat{R} = \begin{pmatrix} 0 & \beta^2 a & -\beta^2 a \\ -n_y & \beta^2 n_x + u(V_n + a) & \beta^2 n_x + u(V_n - a) \\ n_x & \beta^2 n_y + v(V_n + a) & \beta^2 n_y + v(V_n + a) \end{pmatrix}, \tag{9}$$

where $a = \sqrt{V_n^2 + \beta^2}$ is the pseudo sound speed and $\Lambda^{\pm}$ are the positive and negative eigenvalue-matrixes respectively.

For marching in pseudo time the computationally inexpensive fourth order Runge-Kutta method is used to solve equation (7):

$$\begin{aligned} U^0 &= U^n \\ U^k &= U^0 + \alpha_k \Delta t \Re(U^{k-1}) \quad k = 1, \ldots 4 \text{ and} \\ U^{n+1} &= U^m \end{aligned}$$

$$\alpha_k = \frac{1}{k_{max} + 1 - k} \,. \tag{10}$$

1.3 Boundary conditions

The governing equations are of hyperbolic type, so the number of physical and numerical boundary conditions is determined by the theory of characteristics (inlet: p_m^{to}, α_{in}, outlet: p_{out}^{st}, and mirror solid wall). The numerical boundary conditions are computed by both linear extrapolation and characteristic type manner and they are compared with each other by means of qualitative accuracy and number of iteration.

In case of linear extrapolation the unknown numerical flow variables are determined by a simple linear extrapolation.

The system of Euler equations is the hyperbolic type and it can be described by the wave like behaviour, the information propagates along the characteristics. The slope of these characteristic curves is determined by the eigenvalues of Jacobian, while the unknowns are written in the expression of characteristic variables, which are constants along their characteristic lines, along which the information propagates. Take the theory of characteristic into consideration; more consistent boundary treatment is available for determination of numerical boundary conditions expecting less number of iteration.

There is one outgoing characteristic at the inlet, which means that

$$\begin{aligned} W_n^{(3)} &= (V_n + a)_I \, p_I - \beta^2 V_{n,I} = \\ &= (V_n + a)_{B = \lim\limits_{t \to \infty} I} \, p_B - \beta^2 V_{n,B} \end{aligned} \tag{11}$$

relation should keep over the boundary per iterations (*I*: inner parameters, *B*: boundary values). Using equation:

$$V_n = V\left(\frac{-n_x - n_y \, tg\alpha}{\sqrt{1 + tg^2\alpha}}\right) \tag{12}$$

(α is the flow angle, V is the length of velocity vector) equation (11) leads to a second degree equation for V_B to solve. Finally all other numerical unknowns are easy to be recovered.

There are two ingoing chraracteristics at the otlet, which means that next charactersitic variables should be kept constant:

$$\begin{aligned} W_n^{(1)} &= V_{t,I} = V_{t,B}, \; W_n^{(2)} = (V_n - a)_I \, p_I - \beta^2 V_{n,I} = \\ &= (V_n - a)_{B = \lim\limits_{t \to \infty} I} \, p_B - \beta^2 V_{n,B}, \end{aligned} \tag{13}$$

where V_t is the covariant velocity. Equations (13) contain only two unknowns, namely $V_{t,B}$ and $V_{n,B}$ to determine explicitly. Finally the components of velocity vector can easily be calculated.

1.4 Validation

Circular bump in 2D channel test case is used for validation [3]. The results of own code and FLUENT commercial software

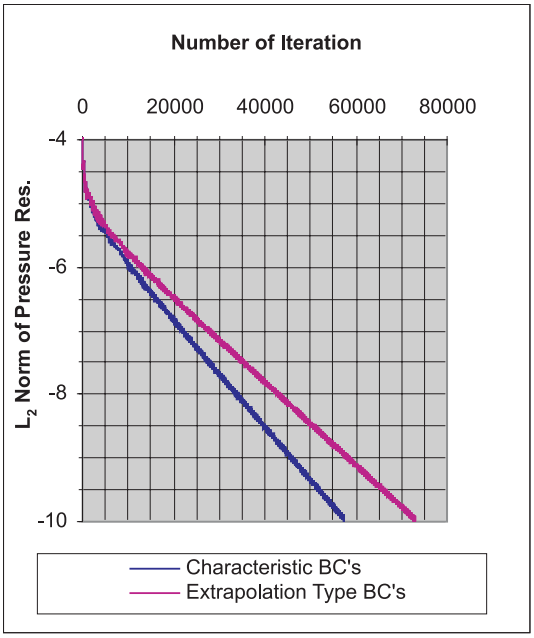

Fig. 1. Comparison of convergence history by means of extrapolation and characteristic types boundary conditions

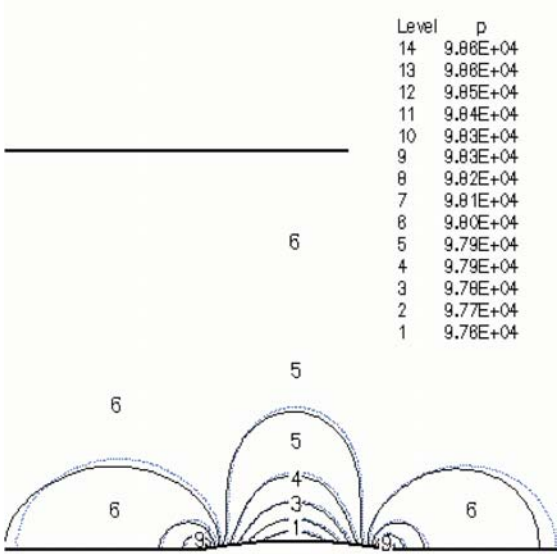

Fig. 2. Comparison of pressure distribution: solid line: FLUENT commercial code, dotted line: own code

are compared with each other at the same geometry, initial and physical boundary conditions. The difference between two results can be found in Fig. 2 and it can be concluded that the difference is negligible. The pressure distributions with the application of two different boundary conditions cover each almost exactly. The characteristic type inlet and outlet boundary condition shows significant improvements (Fig. 1) concerning the number of iteration and so reduces computational time compared to the extrapolation type one. The convergence rate is characterised by the normalized L_2 norm of pressure residual:

$$\left\| \frac{\Delta p}{p} \right\| = \log_{10} \sqrt{\frac{1}{N_p} \sum_{i=1}^{N_p} \left(\frac{\Delta p_t}{p_t} \right)^2} . \qquad (14)$$

All the numerical computations were performed at the Center of Information Systems (CIS) of the Budapest University of Technology and Economics on a supercomputer. This serverfarm contains four Compaq 4100 nodes: 16 x EV5.6 (21164A, 600 Mhz, 8 MByte cache) Alpha CPU, 32 GByte memory, 0.62 TByte harddisc.

2. 2D Direct numerical optimisation of a fuel jet pump

With the application of the code presented in the previous sub-chapters, a new design guideline is developed for the optimisation of a fuel jet pump. Nowadays, this device is widely used in the internal fuel system of a car fuel tank system. The jet pump deliveries fuel from one part of the tank to the other. During the operation, the most important, apart from guaranteeing the maximum volumetric flow rate, is the reliability which can be reached by the optimal design of mixture area.

Concerning the 2D analysis, a low-pressure zone is appeared locally in the outside part of the right side return bend resulting swirling flows (Fig. 3/A). The origin of this phenomenon can be attributed to two occurrences. The most meaningful is the concave curvature effect.

$$\rho \left(\frac{V_t^2}{R_c} \right) = \frac{\partial p}{\partial n} \qquad (15)$$

Near the wall, to ensure radial force balance – kept by centrifugal force and pressure (15) – the absolute velocity decreases. On the other hand, at the inlet of the diffuser the contraction is high because of a sharp corner. Near the inlet of return bend, when the effect of contraction is diminishing and the flow is spread over, the absolute velocity is also decreasing. This phenomenon is superposed to the velocity decrement caused by concave curvature effect results so intensive adverse pressure gradient increment that the stream is not able to follow the solid surface any more and swirling flow is evolved at the outer, concave part of return bend (Fig. 3/A).

According to engineering and computational investigation, the chamfered throat at the inlet of the jet diffuser helps to avoid swirling flow (Fig. 3/B). Furthermore, the flow transportation is also improved by using a relatively small flow driver lug located at the orifice outlet of the jet pump (Fig. 4).

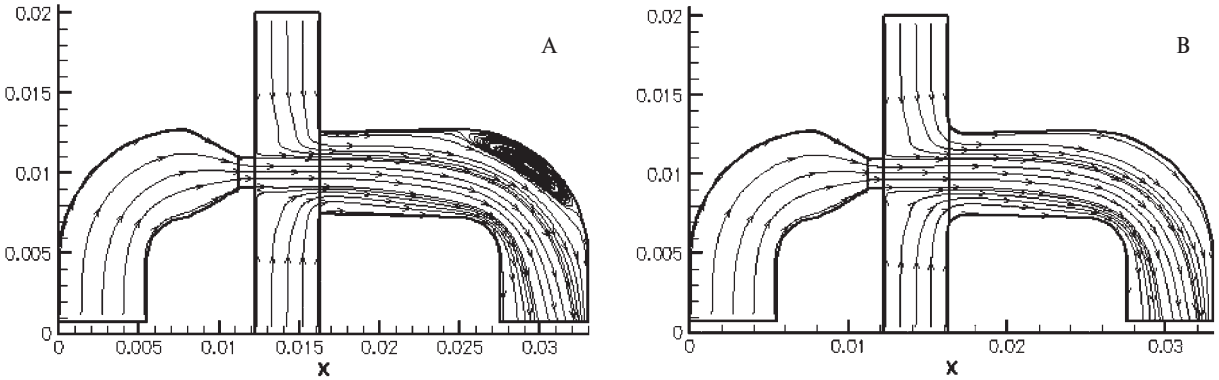

Fig. 3. Stream-traces in 1.9 mm orifice diameter fuel jet pump. A: without (basic configuration), B: with chamfered throat

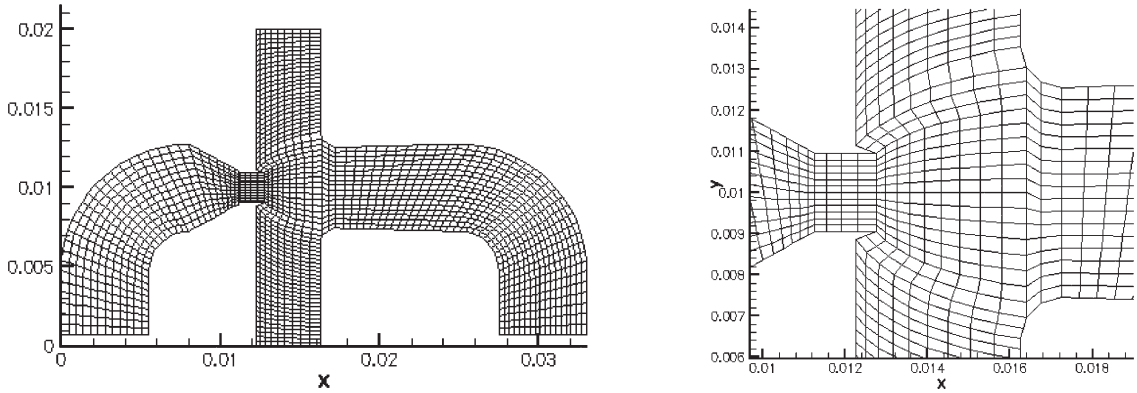

*Fig. 4. Numerical model of 1.9 mm orifice diameter fuel jet pump with structured grid applying chamfered throat+ and 0.5 mm long flow driven**

Finally – keeping the smallest modification concerning the production cost – the combination of three main geometrical sizes has been investigated, namely; the inlet width (inlet for transported fuel), the diffuser inlet diameter and the diffuser length, which are changed over the causality distance by 5 equivalent size-steps and examined with each other. They might have an optimal set of configuration, which belongs to the maximum outlet flow. This direct numerical simulation means 5^3 2D computations, which takes at about 12-24 hours in the function of grid fineness and the specifications of PC. After making optimisation, the results justify our expectations, as it can be seen in Table 1:

The optimum model is called Optimised Geometry with the maximum flow transportation of 3.18. It is interesting also to analyse this configuration. It can be observed in Fig. 5/B that orifice flow gives more rate of kinetic energy to the transported flow than as it can be observed in Fig. 5/A. The streamline distribution becomes more regular, so the risk for swirling flows is decreased and more mass is transported. The fluid dynamics phenomena caused by curvature effects in the return bend have significant effect on processes in the central part of the pump. A low-pressure region is developed at the convex curvature of return bend. Hence, more mass can come from the lower inlet section

Results of optimisation procedure in the function of volume flow rate — Table 1

Models	Basic Configuration	Basic+Chamfered Throat	Basic+Chamfered Throat+0.2 mm Flow Driven Lug	Basic+Chamfered Throat+0.5 mm Flow Driven Lug	Optimised Geometry
$\dot{V}_{out}^{sum}$ [l/h]	307.0	330.69	335.08	338.465	369.1
$\dot{V}_{in}^{sum\ ply}$ [l/h]	129.8	128.83	127.73	128.45	115.9
$\varepsilon = \frac{\dot{V}_{out}^{sum}}{\dot{V}_{in}^{sum\ ply}}$	2.36	2.57	2.62	2.63	3.18

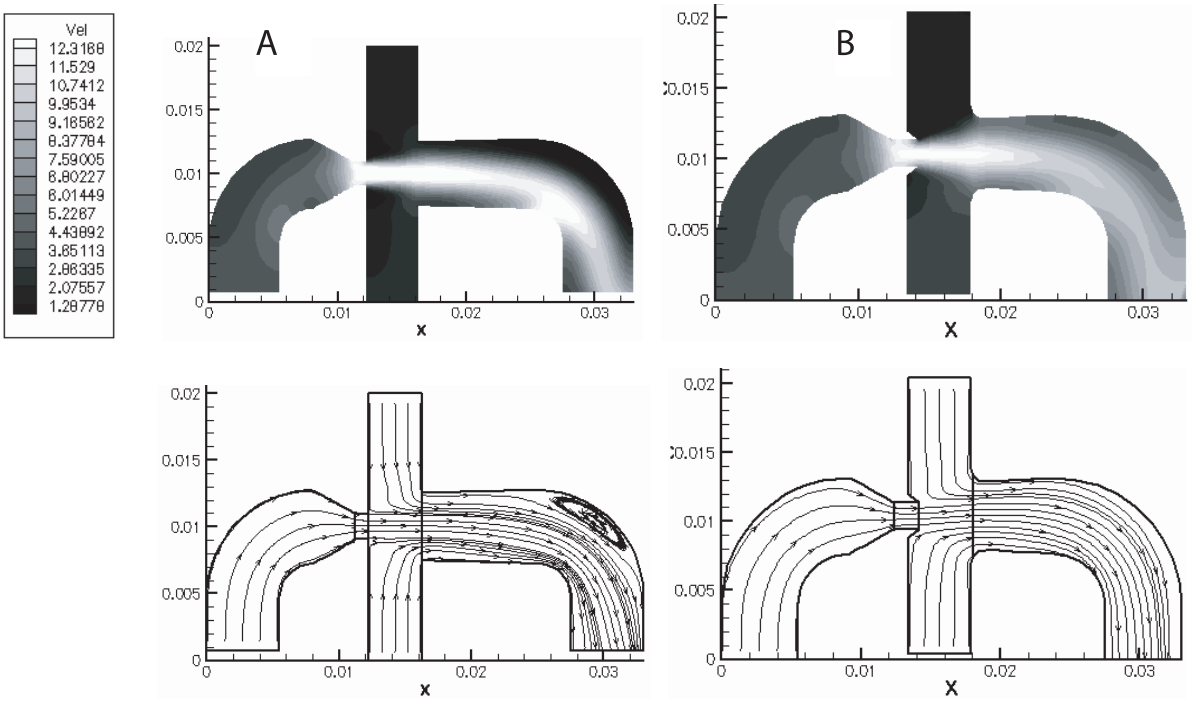

Fig. 5. Velocity distribution [m/s] (above) and stream-traces (below) in the 1.9 mm orifice diameter jet pump. A: Basic configuration B: Optimised geometry

into the diffuser, and so, the stream, which comes from the orifice, is not straight (horizontally) any more but rather slightly turns up. This flow turning makes the streamline distribution more uniform and has a strong effect to sweep out the swirling flow from the bend.

3. Summary and conclusions

Installation of 2D Pseudo-compressibility method is presented for modelling ideal incompressible flow by solving Euler equations to numerically investigate and optimise a small-size fuel jet pump. 4th order Runge-Kutta method is applied for time marching, while the flux difference splitting technique with -class of a higher order scheme approach is used for spatial discretisation. Extrapolation and characteristic type boundary conditions are examined by means of qualitative accuracy and convergence manner. It can be concluded that the scheme using more consistent characteristic boundary conditions shows faster convergence properties to reach steady state conditions saving considerable computational time. After validation of the code a certain combination of the pump geometry is defined, which has the highest effect on flow transportations. Physical interpretation of fluid dynamics phenomena is presented in the all examined cases besides determining an optimum size configuration.

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A STRUCTURE OF THE COOLING SYSTEM

Some problems related to energetic flows in a cooling system of the combustion engine equipped with a non-conventional cooling circuit are described in this paper. The verification was carried out on a real diesel tractor engine by exploring the thermal balance. Actually, it is an assessment of the influence of alternative cooling liquid on the engine parameters with a particular attention to the flow of after-expansion energy into the cooling system for its further use. Thermal balance is evaluated by means of a reduced output number related to heat or energy chemically bound in fuel, energy led by the cooling system and energy corresponding to the effective output. The value of reduced output number gives attainable utility output per a supply unit of the given equipment (supposing that the energy of the coolant is used for the operation of other equipment, e.g. air-conditioning equipment).

The improvement of the output number of the combustion engine as an energetic source can be achieved through the use of exergic part of energy transformed in the combustion engine.

1. Introduction

The present trend of increase in prices for primary energy forces society to implement efficient transformations of energies or to design sets of machines using energy at lower potential levels. Equipment of this type is able to lower energetic demands both in industry and transport.

It is important to pay attention to this issue from the point of view of maintaining economic and trade balance. Apart from these criteria it is also necessary to bear in mind ecology and necessity to provide enough energy for the future. The creation of such a system is substantially affected by energetic machinery and equipment implemented in means of transport. To this group belong also internal combustion engines, either with continuous or discontinuous transformation of primary energy.

2. Energy and exergy

The combustion engine transforms primary energy chemically bound in fuel in the framework of the equation of thermal balance, which can be expressed in a simplified form by means of the following relation:

$$Q_p = Q_e + Q_{ch} + Q_{vyf} + Q_{ol} + Q_{zv} \quad [\mathrm{J.s^{-1}}] \qquad (1)$$

Individual flows of energy are illustrated in Fig. 1 and their exploitation is illustrated too. In the figure we can see the value of accumulated after-expansion energy corresponding to the value of thermal energy related to the energy supplied in fuel. It is actually this part of thermal output, which is used by a non-conventional combustion engine whose definition is connected with its cooling circuit.

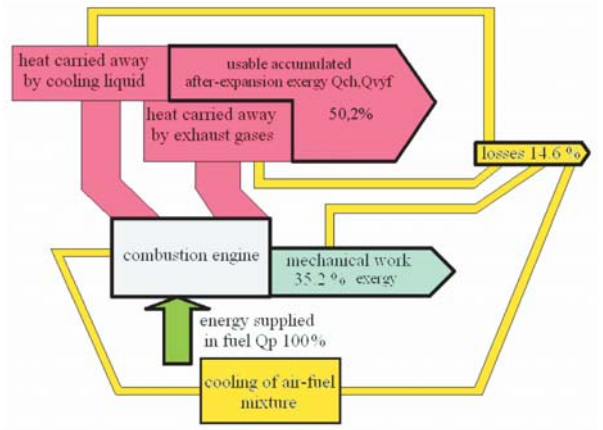

Fig. 1. Flows of energy and part of the conventional cooling system on a test bed [3]

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The closed non-conventional cooling circuit can form part of air conditioning or freezing equipment on the basis of absorption. The working medium from an air conditioning or freezing compartment with its specific physical properties will flow directly into the section of the combustion engine and will completely use the thermal gradient. In this way it is possible to form equipment for ergonomization and ecologization of the environment of means of transport and transportation of goods (e. g. foodstuff), requiring coldness.

To confirm the discussions concerning the use of exergic part of energy by means of a non-conventional cooling circuit some measurements of an alternative coolant have been made. The aim was to assess the influence of an alternative coolant on thermal balance of the diesel engine.

2.1 Reduced coefficient of performance

An energetic source such as a combustion engine can be assessed by the coefficient of performance (COP). The value of the coefficient of performance gives an attainable useful output per unit of supply of the given equipment. There is an objective to attain the highest possible level of the COP. In the case of the combustion engine to simplify the illustration of the COP value we used Carnot circulation – Fig. 2.

The presented unevenness 2 holds for the case when there is a possibility to efficiently use the heat in the cooling liquid and in exhaust gases in other convenient equipment. In such a case the value of the COP increases and energetic efficiency of the combustion engine also increases. The parameter attained in this way must correspond, as for its output, to the associated equipment making use of exergic flows of energy from the combustion engine.

$$COP_M = \frac{Q_e}{Q_p} < COP_M = \frac{Q_e + Q_{ch} + Q_{výf}}{Q_p}$$

During experiments on the test stand the components Q_e, Q_p and Q_{ch} were investigated as priorities. The value of Q_{ch} depends on flow and physical properties of the alternative coolant and for the attained thermal gradient _T it can be expressed by means of the following relation:

$$Q_{ch} = m_{ACH} \cdot c \cdot \Delta T \quad [\mathrm{J.s^{-1}}] \tag{2}$$

With regard to the observed flows, the reduced coefficient of performance COPRED is given in the form [2]:

$$COP_{RED} = \frac{Q_q + Q_{ch}}{Q_p} \tag{3}$$

According to this number it is possible to determine the curve of efficient operation of a non-conventional combustion engine in the forms of $COP_{RED} = f(m_{ACH})$ or $COP_{RED} = f(Q_{ch})$. The functional dependence directly reflects the influence of constructional interventions into the cooling system of the combustion engine and enables to find an optimum of the value COP_{RED}.

This characteristic can be consequently implemented in a design of equipment making use of exergic heat flow.

2.2 Model of an engine jacket

For the purpose of an analytic solution of energetic flows a simplified physical model of the engine jacket was designed – Fig. 3. It can serve for a reference observation of influence of constructional and flow requirements so that the flow of exergic part of energy is maintained as well as operational ability of the combustion engine from the point of view of thermal profiles in the cylinder lining. Fig. 3 shows part of volumetric networking of the jacket. The program packet FLUENT is used for solutions of flowing and energetic flows [1].

3. Dependence COP_{RED}

The experimentally obtained dependence – diagram in Fig. 4 – reflects the following facts at defining the COP_{RED}:

- Comparison of thermal balance for cooling with water and alternative coolant,
- Cooling system without a constructional intervention.

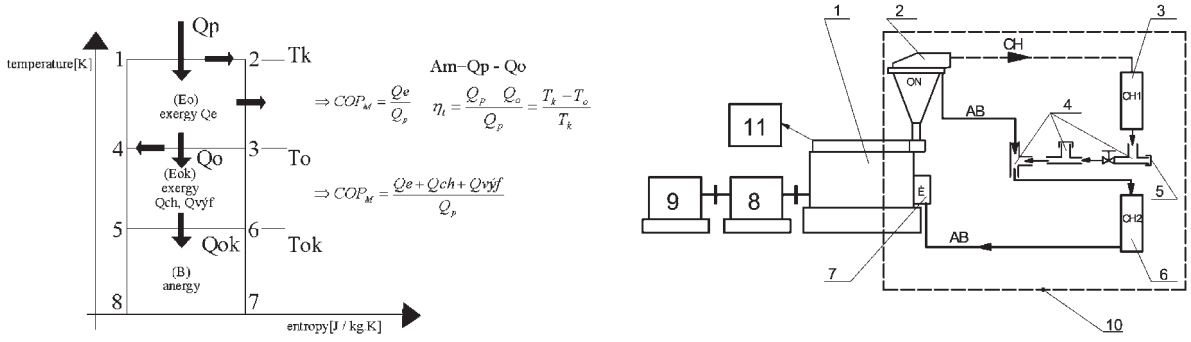

Fig. 2. Carnot circulation and coefficient of performance, scheme of trivalent energetic system on the basis of ICE 1 – combustion engine, 2 – vaporization container, 3 – coolant, 4 – connecting members, 5 – cover, 6 – coolant, 7 – internal pump of ICE, 8 – electric generator, 9 – heat pump, 10 – part of nonconventional cooling circuit under solution, 11 – equipment making use of exhaust gases heat [2].

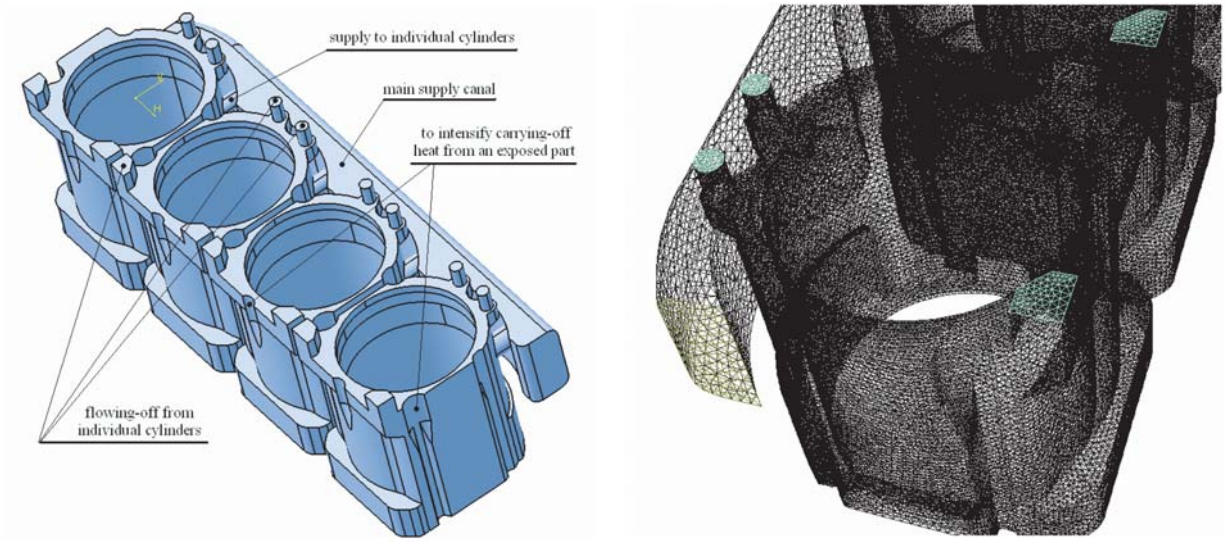

Fig. 3. Shape of the engine jacket for calculation of heat flows and view of part of volumetric networking of an engine jacket.

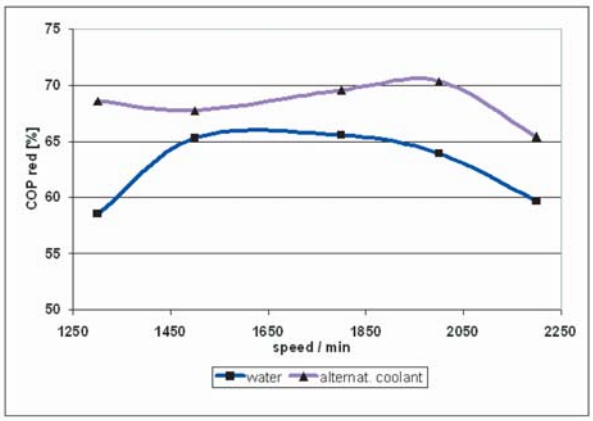

Fig. 4. Coefficient of performance in dependence on engine speed.

4. A real performance number COP_{red}

The determination of a real coefficient of performance for the test stand can be carried out from two criteria:

A. a real coefficient of performance determining the quality of realization of the evaporation physical principal. It determines how much energy contained in the coolant will be transformed into other so called evaporation energy – heat. The mass flow of coolant and cooling output for an absorptive unit correspond to the value of evaporation heat at the defined evaporation efficiently,

B. a real coefficient of performance defining the cooling output achieved by the cooling unit. This assessment can be carried out only when the test stand is able to work at the maximum possible evaporation efficiency so that the operational ability and long life of the combustion engine is sustained.

$$\textbf{A: } COP_{red} = \frac{Q_e}{Q_p}\,\eta_{el} + Q_{ch}\backslash Q_p\, U_{výp}\,, \qquad (5)$$

η_{el} – efficiency of transformation of Q_e e.g. into electric output, $U_{výp}$ – evaporation efficiency.

$$U_{výp} = \frac{Q_{výp}}{Q_{ch}} = 1 - \frac{Q_{och}}{Q_{ch}} = 1 - \frac{(T_{vch} - T_{vych})}{(T_{vm} - T_{vym})} = 1 - \frac{dT^{ch}}{dT_M}\,, \qquad (6)$$

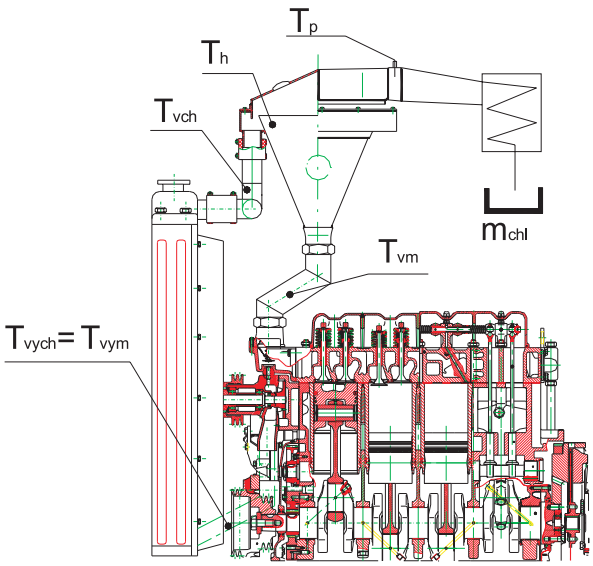

Fig. 5. m_{chl} – mass flow of coolant, T_{vm} – temperature at the combustion engine exit, T_p – temperature of vapor, T_h – temperature of surface in the evaporation vessel, T_{vch} – temperature of lean solution leaving the evaporation vessel and entering the cooler, T_{vych} and T_{vym} – temperatures entering the combustion engine [2].

$Q_{výp}$ – evaporation heat – energy, Q_{och} – heat taken away by means of the cooler, T – temperatures are described in the figure, dT_{ch} – temperature gradient on the combustion engine cooler, dT_M – temperature gradient of the combustion engine. The attainment of maximum evaporation efficiency emerges from pressure conditions in which the absorptive cooling unit is to be operated. It is the case of low pressure conditions. So far we have assessed the cooperation in atmospheric conditions only. After the COP_{red} had been defined from the point of view of evaporation efficiency it is possible to define places for measurement.

$$\textbf{B.}\ COP_{red} = \frac{Q_e}{Q_p}\,\eta_{el} + \frac{Q_{ch}}{Q_p}\,\eta_{nch}\,, \tag{7}$$

$$\eta_{nch} = \frac{Q_{abj}}{Q_{ch}}, \tag{8}$$

η_{nch} – efficiency of the non-conventional cooling circuit of the combustion engine. If the absorptive cooling unit achieves a higher cooling performance than the heat flow to the cooling system, the value of efficiency can be higher than 1.

5. Conclusion

From the values gathered during the experiment on the test stand of the cooling combustion engine the following conclusions can be drawn:

- the change of coolant did not cause any undesired changes of outer speed characteristic for the sake of which the measurement was made,
- there was no increase in temperature of exhaust gases and oil,
- a positive fact is an increase of thermal flow into the cooling system, which increases the reduced coefficient of performance on average by 9%.

It can, therefore, be concluded that the alternative coolant is from the point of view of thermal balance convenient, which provides a good assumption for a reconstruction of the engine on the test stand in compliance with technical requirements for a cooling process.

Part of the research is the determination of methodology for assessment of cooperation of the combustion engine with basic elements of the absorptive cooling equipment.

The first step is to define a cooling potential of the circuit in atmospheric conditions. The definition of a significant efficiency is not expected, but first experiments are aimed at outlining trends of observed parameters. In the circuit illustrated in Figs. 1 and 2 we are able to make use of 5% of energy accumulated in the coolant at the coolant condensate $0.12.10^{-2}$ kg.s^{-1}. In future research it will be necessary to rebuilt the cooling system into low-pressure conditions and use suitable coolant. Subsequently, a significant increase of the coefficient of performance and mass flow of the coolant can be anticipated. In the conditions defined in this way it is necessary to maintain the operational ability of the combustion engine.

The contribution was created within the framework of the project Nr. APVT – 20 – 010302, which is supported by the Agency for Support of Science and Technology of the Slovak Republic.

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DEFECTOSCOPIC SUSCEPTIBILITY OF MACHINE ELEMENTS

In the paper defectoscopic susceptibility of machine elements is analyzed. At first, an objective notion is defined and presented in a practical situation. The defectoscopic susceptibility as a feature can be considered and described also as a system consisting of two subsystems and a collection of non-technical factors. The subsystems are defined as a group of many factors. A mathematical structure of selected factors was shown as an example. Some factors of defectoscopic and diagnostic susceptibilities were calculated and gathered for selected parts of a motor vehicle and for air conditioning systems of selected models of cars. The calculated values of those factors enable us to quantitatively assess such features of a machine as its various susceptibilities. They can be practically used in the design, manufacture and maintenance not only of machines, but also of equipment for examination and service of machines and their subassemblies.

1. Introduction

The defectoscopic susceptibility is a feature which appears while carrying on nondestructive testing, and in particular, during defectoscopic examinations. It has been often indirectly mentioned in descriptions of nondestructive testing (ndt) method of examination. In some fields of technical activity, e.g. service, repair, diagnostic [1-5], these features are already considerably determined. The position of these features in the maintenance sphere of machines is shown in Fig. 1.

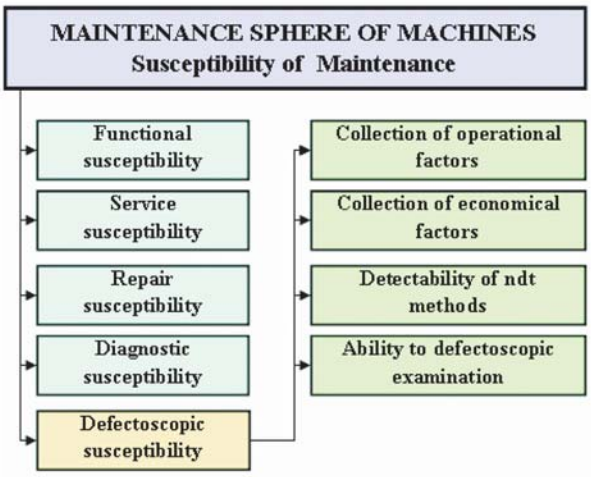

Fig. 1. The defectoscopic susceptibilities as components of maintenance susceptibility of machines

These features could be considered as a system consisting of a subsystem of the elements ability to defectoscopic examination and a subsystem of detectability of ndt methods to flaw detection. These subsystems could be described by the collection of factors. The number of factors has not yet been exactly determined, but the most important of them are known and are included in the paper.

A process of the form of defectoscopic susceptibility occurs during all stages of existence of technical objects, and especially in their design and manufacturing. Both of the mentioned subsystems allow us to characterize the adaptation of the machine element to ndt evaluation and also the ability of means of control to flaw detection in quantitative category. Other susceptibilities characterizing the sphere of machine maintenance are defined as the object of action in this sphere (machines, their subassemblies, parts) as well as the means of action (i.e. methods and technological or measuring equipment) and are used for a given kind of technical activity.

2. Presentation of the problem

Each operator, which executes the defectoscopic control, could meet the problem analyzed in the paper. The problem occurs indirectly during control as a description of the control process. In such a description the defectoscopic susceptibility is, as a rule, characterized qualitatively.

In another field of technology and maintenance of machines, e.g. diagnostics and service, a parameterization of such features as diagnostic susceptibility and exploitational or service susceptibility of an object have been carried out. In the domain of defectoscopic control, quantitatively defectoscopic susceptibility is needed. The need has practical meaning. It enables us the so-called friendly defectoscopic examination [6].

The problem analyzed with the aid of simple practical examples of nondestructive ultrasonic control is illustrated in Fig. 2.

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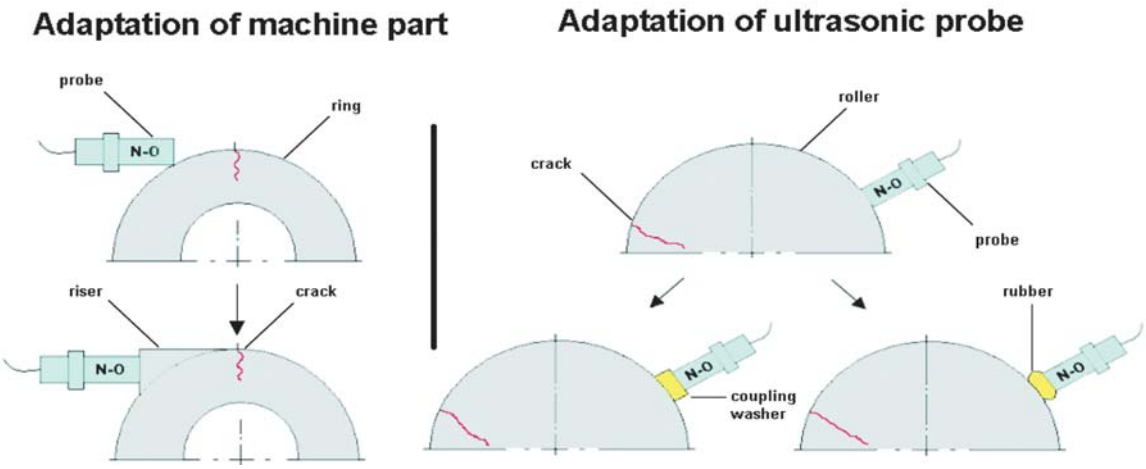

Fig. 2. An illustration of the presented problem in practical operating examples

A detection of discontinuity in parts of machine (ring or roller) by using a typical ultrasonic probe can be resolved in two ways. The first way is connected with designing and carrying out of a riser on ring, which makes ultrasonic monitoring possible in the critical area of the ring. This way is named as adaptation of the parts to ultrasonic examination. The second way is based on the use of coupling means between the probe and the roller. That way can be named as adaptation of the probe to ultrasonic examination. In this case, as a rule, possibilities of adaptation are greater than in the first case.

3. The ability of elements to defectoscopic examination

This feature describes an object of examination, e.g. parts of machines and their connections. Among many factors characterizing the feature, the most important are:

- factor of accessibility of places controlled,
- factor of facility of defectoscopic examination,
- factor of constructional adaptation,
- factor of defectoscopic ergonomy,
- factor of non-dismantling defectoscopic examination, etc.

4. The defectability of ndt methods to flaw detection

The defectability of ndt methods to flaw detection, as a feature of defectoscopic susceptibility, is connected with an application of various nondestructive methods to detection of such discontinuities of machine elements as flaws, cracks and others. To a sufficient quantitative description of this feature the following quantities can be included:

- universality of defectoscopic method,
- likelihood of defectoscopic examination,
- factor of automotion of defectoscopic activity,
- a complex factor of adaptation of nondestructive method to defectoscopic examination, etc.

5. Non-technical factors of defectoscopic susceptibility

The following operational quantities belong to this group of factors:

- time of effective defectoscopic examination,
- time of preparation to defectoscopic examination,
- time of removal of possible effects of examination,
- operational factor, etc.

Another group of non-technical quantities comprises such economical factors as [7]:

- labour consumption of defectoscopic examination,
- labour consumption of all bookkeeping operations,
- costs of defectoscopic examination,
- costs of preparation and termination of defectoscopic examination,
- direct and indirect costs of defectoscopic examination,
- material costs and amortization charges of testing equipment,
- generalized factor of cost of defectoscopic examination, etc.

6. A structure of some factors

Out of the group of factors characterizing ability of elements to defectoscopic examination we can present the factor of accessibility of places controlled K_{dm}:

$$K_{dm} = T_o/T_o + T_d \tag{1}$$

where: T_o – labour consumption of basic activity,
T_d – labour consumption of bookkeeping operations.

Representing the defectability of ndt methods to flaw detection, a factor of automotion of defectoscopic activity K_A, can be described by the formula:

$$K_A = \sum_{i=1}^{m} N_{Ai} \Big/ \sum_{j=1}^{n} N_{Oj} \tag{2}$$

where: $\sum N_{Ai}$ – a number of parameters automatically measured and worked out,
$\sum N_{Oj}$ – general number of parameters used.

As an example of non-technical factors, we can use the factor of labour consumption of all bookkeeping operations K_p:

$$K_p = 1 - T_p / T_d \quad (3)$$

where: T_p – an average labour consumption of all bookkeeping operations,
T_d – an average operational labour consumption of defectoscopic examination of an object.

In the same way, factors of other features of machine elements, connections, subassemblies and devices can be mathematically described as, for example, diagnostic or service susceptibility.

7. Examples of determination of susceptibilities

For numerical illustration of the problem discussed in the paper, the example of evaluation of defectoscopic susceptibility for selected parts of automotive vehicle is shown in Table 1. This evaluation was calculated on the basis of factors mentioned above. The method of multicriterial analysis was used in this case. The assumed scale of defectoscopic susceptibility was from 1 to 5, i.e. very low-1, low-2, medium-3, high-4, very high-5, and the assumed factors weight from 1 to 3, i.e. low-1, medium-2, high-3 [4].

The calculated factor of defectoscopic susceptibility of elements W_{ds} was determined with the aid of the following formula:

$$W_{ds} = \sum_{i=1}^{n} (W_i O_i) \Big/ \sum_{i=1}^{n} W_i \quad (4)$$

where: W – weight coefficient of each criterion considered,
O – scale of influence of each criterion on defectoscopic susceptibility,
n – number of criteria considered.

Analyzed parts of automobile vehicles were divided into three groups depending on the required dismantling and the values of their calculated factors of defectoscopic susceptibility are gathered in Table 1.

On the basis of the calculations carried out (Table 1) it can be noticed that out of those parts of automotive vehicle where dismantling is not required, the highest defectoscopic susceptibility was obtained at the brake disc or chassis of a car. Out of those parts where partial dismantling is required, the best susceptibility is at the drive shaft, and out of these parts where full dismantling is required, the brake drum has the highest value.

Nondestructive methods of flaw detection are connected with the diagnosis of machines [8], thus another example of susceptibility evaluation by calculation of diagnostic susceptibility is presented in Table 2. In this example the same assumptions were made and identical calculations were carried out. The same assembly – air conditioning of some popular models of cars was analyzed. The analysis of diagnostic susceptibility was carried out separately for subassemblies responsible for the flow of refrigerant (refrigerating medium) and responsible for the functioning of the car air conditioning system control. The weights of factors influencing the diagnostic susceptibility of the system were adapted on the basis of the opinion of the experienced servicemen of these systems [9].

On the basis of the analysis carried out (Table 2), it can be noticed that Toyota Prius has the highest factor of diagnostic susceptibility for air the conditioning system, mainly thanks to a con-

Calculated results of defectoscopic susceptibility factor for selected parts of car — Tab. 1

Calculated values of defectoscopic susceptibility factor for parts of car					
No dismantling required		Partial dismantling required		Full dismantling required	
element	value	element	value	element	value
Brake disc	3.7	Drive shaft	3.5	Brake drum	3.4
Chassis	3.5	Axle casing	3.2	Steering knuckle	3.3
Suspension spring	3.1	Stabilizer	3.1	Piston	3.0
Ball joint	2.6	Valves	3.0	Crank shaft	2.7
Bolt of road wheel	2.5	–	–	Cam shaft	2.6

Calculated results of diagnostic susceptibility factor of air condition systems for the selected cars — Tab. 2

Factor of diagnostic susceptibility	Model of car					
	Toyota Avensis	Toyota Prius	Hyundai Accent	Daewoo Leganza	Opel Astra III	Fiat Seicento
Refrigerant flow devices	2.4	3.0	3.7	2.9	2.8	3.8
System control devices	3.4	3.7	2.4	3.1	3.3	2.2
Whole conditioning system	5.8	6.7	6.1	6.0	6.1	6.0

siderable range and facility of receiving the information from the system of air conditioner automatic control. The access to elements of refrigerant flow is difficult because of compact settlement of engine chamber (hybridized drive, safety equipment, etc.).

Such models as Hyundai Accent and Fiat Seicento also have good diagnostic susceptibility of the conditioning system. In these cases the access to elements of the systems is easy, but considerably less diagnostic information can be derived from programmers of automatic control of the systems. The Toyota Avensis has difficult access to the system considered. The systems of such cars as Opel Astra III and Daewoo Leganza obtained average calculated values of evaluation of their diagnostic the susceptibility.

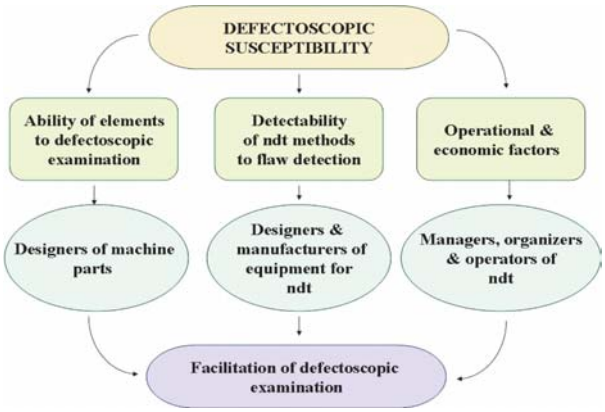

Fig. 3. The scheme of dependencies between defectoscopic susceptibility and simplification of defectoscopic examination

Quantitative information about the values of defectoscopic susceptibility of machine parts or other features such as defectoscopic, diagnostic or service susceptibility can be useful for designers of machine parts and assemblies, organizers or operators of such processes as nondestructive evaluation, diagnosis or service of machines and their subassemblies. Relations illustrating the practical side of the problem discussed in this work are shown in Fig. 3.

8. Recapitulation

The defectoscopic susceptibility is a feature, which appears during nondestructive tests, particularly during defectoscopic control.

The defectoscopic susceptibility can be parameterized and considered as the system containing, as a minimum, the subsystem of an ability of machine elements and their connection to nondestructive testing, and the subsystem of detectability of nondestructive testing method to detection of discontinuities in the machine elements.

The defectoscopic susceptibility can be represented by some technical and non-technical set of quantities.

A formation of the defectoscopic susceptibility of elements and their joints occurs throughout all the “life time” of machine elements, but in particular, during construction and production of machine elements.

The defectoscopic susceptibility, apart from describing that feature, helps us to improve the form (shape, dimensions) of the elements to make the detection of discontinuities in elements during defectoscopic examination easier.

The collections of factors allow us quantitatively evaluate the susceptibility of both sides of the problem: the object of examination and the method of examination.

The problem of defectoscopic susceptibility is still developing. It still needs formal precision and complementation for the application to a greater number of machine real parts with the use of a computer multi criteria analysis method of the presented problem.

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Libor Ižvolt – Ján Kardoš – Ján Leľak – Martin Mečár *

DIAGNOSTICS OF THE TRACK SUBSTRUCTURE MODEL AND ITS PRACTICAL USE

The paper presents mathematical equations of dependence of deformation resistance (compaction degree) and static/dynamic deformation module of elasticity reached by experimental measurements at laboratory model of scale 1:1 in 2003 and 2004. Recommendations for practice from the point of view of dimensioning and suitability of applied materials into the railway substructure are also presented.

1. Introduction

Intensity of traffic loading of a railway construction is a basic factor which influences its composition and arrangement to fulfil the expected function during its durability. Loading of railway lines, especially corridor localities, is supposed to grow because of denser traffic caused not only by the increase of axles loadings, but also by higher traffic speeds. Hence, the high quality of the railway line, especially the railway substructure, has to meet these requirements. Even small defects in geometrical rail position caused by permanent deformations of the railway substructure or the whole ground body subsidence can bring the growth of dynamic strengths having the impulse effect which exceeds the static loading. This fact can lead not only to decrease of traffic safety, but also to the further degradation of the railway substructure. Therefore the choice of suitable ground material and elements of the railway substructure and their proper building-in leads to decreasing of its permanent deformations. This seems to be more efficient than traffic with less axle tension and lower speed in the past.

Dimensioning of the construction thickness of particular layers of the ground material, and also the right choice and building-in of the construction elements (geosynthetics) appears to be important when designing the railway substructure. According to [1], the equivalent static module of deformation of the examined construction is the determining parameter for the design. It is realized by a static loading test at Slovak Railways (SR). The theory of elastic half-space by Ivanov, known as Dornii method is used for calculating substructure layers thickness. Limited conditions of this theoretical solution do not allow to take into consideration a number of factors influencing the construction deformation resistance (bearing capacity), e.g. the type of ground material from the point of view of its granularity, the condition of built-in material from the point of view of its compaction and synergism of individual construction elements (e. g. geosynthetics) with ground surrounding. The monitoring of a real construction or similar model appears to be a reliable way of considering such limitations in designing and dimensioning the railway substructure. The experimental model measurements make it possible to simulate the railway substructure into real conditions. Such a construction will take into consideration a number of real limited conditions and will guarantee economical and reliable construction design.

The Department of Railway Engineering and Track Management (DRETM) of the University of Žilina built a railway substructure model in the scale 1:1 for experimental testing of various ground materials and construction elements under specific conditions. The dependence of static loading tests results and dynamic loading tests results regarding dynamic influence on substructure material and other elements in the railway substructure is shown. Advancing diagnostics of the deformation resistance (bearing capacity) of the construction is monitored on this model.

2. Description of the railway substructure model

The model of the railway substructure construction at DRETM is built in a steel testing stand with the ground-plan dimensions of 3400 mm × 1950 mm and the height of 1200 mm (Fig. 1). The testing stand walls are reinforced by vertical steel profiles (reinforced ribs) to reach transversal and longitudinal stability. There is a transversal steel beam in the upper part of the stand which is fastened on two side poles with possibility to fix them in three exactly specified positions lengthwise the stand. This transversal beam serves as a counter balance for static loading tests. The configuration of the testing stand (Fig. 1) and static loading test conditions make it possible to test in six places (positions $A1 - C2$) in such a way that the realized tests are not influenced by stiffness of the walls.

Material used for the model of the railway substructure is sandy clay which forms the subgrade surface with thickness of 600 mm and granulated gravel with fraction of 0/32 mm which was applied into the subbase (with thickness of 150, 300, 450 and 600 mm). Granulated gravel has various granulometric curves corresponding to the granularity given in the Slovak Technical Standard (STN) 72 1512 (at present replaced by STN EN 13242) (Fig. 2).

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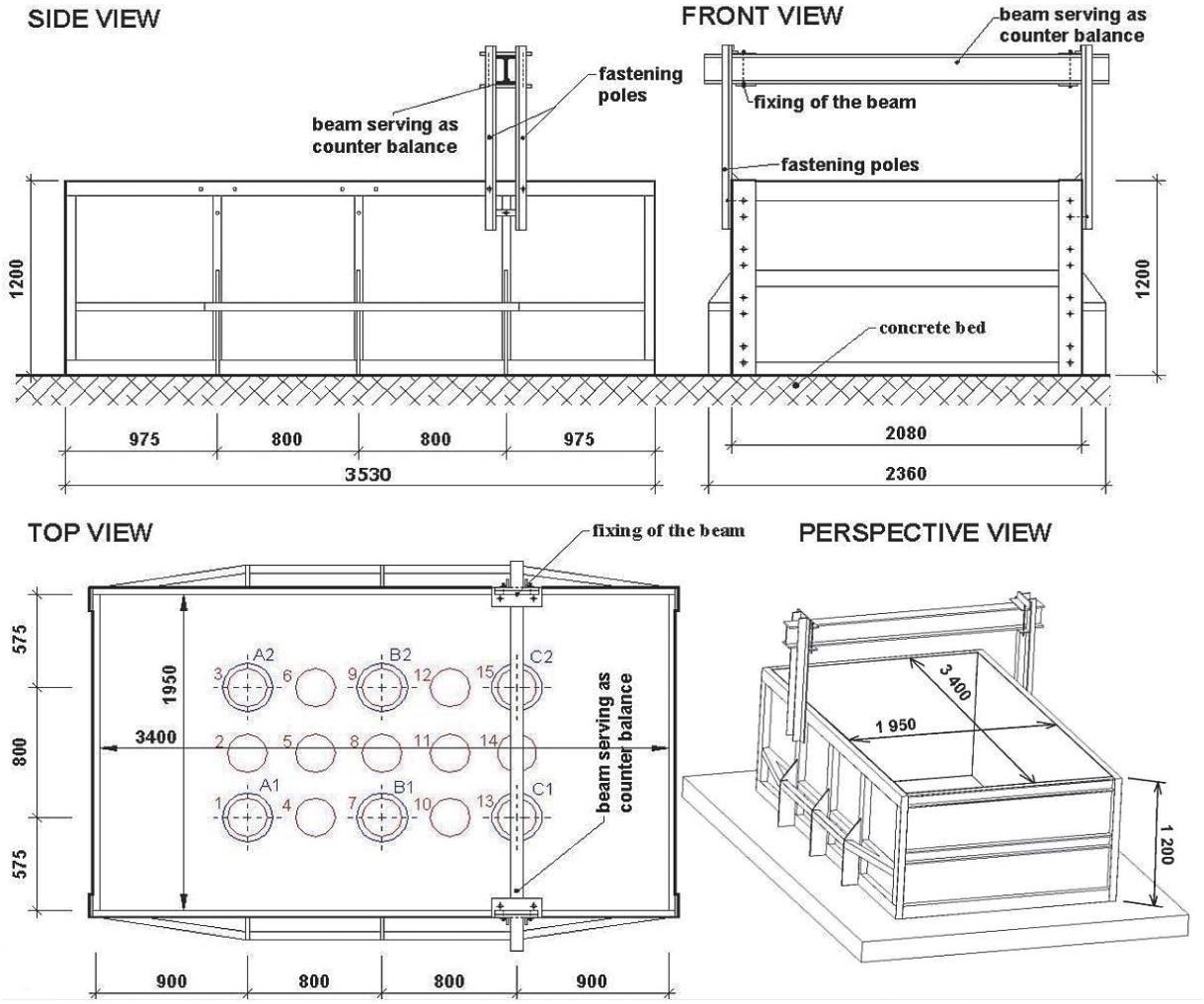

Fig. 1. View of the testing stand

Geosynthetics has a filtering reinforced function and was applied between the subgrade surface and the subbase during each experimental measurement

3 Methodology of experimental measurements

Deformation characteristics of the examined railway substructure models were determined by static and dynamic loading tests according to the mended annex *No.20 of the regulation S4 "Railway Substructure"* [1]. The principle of determining the deformation resistance of the construction is based on creating the real loading (static, impulse) on the tested construction in order to induce certain deformation (plastic, elastic). Measurement of this deformation depends not only on the type of ground, but also on compaction of loose material and its loading (static, dynamic).

The static plate loading test (SPLT) was realized in two cycles with the maximum pressure of 0.20 MPa under a circular plate. Time sequence of loading levels is shown in Fig. 3. The particular loading level was maintained until the deformation of the subgrade changed in the value lower than 0.02 mm per minute (T_i). The static deformation module $E_{s(0,ekv)}$ is calculated from the measured data according to the equation:

$$E_s = \frac{1.5 \cdot p \cdot r}{y} \quad \text{(MPa)} \tag{1}$$

Where:

- p is the specific pressure under the loading plate (0.10 MPa, or 0.20 MPa),
- r is the radius of the loading plate (0.15 m),
- y is the total compaction of the loading plate in meters,
- 1.5 is the constant taking into consideration the plate shape and Poisson`s ratio of tested material.

The compaction degree of construction layer was determined from deformation decreases of the plate measured in two loading cycles according to the equation:

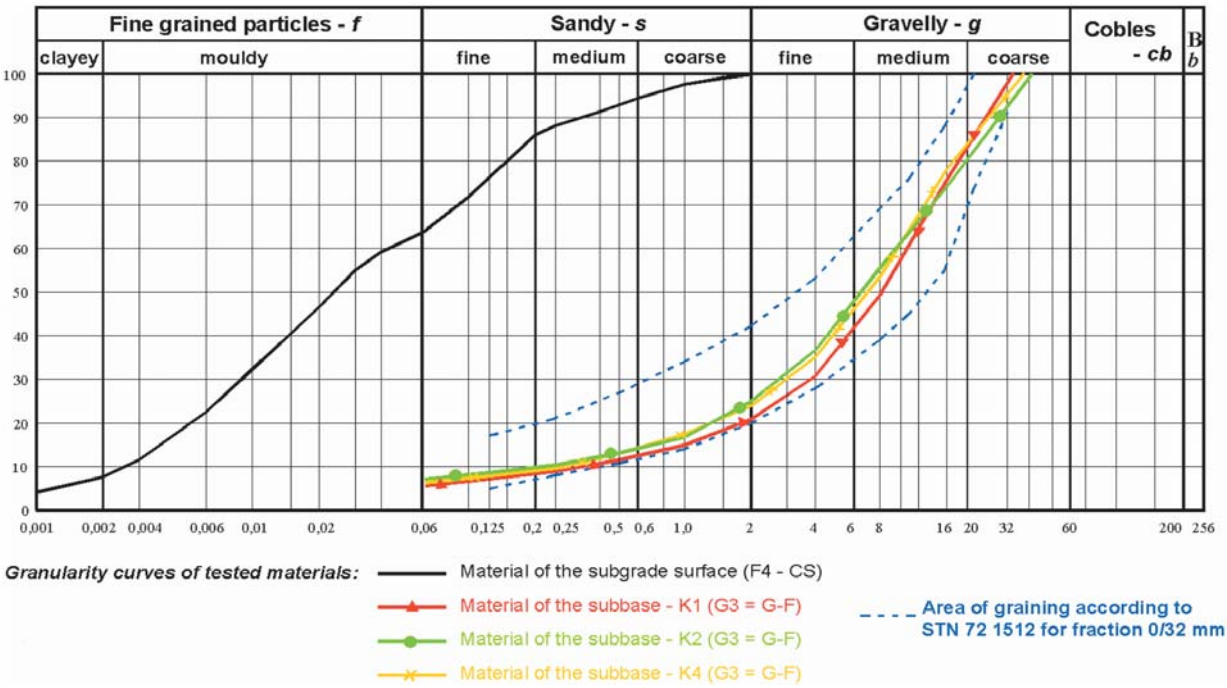

Fig. 2. Granularity curves of materials applied to the model of the railway substructure

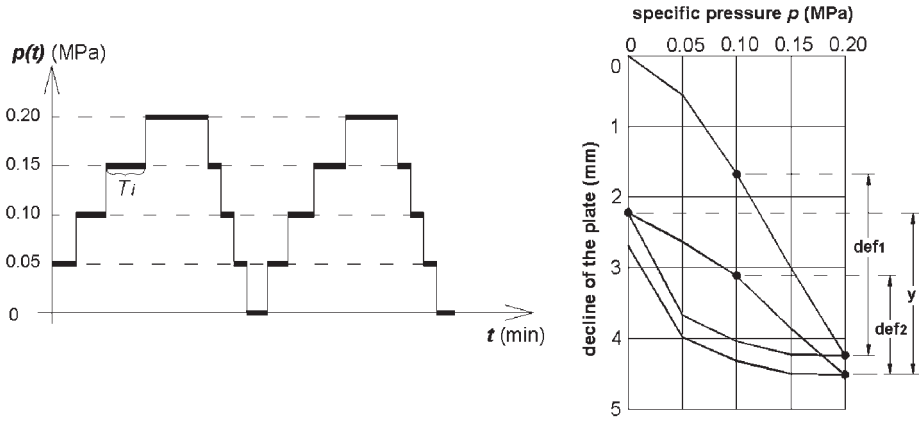

Fig. 3. Work diagrams of SPLT

$$M_z = \frac{E_{def\,2}}{E_{def\,1}} \quad \begin{matrix} \leq 2.20 \text{ – coarse-grained soils} \\ \leq 2.50 \text{ – fine-grained soils} \end{matrix} \qquad (2)$$

Quality of compaction M_z of the construction layer of the railway substructure is suitable if the above mentioned conditions are fulfilled.

The dynamic plate loading test (DPLT) was realized by a light impulse instrument with a circular plate with the diameter of 0.30 m. Impulse loading in the form of a sinusoid was generated by falling ballast on the impulse absorber and caused maximum contact tension of 0.10 MPa with the impulse length of 18 ms under the plate. The graph of impulse tension function under the plate and the output of dynamic test is shown in Fig. 4.

The dynamic module of elasticity $E_{d(ekv)}$ was calculated from the measured data according to the following relation:

$$E_d = \frac{1.5 \cdot r \cdot \sigma}{y_{el}} \text{ (MPa)} \qquad (1)$$

Where:

r is the radius of the loading plate (0.15 m),

σ is the maximum loading pressure under the loading plate (0.10 MPa),

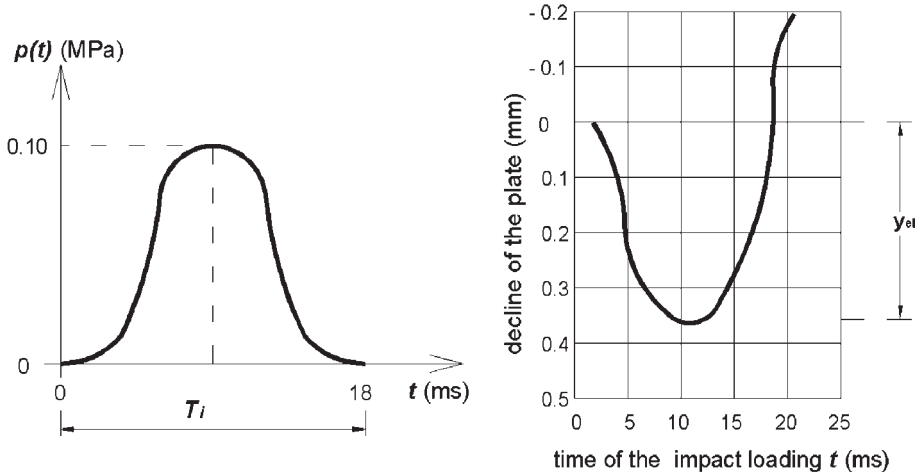

Fig. 4. Work diagrams of DPLT

y_{el} is the size of elastic movement under the plate,
1.5 is the constant taking into consideration the plate shape and Poisson`s ratio of tested material.

4. Regression and correlation analysis of dependence E_{ekv}/M_z

Construction elements applied into ground, as well as granulometric composition of ground and the ground compaction degree remarkably influence the deformation resistance of the railway substructure construction. It is inevitable to determine the dependence between the equivalent deformation module E_{ekv} and the compaction degree M_z on various railway substructures to use these prospectively. After determining regression equations it is possible to examine the railway substructure construction also from the economic point of view, i.e. if it is more advantageous to increase compaction or volume of used material, or to apply a geosynthetic element for reinforcing a structure.

In the following text there are three various compositions of the monitored railway substructure models described:

Construction No. 1	**Construction No. 2**	**Construction No. 3**
– subgrade surface	– subgrade surface	– subgrade surface
– separating geotextile	– reinforcing geocomposite	– separating geotextile
– subbase with thickness of 150 – 600 mm	– subbase with thickness of 150 – 600 mm	– non-rigid geogrid – subbase with thickness of 150 – 600 mm

To achieve the same deformation resistance of the subgrade surface on all tested constructions was the basic assumption for determining relevant dependence E_{ekv}/M_z. This requirement was fulfilled and the subgrade surface deformation resistance about $E_0 = 7.0$ MPa was achieved in all tested railway substructure constructions. Subbase material was another constant factor. It consisted of gravel crushed material with fraction of 0/32 mm – fractional crushed gravel *K*1 (Fig. 2)

Geosynthetics was applied on the subgrade surface in the testing stand and was fixed along the perimeter with steel mandrels. Then the subbase material was being added to the calculated height in order to achieve the required thickness and compaction degree of the layer after (compaction with the compacting equipment ViDo 25/40). The subbase was gradually built from the thickness of 150 mm up to the thickness of 600 mm; the thickness of each step was 150 mm in order to follow deformation resistance of the construction in dependence on the subbase thickness. Six SPLT were realized on each particular layer of the railway substructure, i.e. 36 experimental tests for one cycle; (on the subgrade surface before and after cycle; on the subbase layer with the thickness of 150 mm, 300 mm, 450 mm, 600 mm). 108 results of static loading tests were analysed in total.

Tab. 1 presents a survey of total equivalent module of deformation E_{ekv} and compaction degree M_z in dependence on the type of tested construction and position of measurement on the construction layer. The average values of the equivalent module of deformation E_{ekv} for one construction layer were determined by means of the simple averaging of six reached results on one layer in positions *A*1 – *C*2 (Fig. 1). Average values of the degree of compaction M_z presented in Tab. 1 were determined statistically from all the measured dependences (type, location, level of subbase layer) by means of power regression for each phase of measurements.

When determining regression equation of dependence E_{ekv}/M_z all the results of 108 static loading tests with material according to STN 72 1512 (gravel *K*1) were taken into consideration. The power equation (3) correlates best for describing the above mentioned dependence:

Summary of monitored parameters Tab. 1

Subbase material	Cycle	Construction layer											
		Subgrade surface before cycle		Subbase layer 150 mm		Subbase layer 300 mm		Subbase layer 450 mm		Subbase layer 600 mm		Subgrade surf. after cycle	
		E_0 (MPa)	E_{def2}/E_{def1}	E_{ekv} (MPa)	E_{def2}/E_{def1}	E_{ekv} (MPa)	E_{def2}/E_{def1}	E_{ekv} (MPa)	E_{def2}/E_{def1}	E_{ekv} (MPa)	E_{def2}/E_{def1}	E_0 (MPa)	E_{def2}/E_{def1}
STN 72 1512	Separating geotextile	7.27	2.38	16.0	2.09	37.4	1.82	62.1	1.67	82.2	1.60	9.80	2.27
	Reinforced geocomposite	6.85	2.40	14.0	2.14	37.0	1.82	61.8	1.67	79.8	1.60	9.40	2.28
	Separating geotextile non-rigid geogrid	7.22	2.38	14.2	2.13	30.4	1.88	64.6	1.66	81.9	1.58	12.5	2.18

$$E_{ekv} = (3.3/M_z)^6 \quad (3)$$

The correlation coefficient $R = 0.911$ was determined from the equation (3). It represents a very good correlation dependence. The graphic representation of correlation analysis is in Figure 5.

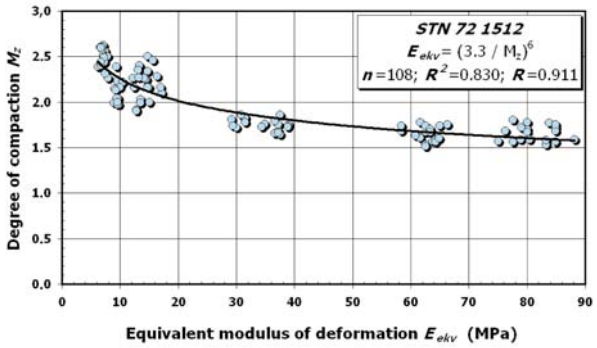

Fig. 5. Regression and Correlation Analysis of Relation E_{ekv}/M_z

5. The regression and correlation analysis of dependence E_s/E_d

An attempt to limit static plate loading tests for diagnostics of deformation resistance of the railway substructure has been observed recently. Less time-consuming tests which take into consideration the dynamic regime of material loading built-in in the railway substructure construction and do not require counter balance are more often applied in practice. The result of the dynamic plate loading test is a dynamic module of elasticity E_d, which is different from static module of deformation E_s because of the principle of diagnostics. The relation between dynamic module of elasticity and static module of deformation depends on the type and deformation resistance of the ground material and can be expressed by comparing measurement. Mathematic relations between E_s and E_d were derived from of the tests realized on the testing model at DRETM. This time the structure of railway substructure construction was not changed, only granularity of ground material of the subbase varied.

Three cycles of experimental measurements were realized with reinforced geocomposite built in the subgrade surface whose deformation resistance was about $E_0 = 7.0$ MPa. The subbase consisted of three various types of granulated gravel with fraction of 0/32 mm (fractional crushed gravel *K*1, *K*2 and *K*4 – Fig. 2) which was in accordance with the required granularity (STN 72 1512). The subbase construction was built in layers of 150, 300, 450 and 600 mm. 15 dynamic loading tests were realized before and also after six static loading tests (see the positions 1 – 15 and *A*1 – *C*2 in Fig. 1). 360 dynamic and 72 static loading tests were analyzed in three cycles of experimental measurements.

The overview of regression and correlation analysis of static and dynamic loading tests (on the subbase surface) for individual tested constructions with various subbase materials can be seen in Figs. 6, 7 and 8. Fig. 9 shows all the results of experimental measurements regardless to the type of ground material.

6. Conclusion

Better compaction of the substructure causes reduction of the pores volume in the ground that means reduction of its permeability, especially if the subgrade surface consists of ground which is sensitive to water influence. That mean the compaction has a great importance in prevention of the reduction of the deformation. The reduction of the pores volume in the subbase causes the increase of shear resistance and so the deformation resistance of the railway substructure is increasing. All these reasons are important not only for reduction of water influence on the subgrade surface but also for increasing quality of the whole railway track construction because both the railway substructure and the railway superstructure (subgrade and track panel) form a technical and physical unit, in which each construction part has its share on the railway traffic loading. Good compaction of the railway substructure materials can reduce and also eliminate permanent deformations of the railway track and also reduce maintenance costs. With the reduction of the subbase construction thickness a more economical design of the railway track construction will be reached.

The experimental measurements proved that not only the type of tested ground (granularity curve) but also compaction measurements have a remarkable influence on the correlation. The more

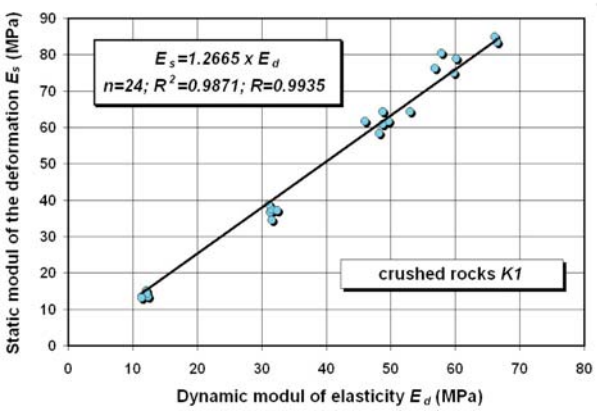

Fig. 6. Correlation estimation of E_s/E_d for granulated gravel K1

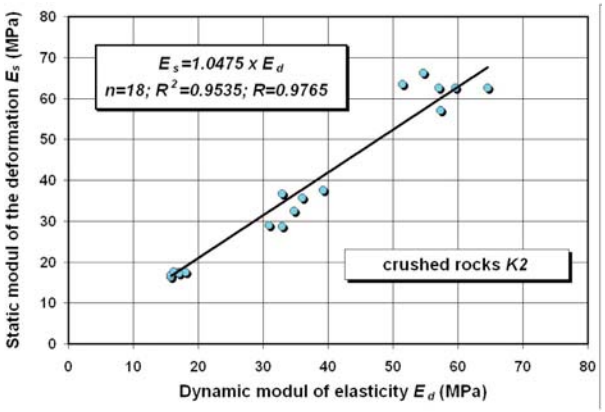

Fig. 7. Correlation estimation of E_s/E_d for granulated gravel K2

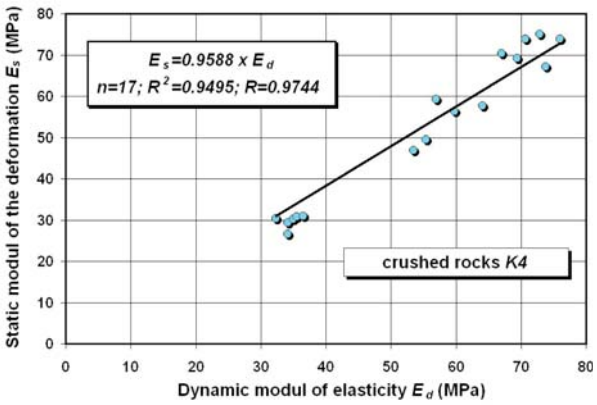

Fig. 8. Correlation estimation of E_s/E_d granulated gravel K4

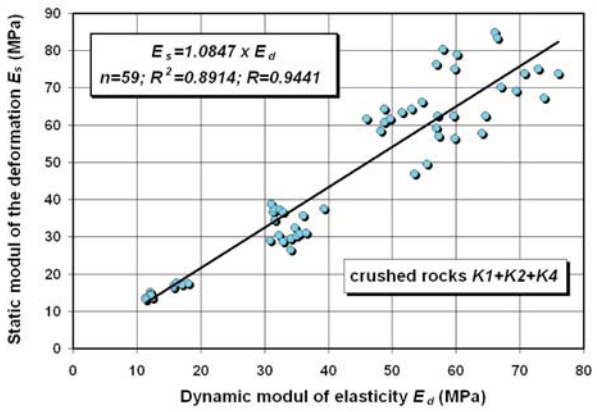

Fig. 9. Correlation estimation of E_s/E_d granulated gravel K1 + K2 + K4

coarse-grained material of the subbase was, the higher correlation coefficient was reached. The experiments also proved the fact that dynamic loading tests are less suitable for materials with higher proportion of fine fraction.

The authors of the paper would like to thank the grant commission VEGA for supporting the project No. 1/0341/03, which allows the realization of experimental measurements and consequently obtaining relevant results that are presented in this paper.

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Ľubica Hanuštiaková – Rudolf Olach *

ON DYNAMICS OF CERTAIN ECONOMIC MODELS

The article deals with the dynamics of two economic models. The first one is a macroeconomic model about national income and its stability. In the second model the price of a certain commodity is treated. The equilibrium points, periodic points, price cycles and their stability in the market is also observed. The article is interdisciplinary in its nature.

Keywords: *Economic model, national income, price, equilibrium point, periodic point, cycle, stability.*

1. Introduction

The basic dynamical macroeconomics model for national income Y follows from the equilibrium condition

$$Y = C + I,$$

where C is national consumption and I is national investment. The usual dynamical assumption is that consumption depends on income with a one-period lag, i.e.

$$C(t) = a + bY(t-1),\ a \geq 0,\ 0 < b < 1, \tag{1}$$

where the constant a characterizes consumption, b is the marginal propensity to consume and t is time. The investment is assumed to be partly autonomous and in the initial period shifts from I_0 to $I_0 + \Delta I$ and remaining at this level in all subsequent periods and partly depending on income (with a one-period lag) according to the marginal propensity to invest h:

$$I(t) = I_0 + \Delta I + hY(t-1),\ 0 < h < 1.$$

Then the difference equation

$$Y(t) = C(t) + I(t) \tag{2}$$

is interpretation of the model.

Our aim is to investigate the stability of the model (2) which expresses its dynamics in the case when the investment has a form

$$I(t) = hY(t-1) + (I_0 + \Delta I)(1 - d^t),$$

$$0 < h < 1,\ 0 \leq d \leq 1. \tag{3}$$

The value $I_0 + \Delta I$ does not remain constant in all the subsequent periods.

From the mathematical point of view we also study the dynamics of the pricing of a certain commodity. In this model our attention is focused on the equilibrium points, periodic points, cycles and their stability.

2. The basic model of national income

We consider the case when $0 < d < 1$ in (3). We invest it gradually. We remind that if $d = 0$ we obtain the model from [3]. If $d = 1$ then the investment depends only on the national product $Y(t-1)$.

So, in the case $0 < d < 1$ the part of investment

$$(I_0 + \Delta I)(1 - d^t)$$

will gradually increase from the zero value in the time $t = 0$ to the value $I_0 + \Delta I$ as $t \to \infty$.

Applying (1) and (3) in (2) we get

$$Y(t) - (b + h)Y(t-1) = a + I_0 + \Delta I - (I_0 + \Delta I)d^t,\quad t \geq 0 \tag{4}$$

The difference equation (4) represents the model (2).

For the simplicity we assume that $d \neq b + h \neq 1$. We can find the particular solution $Y^*(t)$ of (4) in the form

$$Y^*(t) = Y_1^*(t) + Y_2^*(t),$$

where $Y_1^*(t)$ or $Y_2^*(t)$ is a particular solution of the equation

$$Y(t) - (b + h)Y(t-1) = a + I_0 + \Delta I \tag{5}$$

or

$$Y(t) - (b + h)Y(t-1) = -(I_0 + \Delta I)d^t. \tag{6}$$

The general solution of the difference equation (4) has a form

$$Y(t) = \bar{Y}(t) + Y_1^*(t) + Y_2^*(t),$$

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where $\bar{Y}(t)$ is the general solution of the homogeneous part of (4), i. e.

$$Y(t) - (b + h)Y(t - 1) = 0. \quad (7)$$

The characteristic equation of (7) is $\lambda - (b + h) = 0$. Then the general solution of (7) becomes

$$\bar{Y}(t) = A\lambda^t = A(b + h)^t, \quad A \in R, \quad t \geq 0,$$

The particular solution $Y_1^*(t)$ of (5) with assumption $b + h \neq 1$ has a form

$$Y_1^*(t) = A_1, \quad A_1 \in R$$

and applying in (5) we get $A_1 = (a + I_0 + \Delta I)/(1 - b - h)$. So, we have

$$Y_1^*(t) = \frac{a + I_0 + \Delta I}{1 - b - h}.$$

Now we will find the particular solution of (6) in the form $Y_2^*(t) = A_2 d^t, A_2 \in R$, with assumption $b + h \neq d$. According to equation (6) we obtain

$$A_2 = -\frac{I_0 + \Delta I}{1 - (b + h)d^{-1}}$$

and we have that

$$Y_2^*(t) = -\frac{I_0 + \Delta I}{1 - (b + h)d^{-1}} d^t.$$

Now we can establish the general solution of (4)

$$Y(t) = A(b + h)^t + \frac{a + I_0 + \Delta I}{1 - b - h} - \frac{I_0 + \Delta I}{1 - (b + h)d^{-1}} d^t, \text{t} \geq 0.$$

Hence it follows that the model (4) or (2) will be stable if $b + h < 1$, i. e.

$$h < 1 - b \quad (8)$$

Since $0 < d < 1$, then every solution of (4) will converge to the value

$$\frac{a + I_0 + \Delta I}{1 - b - h}.$$

Since $1 - b$ is the marginal propensity to save, condition (8) says that the marginal propensity to invest must be smaller than the marginal propensity to save if the model is to be stable.

Now, we will briefly investigate the case when $d = 1$. From (4) we get

$$Y(t) - (b + h)Y(t - 1) = a. \quad (9)$$

We treat this equation in a similar way as above. We obtain the particular solution $Y^*(t)$ of (9) under condition $b + h \neq 1$,

$$Y^*(t) = \frac{a}{1 - b - h},$$

and also the general solution of (9)

$$Y(t) = A(b + h)^t + \frac{a}{1 - b - h}. \; t \geq 0, A \in R.$$

So, we have that the equilibrium of (9)

$$\frac{a}{1 - b - h}$$

is stable if $b + h < 1$.

3. A model of the price of commodity

By observation of the price $p(n)$ of a certain commodity in the period n and number of units $D(n)$ demanded in period n, we obtained the following values

$(p(1), D(1)), (p(2), D(2)), \ldots (p(m), D(m))$.

Using for example Gauss method of the least squares on the values above, we get the demand function $D(n)$. For simplicity of consideration we assume that $D(n)$ depends only linearly on $p(n)$ and has the concrete form

$$D(n) = -p(n) + 2.225, p \in [0.5, 2.225].$$

Similarly let $S(n + 1)$ be the number of units supplied in period $n + 1$ with the price $p(n)$ one period before and we obtained the quantities

$(p/1), S(2)), \ldots, (p(m), S(m + 1))$.

Using the method of least squares let the supplied function be

$$S(n + 1) = 0.5p^2(n) - 0.5p(n) + 0.125, \; p \in [0.5, 2.225].$$

We remind that the market price is the price at which the quantity demanded and the quantity supplied are equal, that is when

$$D(n + 1) = S(n + 1).$$

By virtue of this fact we get

$$p(n + 1) = -0.5p^2(2) - 0.5p(n) + 2.1, \; p \in [0.5, 2.225]. \quad (10)$$

The difference equation (10) is nonlinear and represents the model of market price. Generally we do not know how to solve such equations. But we can obtain important information about their dynamics, for example by equilibrium points, periodic points, cycles, etc.

We consider the difference equation

$$x(n + 1) = f(x(n)), \; n \geq 0. \quad (11)$$

Number $b \in R$ is called a periodic point with period $m \in N$ (i. e. m-periodic point) of continuous function $f: R \to R$ or equation (11), if $f^m(b) = b$ and $f^j(b) \neq b, j \in \{1, ..., m-1\}$,

where f^m is the m th iterate of function f.

Number $b \in R$ defines an m-cycle $\{b, f(b), ..., f^{m-1}(b)\}$ of function f or equation (11), where

$$f^m(b) = b.$$

According to (10) we denote

$$f(p) = -0.5p^2 + 0.5p + 2.1.$$

Then the equilibrium points of Eq. (10) are obtained from the equation

$$f(p) = p$$

and we have $p_1 = 1.6095$, $p_2 = -2.6095$. The point $p_2 \notin [0.5, 2.225]$ and the point p_1 represents the market price.

2-periodic points of (10) are obtained from the equation

$$f^2(p) = p$$

and we get $p_3 = 0.82918$, $p_4 = 2.17082$.

With regard to 2-periodic points the next 2-cycles of (10) follow

$$[p_3, f(p_3)] = [0.82918, 2.17082],$$
$$[p_4, f(p_4)] = [2.17082, 0.82918].$$

From the economic point of view the 2-cycle of (10) envisages two prices of commodity: the low price $p_3 = 0.82918$ which is advantageous for a consumer and disadvantageous for a producer and high price $f(p_3) = p_4 = 2.17082$ suitable for a producer and unsuitable for a consumer. The cycle is depicted in Fig. 1.

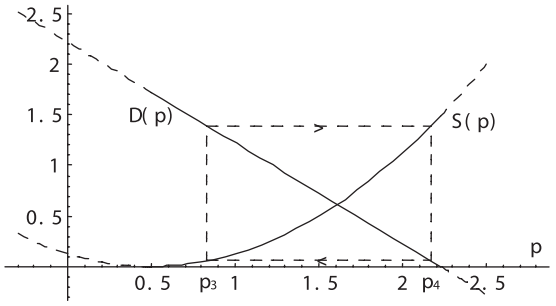

Fig. 1. 2-cycle of Eq. (10)

The pricing cycle is demonstrated in the market in such a way that due to the price p_3 there is a high demand $D(p_3) = 1.39582$ and a low supply $S(p_3) = 0.0541797$ and due to the price p_4 there is a low demand $D(p_4) = 0.0541797$ and a high supply $S(p_4) = 1.39582$.

We remind that 2-cycle $\{p_3, p_4\}$ is a periodic solution of the difference equation (10) and is depicted in Fig. 2.

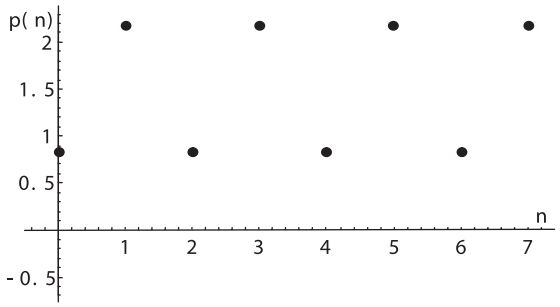

Fig. 2. Periodic solution of Eq. (10)

Observing the model (10) we get the necessary condition for existence of 2-cycle.

Theorem 1. If $\{d, h\}$ is 2-cycle of difference equation

$$x(n+1) = ax^2(n) + bx(n) + c, \ \ a, b, c \in R, \ \ n \geq 0,$$

then

$$a(d+h) + b + 1 = 0 .$$

Proof. Since $\{d, h\}$ is 2-cycle and $f(x) = ax^2 + bx + c$, we get

$$ad^2 + bd + c = h, \ \ ah^2 + bh + c = d.$$

By subtraction we obtain

$$a(d^2 - h^2) + b(d - h) = h - d,$$
$$a(d+h)(d-h) + b(d-h) = h - d,$$
$$a(d+h) + b + 1 = 0.$$

The proof of theorem is complete.

4. The stability of market price, periodic points and cycles

The following theorems are our main tools in this section.

Theorem 2. Let x^* be an equilibrium point of the difference equation (11), where f is continuously differentiable at x^*. The following statements then hold true:

(i) if $|f'(x^*)| < 1$, then x^* is an asymptotically stable (attracting) point,
(ii) if $|f'(x^*)| > 1$, then x^* is not stable. In fact x^* is a repelling point.

The proof of Theorem 2 can be found in [2].

For the study of the stability of an m-periodic point b of Eq. (11), one can use the previous Theorem 2 applied on f^m.

Theorem 3. Let $C(b) = \{b = x(0), x(1), ..., x(m-1)\}$ be an m-cycle of a continuously differentiable function f or Eq. (11). Then the following statements hold:
(i) the m-cycle $C(b)$ is attracting if

$$\left|f'(x(0))\, f'(x(1)) \ldots f'(x(m-1))\right| < 1,$$

(ii) the m-cycle $C(b)$ is repelling if

$$\left|f'(x(0))\, f'(x(1)) \ldots f'(x(m-1))\right| > 1.$$

The proof of Theorem 3 is in [2].

Using Theorem 2 for $p_1 = 1.6095$ we get

$$\left|f'(p_1)\right| = \left|-1.1095\right| = 1.1095.$$

That is the market price p_1 of the model (10) is not stable.

Now we will study the stability of 2-periodic points p_3 and p_4. For $p_3 = 0.82918$ and $p_4 = 2.17082$ we get

$$\left|(f^2)'(p_3)\right| = 0.55, \quad \left|(f^2)'(p_4)\right| = 0.55\,.$$

Both periodic points are asymptotically stable.

By virtue of Theorem 3 for cycles $\{p_3, f(p_3)\}$ and $\{p_4, f(p_4)\}$ we obtain

$$\left|f'(p_3)f'(f(p_3))\right| = \left|-0.32918(-1.67082)\right| = 0.55,$$

$$\left|f'(p_4)f'(f(p_4))\right| = \left|-1.67082(-0.32918)\right| = 0.55\,.$$

So we have that both cycles are asymptotically stable. Since the cycle {0.82918, 2.17082} is attracting (asymptotically stable), every solution of (10) converges to its periodic solution.

5. Conclusions

We can conclude that the model (4) of the national income will be stable, if the marginal propensity to invest is smaller than the marginal propensity to save.

From the economic point of view the model (10) interprets a very common situation in the market at which the price of commodity satisfies the consumer and does not satisfy the producer and vice versa. In this case it is suitable to change the supply and demand function or to come to the market with a new commodity.

Acknowledgements
The research was partially supported by the grant 1/0026/03 of the Scientific Grant Agency of Ministry of Education of the Slovak Republic and Slovak Academy of Sciences.

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Magdalena Markiewicz *

VENTURE CAPITAL IN CENTRAL AND EASTERN EUROPE – SLOVAKIAN CASE

Financing business at the very first stage or expanding it, together with active participation in creating strategies of management, marketing, sales and other fields, may be done by venture capital funds and venture investors. They offer capital, know-how, expertise and assistance and are ready to take significantly higher risk for the average period of 5-7 years. Venture investments are especially effective in stock-oriented markets, due to an opportunity of easy disinvestment through public offering, or in emerging markets, where they meet prospects of very high rates of return. Private equity and venture capital investments may highly support the development of knowledge and innovation, which are among the keys to economic growth and welfare. These investments, rising in Europe, support lowering the development gap between the US and the EU.

1. Venture capital – an opportunity to develop business and support innovation

Venture capital (VC) is a method used for encouraging business development at its very first stage, being an important source of equity for start-up companies. It is called the capital of high risk or the business method of setting up a company. Venture capital should be taken into serious consideration when thinking about financing a new business. It may be a great opportunity for small and medium companies who want to develop in the innovation sector but who stand a very small chance of getting a long-term credit due to their low creditworthiness resulting from the lack of experience and rating in a chosen sector of the market.

Investors in venture capital funds are eager to fund start-up companies and to provide them with capital, as well as know-how and advisory services as soon as they recognize the market potential of a given company. They do it with the aim to achieve a high return in the future. They include active investors, involved in management or strategic marketing activities. The usual period of investments is 5-7 years. Before selecting a limited number of companies with favourable investment opportunities, the investors might have to look upon a variety of investment opportunities. They actually invest in just a few of the reviewed businesses – those with excellent technical and business qualities as well as long-term prospectives. The investments can be made during different stages: the start, early development or growth of a business. A venture capital contributor can invest in the phase of "seed investing", that is before the actual product is manufactured or before the company is established, or in its first or second stage of development, which is usually done by providing capital to start up a company. This method is called "early stage investment".

A VC capitalist can be a professionally managed company in the form of limited private partnership or a company closely related with private and public pension funds, endowment funds, foundations, insurance companies, banks, corporations and foreign investors. Wealthy individuals called "angel investors" can also play an important role in VC investments. These are usually people with management expertise, sometimes retired businessmen or businesswomen. They mentor a selected company and provide it with necessary capital and expertise all the way during the company's development. Venture capital investors often diversify the risk by developing a portfolio of young companies in a single venture fund.

VC provides capital to enterprises which are not yet quoted on the stock exchange. When such a company obtains the results which had been previously agreed on regarding the ways of running business and the schedule of actions to be taken to guarantee the stability of the company, the strategic investor withdraws its venture capital. It is done either by obtaining a direct return on capital or by selling the company's shares after introducing the company to the stock market.

Venture capital appears to be more vital and effective in the stock-oriented systems. It seems to be reasonable due to the fact that the relationship between the entrepreneurs and venture capital providers is based on agreements which guarantee the latter the possibility to control the company while the investment is still in progress, and afterwards – the possibility to regain control by the company itself. The operation of regaining control is usually based upon an initial public offering, which gives the venture capitalist a way out of further investments in portfolio companies.

2. The role of venture capital in economic growth and innovation

There is an increasing number of successful investments in the region of Central and Eastern Europe (CEE). The results include

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the rise of competitiveness and employment prospectives and they play a positive role in the development of chosen sectors and have a positive economic impact on all the CEE countries. These enterprises usually become leaders in their markets. The investors contribute the crucial success factors to the financed entrepreneurs. The basic role is played by the capital, but other factors such as know-how, expertise and assistance are of an extreme importance.

In 2001-2003 the rise of venture capital as a way to encourage the development of small and medium-sized enterprises was noted in Europe. The average ratio of investment value to GDP was estimated at the level of 0.36% of GDP in 2004 (0.26% for buyouts and 0.10% for venture capital), compared to 0.3% in 2003 and starting from 2002 it was constantly at the higher level than in the USA. In 2004 the level of start-up investments rose by 13% as compared to 2003, while investments in high-tech companies increased by 6.5%.

In the years 2000–2003 the performance of venture – grown up companies in the USA demonstrated that venture capital could create market leading companies which contributed significantly to the U.S. economy. Even though they might begin very small, the succeeding ones create new industry sectors and drive economic growth, innovation, and progress. Prominent U.S. companies, being famous examples of ones that had received venture financing early during their growth phases include: Microsoft, Federal Express, AOL, Apple, Office Depot, Intel, Home Depot, Cisco, Compaq, e-Bay, JetBlue, Seagate and Google. The research made in the USA shows that companies receiving venture financing between 1970 and 2003 accounted for 10.1 million jobs and $1.8 trillion in revenue in 2003, representing approximately 9.4% of total U.S. jobs and revenues.

Innovation is recognized as fundamental for economic welfare and GDP growth.

It is observed that a correlation exists between the Summary Innovation Index and GDP per capita, especially when the countries are grouped as of high- and low-income. The relationship between the income and innovation seems to be stronger at lower GDP levels and is more differentiated at higher levels of GDP.

Due to the fact that VC is regarded as vital for innovation, it is annually analysed within the European Innovation Scoreboard (EIS). EIS is an instrument developed by the European Commission used since resolving the Lisbon Strategy for evaluation and comparison of innovation performance in the Member States, candidate countries, Norway, Switzerland, USA and Japan. In 2004 the SII indicated among the first five positions: Japan as the most innovative country, then Finland and Sweden representing the EU, and finally the US and Switzerland. The most innovative among the New Member States are Estonia and Slovenia, ranking above some of the EU15 countries. The most innovative sectors in EU are electrical and optical equipment, chemical products and transport equipment industries.

The EIS is based on 20 indicators combined into the Summary Innovation Index (SII). The main drivers and effects of innovation are: *human resources, creation of knowledge, the transmission and application of knowledge* and finally – *innovation finance, output and markets*. From the point of view of venture capital the most important group of indicators would be the last one, but the first three are complementary to it and they are also extremely important for the development of venture capital.

The *innovation finance, output and markets* group consists of six indicators: share of high-tech venture capital investment, share of early stage VC in GDP, percentage of total turnover of product sales ("new to market" or "new to the firm but not the market"), internet access, ICT expenditures and share of manufacturing value-added in high-tech sectors. The definitions of the indicators have been specified by Eurostat (excluding the first one, given by EVCA).

High-tech venture capital share in EU15 was at quite a high level and European leaders were Denmark, Germany and France.

GDP growth in CEE countries in 2001-2006 [%, change to previous year] Table 1

	2001	2002	2003	2004	2005 - forecast	2006 - forecast	2004 Summary Innovation Index	GDP per capita, 2004 (EUR)
Czech Republic	2.6	1.5	3.7	4.0	3.7	3.9	0.27	8,430
Hungary	3.8	3.5	2.9	4.0	3.8	4.0	0.25	7,960
Poland	1.0	1.4	3.8	5.3	4.2	4.7	0.14	5,100
Slovakia	3.3	4.4	4.2	5.5	4.6	4.8	0.24	6,140
Slovenia	2.7	3.4	2.5	4.6	3.8	4.0	0.32	12,980

Source: Based upon: European Innovation Scoreboard 2004. Comparative Analysis of Innovation Performance, Commission Staff Working Paper, Commission of the European Communities, Brussels, SEC(2004) 1475, 19 November 2004, p.9; *CEE Report. Business Information on Central and Eastern Europe,* no.2/2005, Economic Research, http://economicresearch-e-ba-ca.com.pdf, p. 22; *CEE Economic Data. Outlook for 2006,* Issue 1, Bank Austria Creditanstalt, http://economicresearch-e-ba-ca.com.pdf, p. 10–32.

The highest ratio of early-stage venture capital to GDP was observed in Switzerland, Finland and Denmark.

From 2000, the year when the Lisbon Strategy started till the end of 2003, the European private equity and venture capital industry financed over 40 000 companies and thus formed new industries contributed to creating 6.5 million jobs and brought 415 companies to the stock market. In 2003 the private equity industry raised 27 billion EUR from institutional investors and invested 29.1 billion EUR in the growth of European companies. In 2004 these figures reached 27.5 billion EUR of raised funds and 36.9 billion EUR of investments accordingly (which was the record value and which surpassed the peak value of 35 billion EUR reached in 2000).

The innovation gap between the United States and Europe is still high. It results from the low rate of patents registered in Europe (50% of the innovation gap), working population with tertiary education (26%) and R&D expenditures, mainly business R&D (11%), high tech manufacturing (11%) and early-stage venture capital (10%).

3. Barriers to development of venture capital sector

The barriers to development of that sector are the same or similar in most of the EU countries. In 1998 European Commission identified those handicaps within Risk Capital Action Plan (RCAP) focused on the integration of financial markets within the EU countries. The most important barriers are:

- insufficient knowledge about this way of financing, alternative to bank credits,
- the lack of adequate institutional and legal regulations defining multilateral aspects of investment activities, functioning of VC funds and such institutional investors as investment fund and pension funds,
- low range of integration of capital markets within the EU, together with their low capitalization and liquidity,
- disharmonisation of tax systems, which may discourage potential investors, especially *business angels* – sophisticated private investors providing their capital, from investing into venture capital and private equity funds,
- legal limits of investments in VC by pension funds.

Risk Capital Action Plan is known, together with the Financial Services Action Plan, as a constituent of the Lisbon Strategy. It is aimed at developing capital markets, essential for financing small and medium sized enterprises, through implementation of the legal framework, both on the central level of the European Union and on the level of Member States. The reports of the European Commission indicate positive results, however pointing at the development gap between the EU and the USA, with particular stress on diversification of tax systems, which also complicates the use of venture capital.

The issue of bridging the gap is represented by the innovation trend presented in Fig. 1: the trend is rising for Japan as well for the US (after a slump in 2002), where the peak in innovation performance was reached in 2000-2001 thanks to venture capital achievements. In Europe this trend seems to remain stable. The reports recognize the important role of private equity and venture capital in making Europe a more attractive place to invest and work. There is no doubt that the PE/VC funds may reduce the gap through enhancing research opportunities and providing the companies and the markets with patents. Patents may mean both technical improvements and such non-technical changes like reshaping organization in order to get the most profits from new technologies (thus it may bring about changes in the organizational structure, management techniques and aesthetic appearance).

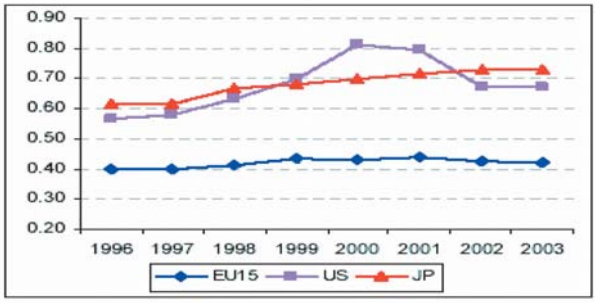

Figure 1. The innovation gap between the USA and the EU measured by Summary Innovation ndex in 1996-2003.

Source: European Innovation Scoreboard 2004. Comparative Analysis of Innovation Performance, Commission Staff Working Paper, Commission of the European Communities, Brussels, SEC(2004) 1475, 19 November 2004, p. 4.

4. Venture capital in Central and Eastern Europe

Private equity and venture capital funds are important part of the CEE capital markets in spite of the relatively young experience in the region. The fund raising and investments started in CEE countries in 1990. The development processes of venture capital in CEE countries were encouraged by public and financial institutions like European Bank for Reconstruction and Development (EBRD) or European Investment Fund (EIF). They invested primarily in early to mid-stage small and medium enterprises. Their actions concern almost all of CEE countries. For instance, until July 2004, EIF has committed in CEE countries 115 million EUR in 8 venture capital funds investing in Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia. It is estimated that within 15 years more than 7 billion EUR were raised to the funds and in 2003 fundraising activity increased by 28% in all CEE countries.

Appreciating the important role of venture financing in creating the economic growth, European Venture Capital Association (EVCA) established in 2003 Central and Eastern Europe Task Force aimed at the development and promotion of private equity and venture capital in the region.

Fundraising for CEE private equity in 2002–2003 Table 2.

EUR,000	Czech Republic	Hungary	Poland	Romania	Slovakia	Baltic States	Other*	Total CEE
Domestic	12.672	16.365	5.242	535	1.539	52.859	34.942	124.154
Other European	35.365	16.994	19.245	5.144	335	50.836	0	127.919
Non-European	45.730	6.546	1.250	2.890	1.444	2.023	0	59.883
Total 2003	93.767	39.905	25.737	8.569	3.318	105.718	34.942	311.956
Total 2002	55.777	31.533	108.763	12.673	9.891	2.111	22.296	243.044

Source: EVCA
* Bulgaria, Croatia, Slovenia

Type of investment by CEE country in 2003 Table 3.

EUR,000		Czech Republic	Hungary	Poland	Romania	Slovakia	Baltic States	Other*
Seed		1	0	166	0	0	0	600
Start-up		1.378	753	2.842	0	0	832	18.428
Expansion		25.421	19.986	39.952	49.887	4.479	131	5.528
Replacement capital		0	1.759	42.199	519	0	6.730	0
Buyouts		12.624	88.257	92.054	31.614	0	2.307	0
Total 2003		39.422	110.755	177.213	82.020	4.479	10.000	24.556
Total 2002		27.370	75.747	137.238	18.008	4.737	2.902	7.726

Source: EVCA
* Bulgaria, Croatia, Slovenia

Investors in CEE countries usually represent foreign capital, but the domestic capital is also invested in the region. Investments concentrated in the field of telecommunication, consumer goods and services, media and financial services (66% of the venture capital investment value) and an analogical tendency could be observed all over Europe.

The important aspect of those investments is the high rate of start-up and early-stage financing capital. The governments in the region make efforts to stimulate such activities. However, it varies in different countries of the region. Early-stage investments are still low in comparison to most of Europe, which creates "an equity gap" for early-stage CEE entrepreneurs.

The average size of investment reflects the increasing trend in the CEE countries, since the companies develop, and is similar to the one visible in the whole Europe. Average European VC investment size was 2.8 million EUR in 2003 and it increased to 3.6 million EUR in 2004. However, the figures concerning the GDP growth show that the CEE countries have still greatly lower GDP per capita than previous 15 Member States (it is a factor of 4 times). Political, administrative, economic and legal reforms offer a chance to improve these factors.

5. Slovakian experience with venture capital

In Slovakia there exist few private equity and venture capital funds, among the first were: the Slovak American Enterprise Fund (SAEF), EBRD Post-Privatisation Fund, the Phare-Funded Seed Company and Genesis Capital operating for Advent International.

A good example of using the described way of financing in Slovakia is Slovpack, a manufacturer of plastic packaging for food and industrial construction sectors. The private equity investor was in that case Raiffeisen Ost Invest (ROI), providing the company with 1.1 million EUR from 1998 to 2002. The company started to exist in 1994 and until 1998 did not have a clear business strategy and complicated formal structure made internal relations and management decisions ineffective. Raiffeisen Ost Invest prepared a management buyout and stated the company's progress using the extensive experience of an earlier team within a five-year strategic plan. The strategy was based on cooperation with the second strategic partner (Slovnaft) and included diversification of products, increase in product quality, improving financial control systems and adjusting the production to the clients' demands and orders. From 1998 to 2002 Slovpack achieved 10 million EUR sales and 2 million EUR EBITDA, its productivity increased by 30%. The company was a leader in the Slovakian market and exported to Germany, the Netherlands, Austria, the Czech Republic and Poland.

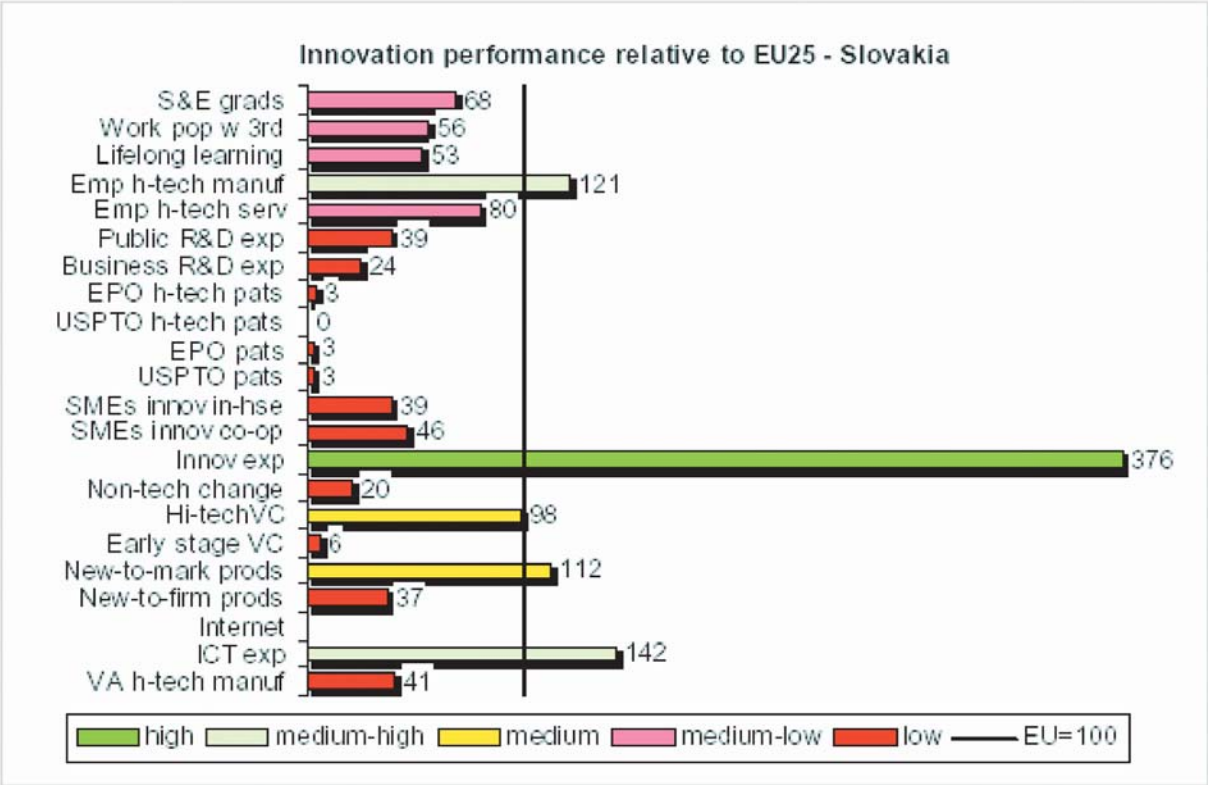

Figure 2. Innovation performance relative to EU25 - Slovakia

Source: 2004 European Innovation Scoreboard. Country Pages, EU25 + Candidate Countries, Commission Staff Working Paper, Commission of the European Communities, Brussels, SEC(2004) 1475, 19.11.2004, p. 44.
Abbreviations in *Figure 2*:
S&E grads – science and engineering graduates; *work pop w 3 rd* – population with tertiary education; *emp* – employment; *h-tech* – high technology; *manuf* – manufacturing; *serv* – services; *R&D* – research and development; *exp* – expenditures; *EPO* – European Patent Office; *USPTO* – US Patent and Trade Office; *pats* – patents; *SME* – small and medium enterprises (a number of firms); *in-hse* – introducing innovation in house, as a single firm; *co-op* – in cooperation agreements with other enterprises or institutions; *innov exp* – innovation expenditure as % of all turnover; *non-tech change* – share of SME using non-technical change in all SMEs; *ICT exp* – total expenditures on information and communication technology; *VA h-tech manuf* – total value-added in manufacturing in five high technology industries (pharmaceuticals, office equipment, telecommunications and related equipment, instruments, aerospace).

In 2002 Raiffeisen Ost Invest disinvested from Slovpack realizing an IRR of 32%.

According to *EVCA Final Activity Figures,* in 2004 private equity funds in Slovakia raised 5,256 million EUR and 4,224 million EUR was invested. The amount of disinvestments was estimated at the level of 1,321 million EUR. These numbers are not high when compared to other European countries (0.0002 of raised funds and 0.0001 of private equity investments). Slovakia is the smallest market within the CEE countries and previously (up to 2000) it was often omitted by investors who were interested rather in the Czech Republic, Hungary and Poland.

Since then the political and economic situation started to be more stable and the government made many incentives to attract foreign direct investments. Now FDI are high also due to low labour costs, highly educated labour force and the flexibility of the workers. The excellent example is automotive sector with Volkswagen, PSA Peugeot Citroen, Renault, Hyundai Motor (Kia brand), all producing the most modern models in Bratislava, Trnava, Kolin, Nove Mesto and Žilina. The Slovakian factories have now even bigger capacity than the factories in its CEE neighbours.

However, venture capital exists in a different way – the government has less direct economic tools to enhance the growth of VC and in many Slovakian enterprises keeping control is one the most important issues put ahead of capital risk.

Despite this fact, the Slovakian market puts itself high in 2004 European Innovation Scoreboard (EIS) regarding ICT expenditures and employment in medium- and high-tech manufacturing, where the figures show accordingly a 15 and 25% positive differ-

ence from the EU trend growth. It is a bit different with public R&D, which are only stated as "catching up" and with business R&D having status "fallen further behind" at EIS. Performance of high-technology venture capital in Slovakia was estimated at the average level achieved in EU25, while early stage venture capital is still very low, at the level of 6% of the EU25 (Figure 2).

High-tech venture capital includes computer-related fields, electronics, biotechnology, medical and health, industrial automation and financial services. The measurement concerns the sum of seed and start-up capital as well as expansion capital. These investments reflect strong annual fluctuations, which are neglected when using a two-year time of observation.

When calculating the share of early stage venture capital, the institutions take into consideration both seed (financing the research, assess and growth of an original concept) and start-up capital (product development, initial marketing, manufacturing and sales). The transactions of management buyouts, management buy-in or venture purchase of quoted shares are excluded.

Non technical change means changes in organizational structures, management techniques and product design, estimated as low in Slovakia.

The strongest point of the Slovakian market was innovation expenditures, which even exceeded those of EU25. The scoreboard for 2004 implied the first rank in that section among all the Member States.

6. Conclusions

The economic growth of the CEE region is expected to rise as a consequence of increasing investment opportunities for private equity and venture capital funds, financing the companies which participate in the economic development of the region. As stated by the European Venture Capital Association: "European private equity and venture capital provides a vital source of long-term investment capital for growing companies across all industry sectors. It contributes to sustainable economic growth, generating employment, financing new research and technologies and supporting Europe's promising growth companies. VC operates according to accepted standards of conduct, reporting and valuation and has a strong network of professional advisors to support its increasingly important role in the European economy".

The important result of using VC financing is the rise in the number of patents, increased support for R&D and lowering the innovation gap between the United States, Japan and Europe. The general strapping trends in the CEE countries are partly explained by the lower starting point as compared to the former EU15. However, the most important fact is that the CEE countries have important achievements in introducing innovative concepts, which may be of a great importance since those results are worse as regards the proportion of GDP they represent. Financing innovation may lead to higher GDP and therefore better GDP-related results in the future.

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ELECTRONIC TOLL COLLECTION AT PARKING AREAS

The paper presents an object-oriented modeling of electronic toll collection in transport applications, deals with designing of a use case diagram, class diagram, sequence diagram, and state chart. The modelling of parking system activities by the UML language (Unified Modeling Language) creates suitable and effective environment for team members communication, simplifies software design process, and unifies principles and techniques used for documentation creation.

1. Introduction

Collection of tolls for parking place rentals is a basic function of parking systems. Experience shows that parking system installation can significantly increase the parking services revenues compared with standard forms of parking toll collection.

Exact specification of on-road vehicles and persons for whom the parking system is to be designed and classification of vehicles based on proper criteria are very important parts of a parking system design. General specification of on-road vehicles is given by the Act of the National Council on Traffic on Land Thoroughfares. Classification of on-road vehicles is performed on the base of their physical properties (size, weight, etc.), produced emissions, vehicle purpose, etc.

Based on the given classification vehicles are given rights to move within a parking system and amount of the parking toll is defined as well. Additional strict check of a vehicle weight must be ensured in the case of closed multi-storey car parks.

Tolls are collected not only by standard forms (human attendance, money and/or card automatons, etc.), but also by automatic forms requiring obligatory installation of on-board transponders and relevant technologies.

Modelling of park system operation by the UML (Unified Modeling Language) consists of creating the following types of diagrams: use case diagram, class diagram, sequence diagram and statechart diagram. Yet another types of diagrams are available but not used in our models. Examples of a use case diagram, class diagram and sequence diagram are given in the paper to model an automatically billing parking system.

The parking system consists of three basic sections that need to be seen as logical units performing specific operations. These are:

Logical unit Input *(presented by classes - Detector, Transceiver, InfoTable, Stop)*

Its task is to control input to a parking place in situations like:
- Input without support of a vehicle on-board unit (OBU). In this case a passive transducer of identification pulse is expected as the minimum on-board equipment. Reservation system and function of priority input are not available;
- Input with support of a vehicle on-board unit. This alternative can be used provided that the vehicle is equipped with a passive transponder at least. Priority input is possible based on request transmitted by the transponder;
- Input of vehicle with a defective transponder will be considered as input without support of a vehicle on-board unit;
- Input in the case of parking system failure. The parking system will be put out of service and its internal functions will be temporary taken over and performed by operative emergency service. The top control level will automatically reroute all requirements from higher levels to other parking systems. Transactions will be stored, and processed immediately after parking system recovery;
- Input with a transponder when an internal discrepancy is detected will be solved when leaving the system (at its output);
- Input rejection occurs when non-standard conditions are detected (vehicle overweight, length of vehicle exceeds defined input length, parking place is full, etc.).

Logical unit Output *(presented by classes - Detector, Transceiver, InfoTable, PaymentAutomaton, Stop)*

Its task is to perform operations that support the following situations:
- Output with a support of vehicle on-board unit, payments through transponder;
- Output without any problems, other payments form (credit card, subscriber card, coins, etc.);
- Output in the case of discrepancy in transponder-system data is considered as output without support of vehicle on-board unit;

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- Output with exit rejection (vehicle theft detection, insufficient credit, etc.);
- Non-standard output (escape, transport in other vehicle, etc.);
- Output of priority vehicles;
- Output from a parking place of an open type.

Logical unit Kernel *(presented by classes - P&Rcontroler, Record, UserDetection, Clasificator, UserIdentification, PaymentRealization,InfoGuidelines)*

Its task is to control a parking system and other partial systems of the parking place. These are:
- Free place guidance system;
- Parking place information system;
- Parking place management;
- Security systems;
- Monitoring system;
- Emergency system;
- Fire systems.

The logical unit *Kernel* simultaneously covers total communication with higher levels of the parking system. The top level is responsible for information exchange between the system and other equipment of ITS subsystems.

Creating an object-oriented model of the parking system and its operation must consider such criteria that enable as many options for future development as possible. This is the reason why the model is realized as an open system. Definition of parking system requirements enables to create a base of basic knowledge usable for logical architecture design.

The use case diagram (Fig. 1.) defines possible uses of the parking system as described above. The class diagram that describes requested functions of the parking system is presented in Fig. 2. Described in detail in literature [2].

Sequence diagrams represent particular situations as indicated and described in an introductory part of this paper. During the modelling process these basic sequence diagrams can be linked to create more complex and integrated units. This way can be used to model even complex situations occurring in individual I/O parts of the parking system. Thus combining different scenarios shown in Fig. 3. it is possible to create specific situations that occur at input or output of the parking system, and consequently to create relevant sub diagrams (Fig. 4.).

Such an approach can be used to include all situations needed to create sequence diagrams with the help of the software tool Rational ROSE.

The use of the described approach resulted in creating sequence sub-diagrams that were further used to model electronic payments for parking system services such as:

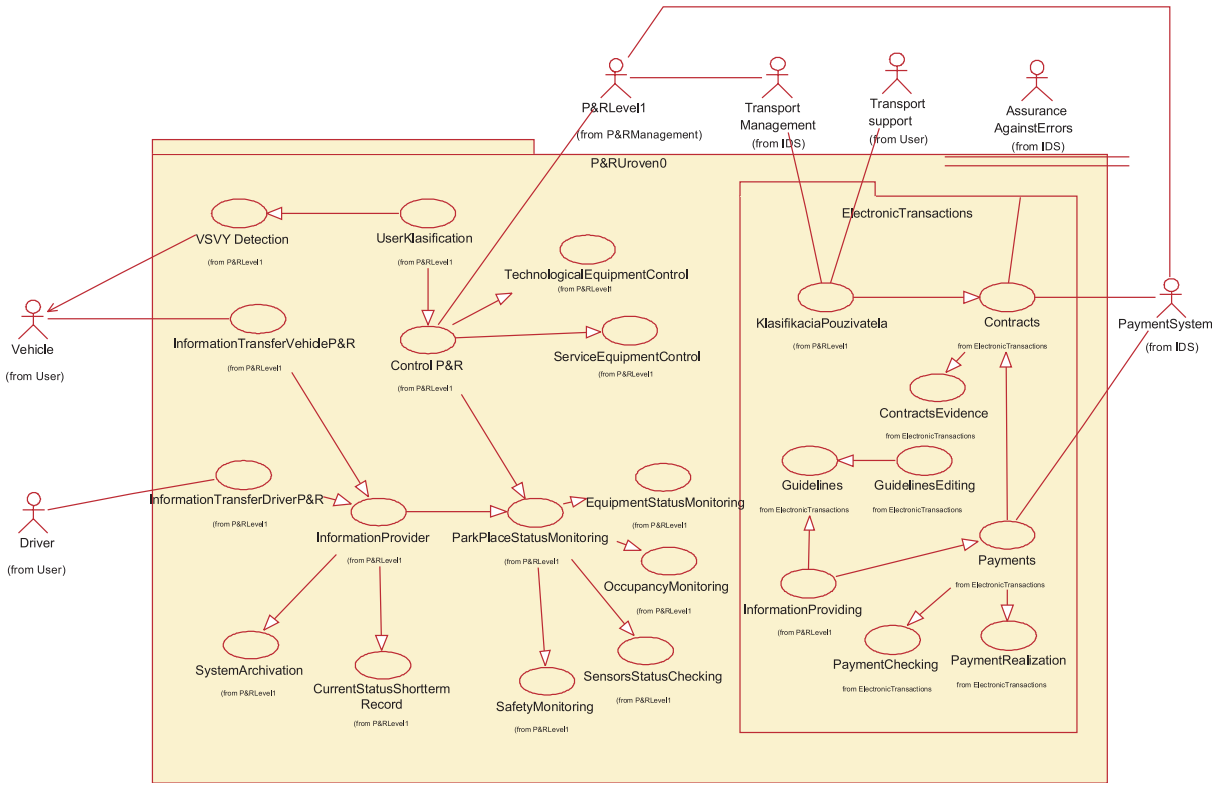


Fig. 1. Use case diagram

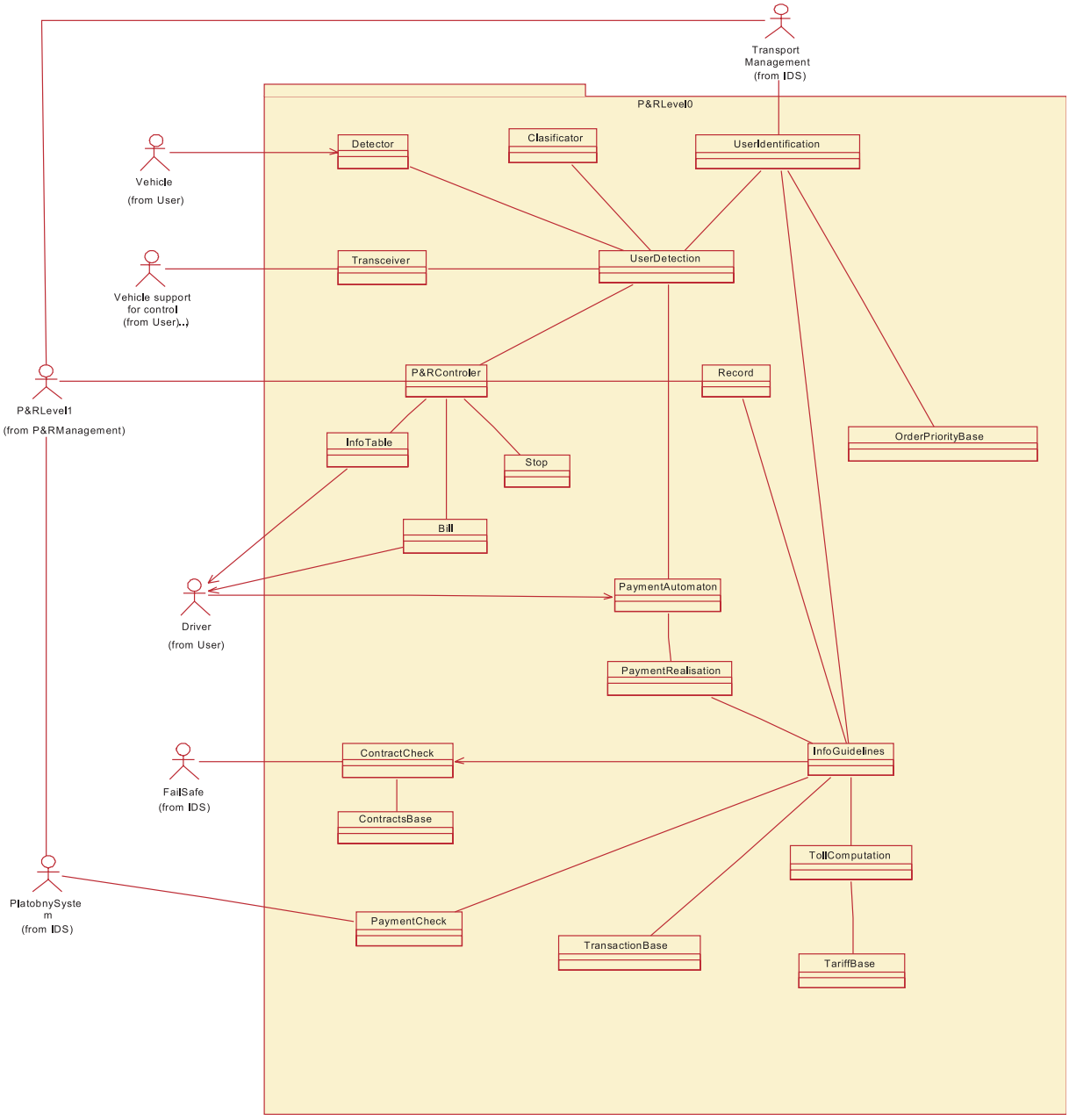
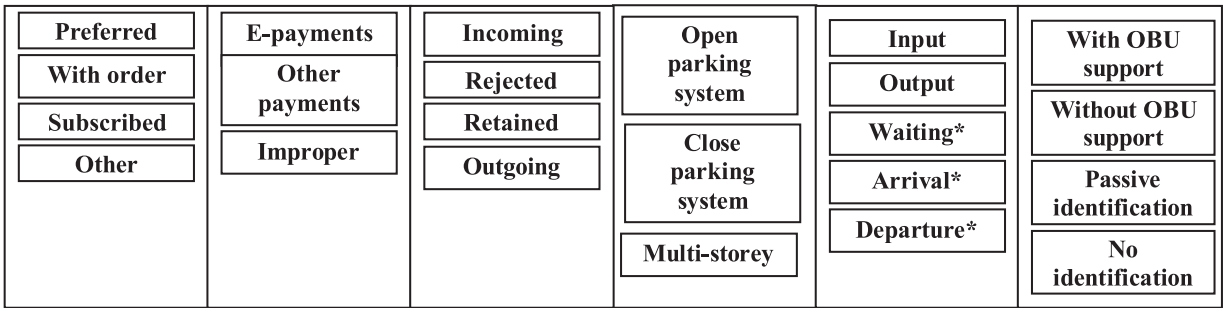


Fig. 2. Class diagram

a) A closed parking place
- Input without support of the vehicle on-board unit;
- Input with support of vehicle on-board unit;
- Input of vehicle with a defective transponder will be considered as input without support of the vehicle on-board unit;
- Input with a transponder when an internal discrepancy is detected will be solved when leaving the system (at its output);
- Input rejection occurs when non-standard conditions are detected (vehicle overweight, length of vehicle exceeds defined input length, parking place is full, etc.);
- Output without support of a vehicle on-board unit, payments through a transponder;
- Output without any problems, other payment forms (credit card, subscriber card, coins, etc.);
- Output in the case of discrepancy in transponder-system data detected will be considered as output without support of a vehicle on-board unit;
- Output with exit rejection (vehicle theft detection, insufficient credit, etc.);
- Non-standard output (escape, transport in other vehicle, etc.);



* valid for open parking places

Fig. 3. Basic sequence diagrams

Input	**Preferred**	**With OBU support**	**Improper**	**Incoming**	**Close parking system**
Input	**Subscribed**	**Passive identification**	**Other payment type**	**Rejected**	**Close parking system**
Output	**Other**	**With OBU support**	**E-payments**	**Outgoing**	**Multi-storey parking place**
Output	**Other**	**Without OBU support**	**Other payment type**	**Outgoing**	**Close parking system**
Arrival	**Other**	**With OBU support**	**E-payments**	**Incoming**	**Open parking system**
Departure	**Preferred**	**With OBU support**	**Improper**	**Outgoing**	**Open parking system**
.....					
Other					

Fig. 4. Modelling of parking system specific situations

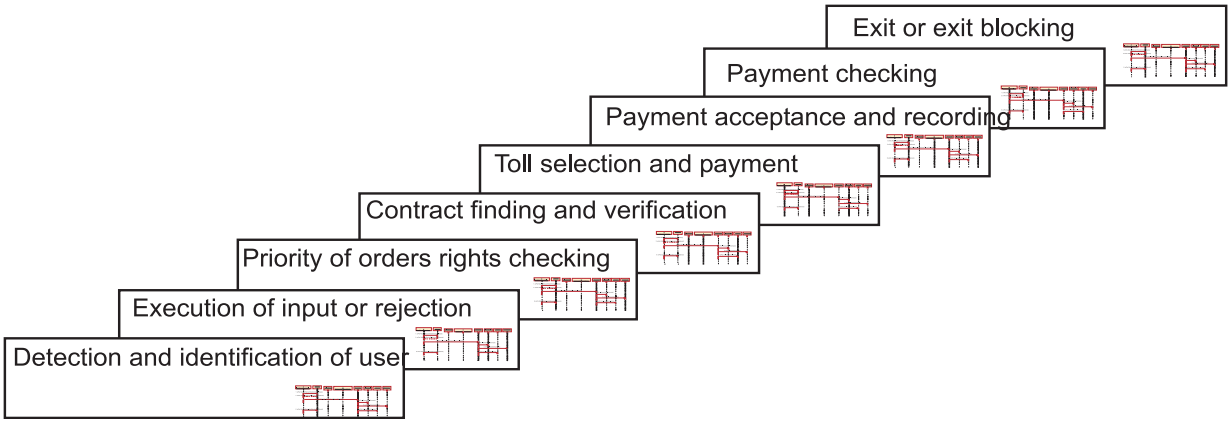


Fig. 5 Sub-diagrams modules

- Output of priority vehicles;
- Output from an open type parking place.

As examples in Fig. 5 there are shown modules of sequence sub-diagrams describing operation of a closed parking place – e-

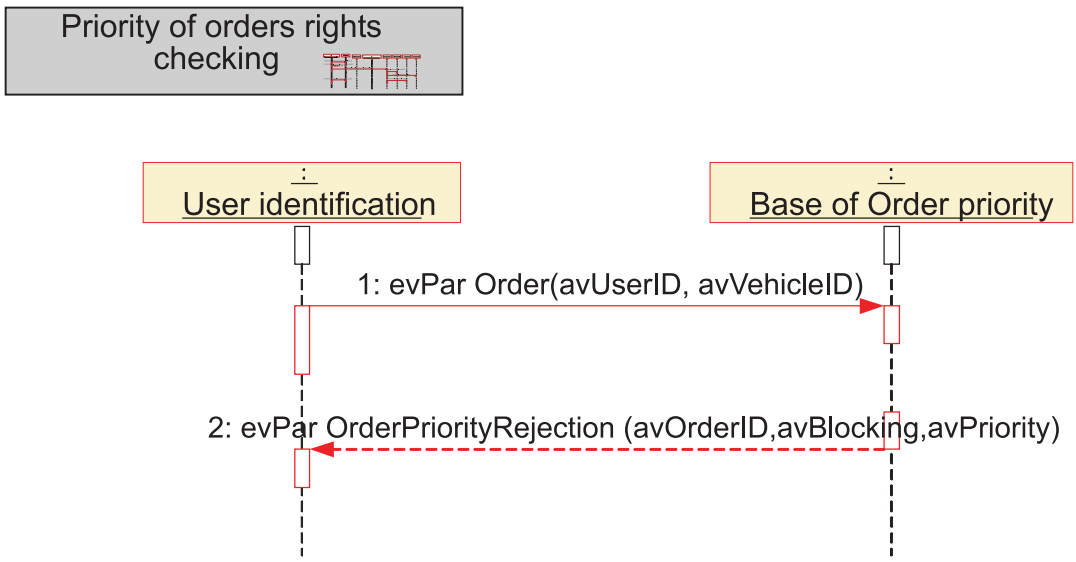


Fig. 6. Sequence diagram for Priority of Orders rights checking

payment, input and output with support of a vehicle on-board unit, payment through a transponder.

b) An open parking place

This type of a parking place does not allow for the use of some of standard elements for checking correctness and validity of payments for provided services. Checking activity must be performed with a help of an "operator".

- Input without any problems, other payments form (credit card, subscriber card, coins, etc.);
- Output without support of a vehicle on-board unit, payments through a transponder;
- Input with a transponder when an internal discrepancy in transponder-system data is detected will be considered as input without support of a vehicle on-board unit;
- Output with exit rejection in situations being considered non-standard and solved by a human "operator" (vehicle theft detection, insufficient credit, etc.);
- Priority vehicles staying;
- Others...

A concrete sequence diagram (presents and specifies one line of Fig. 4.) example of a sub-diagram module from Fig. 5. is a sequence diagram called "Priority of orders rights checking" presented in Fig. 6.

Unlike an open parking place where the payment must be realized by deposit type of payment at the closed parking place the payment is realized at the exit of the system.

Conclusion

Object-oriented modelling of electronic toll collection creates a suitable and effective environment for communication of team members who work over the project, simplifies software development process, supports specifications that are independent from specific programming languages and development processes (specifications are readable and comprehensible for all subjects involved in the process of evaluation and application acceptance). It unifies principles and techniques used to create documentation and simplify maintenance of a model during project development.

A designed and modelled parking system integrates different forms of electronic payments at present mostly realized on the base of service subscription. An electronic system realising electronic toll collection evaluates and on the base of selected criteria makes modification of operation conditions possible. Thus effective control and maintenance of a parking system can be reached while a unified form of toll collection increases quality and convenience of services towards a user.

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COMMUNICATIONS

Lýdia Gábrišová *

LIMITS OF THE MULTIPLIER ADJUSTMENT APPROACH TO CAPACITATED LOCATION PROBLEM

This contribution deals with a distribution system design problem, in which the located facilities satisfy all customer demands under limited abilities. The objective is to minimize the total costs, including both fixed charges and service costs. A special approach based on Lagrangean relaxation will be discussed here for its ability to cope with limited capacities of located facilities. Using the Lagrangean relaxation, the model of the original problem is rearranged to a model, which can be solved by exact algorithms for considerably large size. The capacities of the located facilities bring serious difficulties concerning solving technique, in the cases, where real-sized facility location problems are solved. In contrast to an uncapacitated facility location problem, which can be solved exactly in reasonable time for real-sized case containing hundreds of possible locations and thousands of customers.

In this paper, we shall discuss a transformation of the capacitated location problem into the uncapacitated location problem by means of Lagrangean relaxation of capacity constraints. To demonstrate the efficiency of the studied approach, numerical experiments were performed and their results are reported in the concluding part of this paper.

1. Introduction

A distribution system can be considered as a sort of a transportation system, which enables delivering goods from one or several sources to customers. This delivering can be either direct or with transhipment at several places (these are generally called terminals or facilities) – see Fig. 1.

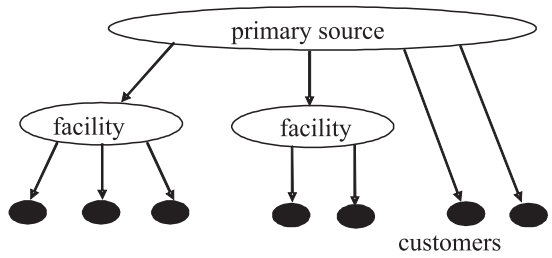

Fig. 1. Design of a distribution system

Determination of structure of a distribution system with transhipment belongs to the family of location problems. The associated location problem can be formulated as follows: given a set of possible facility locations and a set of customers, which are served from a finite number of located facilities, find which facilities should be used and which customers should be served from which facilities so that to minimise the total cost of serving all the customers and the fixed investment costs of building and maintaining the facilities.

In this paper, we shall investigate the capacitated location problem, with limited annual capacities of individual facilities. We shall devise the appropriate mathematical model and the solution method.

The capacitated location problem can be formulated as 0 – 1 linear programming problem, but the searching of its exact solution is very time-consuming or nearly impossible for large cases. One of possible approaches to a capacitated location problem can be based on its rearrangement to the uncapacitated location problem, solution of which can be found relatively fast, also for real-life size.

2. A Model of the Capacitated Location Problem

As preliminaries for a model construction we introduce the following notation of particular terms, which will be used throughout the whole paper.

Let J denote a finite set of customers and if a quantity of customer's demand can be expressed by a real number, then the demand of customer $j \in J$ is denoted by b_j.

Let I denote a finite set of possible facility locations, than the decision on a facility location at place $i \in I$ is modelled by zero-one variable $y_i \in \{0,1\}$, which takes value 1 if a facility should be located at i and it takes value 0 otherwise.

The model of the problem can be formulated as follows:

$$\textit{Minimize} \quad \sum_{i \in I} f_i y_i + \sum_{i \in I} \sum_{j \in J} c_{ij} z_{ij} \qquad (1)$$

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$$\text{Subject to} \quad \sum_{i \in I} z_{ij} = 1 \qquad \text{for } j \in J \tag{2}$$

$$y_i - z_{ij} \geq 0 \qquad \text{for } i \in I, j \in J \tag{3}$$

$$\sum_{j \in J} b_j z_{ij} \leq a_i \qquad \text{for } i \in I \tag{4}$$

$$y_i \in \{0, 1\} \qquad \text{for } i \in I \tag{5}$$

$$z_{ij} \in \{0, 1\} \qquad \text{for } i \in I, j \in J \tag{6}$$

In this model f_i denotes the fixed investment and maintenance cost of the facility with location $i \in I$ in the considered time period.

c_{ij} is the cost of demand satisfaction of customer $j \in J$ via the facility $i \in I$. Size of the demand is b_j and cost c_{ij} can be modelled as follows:

$$c_{ij} = (e_0\, d_{si} + e_1\, d_{ij} + g_i)\, b_j$$

where d_{si} is the distance between a primary source s and a facility i, d_{ij} is the distance between a terminal (facility location) i and a customer j, e_1 denotes unit transportation costs on the link between the primary source s and the facility i, e_0 denotes unit transportation costs on the link between the facility i and the customer j and g_i denotes the unit cost for the reloading of goods in the facility location i.

We suppose that the capacity of a facility located at i is a_i.

Constraints (2) ensure that each customer demand must be satisfied from exactly one facility location and constraints (3) force out the placement of a facility at location i whenever a customer is assigned to this facility location. Constraints (4) ensure that the total demand satisfied via facility i does not exceed the given capacity a_i.

If constrains (4) are omitted, the problem (1) – (3), (5), (6) is known as the uncapacitated location problem.

3. A Solving method for the Capacitated Location Problem

For the exact solving of an uncapacitated facility location problem (1) – (3), (5) – (6), the suitable solution method is the branch-and-bound method with branching performed by fixing the chosen variable y_i to the value 0 or 1 in the depth-first search of the solution tree.

We shall use the branch-and-bound method for the exact solution of the uncapacitated location problem based on Erlenkotter's approach [Erlenkotter, 1978], which was modified as *BBDual* algorithm by [Janáček, Kováčiková, 1997]. The solution yields the number of used facilities, their spatial distribution and the association of the customers with the facilities.

Next, let us show how we can reduce the capacitated location problem to the uncapacitated one by means of Lagrangean relaxation. Let us introduce the vector u of non-negative Lagrangean multipliers, $u_i \geq 0$ for all $i \in I$ and rearrange the objective function (1) to the following form:

$$\sum_{i \in I} f_i y_i + \sum_{i \in I} \sum_{j \in J} c_{ij} z_{ij} + \sum_{i \in I} u_i \left(\sum_{j \in J} b_j z_{ij} - a_i \right) =$$

$$= \sum_{i \in I} f_i y_i + \sum_{i \in I} \sum_{j \in J} c_{ij} z_{ij} + \sum_{i \in I} \sum_{j \in J} u_i b_j z_{ij} - \sum_{i \in I} u_i a_i =$$

$$= \sum_{i \in I} f_i y_i + \sum_{i \in I} \sum_{j \in J} z_{ij} (c_{ij} + u_i b_j) - \sum_{i \in I} u_i a_i. \tag{7}$$

By omitting the last term of expression (7), we obtain the following expression:

$$\sum_{i \in I} f_i y_i + \sum_{i \in I} \sum_{j \in J} \underline{c}_{ij} z_{ij} \tag{8}$$

where $\underline{c}_{ij} = c_{ij} + u_i b_j \qquad \text{for } i \in I, j \in J.$

The last term in (7) is a constant for fixed u_i, and so we can omit it when solving the reformulated problem. Substituting the optimal solution of (8), (2), (3), (5), (6) into (7), we obtain a lower bound of the objective function value of a so-far unknown optimal solution of (1) – (6). Moreover, if a solution of (8), (2), (3), (5), (6) satisfies constraints (4) and complementarity constraints (9), then this solution is the optimal solution of the capacitated problem.

$$u_i \left(\sum_{j \in J} b_j z_{ij} - a_i \right) = 0 \quad \text{for } i \in I \tag{9}$$

In the other case, we can use this solution as a starting point of a dual heuristics.

To obtain an approximate solution of the capacitated location problem we start with the relaxed problem model, Lagrangean multipliers of which are set to zero. If the optimal solution of this problem obtained by *BBDual* algorithm satisfies capacity constrains (4), then the optimal solution of the original problem is found.

Otherwise (if capacities of some of the facilities are not sufficient for the given demands), we change multiplier values. We make the changes by choosing the facility sequentially with the maximal difference between capacity and total demand of the associated customers and solve the relaxed problem with adjusted multipliers by *BBDual* algorithm.

An increase of the multiplier associated with a given facility should result in decrease of the capacity deficit associated with the facility. The stopping criterion for our algorithm was that the summary deficit of all located facilities should be less than 5 % of the summary demand of all customers, i.e.:

$$\sum_{i \in I_k} \left(\sum_{j \in J} b_j z_{ij} - a_i \right) \leq \sum_{j \in J} b_j / 100 * 5 \quad \text{where } I_k \subseteq I,$$

$$I_k = \left\{ i \in I \sum_{j \in J} b_j z_{ij} > a_i \right\}. \tag{10}$$

4. Experiments

Lagrangean relaxation of the capacitated location problem was implemented in Delphi and real data from the Slovak road network was used for numerical experiments. In the solved problems, 71 regional towns form the set of possible facility locations and 2907 villages form the set of customers. Demands of customers depend on the number of inhabitants in the villages. The costs connected with serving customers from a located facility are derived from distances in the real road network. The computations were performed with various values of fixed costs and capacities of facilities.

In most cases, a change in fixed costs causes a change in the number and locations of facilities, which can increase if the values of multipliers increase. This raise of the number of facilities may cause that all customer's demands are satisfied unless the facility capacities are exceeded (see Table 1).

The experiments showed that the change of the multiplier (increment by 1) could cause increase of the objective function (1), and we can obtain a new solution.

In Table 2 there is an example in which the sum of all customer demands is 53808 and the first selection of 10 facilities has a total capacity of 53900. Increase of u4 to 4 decreased the sum of all deficit demands from 7.98% to 3.22% and added 1 facility. Other changes of multiplier values in the above-mentioned way do not decrease the sum of deficit demands.

Location problem for various capacity of a facilities — Table 1

number of steps	located facilities	values of multiplier			objective function (1)	objective function (7)	not covered customer demands (max)	not covered customer demands (sum)	%
		4	47						
Capacity of 2 facilities:								**59840**	
0	2	0	0		17865901	17865901	7795	7795	14.49
1	2	1			17865901	17873696	7795	7795	14.49
2	2	2			17866076	17881316	7620	7620	14.16
3	2	3			17866076	17888936	7620	7620	14.16
4	2	4			17986996	17986996	7592	7592	14.11
5	2		1		17866076	17896556	7620	7620	14.16
6	2	5			17986996	17994574	7578	7578	14.08
7	3		2		17943985	17886395	0	0	**0.00**
Capacity of 2 facilities:								**49234**	
0	2	0	0		17865901	17865901	13098	13098	24.34
1	2	1			17865901	17878999	13098	13098	24.34
2	2	2			17866076	17891922	12923	12923	24.02
3	2	3			17866076	17904845	12923	12923	24.02
4	2	4			17986996	17986996	12895	12895	23.96
5	2		1		17866076	17917768	12923	12923	24.02
6	2	5			17986996	17999877	12881	12881	23.94
7	3		2		17943985	17912910	0	0	**0.00**

Location problem for 53900 capacity of 10 facilities — Table 2

number of steps	located facilities	values of multiplier			objective function (1)	objective function (7)	not covered customer demands (max)	not covered customer demands (sum)	%
		4	47						
0	10	0	0	0	11684833	11684833	2833	4295	7.98
1	10	1			11684837	11687666	2829	4291	7.97
2	10	2			11684843	11690489	2823	4285	7.96
3	10	3			11684876	11693312	2812	4274	7.94
4	11	4			11693307	11694387	1063	1732	3.22

Location problem for 48510 capacity of 9 facilities Table 3

number of steps	located facilities	values of multiplier			objective function (1)	objective function (7)	not covered customer demands (max)	not covered customer demands (sum)	%
		4	47	36					
0	9	0	0	0	12058775	12058775	4275	6772	12.59
1	9	1			12058798	12063050	4252	6772	12.59
13	9	13			12060284	12112440	4012	6772	12.59
14	9	14			12060479	12116437	3997	6765	12.57
20	10	20			12118942	12136922	1965	5276	9.81
21	10		1		12121718	12139598	1925	4492	8.35
22	10			1	12118944	12138887	1963	5294	9.84
23	10		2		12121618	12141523	1925	4500	8.36
24	10			2	12118990	12140804	1917	5253	9.76
31	10		6		12123534	12147239	1145	3766	7.00
32	10			6	12111701	12147163	1471	3940	7.32
33	10	21			12246944	12256388	1574	5007	9.31
34	10		7		12250594	12257464	1145	3550	6.60
35	10			7	12294238	12294238	2429	4630	8.60
		42							
36	10	1			12251266	12257363	871	2164	4.02

If we choose different input fixed costs in the testing instance, we can obtain 9 facilities with a total capacity of 48510. That is less than 90.16% of total demands. The first selection of the facilities caused total difference of 12.59%. Successive increase of multipliers decreased the total difference to 4.02% after 36 steps, but caused the raise of the number of facilities to 10 (see Table 3).

5. Conclusions

The Lagrangean relaxation seems to be an effective solving method for some cases of capacitated location problems with limited annual capacities of individual located facilities. If the capacity constraints need not be satisfied exactly and values of multipliers are successively increased for a located facility with the maximal number of deficit demands then the numerical experiments in most cases give acceptable results.

Acknowledgement: This paper was supported by the institutional grant of Faculty of Management and Informatics Science, University of Žilina: 19/2005 and VEGA No.1/0490/03.

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Joanna Bednarz *

ANALYSIS OF COOPERATIVE UNIONS' DEVELOPMENT CASE STUDY: POLAND

Cooperative unions in Poland are self-aid communities acting on the market of financial services. They gather people connected by the same working place or membership in the same community or professional group, who save together and lend money one another. They play an important economic role in Poland because of the fact that they are servicing people who because of their unfavourable or unstable financial condition could not be clients of commercial banks, and in this way would be denied the access to certain financial services, mainly to credits. In the presented article the quick development of the cooperative unions in Poland is presented.

1. Introduction

The history of Polish cooperative unions goes back to the inter-wars period when the people's banks and saving-banks were founded, aiming at the mutual help, self-management and economic democracy. They were based on the ideas of Friedrich Wilhelm Raiffaisen – the creator of financial cooperatives, in the mid 19th century in Germany. Nowadays, similar financial institutions called credit unions operate in 79 countries, gathering 118 million of people. They are supported by the philosophy of cooperation and by the basic values like: equality, members' capital and mutual aid. The motto of the American movement is: not for profit, not for charity, but for service.

2. Cooperative unions in Poland

Restoration of the cooperative unions in Poland started after 1989. They are the self-aid communities acting on the market of financial services, they gather people connected by the same working place or the membership in the same community or professional group, who save together and lend money one another. They operate on the basis of the Act of Cooperative Unions' Law and the Act of the Law of Cooperatives. They are supervised by the National Council, whose basic aim is ensuring the financial stability of all cooperative unions and security of the savings collected there. National Council in Poland is the member of World Council of Credit Unions, Inc. (WOCCU)[1)] and International Co-operative Alliance (ICA)[2)].

Fig. 1. Logo of cooperative unions in Poland
Source: National Council of Cooperative Unions in Poland.

Cooperative unions in Poland play an important economic role, because of the fact, that they are servicing people, who because of their unfavourable or unstable financial condition could not be clients of commercial banks, and in this way would be denied the access to certain financial services, mainly to credits (see SWOT analysis – Table 1).

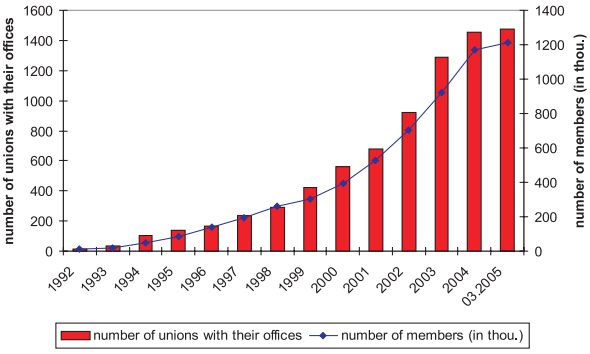

Fig. 2. Number of cooperative unions with their offices and the number of members (in thou.) in 1992–2005
Source: National Council of Cooperative Unions in Poland.

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1) World Council of Credit Unions, Inc. (WOCCU) is the world's leading advocate, platform for knowledge exchange and development agency for credit unions. Members of the World Council include regional and national credit union associations, cooperative associations and business service organisations. Today, credit unions in 84 countries provide more than 123 million people worldwide with an opportunity to grow through access to safe savings, affordable credit and the chance for a better tomorrow; http://www.woccu.org

2) The International Co-operative Alliance is an independent, non-governmental association which unites, represents and serves organisations in all sectors of activity including agriculture, banking, energy, industry, insurance, fisheries, housing, tourism and consumer co-operatives. ICA has more than 230 member organisations from over 100 countries, representing more than 760 million individuals worldwide; http://www.ica.coop/ica/ica

SWOT analysis of cooperative unions in Poland Table 1.

Strengths	Weaknesses
– stable position on the market – good quality of the offered services (PN-ISO 9002 certificate for rendering financial services) – knowing the members and their needs within the local society – high level of customers' service – activities done promptly and reliably – confidence, long tradition, members' feeling of integrity – quick increase of the number of new members – qualified personnel and professional management – a broad network of branches in the whole country – more flexible response to the market changes following from a limited range of activities	– high unit costs following from a relatively narrow scale of activity – relatively low proper funds – high costs of acquiring the membership – principles of membership difficult to understand by a potential member – a broad organisation structure – lack of good contacts of the branches with the head office – bureaucracy – lack of professionally elaborated documents – marketing located in the head office – poorly developed banking technology
Opportunities	**Threats**
– possibility of offering services at more advantageous conditions than those on the market – a gradual economic growth manifested with a great number of financial undertakings and with the need for capital – new products offered to the retail customers, such as internet banking – a gradual development of the segment of enterprises – increase of the volume of the given credits	– subordination of the cashiers' desks to the bank supervision and introduction of the obligatory provision – dependence of the acquired financial results on the policy of the National Council – a great competition of institutions of the similar character – attraction of commercial banks and their services – high rate of unemployment leading to resignation from the services

Source: own study.

After 13 years of cooperative unions' activity in Poland they have over 1.2 million of members and the network of their branches is the biggest one among the financial institutions offering financial services to people (Fig. 2). In March 2005 unions' assets exceeded PLN 4,5 billion and their members borrowed over PLN 2.9 billion (Table 2).

During last 6 years the number of cooperative unions decreased from 200 down to 83, mainly because of mergers (Figure 3). Right now, the 10 biggest unions serve ca. 70% of all clients. The biggest of them is the F. Stefczyk Union, having over 200 offices and gathering ca. 400 thousand of retail clients, which means more than the CitibankHandlowy[3)]. The reasons of mergers is mainly the tendency to strengthen of the market position of banks and financial conditions of the overtaken unions. Moreover, the growing requirements of the members, pertaining mainly to taking advantage of the bank services (like ATM), or to a bigger number of offices cause that the merging divisions decrease the risk connected with the concentration of servicing of a homogeneous group of clients, and they lower the costs of their operations.

In spite of the fact that the cooperative unions are going to develop the network of their offices, on the other hand they work intensively on introducing the electronic methods of access to the

Cooperative unions in Poland – assets, deposits and loans (in millions of PLN) in 1992–2005 Table 2.

Years	Assets (in millions of PLN)	Deposits (in millions PLN)	Loans (in millions of PLN)
1992	4	4	3
1993	11	9	9
1994	35	29	26
1995	101	92	83
1996	219	190	161
1997	368	313	281
1998	590	528	412
1999	883	740	668
2000	1 199	995	866
2001	1 752	1558	1236
2002	2 455	2254	1660
2003	3 344	3112	2213
2004	4 233	3 938	2 857
03.2005	4 506	4 212	2 940

Source: National Council of Cooperative Unions in Poland.

[3)] A. Myczkowska, SKOK. Coraz więcej kas znika z rynku, „Rzeczpospolita", 2 February 2005.

money – such as: by telephone and through the Internet. It has been assumed, that until the end of the present year, the electronic facilities will have been available in the biggest unions.

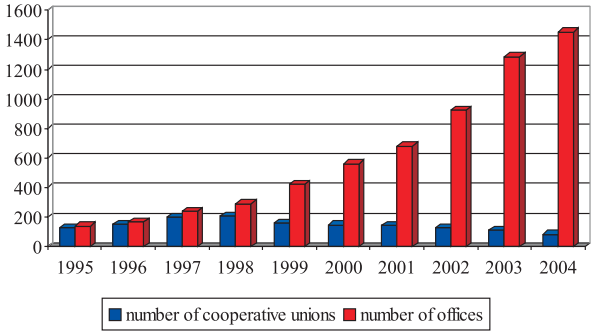

Figure 3. Number of cooperative unions and their offices in 1995-2004
Source: National Council of Cooperative Unions in Poland

3. Products offered by the cooperative unions in Poland

A quick development of the cooperative unions follows also from the fact of a very fast developing offer of financial products. The unions are proposing to their clients long-term programmes of systematic savings, and the collected savings are the security for the loans and credits. Since the beginning, the cooperative unions offer the simplest bank products i.e. loans and deposits. In the scope of savings, they propose á vista accounts, fixed-term deposit accounts, rentier deposit accounts, current accounts, company accounts for the members conducting the economic activity and special systematic saving deposit accounts: for Christmas, holidays and health[4]. Credit services also encompass a range of products: short and long term credits and "immediate loans" popular among of the members (until the nearest payment of salary).

Since autumn 2002, when cooperative unions were connected to the new ELIXIR system of inter banking settlements, they offer the settlement bank products (encompassing current accounts and VISA Electron payment cards, see Figure 4).

Fig. 4. Design of VISA Electron payment card
Source: National Council of Cooperative Unions in Poland.

The cooperative unions offer to their clients the estate, personal and life insurance, including group life insurance with additional options, and since 1 September 2004 – also Individual Pension Accounts. Moreover the Open Investment Fund of the Financial Market offers the possibility of depositing members' financial means in securities issued or guaranteed by the Treasury, National Bank of Poland and the units of local governments.

Cooperative unions in Poland offer their products under more advantageous conditions when compared to commercial banks. Interests on deposits are of about 2 percentage points higher than in banks and on loans and credits – correspondingly lower.

4. Conclusion

The Chairman of the Board of WOCCU, Robert McVeigh estimates, those Polish cooperative unions based on the experience of American, Canadian and Irish ones could offer in a very short time, financial services at the highest level. It is estimated that the cooperative unions in Poland would still develop very dynamically and in 10 years, their members would constitute ca. 40 % of the adult Poles[5].

Nowadays, the development of cooperative unions in Ukraine, Belarus, Russia, Moldova and Romania is planned. This time, it is Poland that is to take part in consulting and help for these unions on the new markets.

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Dariusz Janecki – Krzysztof Stępień *

LEGENDRE POLYNOMIALS USED FOR THE APPROXIMATION OF CYLINDRICAL SURFACES

The paper deals with a concept of application of orthogonal Legendre polynomials for the approximation of cylindrical surfaces. It presents fundamentals of a mathematical model of such approximation. The theoretical considerations are supported by the results of the experimental verification of the developed concept.

1. Introduction

Today's metrological tasks make use of various methods and strategies of measurement. The discrete data representing an analyzed form profile, however, are frequently insufficient. In other words, it is impossible to know all the profile values, as measurement can be conducted only for a certain, limited number of points. In order to obtain the entire profile, approximation is necessary.

In the case of cylindrical surfaces, the approximation involves:
- obtaining the view of the whole surface being measured; this will allow visual assessment of the form errors,
- filtering the obtained profile,
- specifying the parameters of the cylinder under measurement,
- comparing the profiles of cylindricity.

2. The Legendre/Fourier cylindricity profile approximation

Suppose that a current cylindricity profile is described by means of the function

$$R(\varphi, z),\ 0 \le \varphi < 2\pi,\ 0 \le z \le H \tag{1}$$

(*It would be good to specify R, φ, z, H by the words!!!!*)

Assume also that by applying a certain strategy, we obtain a number of measuring points with the coordinates

$$\varphi_k, z_k, R_k \quad \text{for} \quad k = 1, 2, ..., N. \tag{2}$$

Let $\Psi(\varphi, z, a)$ be a certain parametrized class of functions, where is a vector of the parameters. The problem of approximation of the measured points with a selected class of functions is commonly formulated using the least squares principle. Define the approximation quality by means of the index

$$J = \sum_{k=1}^{N} (R_k - \Psi(\varphi, z, a))^2. \tag{3}$$

The aim is to select values of the parameters a so that the value of the coefficient J is minimized. If the approximating function is a linear combination of certain linearly independent base functions $\psi(\varphi, z)$, i.e.

$$\Psi(\varphi, z, a) = \sum_{j=1}^{M} a_j \psi_j(\varphi, z)\ , \tag{4}$$

then the problem of approximation by the least squares method can be solved analytically. Indeed, thus

$$J = (R - \Psi a)^T (R - \Psi a), \tag{5}$$

where R is a column vector with the length N containing the values of the measured profile, and Ψ is the matrix with the size $M \times N$, the elements being equal to $\psi_j(\varphi_k, z_k)$, $j = 1, 2, ..., M$, $k = 1, 2, ..., N$. If $N \le M$ and the columns of the matrix Ψ are linearly independent, then the vector of the parameters a, for which the coefficient reaches a minimum is equal to

$$a = (\Psi^T \Psi)^{-1} \Psi^T R. \tag{6}$$

The set of basic functions should be complete in such a sense that by selecting an appropriately great order of approximation M, we are able to approximate an arbitrary function of two variables with predetermined accuracy. Since, for the fixed z, the function $R(\varphi, z)$ is a periodic function of the variable φ with a period of 2π, we shall assume that for the fixed z, the approximating function is a partial sum of a trigonometric Fourier series. The profile $R(\varphi, z)$ as a function of the variable z is certainly not a periodic function. Thus, assume that for the fixed value of the angle φ, the approximating function is a polynomial. For many reasons it is favorable to represent the polynomial as a sum of orthogonal polynomials. Accordingly, consider the following class of functions approximating a cylindrical area:

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$$\Psi(\varphi, z, a) = \sum_{m=0}^{M_z} L_m(z)\left(\frac{1}{2}a_{m0} + \sum_{n=1}^{M_\varphi}(a_{mn}\cos(n\varphi) + b_{mn}\sin(n\varphi))\right), \tag{7}$$

$$L_m(z) = \overline{L}_m\left(\frac{2z}{H} - 1\right), \tag{8}$$

where $\overline{L}_m$ is a Legendre polynomial of the m degree. Since Legendre polynomials are orthogonal in the interval $(-1, 1)$ [2], a set of polynomials $L_m(z)$ is orthogonal in the range of variability of the variable z of the cylindrical surface. With so defined an approximating function, the vector of the parameters a includes all the coefficients a_{mn} and b_{mn} occurring in equation (7), while the basic functions have the form

$$L_m(z)/2,\ L_m(z)\cos(n\varphi) \text{ and } L_m(z)\sin(n\varphi). \tag{9}$$

3. Experimental verification of the proposed concept

In order to experimentally verify the method of approximation of cylindrical surfaces using the Legendre orthogonal polynomials, it was necessary to apply the mathematical apparatus discussed in Section 2. The analyzed cylindrical element was measured with the method of cross-sections. The graph in Fig. 1a was prepared on the basis of the results of measurement of a cylindrical element with the mean cylinder axis in the assumed position.

The element was measured at 1024 points located in the cylinder cross-section. Due to some calculation problems, it was essential to filter the data, i.e. reduce the number of measuring points. Eventually, the number of points per circuit amounted to 128. With the data having been filtered, the next step was to determine the matrixes of Legendre approximation coefficients. In the experiment, we assumed that the maximum degree of the approximation polynomial was one less than the number of the measured cross-sections. The number of profile harmonics to be analyzed was reduced and ranged 0–25 owing to calculation problems. Figure 1b) shows a graph produced after the approximation of the measured surface using the proposed method.

In Fig. 2, on the other hand, there is a spatial representation of the approximation error, i.e. the difference between the initial and the approximated values of profiles of the analyzed cylindrical surface. The analysis of Fig. 2 shows that the approximation error of the cylindrical surface obtained when using the suggested method is negligible, its maximum value being 0.4 μm. The average relative error of approximation in this case (i.e. when applying the suggested method) is 1.01 %.

4. Conclusions

Analyzing the graphs in the Section 3, we can notice that the proposed method assuming the application of Fourier series and Legendre orthogonal polynomials enables us to approximate cylindrical surfaces with high precision. Since the orthogonality of Legendre polynomials allows obtaining better-conditioned matrixes, the method appears to be more useful and does not cause such calculation problems as other methods, for instance, those using Chebyshev polynomials described in Refs. [5, 6]. However, if there are no calculation problems, and it is not necessary to reduce the number of analyzed profile harmonics, this method can provide us with even more precise information. The results confirm the rightness of the proposed concept of approximation. Thus, it can be used in practice, for example, for determining the parameters or filtering the profiles described by means of a small number of discrete measuring data or for comparing cylindricity profiles obtained with the aid of various measuring devices and strategies.

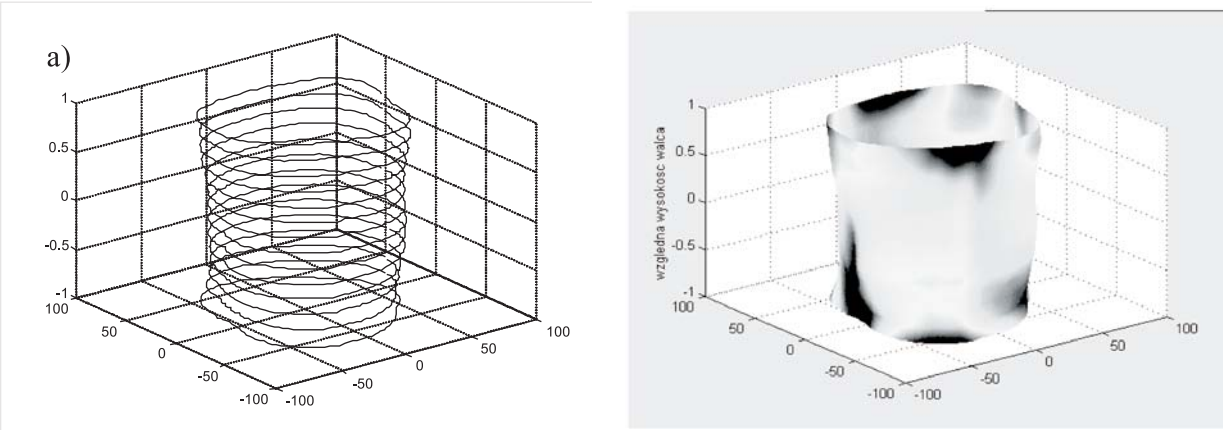

Fig. 1. Representing a measured cylindrical element using: a) measuring discrete data; b) approximation coefficients

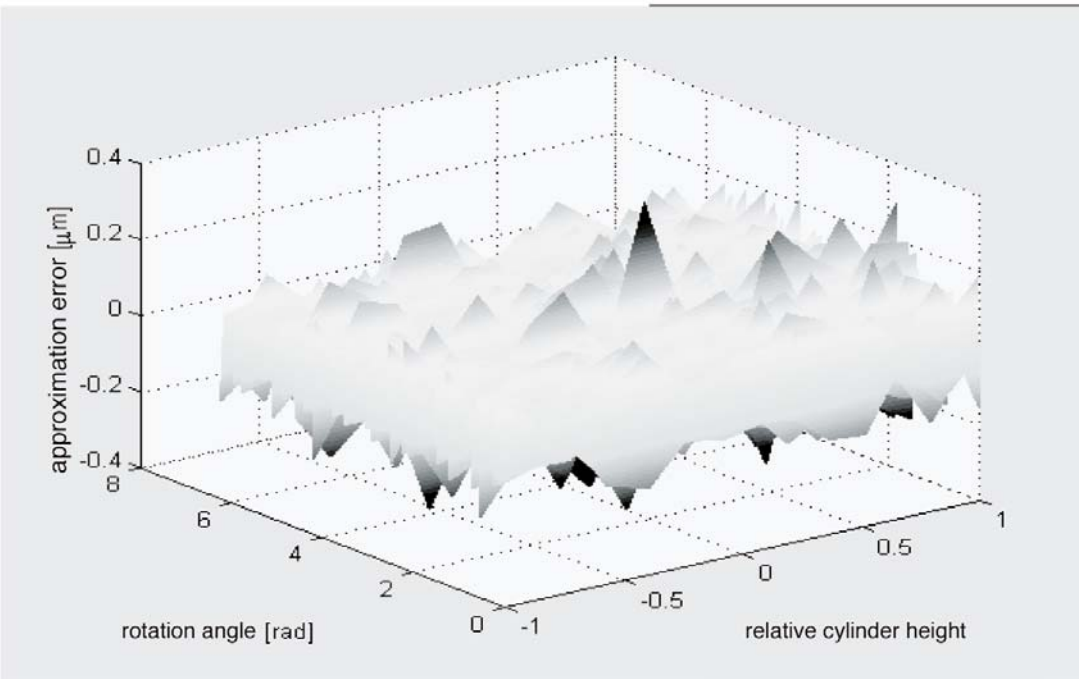

Fig. 2. Approximation error

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Mariana Strenitzerová *

THE DEVELOPMENT OF STRATEGIC MANAGEMENT

The top managers agree on the fact that the development of new strategies is their most important task. However, up to what extent do the time and means expended on the more or less formalized strategic processes really lead to a better efficiency and productivity of the firm? It was dominant task of the study of the German counselling firm The Galileo Consulting Group in cooperation with the European Business School in Oestrich-Winkel. Interactive strategic modelling is a method of an individualizing instrumentarium by means of which it is possible to depict interactively various variant of future actions.

1. Introduction

Strategic management can be defined as the art and science of formulating, implementing, and evaluating cross-functional decisions that enable an organization to achieve its objectives. As this definition implies, strategic management focuses on integrating management, marketing, finance/accounting, production/operations, research and development, and information systems aspects of a business to achieve organizational success [1].

The strategic-management process can best be studied and applied using a model. Every model represents some kind of process. The framework illustrated in Figure 1 is a widely accepted, comprehensive model of the strategic-management process. This model does not guarantee success, but it does represent a clear and practical approach for formulating, implementing, and evaluating strategies. Relationships among major components of the strategic-management process are shown in the model [1].

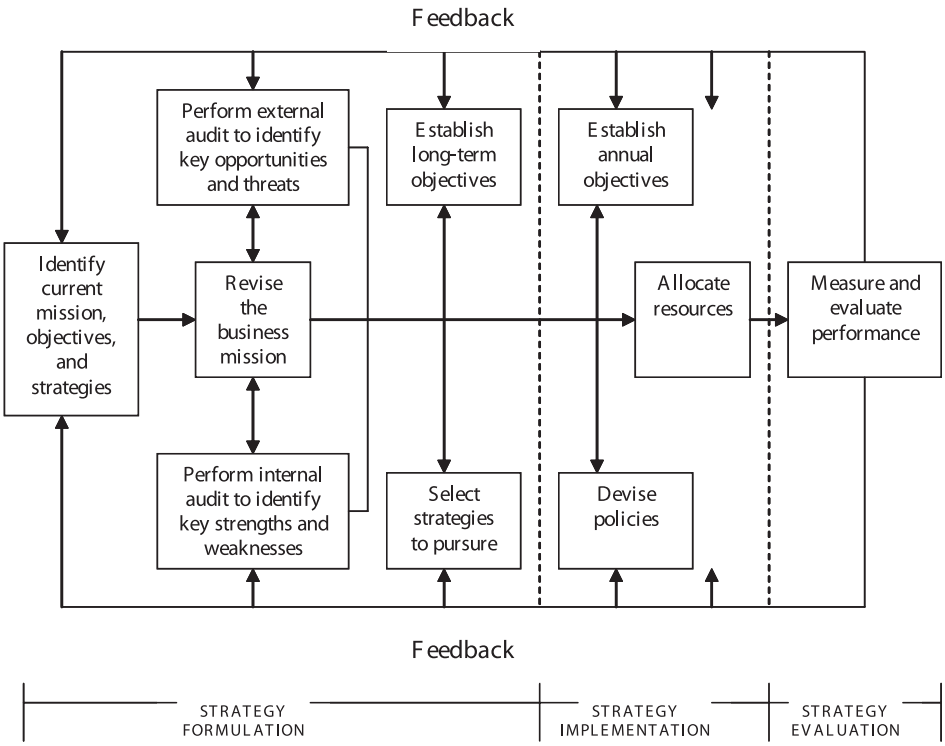

Fig. 1 A comprehensive strategic-management model

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2. The development of new strategies

The top managers agree on the fact that the development of new strategies is their most important task. That is why the majority of firms invest a lot of time and means in strategic planning.

However, up to what extent do the time and means expended on the more or less formalized strategic processes really lead to a better efficiency and productivity of the firm? That was the key problem led to the birth of a study realized in German companies in 2003 – 2004.

The study of the German counselling firm The Galileo Consulting Group in cooperation with the European Business School in Oestrich-Winkel was supposed to answer three questions [2]:

- *How should the strategic processes be outlined in order to have a positive effect on the survival of the firm?*
- *How do the successful strategic conceptions differ from the less successful?*
- *How should the strategic processes look like in order to assure an early acceptance or reassessment of the firm's strategy and realize the strategy in a successful way?*

Within the said study 428 firms in Germany were addressed taking into account the extent of their turnover. The invitation to join the study was positively accepted by 28 % of the addressed firms, i.e. 122 firms. 80 % of the firms participating in the research, including the banks reported a turnover exceeding a milliard euros. The research has shown that the success of the strategies is supported by the six of the most important factors:

1 Integrated conception

More successful are those firms which manage to combine and integrate various analytical approaches than firms applying one isolated approach. In strategic analyses and within the preparation of strategies, successful firms use the information from internal and external resources.

2 Behaviour of the competition

The firms that incorporate also the behaviour of the competition into their strategic plans and are able to anticipate the reaction of their competitors are more successful. Nevertheless 31 % of the addressed firms make up their strategies without taking into account the reaction of their competitors. There is a substantial deficit of the strategic management there.

3 Development of alternative strategies

The development of alternative strategic plans increases the hope for the success of the strategies. Still, only 38 % of the addressed firms make up various strategic variants and less than a half of them use the technique of scenarios. At the same time 76 % live in a complicated dynamic environment. An explanation can be found in the fact that the possibility of the technique of scenarios in underestimated and its time exigency is overestimated. And then, there is a strong belief in the correctness of a single proposed and elaborated strategy.

4 IT simulation

Only 19 % of the addressed firms use the computer simulation in the analytical phase of the strategy preparation and only 4 % of the firms use it at the development of strategic alternatives. That is a surprising fact because computer-supported controlling systems at present are standard in big firms. The potential of the use of the computer simulation in this field, however, is significant and a substantial expansion is being expected in the coming years.

5 Engagement of co-workers

Even though 70 % of the addressed firms declared this factor as highly important for the success of the strategic processes, only 51 % of the addressed firms inform their employees purposefully about the contents of the strategies. Systematic education of employees in strategic problems takes place only in 42 % of the addressed firms. How can the staff of the firm and its managerial workers realize the strategy if they are not properly informed about its contents? From this point of view, the requirement of involving one's co-workers in the development of the strategies is imprudent. In spite of the fact it holds true that to get the co-workers involved in the strategic processes provides the assumptions for the identification of the employees with the strategic orientation of the firm and it is a resource of their deeper motivation. Without such an involvement of the employees, the knowledge potentials of the employees, who are often able to discover the weak signals that are important from the strategic point of view much sooner than the management, are not exploited.

6 Regular updating

Three quarters or the addressed firms adapt their strategies to the altered conditions on a regular basis. In a turbulent environment of present markets, the adaptation of the strategies is inevitable. The firms, however, should not wait till some critical situation occurs and then alter the strategy. A continuous controlling process should be applied which will signal the necessity of the updating of the strategy. According to the aforementioned research, only 24 % of the big firms analyze the weak signals of strategic importance on a regular basis.

The overall analysis of the said six factors has shown that only one of fifth of the addressed firms had introduced more than three of the said six factors and none of the addressed firms had introduced all six factors.

In this connection, it is advisable to remember Ashby's law of required diversity which says that only diversity may govern diversity. It is possible to react and respond to the most diverse appeals of the present world only then, if the management system of the firm shows a similar diversity like that shown by the entrepreneurial and market environment. It means that a firm which wants to be successful should use all the six indicated key factors of success.

3. Interactive strategic modelling

It is necessary to bring the strategic management up to date. There is the possibility how to do it. The said possibility is the

interactive strategic modelling (ISM). It is a method of an individualizing instrumentarium by means of which it is possible to depict interactively various variant of future actions. Within this method classic concepts of the development of strategies such as the SWOT analysis or the portfolio method can be connected with the up-to-date approaches such as the technique of scenarios or the simulation technique [3].

The ISM conception divides the strategic management processes into four phases (Fig. 2):

- *Analysis of the present state*
- *Analysis of scenarios*
- *Strategic simulation*
- *Introduction of the results into practice*

These phases should proceed in an interactive way.

1 Analysis of the present state

"To know where we are"

A detailed analysis of the present state should precede the development of the strategic variants. On the one hand, by means of this analysis a frame for the formation of more real strategies is provided and on the other hand a comparative basis for a future time comparison is being formed. Within such an analysis, suitable indexes for the expression of the attractiveness of the market on which the firm functions, for the assessment of the competitive power of the individual participants of the market and for the expression of the own firm are searched for. Mutual connections between such indexes are looked for. Such problems are usually analyzed by small groups from 4 up to 10 people consisting of representatives of different departments.

2 Analysis of scenarios

"Reflection of the future"

In order to represent the present state, the project group analyzes the problem how the chosen indexes in the planned horizon will develop. Scenarios of a specific market development with specific effects for strategic and financial indexes are proposed. Assessment concerning the development of the negotiating power of the firm in relation to the suppliers and customers in the individual years in accordance with the individual scenarios of the future development takes place. Also discussions are held analyzing how the individual scenarios will affect the strong and weak spheres of the firm.

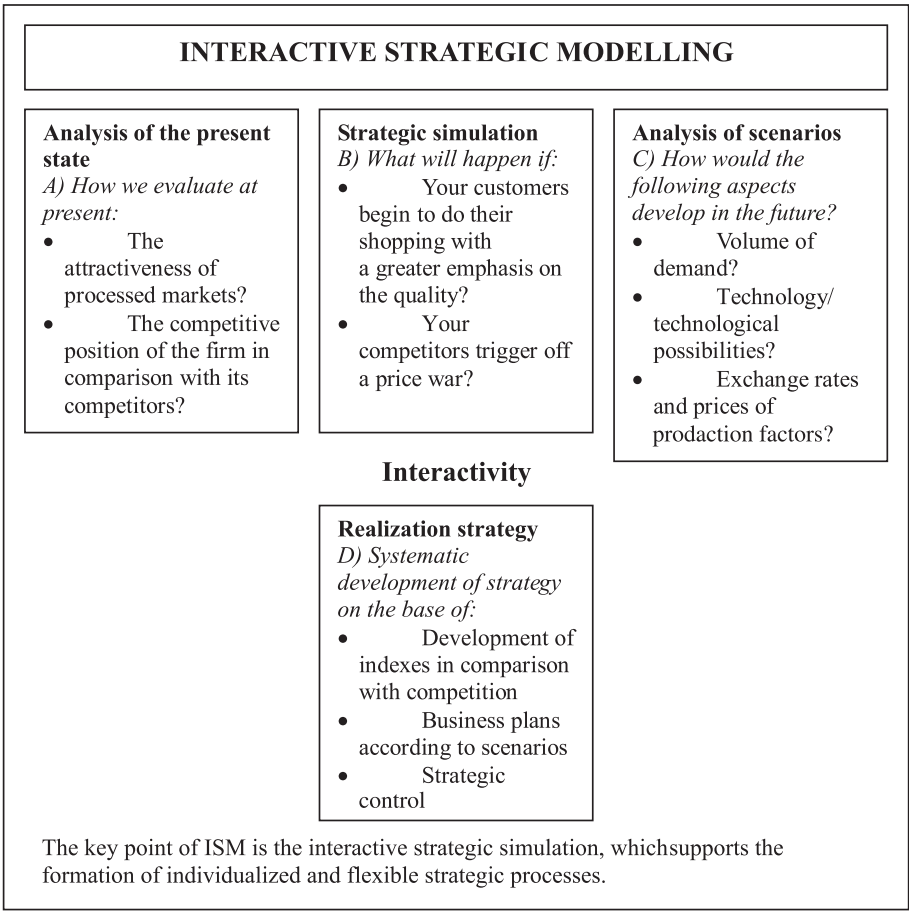

Fig. 2 Phases of interactive development of the strategy by means of ISM

3 Strategic simulation

"What will happen, if ....?

The interactive approach to the computer simulation makes it possible continuously to adapt the alternative strategies to the changing conditions, changes in the behaviour of the competition and to the internal factors of the firm and to discover the effect of the changes on the success of the individual variants of the strategy. The simulation makes it possible to discover not only the short-term, but also the long-term effects of the changes.

4 Realization of results

"Who can do what + when?"

On the base of the results of the first three phases, investment plans, catalogues of realization provisions and realization plans are elaborated for a narrower choice of strategies. Since in the elaboration of simulations one works with concrete financial indexes, it is possible to incorporate the realization plans and the provisions immediately in the financial budgets and business plans. In order to make it possible to ensure an active cooperation of the employees in the realization of the strategy, the result of the simulation is reflected in the mutual cooperation with the employees.

4. Conclusions

At present, hardly any firm would rely on the technology of the seventies or eighties in the production sphere. However, we are witnesses of the fact that many firms rely on the outdated approaches.

According to the aforementioned German research, strategic processes suffer from a series of drawbacks. A firm that wishes to increase its hope for a future success will do good, if it brings its strategic management up to date. The interactive strategic conception, such as the said ISM system, provides tools for the modernization of the strategic management. The principle of interactivity included in this methodology, enables to rectify and to outline the initial real state by means of an improved database and to modify strategic scenarios in accordance with an altered development on the market. Despite an increased engagement, the role of the top management in the preparation of strategies remains unshaken. Every computer-supported programme is dependent on the quality of input data, after all, there must be somebody who knows how to interpret the results of the computer simulation in a qualified way. Here lies the unsubstitutable task of the top management.

There is no high-quality strategic management without the intuition of the experienced top manager. On the other hand, it is of importance if intuitively based strategies, in their consequences, can be simulated on computers and if their weak points and risks can be discovered.

Risks cannot be excluded from the strategic management, however, in this way, it is possible to discover many uncertainties which will make it possible for the top management to analyze them and to take necessary measures for their restraint.

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Andrej Husár – Peter Čepel – Peter Brída – Vladimír Wieser *

RADIO RESOURCE ALLOCATION IN MOBILE COMMUNICATION SYSTEMS

In the article we deal with two types of Call Admission Control Schemes (Reservation-based CAC scheme and Probability-based CAC scheme) and we made simulations in Matlab environment. Both types of these transmission schemes belong to homogeneous type of radio resource management applications. Only voice application belongs here (traditional wireless networks) and each call demands the same amount of bandwidth (channel, frequency or time slots). Both schemes are compared and evaluated at the end of the article.

1. Introduction

Mobile communication systems have attracted great attention during the past several years. These systems have been developed in a distributed fashion. The mobile user population has been growing at a rapid rate. More recently, the demand for multimedia application requiring high bandwidth (for example video, pictures and Web application) has increased. The core issue of providing multimedia services over a mobile wireless network is the quality of service (QoS) support in the presence of changing network connectivity due to user mobility and limited wireless communication links.

An important QoS issue in wireless multimedia networks is how to control new and handoff calls. This is a work for Call Admission Control (CAC). Another, also important issue is in Radio Resource Allocation (RRA). Both, CAC and RRA are a part of Radio Resource Management (RRM). RRM is a set of algorithms that control the usage of radio resources. It is located in user terminal, base station and radio network controller. The RRM infrastructure is described in [1]. RRM functionality is aimed to guarantee QoS, offer high capacity and maintain the planned coverage area.

2. Radio Resource Allocation

Radio resource allocation algorithms aim to optimal use the code-division multiple access (CDMA) capacity [2]. RRA algorithm should maximize the number of satisfied users within the available radio bandwidth. Considering the wide range of quality requirements, the RRA algorithms must perform very complex tasks.

Let $M(t)$ be the number of active mobiles in the coverage area. This number changes depending on the offered load. The number of all base stations (BSs) is $K = \{1, 2 \dots K\}$. $C = \{1, 2 \dots C\}$ is the number of all available channels. The gain matrix G_m, which describes the radio environment, is defined as $G_m = [G(t)_{i,j}]_{KxM(t)}$, where $G(t)_{i,j}$ is the link gain between the base station BSi and mobile station MSj that changes with the mobile's movement.

RRA algorithms consider the link gain matrix G_m and perform the following tasks:

- Assign one or more (e.g., soft handoff) BS from set B. Call admission control algorithm decides if and where the new (or handoff) call is accepted or rejected;
- Assign one or more channels (e.g., codes for WCDMA, and combination code-timeslot for time-division CDMA, (TD-CDMA) from set C. The rate scheduler assigns appropriate code for the call, and the time scheduler (TS) decides when these resources can be used;
- Differentiate in resource allocation between several traffic classes. TS decides about the time moment and the amount of used resources based on the session's quality requirements.

There is a model of Radio Resource Allocation shown in Figure. 1. From the figure it is clear that a resource estimator (RE) controls the RRA algorithm represented by the dotted arrows. The solid arrows present the flow of the user information. The RE has several inputs such as the measured interference conditions, radio channel characteristics, current load in the BS, calls' traffic characteristics and QoS requirements. The RE by considering inputs performs the following control tasks:

- The radio channel characteristics and call quality requirements are used for optimal power and rate allocation;
- The current BS load, call traffic characteristics, and quality requirements are used to control the time scheduler;
- With the built-in capacity model, the RE assists CAC in accepting or rejecting new (or handoff) calls.

2.1 RRA techniques

There are many ways of allocating the resources, in response to a new call arrival or handoff attempt. The goal is to maximize

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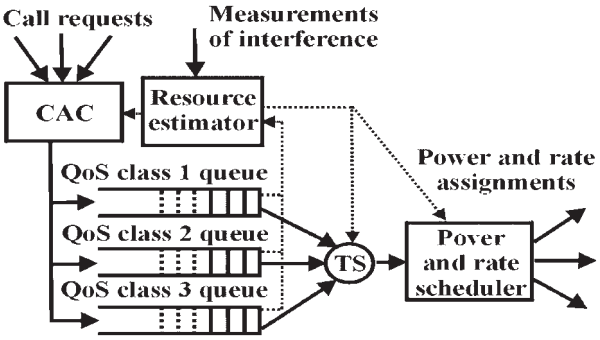

Fig. 1 RRA algorithm in the base station

system efficiency while meeting the QoS requirements of users. Some channel assignment techniques allow channel sharing among several cells. Such schemes, known as Dynamic Resource Allocation (DRA) schemes have a common resource sharing pack that can be allocated to users upon request. In DRA, channels are not permanently assigned to cells. These schemes can borrow channels from neighboring cells if necessary. However, once a channel is borrowed from a neighboring cell, all other cells are prohibited from using the channel. The other channel assignment schemes allocate a fixed amount of resources to each cell. They are referred as Static Resource Allocation (SRA) schemes.

Among RRM techniques, which are suitable for resource allocation, are the already mentioned (DRA) and SRA techniques. DRA usually co-operates with multiple access, e.g. FDMA, TDMA and with their combinations. In DRA, real time measurements of propagation and traffic conditions are used to allocate and reallocate spectrum resources. The performance of DRA schemes is very good, in particular when integrated DRA and power control is used. The performance of the DRA schemes is critically dependent on the rate at which allocation or reallocation occurs. DRA schemes have to observe the changes of signal power (at least slow fading).

A second class of allocation schemes is the class of SRA schemes. One of the representatives is Random Resource Allocation (RRA) scheme. In this scheme resource allocation is permuted in a random fashion. The simplest way to achieve this is to use orthogonal frequency hopping which can be regarded as a static allocation, where mobile terminals allocated to a certain access port swap channels with each other. Frequency hopping occurs typically 100 – 1000 times per second.

3. Call Admission Control

Call admission control is a method of radio resource management whose target is to adapt radio resource allocation to traffic variations. We denote CAC as the process to make a decision about acceptance or rejection of a new admission according to the number of available resources. We also take into consideration QoS requirements of the present users and possible effect of a new call. CAC algorithms can be divided into some groups, e.g. reservation based CAC, probability based CAC, etc. More about CAC techniques can be seen in [3].

3.1 Reservation-based CAC scheme

The bandwidth (or a number of channels) available in a cell must be shared by calls of the different service classes and the different service requirements, which have to be met. The partition of channels in this scheme is important and it is second in the order after CAC. A portion of channels is exclusively reserved for handover calls from neighboring cells. A next portion is reserved for real-time and non real-time data. The remaining bandwidth (channels) can be allocated on demand to voice new calls. In Fig. 2 we can see the process of resource reservation for handoff calls in the real time. Algorithm 2 computes with the greater amount of resources (48 channels) for handoff than algorithm 1 (32 channels). In our simulation we consider the QoS probability $P_{qoS} = 0.001$. Fig. 3 shows the total number of free channels for new calls and data transfer, which depends on the reserved resources for handoff.

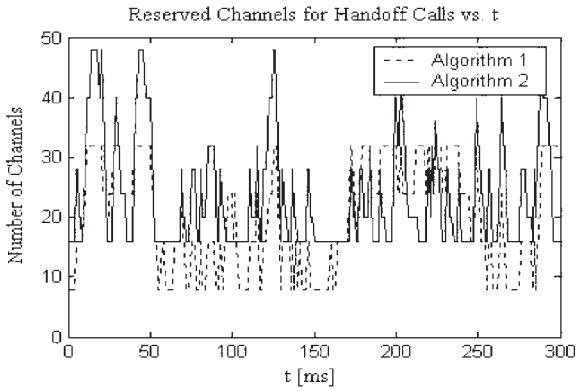

Fig. 2 Reserved channels for handoff calls

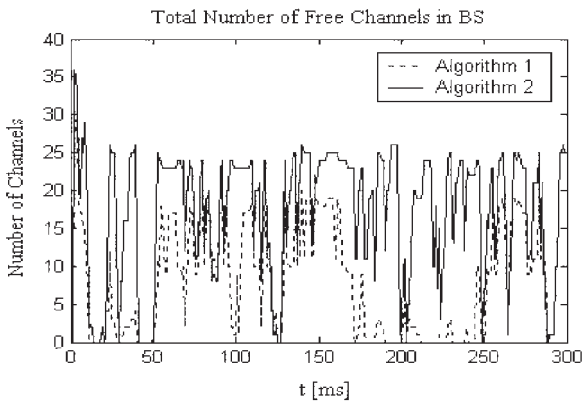

Fig. 3 Total number of free channels in BS

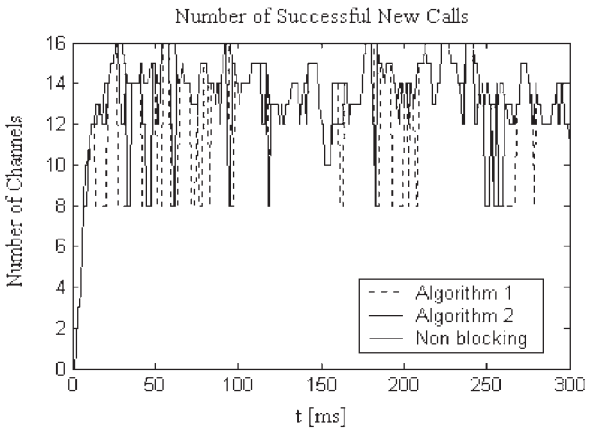

Fig. 4 Number of successful new calls

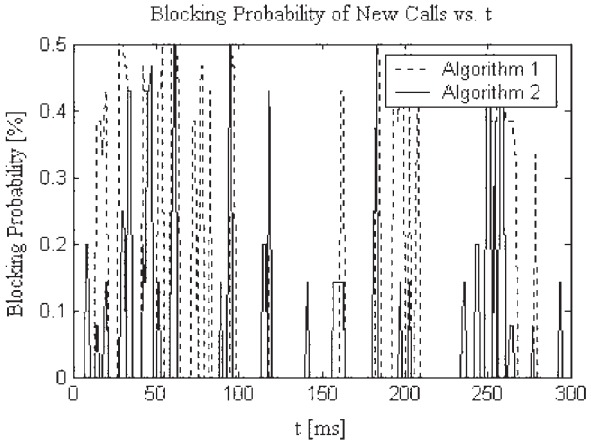

Fig. 5 Blocking probability of new calls

3.2 Probability-based CAC scheme

In this scheme, the amount of reserved bandwidth (channels) for handoff calls and new calls is determined according to a call dropping probability measured during the last few time [4]. However, if this measurement time range is short, accuracy of the call dropping probability is not good. In this scheme we can estimate a call dropping probability. It is possible to manage free resources in the main cell and in the neighboring cells according to a given dropping probability. In Fig. 4 is the time behavior of the number of successful new calls in the main cell. It depends on the probability of dropped calls and on the reserved resources for handoff calls. When the system has limited resources due to handoff process, blocking probability of new calls increases (Fig. 5). The amount of the blocking probability depends on the used algorithm and free resources in the current cell.

4 Conclusion

In this paper, we describe the basis of radio resource allocation and two techniques of CAC. This is an important part of adaptive radio resource management in mobile communication systems. We have simulated two CAC techniques in the Matlab environment to illustrate the radio resource utilization in a seven-cell model of the mobile system.

In the reservation-based CAC scheme free resources for new calls and data applications depend on the handoff calls and on the amount of resources reserved for these calls. In the probability-based CAC scheme free resources depend on dropping probability of the handoff calls. These calls are dropped in the handover process among the main cell and neighboring cells.

Acknowledgements:

The authors gratefully acknowledge support from the VEGA project No. 1/0140/03 “Effective radio resources management methods in next generations of mobile communication networks” and State project No. 2003 SP 51/028 09 00/028 09 10 “Communication Networks and Services of New Generations”.

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komunikácie
COMMUNICATIONS

Marta Kadorová – Zuzana Ondráčková *

ILLNESSES AND DISEASES: ARTICLE OR NOT? THAT'S QUESTION!

The paper analyses the use of articles with the names of illnesses, diseases and disorders in the English language. The paper is divided into three parts. The first one summarizes rules about the articles and illnesses in prescriptive grammar books. The second one contains a table which aims to present the list of illnesses, diseases and disorders with corresponding articles. The final one focuses on the results of the research which was based on the comparison of the theoretical background and the actual use of articles with the names of illnesses, diseases and disorders in The Family Medical Reference Book.

1. Introduction

In general, the functioning of articles in the English language is far from being clear. One of the most controversial areas and at the same time the least dealt with is the use of articles with illnesses and diseases. This is the main reason why we have concentrated on this field of research.

2. Various approaches to the use of articles with the names of illnesses

Studying the essential prescriptive grammars of the English language only the following information has been found:

A Comprehensive Grammar of the English Language (2004, p. 279) suggests the zero article for the following illnesses: *anaemia, appendicitis, diabetes, influenza, pneumonia.* However, the definite article alternates with the zero article for infectious diseases: *(the) flu, (the) measles, (the) mumps, (the) chicken pox, (the) hiccups*. The article is not normally omitted with *the/a plague, the bends, the jitter, the/a bellyache, a cold, a fever, and a temperature*. The fixed expression catch cold is an exception. Nouns formed from ache are noncount when they denote a condition. On the other hand, when they denote a single attack, they are count in AmE and noncount in BrE.

According to Alexander (1998, p. 61), the indefinite article is obligatory in these instances: *a cold, a headache, a sore throat, a weak heart, a broken leg.* We can use or omit the indefinite article in these expressions: *catch (a) cold, have (a) backache, (a) stomach-ache,(a) toothache, (an) earache*. Articles are not used with illnesses which are plural in form: *measles, mumps, shingles* and with illnesses which are considered as uncountable: *flu, gout, hepatitis, high blood pressure*. But at the same time it is possible to combine the definite article with *flu, measles and mumps.*

Hais (1991, p. 62) introduces articles in the cases of: *a headache, (the) toothache, (the) measles, (a) flu*. An article is not placed before the names of the following illnesses: *pneumonia, bronchitis, influenza, fever, cancer, lumbago, sunstroke*. If the illness is described in more details, we use the article.

A Grammar of Contemporary English (1984, p. 158) recommends the zero article in the following expressions: *appendicitis, anaemia, diabetes, influenza*. However, some names of illnesses can be preceded by the definite article: *the plague, (the) flu, (the) measles, (the) mumps*.

A University Grammar of English (1975, p. 74) gives the same rules with the same examples for the use of articles with the names of illnesses.

According to Advanced Learners' Grammar (2003, p. 274) we do not use any article with illnesses: *He's got lung cancer. She's had German measles.*

There is no mention about the use of articles with illnesses and diseases in Grammar of Spoken and Written English (2000).

3. The overview of illnesses, diseases and disorders with corresponding articles

THE FAMILY MEDICAL REFERENCE BOOK has been chosen to verify the above mentioned concepts and, at the same time to provide us with the possibility to work out a more complete overview of the use of articles with illnesses and diseases which have not been taken into consideration yet. The following table aims to present the list of illnesses, diseases and disorders

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Class of illness according to systems of body	**Particular illness, disease and disorder**	**Marked use of articles with illness, disease and disorder**
Mental illness	Anxiety – Chronic anxiety Phobia – Agoraphobia – Social phobia Depression – Neurotic/reactive depression – Endogenous depression – Psychotic depression – Manic depression – Mild reactive depression Suicide Anorexia nervosa Bulimia nervosa Alcoholism Senile dementia Multi-infarct dementia Pre-senile dementia Alzheimer's disease Schizophrenia Obsessional neurosis Hysteria	*If there is a specific reason for* ***the*** *anxiety* – the generic use of the definite article (the class represented by its typical specimen) ***an*** *anxiety about being contaminated would be reduced by washing hands, but since* ***the*** *anxiety soon returns* – anaphoric ref.- direct ***the*** *anxiety increases and the patient does what he or she has always done – tries to avoid the anxiety by withdrawing from the situation* – ***a*** – generic use of the definite article (the class as represented by its typical specimen); ***the*** – anaphoric ref.- direct ***The*** *commonest phobia* – logical use of the definite article *Social phobia is also* ***a*** *common phobia* - nonreferring use of the inde finite article *it is possible to develop* ***a*** *phobia of almost anything* – the generic use of the indefinite article (any representative member of the class)
Skin disorders and diseases	Xeroderma Anhidrosis Epidermolysis bullosa Psoriasis A birthmark/naevus A mole Dermatitis – Atopic dermatitis Eczema – Atopic eczema Contact dermatitis Seborrhoeic dermatitis Lichen simplex Stasis dermatitis Varicose eczema Nappy rash Allergic eczema Impetigo A boil Erysipelas / Cellulitis A wart	*Two types of naevus are* ***the*** *Port-wine stain and* ***the*** *strawberry mark.* – the generic use of the indefinite article (any representative member of the class) ***The*** *eczema usually begins as red pimples on the face* – anaphoric ref. – direct ***The*** *eczema usually clears up by the second year of life* – anaphoric ref. – direct *the doctor is usually able to remove* ***the*** *wart with chemicals* – anaphoric ref. – direct

	Cold sores Genital ulcers Shingles Chickenpox Thrush / Monilia Athlete's foot Ringworm Scabies Lice – Head lice – Body lice – Pubic lice Fleas A tumour Rodent ulcers Solar keratosis Squamous cell carcinoma Malignant melanoma Acne Chilblains Ichthyosis Urticaria / Nettle rash / Hives Pruritus – Pruritus vulvae – Pruritus ani Jaundice	*to kill **the** lice in them* – cataphoric ref. ***the** ulcer starts as a small raised patch* – anaphoric ref. – direct ***the** tumour grows* – anaphoric ref. – direct
Hair diseases	Ringworm Baldness/Alopecia – Male-pattern alopecia – Alopecia areata An ingrowing hair Hirsutism	 ***the** ingrowing hair can be removed with a needle* – anaphoric ref. – direct
Disorders of the respiratory system	Rhinitis Hay fever Perennial rhinitis Vasomotor rhinitis Allergic rhinitis Sinusitis – Acute sinusitis – Chronic sinusitis – Maxillary sinusitis – Ethmoid sinusitis – Frontal sinusitis – Sphenoid sinusitis Laryngitis Pharyngitis Scarlet fever Whooping cough Overgrowth of the adenoids Tonsillitis A sore throat A cough A sneeze Choking Croup – Catarrhal croup Laryngotracheobronchitis	 *The main symptom is **a** persistent chronic cough* – the indefinite article with a descriptive role *The duration of **the** cough* – anaphoric ref. – direct

	Hiccups Asthma Bronchitis – Acute bronchitis – Chronic bronchitis Emphysema Pneumonia – Pneumococcal pneumonia – Double pneumonia – Acute pneumonia Legionnaire's disease Tuberculosis – Pulmonary tuberculosis Pneumoconiosis – Coal-miner's pneumoconiosis – Asbestosis pneumoconiosis – Byssinosis pneumoconiosis Lung cancer – Adenocarcinoma of the lung – Bronchogenic carcinoma – Bronchial carcinoma – Mesothelioma Pleurisy – Primary pleurisy – Secondary pleurisy Pulmonary embolism Pulmonary abscess Bronchiectasis Pneumothorax	*until **the** hiccups die away* – anaphoric ref. – direct *to find the cause of **the** asthma* – the generic use of the definite article (the class represented by its typical representative)
Disorders of the digestive system	Stomatitis – Gangrenous stomatitis – Aphtous stomatitis Glossitis Gingivitis Thrush Lichen planus Halitosis Parotitis – Septic parotitis – Recurrent parotitis Salivary calculus Cleft palate Dental decay An abscess Dysphagia A peptic ulcer – An aduodenal ulcer – A gastric/stomach ulcer – A oesophageal ulcer – A pyloric ulcer Peritonitis Gastritis Heartburn Pyrosis Flatulence Aerophagia Stomach/Gastric cancer Pyloric stenosis – Hypertrophic pyloric stenosis – Adult pyloric stenosis Hepatitis	

	– Infectious hepatitis – Serum hepatitis – Chronic hepatitis – Viral hepatitis Cancer of the liver Cirrhosis Gallstones Cholecystitis – Chronic cholecystitis Acute pancreatitis Chronic pancreatitis Cystic fibrosis Cancer of the pancreas Crohn's disease Paralytic ileus Malabsorption syndrome Steatorhea Coeliac disease Tropical sprue A hernia – An inguinal hernia – A femoral hernia – An umbilical hernia – A hiatus hernia Appendicitis Colitis – Mucous colitis – Ulcerative colitis Hirschsprung's disease Diverticulosis Prolapse of the rectum Haemorrhoids – Internal haemorrhoids – External haemorrhoids Anal fissure Fistula Cancer of the colon and rectum Constipation Diarrhoea – Acute diarrhoea Gastroenteritis Typhoid fever Botulism Dysentery – Bacillary dysentery – Amoebic dysentery	***the*** *gallstones may form in the gall bladder* – anaphoric ref. – direct ***the*** *hernia formed from part of the small intestine* – anaphoric ref. – direct
Diseases and disorders of the urinary system	Kidney failure – Acute kidney failure – Chronic kidney failure Glomerulonephritis – Acute glomerulonephritis – Chronic glomerulonephritis Bright's disease Toxaemia Cystitis Urethritis Gonorrhoea Urinary incontinence – True incontinence – Stress incontinence	*If* ***the*** *incontinence is caused by an underlying disorder* – anaphoric ref. – direct

	– Temporary incontinence Stones Renal colic	
Muscle disorders	Paralysis Peripheral neuritis Flaccid paralysis Progressive spinal muscular atrophy Progressive spinal muscular atrophy of infancy Peroneal muscular atrophy Muscular dystrophy – Duchene dystrophy – Facioscapulohumeral dystrophy – Myotonic dystrophy Myasthenia gravis Pigeon breast Osteoarthritis Rheumatoid arthritis Gout Ankylosing spondylitis Bursitis	
Diseases of bone	Osteoporosis Paget's disease Osteomyelitis Septicaemia	
Blood disorders	Anaemia – Iron-deficiency anaemia – Pernicious anaemia – Aplastic anaemia – Haemolytic anaemia Bleeding disorders – Haemophilia – Purpura – Leukaemia	*If **the** anaemia is due to bleeding* – anaphoric ref. – indirect *If the deficiency is severe it causes **an** anaemia very similar to that caused by vitamin B12 deficiency.* – the indefinite article with a descriptive role *Treatment depends on the cause of **the** purpura.* – the generic use of the definite article (the class as represented by its typical specimen)
Disorders of the lymphatic system	Hodgkin's disease Lymphoma Lymphangioma Lymphosarcoma Macroglobulinemias	
Heart disease	Coronary heart disease Angina pectoris Coronary thrombosis (A heart attack) (A coronary attack) Congenital heart disease – Patent ductus arteriosus – Septal defects – Fallot's tetralogy – Damaged valves Heart failure Pericarditis Cardiomyopathy Disorders of heart rhythm – Extrasystole	*the person may survive **the** heart attack* – the generic use of the definite article (the class as represented by its typical specimen) *In **a** so called "silent" coronary thrombosis* – the indefinite article with a descriptive role *to have **a** very severe attack* – the indefinite article with a descriptive role *convalescence after **a** heart attack depends on the severity of **the** attack* – ***a*** – the generic use of the indefinite article (any representative member of the class); ***the*** – anaphoric ref. – direct *Sometimes **the** extrasystole is not even noticed.* – the generic use of the definite article (the class as represented by its typical specimen)

	– Sinus arrhythmia – Atrial fibrillation – Heart block	
Diseases of the blood vessels	Arteriosclerosis Thrombosis Embolism An aneurysm Varicose veins Fainting Haemorrhage (bleeding) – External haemorrhage – Internal haemorrhage Hypotension (Low blood pressure) Hypertension (High blood pressure)	***An*** *air embolism – a bubble of air in the veins* – the generic use of the indefinite article (any representative member of the class) *blockage in the lungs – **a** pulmonary embolism* – the generic use of the indefinite article (any representative member of the class) *The condition can lead to **a** potentially fatal pulmonary embolism* – the indefinite article with a descriptive role *Often the individual is not aware of **the** aneurysm* – the generic use of the definite article (the class as represented by its typical specimen) *If **the** aneurysm is detected* – anaphoric ref. – direct *blood which leaks from **the** aneurysm* – anaphoric ref. – direct *In **a** varicose vein* – the generic use of the indefinite article (any representative member of the class) ***A*** *single large haemorrhage will not cause anaemia* – the indefinite article with a descriptive role *Treatment is needed to relieve **the** hypertension in these cases.* – catap horic ref.
Eye disorders	Refractive errors – Hypermetropia (Long sight) – Myopia (Short sight) – Astigmatism Infections and inflammations – Conjuctivitis – Styes and chalazions – Trachoma – Iritis and iridocyelitis Glaucoma Blindness	
Disorders of the ear **Disorders of metabolism**	Earache – Otitis externa – Otitis media Hearing loss and deafness – Otitis barotrauma – “Glue ear” – Otosclerosis – Chronic otitis media – Perceptive deafness Vertigo and dizziness Diabetes mellitus – Hypoglycaemia – Hyperglycaemia Diabetes insipidus	
Diseases and ders of the nervous system	A headache	*Meningitis is important cause of severe headache* – the zero article **disor-** denoting condition *Pressure inside the skull causes headache* – the zero article denoting condition *failure of vision associated with headache* – the zero article denoting condition ***A*** *simple, occasional headache* – the indefinite article with a descriptive role

	Migraine	*If headache is a feature of depression* – the zero article denoting condition *antidepressant drugs may help **the** headache* – anaphoric ref. – direct *to cure **a** tension headache* – the generic use of the indefinite article (any representative member of the class) *Then comes **the** headache: a severe throbbing pain* – anaphoric ref. – indirect *to eliminate other causes of **the** headache* – anaphoric ref. – indirect *followed by **a** serious headache* – the indefinite article with a descriptive role *Headache is one of the conditions in which alternative therapies have had some success.* – the zero article denoting condition *Worry about **the** migraine can bring on further attacks* – the generic use of the definite article (the class as represented by its typical specimen) ***A** migraine may last several hours* – the generic use of the indefinite article (any representative member of the class)
	Congenital malformations of the nervous system – Spina bifida – Hydrocephalus Infections of the nervous system – Encephalitis – Meningitis	*Viruses are a common cause of meningitis. **The** meningitis may be the only sign of infection* – anaphoric ref. – direct
	– Neuritis Apoplexy (A stroke) – A major stroke on the right side of the brain – A stroke in the left side of the brain – A mild stroke (A transient ischaemic attack) – Cerebral haemorrhage – Subarachnoid haemorrhage – Cerebral thrombosis Epilepsy Cerebral palsy and spasticity Parkinson's disease Multiple sclerosis Mental handicap – Down's syndrome	*If the patient survives **the** initial stroke* – anaphoric ref. – indirect
Disorders of the immune system	Acquired immune deficiency syndrome (AIDS) An allergy and hypersensitivity – Anaphylaxis	*Sometimes **the** allergy can be associated with eating* – anaphoric ref. – direct *substance that causes **the** allergy* – anaphoric ref. – direct
Infections and Infestations	Bacterial infections – Anthrax – Cholera – Typhoid fever – Paratyphoid fever – Tetanus (Lockjaw) – Plague – Leprosy – Leptospirosis – Psittacosis Viral infections – Colds	***The** common cold can be cause* – the generic use of the definite article (the class as represented by its typical specimen) *the severity of **the** col* – the generic use of the definite article (the class

		as represented by its typical specimen) *Colds are commoner in winter* – the generic use of the zero article *There is no specific cure for colds* – the generic use of the zero article
	Influenza – Glandular fever (Infectious mononucleosis) – Poliomyelitis – Rabies (Hydrophobia) – Smallpox – Dengue fever – Lassa fever – Yellow fever Rickettsia Fungi Common childhood infections – Measles – German measles (Rubella) – Scarlet fever – Chickenpox (Varicella) – Mumps – Diphtheria – Whooping cough Parasitic animals – Parasitic protozoa – Malaria – Trypanosomiasis – Leishmaniasis – Toxoplasmosis – Parasitic worms – Nematodes (Roundworms) – Trematodes (Flukes) – Cestodes (Tapeworms)	***The*** *flukes burrow through the liver* – anaphoric ref. – indirect ***The*** *oriental lung fluke* – the generic use of the definite article (the class as represented by its typical specimen) *The commonest infection is by* ***the*** *dwarf tapeworm* - the generic use of the definite article (the class as represented by its typical specimen) *infection is caused by the adults of* ***the*** *beef tapeworm,* ***the*** *pork tapeworm and* ***the*** *fish tapeworm* – the generic use of the definite article (the class as represented by its typical specimen) ***The*** *fish tapeworm, which absorbs vitamin* the generic use of the definite article (the class as represented by its typical specimen) *A drug to kill* ***the*** *worm may be prescribed.* – anaphoric ref. – direct *final host of* ***the*** *liver fluke* – the generic use of the definite article (the class as represented by its typical specimen)

4. Conclusions

There have been found several differences between the use of articles with illnesses and diseases as suggested in the grammar books and their actual use in The Family Medical Reference Book. *Plague* could serve as a typical example of such a difference: while in the grammar books the definite or indefinite article is recommended, it has not occurred in any instance in the analysed text. Many other examples are even more ambiguous.

Where the article with a particular illness is considered as unmarked, it is placed in the second column of the table. On the other hand, where the use of article is felt as marked, it is given in the third column with a suggested explanation.

As found in the analysed text, if an illness is understood as uncountable and 'abstract' the zero article is preferred. On the contrary to this, if an illness or disorder is countable and somehow visible or touchable, the indefinite article is used (*a mole, a wart, a hernia, an aneurysm, an allergy*).

When the combination of the definite or indefinite article with an illness represents the whole class or any representative member the reference has been classified as generic.

If the name of an illness or disorder is mentioned earlier in the context or specified later in the context it is taken as a typical example of anaphoric (direct, indirect) or cataphoric reference.

In the instances where an illness is described in more details, the indefinite article is used and it is felt as nonreferring and have a descriptive role.

In the specific case of *headache* when it denotes a condition it is used with the zero article but when it denotes a single attack the indefinite article is preferred.

This was just an attempt to analyse the use of articles with the names of illnesses, diseases and disorders based on the content of The Family Medical Reference Book. We understand that the topic has not been covered in its full range and requires further investigation. This will hopefully be found in subsequent papers.

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COMMUNICATIONS

Michal Hottmar *

LUTE MUSIC IN THE AREA OF CONTEMPORARY SLOVAKIA IN THE PERIOD OF RENAISSANCE JEAN BAPTISTA BESARD – THESAURUS HARMONICUS

The article analyses the issue of occurrence of lute music, its repertoire, players, and composers connected with the area of Slovakia in the age of humanism.

1. Introducion

Lute played an important role in the history of the European musical culture of the 16th and 17th centuries. It influenced some processes of musical history to a considerable extent, e.g. stabilization of tonality, development of variety principle, formation of suite and development of note writing. In our musicology literature there are not many works to be found that would deal in detail with the occurrence of lute music in Slovakia or individual relics related to this kind of music. Some mentions about lute music in Slovakia can be found in compilatory /synthetical works of František Fagiba [1], Richard Rybarič [2], Ladislav Kačic [3]. Antonín Hořejš[4] and Marta Hulková [5] make analyses of lute relics in the area of Spiš region. Ingeborg Šišková [6] brings scientific elaboration of the transcription of the lute tablature in Slovakia. Péter Király [7] ranks among the experts abroad dealing with study of lute play in the area of the former Hungary. Foreign lexicons also cover the issue of lute play.

2. Lute music in the area of contemporary slovakia in the period or renaissance

During the period of Renaissance in the area of the present-day Slovakia significant economic, political and cultural changes were happening and they resulted in better conditions for the development of musical culture and the occurrence of lute music accordingly. The evidence of this are also some references about activities of some lute players of European dimension like Hans Newsidler or Bálint Bakfark [8]. The highest level of musical life was reached together with Bratislava in towns of Eastern Slovakia – the extent of music collections of Levoča and Bardejov confirm this.

[5] In literature we can find information about an early existence of music for this instrument from the 1st half of the 16th century. Several significant people - lute players of that time – are related to Slovakia. Bratislava is stated as a birthplace of the Newsidler brothers, Hans (1508-1563) and Melichor (1507–1590), German lute players acting in Norimberg. In 1530 Hans Newsidler moved from Bratislava to Norimberg where he published a few tablature books for six-course lute. Despite his numerous stays in Vienna during his journeys across Europe, there were no traces left of him in Slovakia. We can assume that he gained basic musical education in Bratislava, which can be proved by the existence of lute playing in this town in that period. A Hungarian poet, Sebestyén Tinódi (1505–1556) was another lute player, a creator of a historical song and the author of the collection Cronica In 1544 he stayed in Trnava as well as in other parts of Slovakia. Tinódi ranked among the musicians (lute players) wandering around Slovakia and with his singing accompanied by lute revolting against the Turks [1]. Some connections between Slovakia and Bálint Bakfark (1507–1576),

one of the most important lute players in the 16th century, have been made in literature. He was active in the noble courts of Europe. František Zagiba [1] traces back his stay in our area, his visit to Trenčín and possibly giving concerts in 1566. Lives of these three personalities of lute music are closely connected with the period when in Slovakia – in contrast to the past – there were many major political, industrial and cultural changes With the oncoming reformation the gregorian chant ceased to be the object of interest and attention was shifted to spiritual songs and secular music. These tendencies were best demonstrated in three regions – Bratislava in the west, Kremnica and Banská Bystrica in central Slovakia and Spiš region and Bardejov in the east. In the inventory of an evangelical church in Bratislava there are two compositions from 1651 where lutes are mentioned in consort music. [9] On the basis of this we can come to the conclusion that lute music existed in this town. In towns of eastern Slovakia the musical life reached the highest level, together with Bratislava. The evidence of this is the scale of Levoča's and Bardejov`s collections of music of 16th

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and 17th centuries. Among numerous printings and manuscripts of sacred characters predominantly, also some relics of secular instrumental music were preserved from those times. Among them three printed lute tablature books, too [5] Two of these – Waisselius`s *Tabulaturbuch* from 1592 [10] and Besard's *Thesaurus harmonicus* from 1603 [11] have been preserved until today. About the last Phales's printing *Lucullentum theatrum muscum* from 1568 [1] we can learn from literature [1]. The occurrence of these pieces of art witnesses the presence of brilliant players among nobility or townsfolk of whom we can claim that they reached the same level as the European ones. We do not have much knowledge about the way of education of lute playing as well as of education of professional lute players in this area. We know that in Banská Bystrica Gerle's lute book from 1546 was used, which is a part – as Marta Hulková claims – of music collection of the library of Johann Dernschwam. The library is currently archived in Nationalbibliothek of Vienna (sig. Cod. 12652). In Levoča Besard's lute book from 1603 containing lute instructions was used [12].

The preserved lute books' repertoire of lute players active in the area of the former Hungary is dominated by Italian and German composers, but there are also some compositions of French and English authors. As Király says, for example the content of Waisselius's tablature is identical with the contents of richer Czech, Polish, Austrian and German collections [9]. In the repertoire of Bakfark, both Newsidlers and also Tinódi we could find some compositions containing characteristic features of music of various countries, influenced by folk elements of certain environment as well phantasies, preambles, intavulations and international dance compositions [9]. The professional lute players are supposed to have played international repertoire, but they certainly played some of their own compositions, too. The dance compositions formed the main part of European lute repertoire of those times. Lute became the means of their popularization in our territory. From the above mentioned (though fragmentary) facts we can conclude that lute music in the area of the contemporary Slovakia might have been present to a much greater extent than one would have expected.

3. Jean Baptista Besard [13]

He was born around 1567 in Jussey or Besancon, and died after 1617. He studied law and theology at a university in Dôle and graduated there in 1587 in civil and ecclestiastical law. From 1587 to 1592 (or 1596) he stayed in Rome where he probably studied medicine and learned to play the lute at Laurencini [13]. On 13th May 1592 Besard was matriculated at a university in Heidlberg. No later than from March 1597 he was active in Koln where he tutored at least 20 students of lute. In summer or autumn 1597 he was not successful in applying for the position of a lute player in the court of the landgrave Moritz Hessen in Kassel. From October 1600 to March 1601 he worked as a lute teacher in Koln. In February 1602 in Besancon he married Péronne Jacquot. She came from an aristocratic family of lawyers. In 1603 in Koln Besard published – at his own expense – lute anthology *Thesaurus hamonicus*. In 1604 in Koln he compiled the 5th volume of *Mercurii Gallobelgici*, one of the most plentiful series of edition of historical and law documents. Besard's relations to Besancon were very close at that time. *Thesaurus* and *Mercurii* are dedicated to personalities from Franche – Comté. In October 1605 he had to go back to Besancon to arrange law and economic claims of his wife which resulted from their marriage settlement. During the following years Besard spent most of the time in Koln. In November 1613 he came back to Besancon again to receive his wife's father's patrimony after he had died the same year. Around 1617 Besard settled in Augsburg, the hometown of his friend Phillip Hainhofer. Thanks to Besard, encyclopaedia of diseases and medical procedures *Antrum philosophicum*, the collection for lute orchestra *Novus partus* [14] and school for luteplaying *Isagoge in artem testudinarium* [14] which he dedicated to his four Augsburg students were published here. Besard left Augsburg shortly after publishing *Novus partus* on 1th September 1617.

Tablatures from Besard's collection which were not attributed to other authors, may not have been written by Besard himself as he was considered to be more a publisher and an elaborator. His authorship of majority of works that are connected with his name is uncertain as well. Jean Baptista Besard was also the author of books and writings concerning music like *De modo in testudine libellus* [11] that is a part of *Thesaurus* He is the author of *Ad artem* which is a revised edition of *De Modo*.

Some other documents written by him are: *Mercurio Gallobelgici* from 1604, which is the collection of historical documents, *Antrum philosophicum in quo pleraque arcana physica quae ad vulgariores humani corporis affectus currandos attinent*, which is a large compendium of medical knowledge of that period.

4. Thesaurus harmonicus

The original of this precious document is a part of Levoča's collection of music and is in the depository of the Evangelical Church under the signature 5157, new signature is 7A. It is also available in the form of a microfilm at The Institution of Musical Science of Slovak Academy of Science (SAV) in Bratislava. The musical print *Thesaurus harmonicus divini Laurencini Romani*, Koln 1603, contains 405 compositions in French lute tablature in ten books, from which probably 46 works are Besard's, 4 preludes, 3 phantasies, 6 canciones gallicae, 9 passamez, pavana hispanica, bergamesca, 4 galiards, 14 allemandes, courant de guerre and 3 ballets.

Besard's lute music is not of extraordinary quality. Short preludes win the audiences over mostly with their improvisational quality while long passamezo – variations consist only of many mechanical cumulated reversed chords. Compositions are characterized by very difficult technique of play. Frequent and extreme change of positions, fast passages, nervous rhythm, unusual touch sequences as well as expressive disonancies show that Besard was a pupil of the great Italian lute virtuoso Laurencini. *Thesaurus*, European anthology of lute music which includes nearly complete

sequencing of lute music, preludes, phantasies, intavulations of madrigals, psalms and chansons, songs accompanied by lute, dance forms like passamezo, galliard, allemand, courant, branl, contains apart from known pieces also compositions of unknown composers. *Thesaurus* was used by lute players from all Europe as a source of a new repertoire as well as a textbook and a manual. The repertoire collected by Besard in this work emphasizes lute encyclopaedic knowledge of that period. As the most appreciated lute player of his time he considers, apart from his teacher Laurencini, a Frenchman A. Francisque whose collection *Trésor d'Orpheé* is similar to *Thesaurus* [14]. A Norimberg editor of the large lute anthology *Testudo Gallo-Germanica* from 1615 G. L. Fuhrmann was in personal contact with Besard which is evidenced by Besard's vote of thanks and a high number of concordances between Fuhrmann's publications and *Thesaurus*. Another model for this collection are also publications of Piere Phalese [13].

In the introduction Besard deals with the typology and classification of various forms. In case of e.g. galliard, which Besard dedicated one whole book, he differentiates dance form with a periodical structure and stylized galliarde with variation forms. *Thesaurus* with 14 Besard's compositions in the 7th book was the most important source for allemand at that time.

5.Conclusion

In the end we can conclude that musical life in Slovakia in the period of humanism – even if little later – tried to keep up with the development of trends in European secular music which is proved also by the existence of some precious documents of lute music of that period in this area. It is also recorded in primary and secondary sources. At the beginning of the 17th century Jean Baptista Besard was considered the best expert at the technique of lute playing. Along with the stated historical facts Besard is presented as a well educated man in more fields which only confirms the ideal of a man of those times.

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The 100th Birthday Anniversary of Professor Frantisek Kroutl

Studies and places of work

Professor Frantisek Kroutl was born in Ceske Budejovice on 24th February 1905. From 1923 he studied at the Faculty of Electrical Engineering of the Czech Technical University (CVUT) where he graduated in 1929. After having finished his studies, he started work as an operational engineer for a technical department of the VES company in Bratislava. From 1930 to 1942 he worked at the Headquarters of Posts and Telegraphs in Prague.

From 1942 to 1944 he worked as an engineer with Standard Electric DOMS et Co in Prague. From 1944 until the liberation he was kept prisoner in a concentration camp in Germany for his membership of the resistance organization called Bila Hora. From 1945 to 1948 he was the head of the Office of Long-distance Cables at the Post Board of Management in Prague. In 1946 he became the head of the Provincial Telecommunication Group. In 1950–56 he worked at the Ministry of Postal and Telecommunication Services at various management positions, for two years he had been a personal advisor to the minister of postal and telecommunication services. In 1957-59 he was a director, later a deputy director of the Research Institute of Postal and Telecommunication services in Prague.

From 1960 until the end of his life he worked at the University of Transport in Žilina as a university professor; first at the Department of Interlocking, Signalling and Communications (1960–1970) – nowadays the Department of Control and Information Systems; later (1970–1977) at the Department of Telecommunications. During these periods his assistants were Milos Zavoral, Dusan Trstensky, Julius Rozai, Fedor Hrnciar, Matilda Drozdova and Milan Konvit.

In 1960-63 he held a post of vice-dean for science and research at the Faculty of Machine and Electrical Engineering at the University of Transport in Žilina. He was also a permanent member of the Scientific Boards of the Faculty and University. From 1969 to 1970 he was a vice-head of the Department of Interlocking, Signalling and Communications.

In 1957 he defended his Ph.D. thesis named "Is it necessary to equalize the capacity couplings of local telephone cables?", and obtained the scientific degree of "CSc." (Ph.D. equivalent). In 1960 he became a university professor, and in 1970 he defended his "great doctoral" thesis, and obtained the degree of doctor of sciences "DrSc."

His work was interrupted by his sudden death on 2nd June 1977 in Žilina.

Scientific work

In late 1950s, the professional public was getting more and more aware of the conclusions of Shannon's works from the area of information theory. They concerned mainly the attributes of communication channel, and source and channel coding. Professor Kroutl transferred the first results of these works into education, research and into international standardizing projects within the framework of CCITT (ITU). He put systematic foundations to scientific school which influenced namely the educational process for many years from then on.

In the course of professor Kroutl's active work some essential tendencies of the information theory development were identified, namely working out an exact theoretical apparatus for a multichannel with a multi-access to network applications; the processes of constructing channel codes with defined securing attributes; theoretical bases of risk-defining with critical processes, and the transfer of the game theories into the economic processes management.

All of the above-mentioned concern the rules of manipulation with information – its acquisition, storing, transmission and transformation. The development of information theory and the tasks related to it are closely connected to the management of basic processes (natural, technical as well as social). The scientific school established by professor Kroutl prioritizes the identification of these tasks out of the practice of communication systems. After the theoretical apparatus has been processed, the solutions are transferred into applications of the circuit theory.

Publishing activities

Professor Kroutl published the results of his scientific and research work in journals and proceedings in his country as well as abroad.

This includes tens of papers. He is the author of important monographs, university textbooks and professional publications:

- *Technology of Long-distance Communication Cables (Technika dálkových sdělovacích kabelů), Prague, 1949*
- *Távkábeltechnika, Kőzlekedési kőnyvkiadó, Budapest, 1954*
- *Information Theory in Communications (Teorie informací ve spojích), Ediční a propagační středisko spojů, Prague, 1960*
- *Signals and Noises (Signály a hluky), Nadas, Prague, 1964*
- *The Theory of Reporting Lines (Teorie sdělovacích vedení), Nadas, Prague, 1966*
- *The Theory of Communication Networks (Teorie sdělovacích sítí), Nadas, Prague, 1968*
- *The Theory and Logic of Communication Transmissions (Teorie a logika sdělovacích přenosů), Nadas, Prague, 1981*

Apart from these, he published several university textbooks.

Professor Kroutl was very flexible at reacting to the needs of practice. For example, when in 1953 wired broadcasting started being implemented in the Czechoslovak Republic, in 1955 he published "The Theory of Wires with an Equivalent Load", or, at the beginning of the area automation of telephone operations in 1956 he published his lectures "Telephone Networks" and "Communication Networks Planning".

Working for CCITT (ITU-T)

The professional public not only in the Czech and Slovak Republics but also in other countries has known Professor Kroutl. His activities abroad were associated especially with Geneva.

In 1964–1972 he was President of the XII-th "Telephone Transmission Quality" Commission, by the International Advisory Body for Telegraphy and Telephony CCITT in Geneva. He was also President of a working group "CCITT Laboratory" for telephonometric measurements.

After he became President of the XII-th Commission, professor Kroutl headed the group making the working plan of the "CCITT Lab". The Lab dealt with the telephone services quality, objective measuring of telephone transmission quality, with the quality of transmission on PCM systems, measuring frequency characteristics of microphones and telephones (artificial mouth, voice, ear), with nonlinear distortion of telephone apparatus, limitations of transmission quality in local networks, limitations of intelligible crossed lines in networks, loudly speaking telephones, variations of telephone apparatus impedance. Among significant results of the "Lab's" works we might mention a study on the reading of a relative damping definition, subjective measuring methods on fixed telephone apparatus, a revision of reference system definition, transition to objective measuring methods and further results of the XII-th Commission's studies.

Professor Kroutl has also been highly credited for his share of the development of the mathematical theory of availability, dependability and quality of transmission on communication networks. At the meeting of the XII-th Commission in Melbourne, Australia in 1970 he presented the results of research he had been significantly contributing to for a few decades.

Preserved letters prove how highly Professor Kroutl has been acknowledged by world-wide known experts.

Educating of scientific professionals

Another of professor Kroutl's credits is his role of a supervisor to educating post-graduates and bringing-up pedagogical workers; last but not least he was chairman of the board for awarding scientific degrees and was involved in career development of many other outstanding university teachers (Assoc. Prof. Milos Zavoral, Prof. Karol Blunar, Prof. Dusan Trstensky, Assoc. Prof. Fedor Hrnciar, Milan Krpata, Assoc. Prof. Izabela Krbilova, Assoc. Prof. Jozef Cuntala, Assoc. Prof. Fedor Kallay, Assoc. Prof. Matilda Drozdova, Prof. Milan Konvit, etc.).

Lots of current teachers, managers of important enterprises, and research workers in Žilina , Slovakia, Czech Republic and also other countries were professor Kroutl's disciples or at least followed his scientific activities. Plenty of teachers have been influenced by his scientific work indirectly (Prof. Milan Dado, Assoc. Prof. Martin Klimo, Assoc. Prof. Rudolf Hronec, Assoc. Prof. Martin Vaculik etc). Even after 27 years his name and work have been still known to the scientific world, as well as to the world of telecommunications. This is because of his ability to perceive and structure problems regardless their size.

Very unique were his creativity and ability to adapt the mathematical and physical apparatus to the needs of an exact description of processes when accompanying manipulation with information.

doc. Ing. Izabela Krbilová, PhD.

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komunikácie
COMMUNICATIONS

VEDECKÉ LISTY ŽILINSKEJ UNIVERZITY
SCIENTIFIC LETTERS OF THE UNIVERSITY OF ŽILINA
7. ROČNÍK – VOLUME 7

Adresa redakcie:
Address of the editorial office:
Žilinská univerzita
Oddelenie pre vedu a výskum
Office for Science and Research
Univerzitná 1, Slovakia
SK 010 26 Žilina
E-mail: komunikacie@nic.utc.sk, polednak@fsi.utc.sk,

Každý článok bol oponovaný dvoma oponentmi.
Each paper was reviewed by two reviewers.

Časopis je excerpovaný v Compendexe
Journal is excerpted in Compendex

Vydáva Žilinská univerzita
v EDIS – vydavateľstve ŽU
J. M. Hurbana 15, 010 26 Žilina
pod registračným číslom 1989/98
ISSN 1335-4205

It is published by the University of Žilina in
EDIS - Publishing Institution of Žilina University
Registered No: 1989/98
ISSN 1335-4205

Objednávky na predplatné prijíma redakcia
Vychádza štvrťročne
Ročné predplatné na rok 2006 je 500,– Sk

Order forms should be returned to the editorial office
Published quarterly
The subscription rate for year 2006 is 500 SKK

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