VEDECKÉ PRÁCE

MATERIÁLOVOTECHNOLOGICKEJ FAKULTY
SLOVENSKEJ TECHNICKEJ UNIVERZITY
V BRATISLAVE SO SÍDLOM V TRNAVE

ČÍSLO 30
2011

RESEARCH PAPERS

FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY
SLOVAK UNIVERSITY OF TECHNOLOGY IN TRNAVA

NUMBER 30
2011

SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA
Faculty of Materials Science and Technology in Trnava

The scientific journal of the Faculty of Materials Science and Technology (FMST), Slovak University of Technology (SUT) in Trnava. *It is issued twice per year.* The journal is issued by the Slovak University of Technology in Bratislava Publisher, Vazovova 5, Bratislava. Address of editorial office: Publisher AlumniPress, Faculty of Materials Science and Technology SUT, Paulínska 16, 917 24 Trnava, Slovak Republic.

Editor-in-chief: Kvetoslava Rešetová, Ph.D.

Phone: 0915847111, fax: 033/5521002 e-mail: kvetoslava.resetova@stuba.sk

ISSN 1336-1589

CONTENTS

RESEARCH PAPERS
FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA
SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

2011 Number 30

NUMBER OF POINTS FOR ROUNDNESS MEASUREMENT – – MEASURED RESULTS COMPARISON

Augustín GÖRÖG

Abstract

Paper deals with filtering roundness. It presents experimental results measured for roundness turning and cylindrical grinding. Roundness was measured using Prismo Navigator 5 coordinate measuring machine. Evaluation was done by four methods: Minimum zone reference circles (MZCI), Least squares reference circle (LSCI), Minimum circumscribed reference circle (MCCI) and Maximum inscribed reference circle (MICI). The filters used were: Gauss, Spline and no filter.

Key words

roundness, reference circle, filter, measurement, evaluation methods

Introduction

It is impossible to produce ideal parts. Deviations are a natural result of production. These deviations should be determined. Standards STN EN ISO 1101: 2006 [1] does not define the term tolerance. It introduces the term "tolerance zone", which is defined as a circumscribed area by one or more geometrical exact lines or surfaces. This tolerance zone is characterized by a linear dimension which is called "tolerance" [2].

Standard STN EN ISO 1101: 2006 [1] defines "roundness tolerance" as follows: the tolerance zone is delimited by two concentric circles with their radial distance equal to value „t" at under consideration cross section. That means the entire extracted (real) circumferential line of random cross section of cylindrical or conical surfaces must be found between two complanationary (that are inboard one plane) concentric circles with their radial distance that is specified by tolerance on mechanical drawing.

Augustín Görög, Assoc. Professor, Ph.D. - Institute of Production Technologies, Faculty of Materials Science and Technology in Trnava, Slovak University of Technology in Bratislava, J. Bottu 25, 917 24 Trnava, Slovak Republic, e-mail: augustin.gorog@stuba.sk

Roundness plane is perpendicular to the roundness axis within the full extent of the feature. Measured is real surface of a workpiece, which is an integral feature part of real surface of a workpiece limited by the adjacent real (integral) features. Thus, roundness profile which is defined as extracted circumferential line (digital representation of the intersection of the real surface and the roundness plane) intentionally modified by a filter can be determined.

Circle that is faced with measured profile is called “reference circle”. This is defined as an associated circle fitting the roundness profile in accordance with specified conventions, to which the deviations from roundness and the roundness parameters are referred. Reference circle can be:

1. *Minimum zone reference circles MZCI:* two concentric circles enclosing the roundness profile and having the least radial separation (see Fig. 1):
   - *outer minimum zone reference circle:* outer circle of the minimum zone reference circles;
   - *inner minimum zone reference circle:* inner circle of the minimum zone reference circles;
   - *mean minimum zone reference circle:* arithmetic mean circle of the minimum zone reference circles.

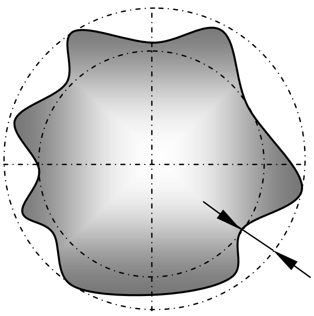


***Fig. 1** Minimum zone reference circles MZCI*

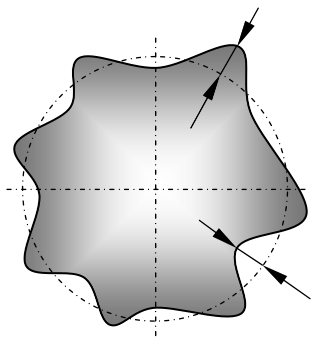


***Fig. 2** Least squares reference circle LSCI*

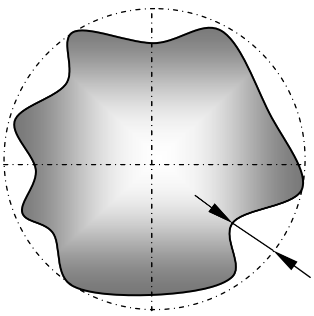


***Fig. 3** Minimum circumscribed reference circle MCCI*

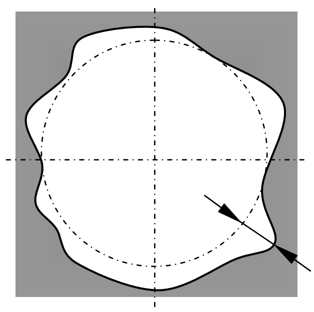


***Fig. 4** Maximum inscribed reference circle MICI*

2. *Least squares reference circle LSCI:* circle such that the sum of the squares of the local roundness deviations is a minimum (see Fig. 2).

3. *Minimum circumscribed reference circle MCCI:* smallest possible circle that can be fitted around the roundness profile (see Fig. 3).
4. *Maximum inscribed reference circle MICI:* largest possible circle that can be fitted within the roundness profile (see Fig.4).

Roundness measuring methods

Basic roundness measuring manners are presented in Fig. 5. Experimental work was carried out by Prismo Navigator 5 coordinate measuring machine using a multi-point method (Fig. 6). Measurements were made with 8, 16, 32 and 64 points and scanning with 500, 1000, 2000 and 4000 points. Measured was the turned and grinding surface.

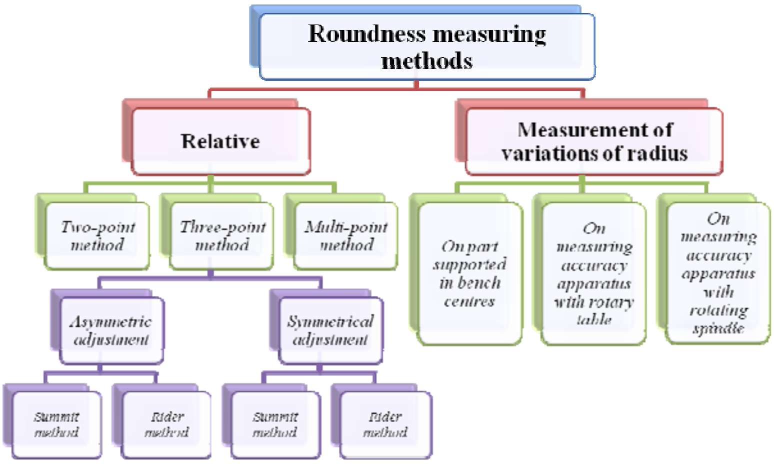


***Fig. 5** Basic roundness measuring manners [3]*

***Fig. 6** Prismo Navigator 5*

Filtering data

To evaluate deviations of form, data are filtered. Via a suitably chosen touch (e.g. large diameter balls), it is possible to eliminate the roughness element. Sensor is used as a mechanical filter. This arises through the form and radius of the sphere which is replicating the workpiece surface. Other harmonic components need to be eliminated by filtering [2]. Filtering can be simply called the smoothing of the recorded profile, as it removes undesirable elements (in this case, data or points). Evaluation Software offers several filters. It is not possible to specify clearly the best one. The most common ones include:

2RC filter (RC - Resistor and Capacitor) - This type of filter was taken from the filtering of sound waves and is the oldest of the methods.

Gauss filter is newer than 2RC and used more often than 2RC. It solved the problem of non-linear phase of the 2RC and could be implemented digitally quite easily. Commission for approval of ISO standards introduced Gauss filter for filtering the measurement data of 2D profiles as a standard [4].

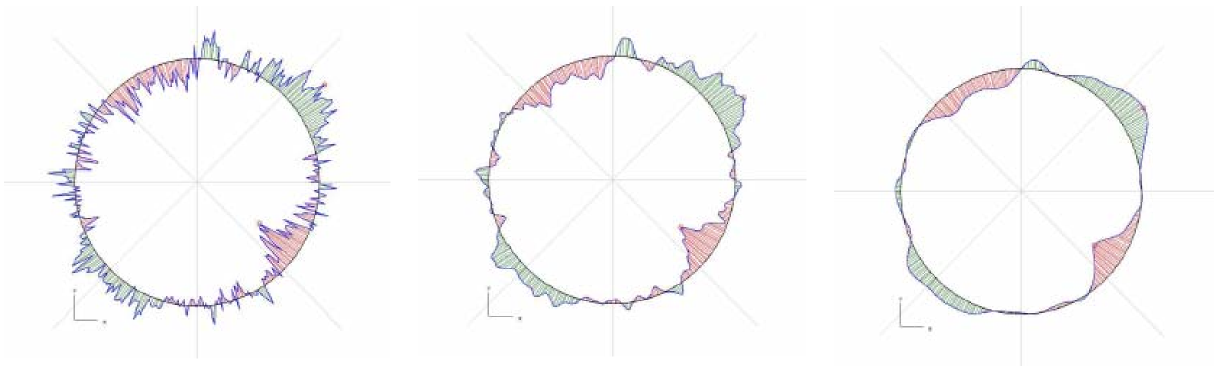
Spline filter is the latest method of filtering. When compared with the Gauss filter, it has better results. It was approved as an ISO standard in 2006. It eliminates two problems associated with Gauss filter: edge distortion and poor results achieved in measuring larger parts [5].

In case of roundness, the value is set up to display the harmonics components (UPR - undulations per revolution). Waves with high frequency (short period) represent the surface roughness, mid-frequency - waviness and low frequency - form of profile. All the harmonic components together create the primary profile. To view harmony, the following filters are used:

Low-pass - filtered harmonic components with high frequencies. It usually filters roughness, while waviness remains. An example is presented in Fig. 7.

Height-pass - is the opposite of low-pass filter. Long wave (waviness) is filtered and short wave (roughness) remains unchanged.

Band-pass - is a combination of low-pass and high-pass filters. Filtered harmonic components in that range (waviness and roughness).



a) without filter　　b) low-pass filter to 50 UPR　　c) low-pass filter to 15 UPR

Fig. 7 *Filtered profile [6]*

Results of experimental work

Results of measured roundness are presented in Fig. 8:

- for turning and grinding surfaces,
- for different numbers of points,
- for Gauss filter, spline filter and without filter,
- for MZCI, LSCI, MCCI and MICI methods.

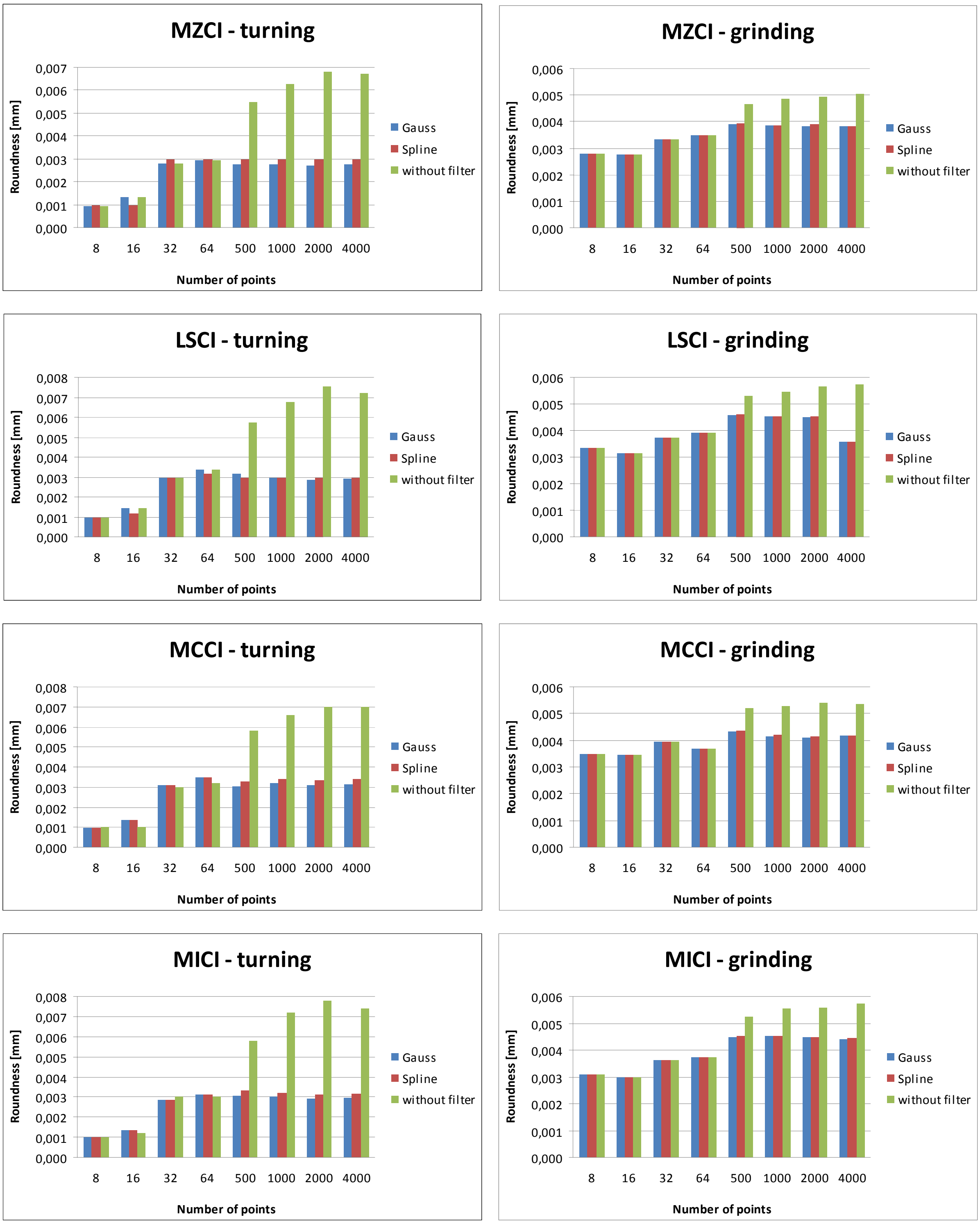


Fig. 8 *Roundness turning and grinding surface – MZCI, LSCI, MCCI and MICI methods*

Conclusion

Results of the measured roundness indicate the following:

- In turning area, the number of points 8 and 16 is inadequate (for all methods - MZCI, LSCI, MCCI and MICI). Results there were smaller. With higher number of points, roundness varied a little.
- In grinded surface, the values measured with 8, 16, 32 and 64 points were smaller than those measured by scanning.
- When using 8, 16, 32 and 64 points, the roundness was similar for all filters.
- In scanning without filter, roundness is significantly higher than when using Gauss and Spline filters.

In conclusion we can say that, when measuring roundness, it is appropriate to use scanning and filter data.

References:

[1] STN EN ISO 1101: 2006, *Geometrické špecifikácie výrobkov (GPS). Geometrické tolerovanie. Tolerancie tvaru, orientácie, polohy a hádzania (ISO 1101: 2004).*

[2] DOVICA, M. Odchýlky tvaru a polohy – meranie kruhovitosti a radiálneho hádzania. In *Portál strojárskej metrológie* [online]. [cit. 2010-12-15; 18:15SEČ]. Dostupné na internete <: http://web.tuke.sk/smetrologia/navody/uloha9.pdf >

[3] CMM QUARTERLY. Filtering of Scan Data [online]. [cit. 2010-12-31; 12:00SEČ]. Dostupné na internete <:http://www.cmmquarterly.com/site/index.php?option=com_content&task=view&id=66&Itemid=69 >

[4] GÖRÖG, A., LAKOTA, S., MALÍK, A. Roundness measuring methods - measured results comparison. In *International Doctoral Seminar 2010* : Proceeding. Smolenice, 16-19 May 2010. Trnava: AlumniPress, 2010, pp. 156-165. ISBN 978-80-8096-118-3

[5] MURALIKRISHNAN, J. Computational Surface and Roundness. In *Springer.* [online]. 2009 [cit. 2010-12-31; 18:30SEČ]. Dostupné na internete <: http://www.springerlink.com/content/n13r3q144660u148/ > ISBN 978-1-84800-296-8

[6] KAŤUCHA, P., KOVÁČ, J. Bezkontaktné meranie tvaru telies pomocou optických metód. In *Portál strojárskej metrológie* [online]. [cit. 2010-12-29; 20:00SEČ]. Dostupné na internete <: http://web.tuke.sk/smetrologia/poklady/kszr2010.pdf >

Reviewers:

Zdenko Lipa, Professor, Ph.D. – Institute of Production Technologies, Faculty of Materials Science and Technology in Trnava, Slovak University of Technology Bratislava

Dana Stančeková, Assoc. Professor, Ph.D. – Department of Machining and Automation, Faculty of Mechanical Engineering ŽU, Žilina

RESEARCH PAPERS
FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA
SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

2011 Number 30

METROLOGICAL CONTROL OF SELECTED SURFACE TYPES OF A MECHANICAL PART BY USING ON-MACHINE MEASUREMENT SYSTEM

Michal OMÁMIK, Ivan BARÁNEK

Abstract

The paper is focused on the research of On-machine measurement systems for a CNC multi-axis milling machine. Research is aimed at the suitable selection of measuring parameters for On-machine measurement systems in order to reach an accurate and reliable quality control of the mechanical part. Theoretical information and overall concept of research are also presented.

Key words

on-machine measurement systems, coordinate measuring machine, accuracy, touch probe

Introduction

Quality control is one of the important parts of production process which can be performed trough many possible ways with different measuring gauges and equipment. New products following the trends of designers or requirements of industrial applications with freeform surfaces require instruments with high ability of measuring tasks solving. Regarding many advantages of On-machine measurement system, the utilization of the systems has become a subject of many researches. These systems allow controlling the parts directly on the machine tool, and also the process can be integrated directly to the machining process whereas the delays from transportation and measuring process performed on coordinated machine are omitted.

Michal Omámik, MSc. Eng., Ivan Baránek, Professor, Ph.D. – Institute of Production Technologies, Faculty of Materials Science and Technology, Slovak University of Technology Bratislava, Paulínska 16, 917 24 Trnava, Slovak Republic, e – mail: michal.omamik@stuba.sk, ivan.baranek@stuba.sk

Research concept of On-machine measurement system

Latest trends of metrological control of mechanical parts containing also freeform surfaces have brought requirements of the research in the field of On-machine measurement systems. Generally, the accuracy of measurements and authenticity of the results from the measurement is in most cases affected by many factors and this is truth also for the measurement by using CMM (Coordinate measuring machine) as well as in On-machine measurement systems. This fact brings questions related to the research needs of suitable selection of measuring parameters for On-machine measurement systems in order to reach an accurate and reliable quality control of a mechanical part produced on multi-axis milling machines. The factors affecting the accuracy, efficiency and uncertainty of measurement performed via On-machine measurement systems are the object of the research. Influence of partial factors and their interaction are going to be studied in the planned experiments. Partial stages of experiments will be carried out in order to observe the increasing complexity of the measuring task on the machine tool.

Aims and stages of experiments

Partial stages of experiments (Fig. 1) are planned in order to observe the increasing complexity of the measuring task depending on the complexity of the measured part. Based on this, there are the possibilities of On-machine measurement systems shown and compared to CMM.

Partial experiments can be divided into four stages:

Accuracy demonstration of On-machine measurement systems compared to CMM depending on suitable selection of measuring parameters

1. or surfaces from Primitive analysed on “artefact” for accuracy of dimension as well as for the derivate deviation, e. g. roundness, etc.,
2. for surfaces from Primitive analysed (the accuracy of dimensions as well as the derivate deviation, e. g. roundness, etc.) on part machined on the same machine tool from which On- machine measurement system is developed.
3. for features commonly machined and measured by the machine tool cycles (machined and measured at the same milling centre from which On - machine measurement system is developed)
4. for selected types of parts (with the different complexity designed for 3D, 4D and 5D milling) machined and measured on the same CNC milling machine.

In foreign literature, a term “artefact” is used as an etalon part with known and high accuracy, or as a test work piece for the machine tool evaluation or CMM (Coordinate measuring machine).

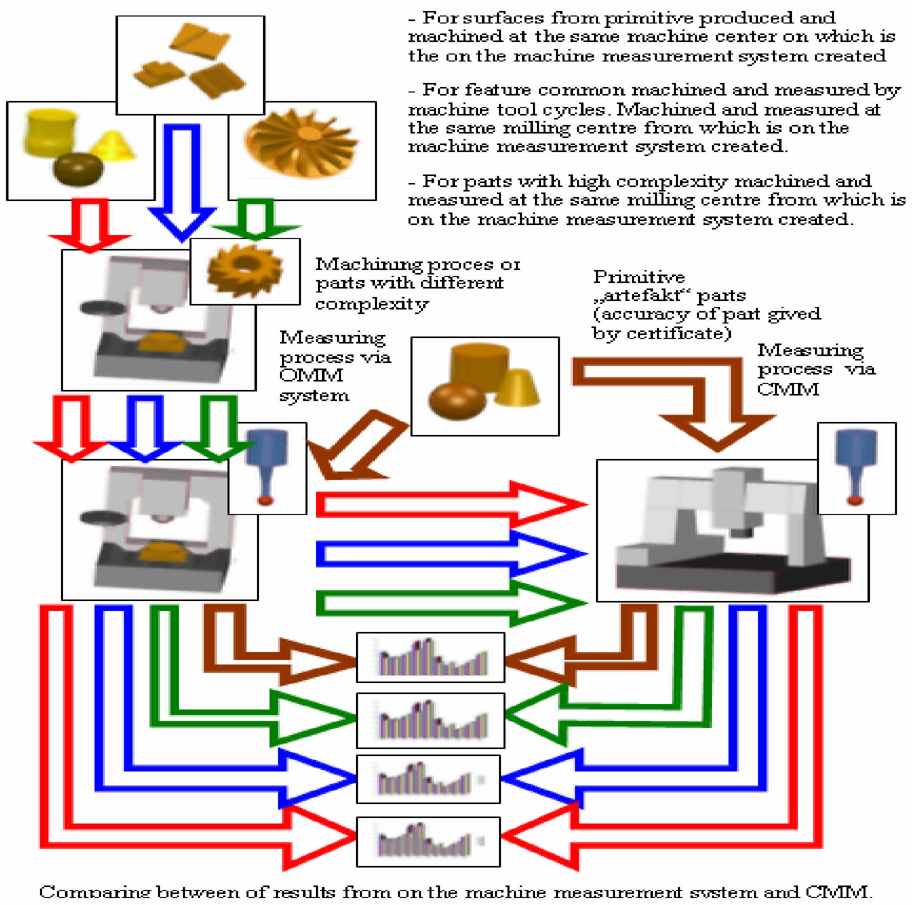


Fig. 1 *Partial stages of the research of On-machine measurements system compared to CMM (Coordinate measuring machine)*

Parameters of experiments

Parameters of measurement and their interaction which could by set or selected will be the objects of experiments within the research of a suitable selection of measuring parameters for On-machine measurement system. This will bring complex information about On-machine measurement systems.

Following parameters are the objects of experiments:

- number of measuring points,
- distribution of measuring points based on different patterns of distribution as well as based on patterns of measuring points distribution depending on the curvature of surface (stable, unstable and number of curvatures),
- Position and orientation within a range of part fixing on the machine tool table,
- Tilt angle of machine tool spindle (constrain from angle of measured part),
- Styli length,
- Speed of measuring.

A detailed view of experiment parameters using the “artefact” parts in research of On-machine measurement system compared to CMM is illustrated in Fig. 2. In the same way, it is also possible to present details for other stages of experiments, e. g. for primitive surfaces machined and measured on the same milling centre on which On-machine measurement system is developed, etc.

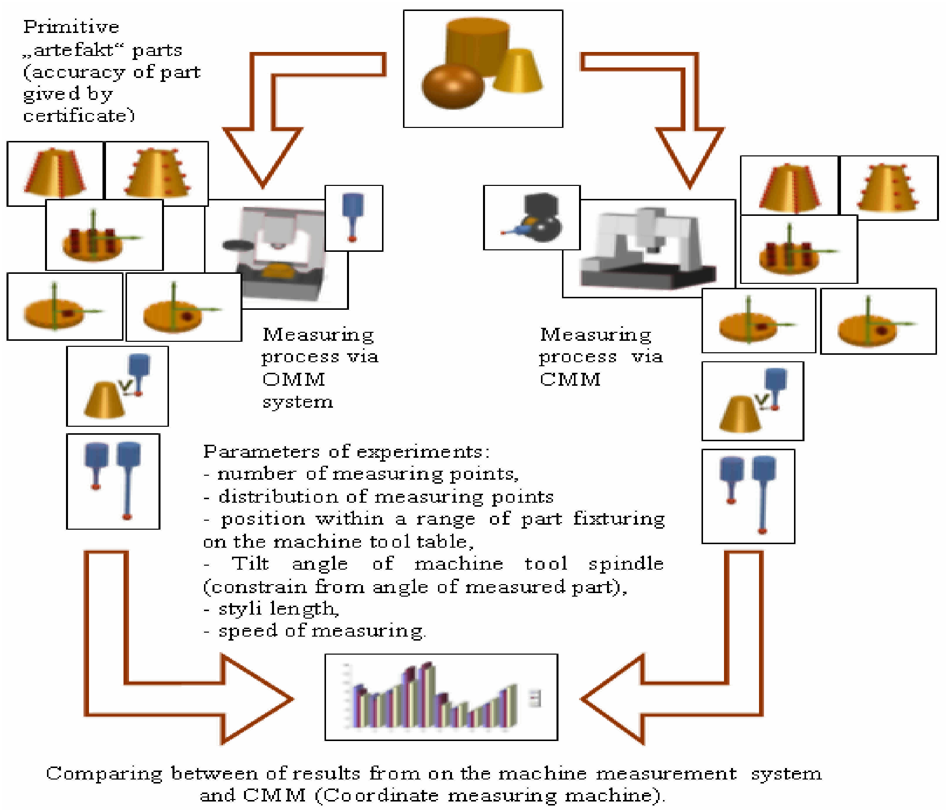


Fig. 2 *A detailed view of parameters of experiments with using "artefact" parts in research of On-machine measurement system compared to CMM (Coordinate measuring machine)*

Influence of partial factors of experiments

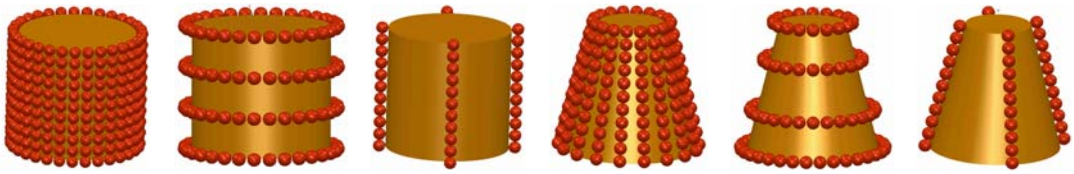
Since the result of measurement process depends on many factors, it is necessary to find their partial importance. As mentioned above, the interaction between partial factors also plays an important role. The influence of partial major factors within the research of a suitable selection of measuring parameters for On-machine measurement system can be described as follows:

Number of measuring points – Number of measuring points has been the research subject of many authors focused on CMM measurement. It is necessary, however, to observe the interaction and impact of numbers of measuring points on the authenticity of measurement result together with other parameters. The importance of measuring point number is the result of the shape and dimension variability of the machined part (example for cylinder - Fig. 3), which can be caused by many factors as well (e. g. tool deflection, etc.). Accuracy of measured dimensions and derivate deviation, e. g. roundness, etc., is due to this fact directly influenced by the measuring point number. Moreover, the substitute element determined is also influenced by itself.

a) ***b)*** ***c)*** ***d)*** ***e)*** ***f)***

Fig. 3 *Typical form deviation for cylinder, a) nominal surface, b) taper, c) bow, d) barrel, e) twisted, f) camber*

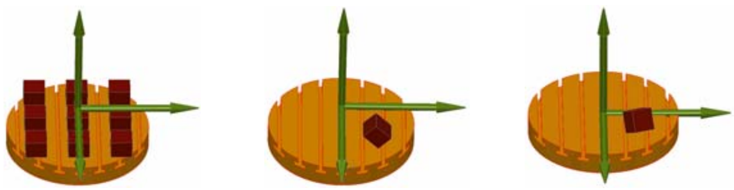
The distribution of measuring points based on different patterns of distribution – influence on the authenticity by the distribution of measuring points is caused by similar reasons as the number of measuring points. Some examples of measuring point distribution are in Fig. 4. In the same way, it is also possible to illustrate other primitive surfaces.



a) ***b)*** ***c)*** ***d)*** ***e)*** ***f)***

Fig. 4 *Examples of measuring point distribution based on different patterns of distribution for measured primitive surfaces, a) measured primitive surface – cylinder (full covering of surface), b) c) different pattern of measuring points onto surface for cylinder, d)) measured primitive surface – cone, e) f) different patterns of measuring points onto surface for cone*

Position and orientation within the range of parts fixing on-machine tool table – overall influence of factors on the measuring of accuracy caused by the change of orientation and by the movement of measuring system parts comprise influences of certain parts on which On-machine measured system is developed. The abovementioned influences are observed due to the change of position and orientation of the measured parts which is caused by the necessity of the change the orientation or position of the measuring probe to reach the measured part within optimum conditions (e. g. reach the measuring point without measuring probe collision, etc.). Different position and orientation within the range of parts fixing on-machine tool table is shown in Fig. 5.

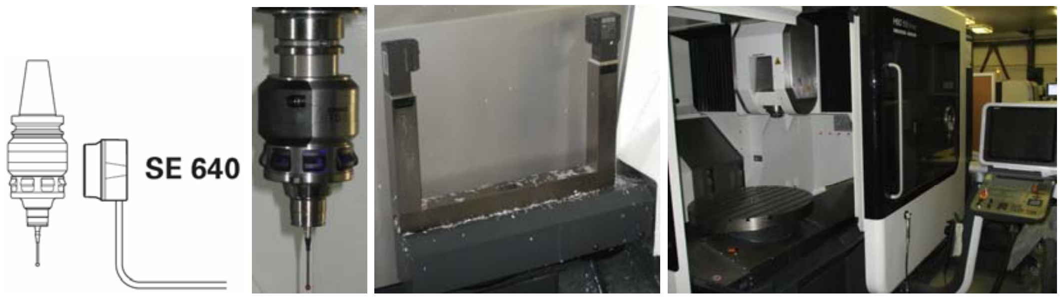


a) ***b)*** ***c)***

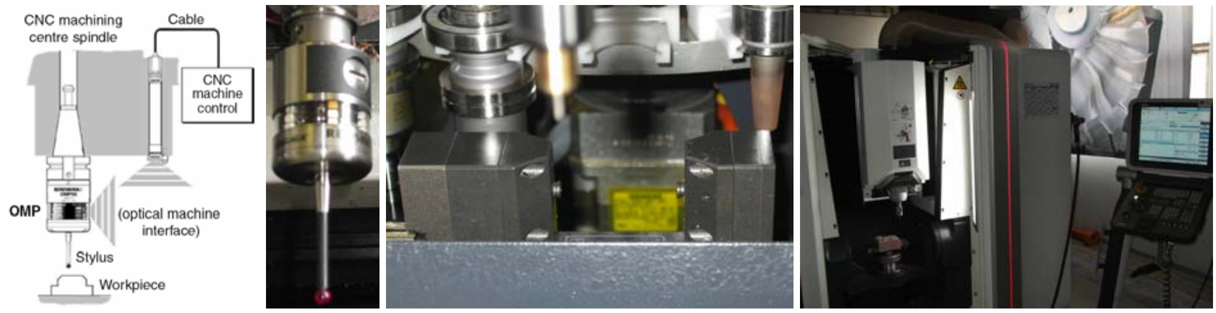
Fig. 5 *Different position and orientation within the range of parts fixing on the machine tool table, a) different position of measured part within fixing on machine tool table, b) measured part under selected angle which caused by the necessity of changing the orientation or position of the spindle with the measuring probe a c) measured part under two selected angles which cause the necessity of change orientation or position of the spindle with the measuring probe*

Instruments for research implementation

To carry out the experimental part of research, a brand new CNC milling centres which are located at the laboratory of the Department of Machining and Assembly will be used. This machine tool is a part of equipment which was implemented within the Centre of five-axis machining. Five-axis CNC milling centre HSC 105 linear from DMG (Fig. 6 d) is equipped with Heidenhain TS 649 touch probe (Fig. 6 b) and also with Blum tool measurement system (Fig. 6 c). Five-axis milling centre Ultrasonic 20 linear (Fig. 6 h) is equipped with Renishaw OMP 400 touch probe (Fig. 6 f) and also with Blum tool measurement system (Fig. 6 g). Both measuring probes use an infrared receiver for signal transmission. SE 640 (Fig. 6 a) is used for TS 649 probe which is HSC 105 linear equipped. OMM-C (Fig. 6 e) is used for Renishaw OMP 400 probe with Ultrasonic 20 linear. In order to carry out the measuring task requested by the experimental part of research, it is necessary to employ useful software which is planned to be obtained. Following are the examples of possible software which could be used: Productivity Active Editor Pro, Renishaw OMV or PowerInspect OMV. At present, it is possible to employ just measuring cycles by Heidenhain iTNC 530 and Simens 840D powerline controls.



a) ***b)*** ***c)*** ***d)***



e) ***f)*** ***g)*** ***h)***

Fig. 6 *Instruments for research: a) diagram of Heidenhain TS 649 probe and infrared receiver SE 640 (Heidenhain) [1], b) Heidenhain TS 649 touch probe, c) Blum tool laser measurement system d) HSC 105 linear at laboratory of the Department of Machining and Assembly, e) diagram of Renishaw OMP 400 probe and optical machine interface with receiver [2], f) Renishaw OMP 400 touch probe, g) Blum tool laser measurement system h) Ultrasonic 20 linear at the laboratory of the Department of Machining and Assembly*

Anticipated research results

Future research and experiments will be divided into few stages bringing complex information about On-machine measurement systems compared to CMM.

Following research and experiment results are expected:

- dependence of accuracy for On-machine measurement systems comparing with coordinate measuring machine,
- dependence of partial parameters of measurement in order to reach required accuracy and uncertainty of measurement,
- interaction between partial factors within research of partial factors and their impact on the accuracy and uncertainty of measurement,
- information about the possibilities of parameters optimization in order to reach required accuracy of measurement,
- information about the levels of measurement inaccuracy performed by using On-machine measurement systems compared to the measurement via the coordinate measuring machine (this will show deficiencies of the whole system developed by the machine tool and probe).

Completed Research Phase

The complex experimental artefact was made during the experiment preparation stage. As was mentioned in previous chapters of the article, the first stage of the complex planned experiment is focused on research experiments performed on parts of a primitive shape. The parts which have a primitive shape are represented by the part named "Artefact", which has both high dimensional and shape precision combined with low roughness of surface.

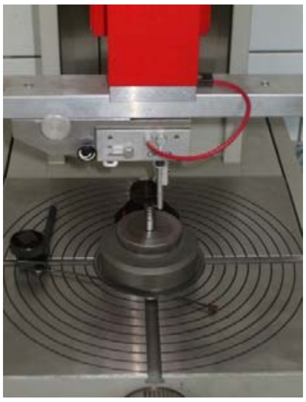
The complex experimental artefact (Fig. 7) was assembled from a partial artefact by using a resin metal binder from two agents. Extreme care was taken to ensure the precision and purity of the assembly process. Of course, this effort to get high precision of the angular orientation of the artefact is difficult to attain by hand only. This was ensured by special gauges and by the means of fixing the part.

Fig. 7 *Complex experimental artefact with high and known precision.*

Artefact calibration

The partial artefact with a primitive shape was calibrated in a Metrological laboratory with official accreditation. Every artefact has its own certificate of declared calibration. These measurements were executed with high precision laboratory gauges (Tab. 1). However, some of the measurements were performed in another metrological laboratory, e. g. the measuring on MK 300 (Fig. 8) and measurement on the DEA Global Performance coordinate measuring machine. All of these measurements provide information concerning precision, which is important for the partial steps of planned experiments.

The level of the artefact's precision is thus known from the calibration and measurement of the partial artefact.



a)

b)

c)

Fig. 8 *Measuring process of roundness deviation for partial artefact part performed on MK 300 roundness tester, a) view of measuring the roundness deviation of a cone, b) detailed view of measuring the roundness deviation of a cone, c) detailed view of measuring a sphere.*

USED GAUGE FOR CALIBRATION OF PARTIAL ARTEFACT — Table 1

Calibrated artefact	Cylinder1	Cylinder2	Sphere	Cone (small)	Ring with external cone	Ring with internal cone	Gauge block
Gauge							
ULM 600	X	X					
Zeiss OPTON ZMC 550	X	X		X	X	X	
MAHR-MESING-TB2							X
Mahr 828			X				
MK-300	X	X	X	X	X	X	
DEA Global Performance	X	X	X	X	X	X	X
Hommel Tester T1000 C	X	X	*	X	X	X	X

* Note: Roughness of artefact surface is lower (mirror sparkling) than Ra < 0.00 [μm] i. e. than the sensitivity of the roughness tester.

Note: Length measuring instrument UML 600, coordinate measuring machine Zeiss OPTON ZMC 550, measuring gauge MAHR-MESING-TB2, length measuring instrument Mahr 828, roundness tester MK 300, coordinate measuring machine DEA Global Performance, roughness tester Hommel Tester T1000 C.

Complex artefact calibration

Even though the assembly process was performed with the highest care in order to ensure a precise axis, the plane orientation of the artefact part, it was necessary to obtain the value of the angular deviation from the base. In order to obtain the aforementioned angular value measurement, the coordinate machine DEA Global Performance was employed (Fig. 9).

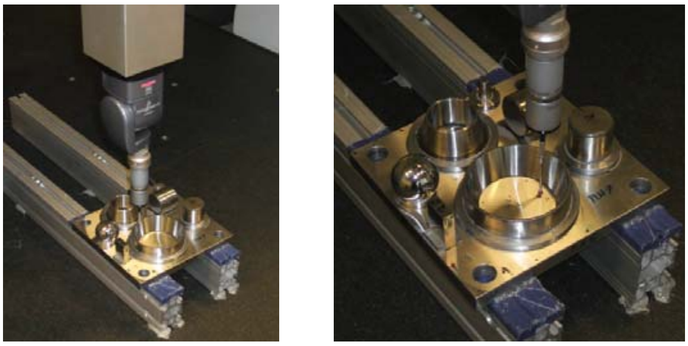
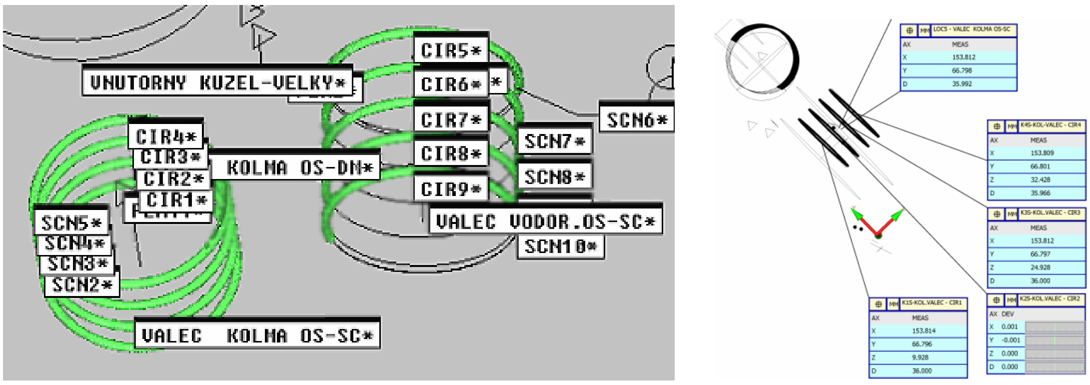


Fig. 9 *Calibration of artefact's orientation and position on experimental base*

Short summary of results

Firstly, the diameter of the cylinders was compared. Both cylinders were calibrated by high precision length measuring instrument ULM 600 with uncertainty of measurement U 0.7 [µm], k=2. Measurements performed on the coordinate measuring machine were performed in scanning mode with the scanning measuring probe Renishaw SP25M with measuring head TesaStar – M. Measurement of the diameter was performed in both cases in the same cross-sections at the same Z high level. Part of the screen from the measurement of the cylinders' diameter is shown in Fig. 10 a, and a view of the passport with some results is shown in Fig. 10 b. The results show the differences between the high precision measurement performed on UML 600 and the results from measurement via the coordinate measuring machine. Note that the comparisons were made only on two measuring paths since artefact cylinder No. 1 has only three measured sections via UML 600 and one of those is hidden by the fixing part. The results from comparison of measured diameters on cylinder No. 1 are in Fig. 11. The results from comparison of measured diameters on cylinder no. 2 are in Fig. 12. In the case of the cylinders' measurement two different Best fit methods were used by PC-DMIS software. The former was the Least square method and second was the Minimum circumscribed method.



a) ***b)***

Fig. 10 *Measuring process of cylinders, a) view of part of screen with measured cylinders in PC-DMIS software, b) view of passport involving the measuring of the cylinder's diameter*

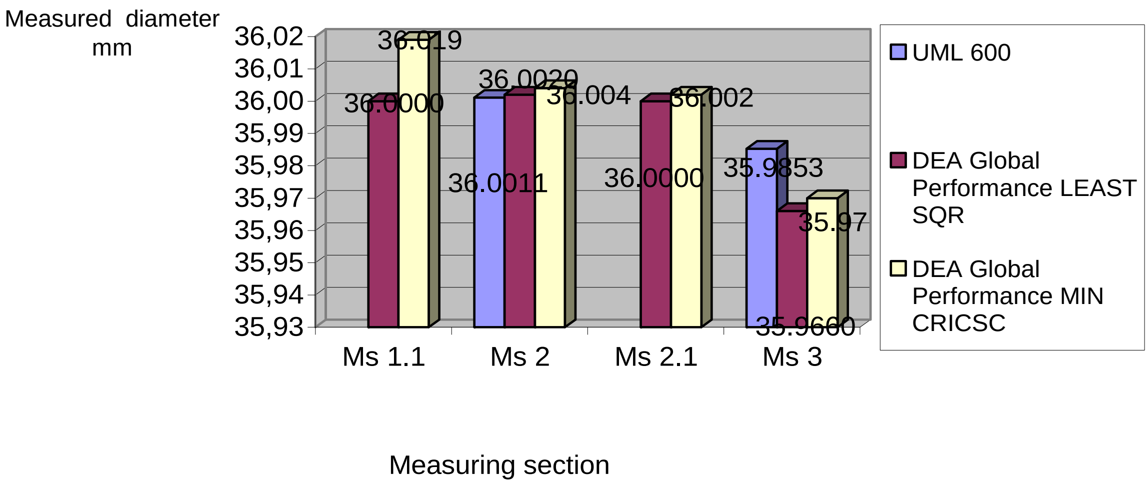


Fig. 11 *Results from comparison of measured diameters on cylinder No. 1 between the values from UML 600 and CMM DEA Global Performance*

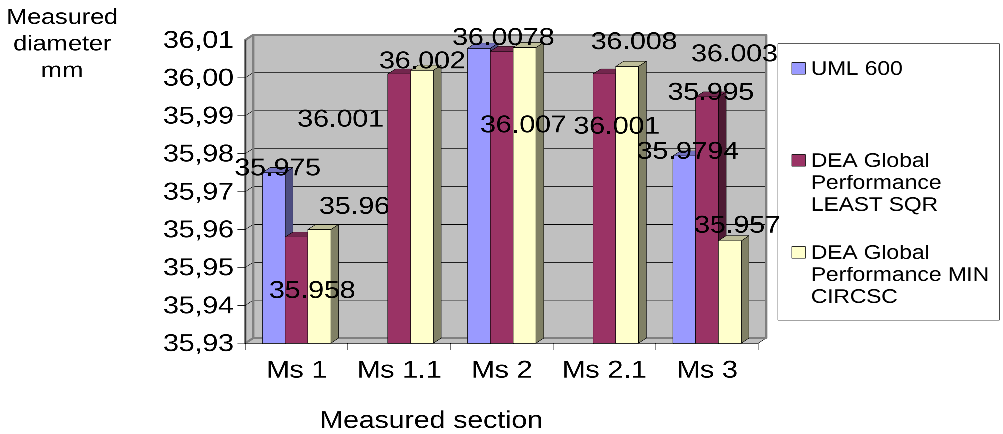


Fig. 12 *Results from comparison of measured diameters on cylinder no. 2 between the values from UML 600 and CMM DEA Global Performance*

As evident from Fig. 11 and Fig. 12, in both cylinders, the most valid value of diameter is that from the measured section 2, where the lowest roundness deviation is. The values from measured section 1 and measured section 3 are in some way also influenced by roundness deviation. In measuring sections 1 and 3, where there is a slightly greater deviation of form (roundness deviation in this case), and the impact of "Best fit method" on the measured value of the diameter is increased.

Future stage of research

Excluding the above mentioned experiments from CMM measurement, the next stages of research experiments are currently at a high degree of completion. The next phase of research consists of measuring the Complex experimental artefact performed via an On-machine measurement system with touch probe, according to the planned list of research experiments.

Conclusion

This paper was written in order to present the planned as well as completed research activities focused on On-machine measurement systems and their properties. Recent trends in mechanical parts quality control focused on On-machine measurement have produced new questions that have not yet been solved completely for this system. In order to investigate the above mentioned problems, we suggested further research and partial experiments. In the final part of this article, the initial results from the first phase of the research experiments are being discussed.

This paper was elaborated within the **VEGA 1/0250/11** project "Investigation of dynamic characteristics of the cutting process in 5-axis milling in condition of Centre of 5-axis machining".

References:

[1] Touch probe for Machine Tools, Heidenhain, Germany 2008, 64 p. [on-line], [4-12-2009] http://www.heidenhain.com/fileadmin/pdb/media/img/208_951-28.pdf.

[2] Probing systems for CNC machine tools, Renishaw, Uk 2007, 72 p. [on-line], [15-5-2010] http://resources.renishaw.com/download/(b1264b950ce44583bab73d6b965f7616)?lang=en&inline=true.

Reviewers:

Zdenko Lipa, Professor, Ph.D. - Institute of Production Technologies, Department of Machining and Assembly, Faculty of Materials Science and Technology in Trnava, Slovak University of Technology in Bratislava

Augustín Görög, Assoc. Professor, Ph.D. - Institute of Production Technologies, Department of Machining and Assembly, Faculty of Materials Science and Technology in Trnava, Slovak University of Technology in Bratislava

Rastislav Vojtek, Ph.D. - KONTROLTECH, s.r.o. Dubnica nad Váhom

RESEARCH PAPERS
FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA
SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

2011 Number 30

APPLICATION OF SIX SIGMA METHOD TO EMS DESIGN

Miroslav RUSKO[1], Ružena KRÁLIKOVÁ[2]

Abstract

The Six Sigma method is a complex and flexible system of achieving, maintaining and maximizing the business success. Six Sigma is based mainly on understanding the customer needs and expectation, disciplined use of facts and statistics analysis, and responsible approach to managing, improving and establishing new business, manufacturing and service processes.

Key words

management, LCA, SixSigma, quality, environment

Introduction

Globalization and instant access to information, products and services keep changing the way of customers' behaviour. Current policy changes in the economy and society should be carried out in accordance with the principles of sustainable development and environmental protection. Therefore, our country introduces a series of voluntary environmental tools and methods such as environmental audits, Environmental Management Systems (EMS according to ISO 14 001), environmental assessment and labeling of products, Life Cycle Assessment (LCA), ecological profile of the product etc. With their introduction, the organizations create the way for a balanced and integrated approach in terms of economic, quality, environmental and security interests. One of the major tools used in practice especially abroad, is Six Sigma, whose implementation has been gradually promoted in business also in Slovakia.

[1] Miroslav Rusko, Ph.D. - Institute of Safety and Environmental Engineering, Faculty of Materials Science and Technology, Slovak University of Technology in Bratislava, Botanická 49, SK-917 24 Trnava, Slovak Republic, e-mail: >miroslav.rusko@stuba.sk<
[2] Ružena Králiková, Assoc. Professor, Ph.D. - Department of Environmental studies and information engineering, Faculty of Mechanical Engineering, Technical University in Košice, Park Komenského č.5, SK-041 87 Košice, Slovak Republic, e-mail

Concepts of Six Sigma

The word “Sigma” is a statistical term that measures how far a given process deviates from perfection as a new methodology using old tools. Six Sigma is a comprehensive system for achieving, maintaining and maximizing business success. The basis of Six Sigma is a detailed knowledge of customer requirements, disciplined use of facts and objective data, statistical analysis and ongoing efforts focused on optimizing business processes. Six Sigma revolves around a few key concepts:

- Critical to Quality: Attributes most important to the customer;
- Defect: Failing to deliver what the customer wants;
- Process Capability: What your process can deliver;
- Variation: What the customer sees and feels;
- Stable Operations: Ensuring consistent, predic-table processes to improve what the customer sees and feels;
- Design for Six Sigma: Designing to meet customer needs and process capability.

Philosophy and methodology of improvement by Six Sigma method

It is said, that philosophy and methodology of Six Sigma improvement is a revolution in increasing the efficiency of organizations. In recent years, it has become popular not only with specialists in the field of process improvement, but has become also common on the boards of directors and senior management of the world’s largest industrial companies, as well as in programs improving services in banks and hospitals. It has much in common with its predecessors, while there is a new approach in the organization and standardization process improvement projects and measuring their benefits. Six Sigma is a method of improving productivity, efficiency and quality of products and services. Based on perfect understanding of the requirements and expectations of customers, it is a proven tool to eliminate errors in processes leading to customer satisfaction. Six Sigma is implemented through its own employees. The involved employees represent the most important capacity of improvements. Focusing on customers, processes and staff makes Six Sigma a way of building and developing a new corporate culture. The method Six Sigma is a high technological method used by engineers and statisticians to fine-tune products and processes. But that is just a part of the truth. Six Sigma presents a measurement and statistics as an essential part of improving. It aims at nearly complete coverage of all customer expectations. The term Six Sigma is derived from the mode of a control process, which shows less than 3.4 defects per million opportunities.

Six Sigma is mainly based on understanding the customer needs and expectations, using the facts, data and statistical analysis and a thorough approach to managing, improving and creating new business, production and service processes. Six Sigma in particular focuses on:

- Method of measuring quality, which allows you to compare different processes according to the achieved level SIGMA – variability of process 6];
- Project-oriented methodology for solving problems using statistical tools;
- The quality improvement system, aimed at reducing errors and maintaining them at a low value, "Six sigma", meaning DPMO (DPMO = Defects per Million Opportunities);

- Philosophy and managerial strategy oriented on customer satisfaction and making decisions based on verified data.

Chosen Six Sigma methods

Six Sigma is based on six basic principles that help with launching the initiative implementation of Six Sigma method to production companies or service industries. Sigma uses the base tools to improve the quality of products and processes as MSA (Measurement System Analysis), IPO Diagram (Input-process-output), CE (Cause-and-effect diagram), Histogram, Pareto diagram, DMAIC (Define, Measure, Analyze, Improve, Control) , Run chart, Control chart, Scatter diagram, Regression Analysis, DOE (Desing of Experiments), FMEA (Failure Mode and effect analysis), SOP (Standard Operating Procedure) and QFD (Quality Function Deployment).

Measurement System Analysis

Diffusion of the watched commodities' parameter can be connected by the commodity itself (deformation, ovality) or the system of measuring. The system of measuring is made by operator, benchmark and the method (the way) of measuring. Measuring System Analysis (MSA) is a tool for the evaluation of accuracy and advisability of the measuring system. It goes with testing (measuring) the chosen parameter by an operator or a group of operators. It monitors the influence of repeatance (one operator copies the measuring of the watched commodity's parameter) and reproducibility (group of operators measures the very same parameter) of the total variance. The goal of MSA is to estimate how the system of measuring contributes to the total variance of watched parameter, Fig.1 [6]. Most of the time, analysis of the measurement system is used in the phase of Measurements.

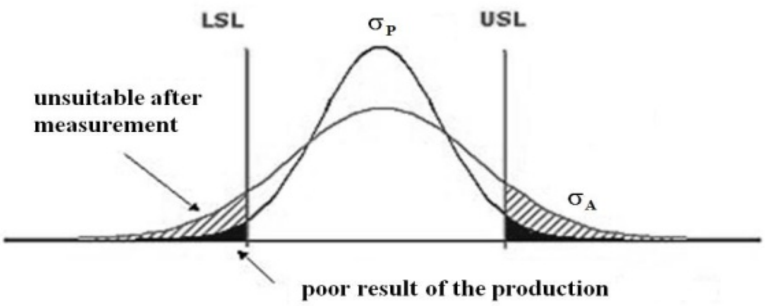


Fig. 1 *Measurement System Analysis*

Legend: *Tolerance = USL – LSL (area of matching values for the customer), LSL - Lower Specification Limit,USL - Upper Specification Limit,* $\sigma^2{}_A$ *(absolute) =* $\sigma^2{}_P$ *(of product) +* $\sigma^2{}_M$ *(of measurement system),*σ^2 *– variance*

Analysis of the causes and consequences

CE (Cause-and-effect diagram) is a tool to solve problems through finding the cause of their occurence. It helps to find all possible causes, to split causes into cathegories and organize their relationships and impact on output, and to identify opportunities for improvement. In general, these categories are commonly known as 7M causes:

- Man -people, job;
- Methods and mechanics, process;
- Machine – machines, eguipment;
- Measurement;
- Management - system of organisation and management;
- Material;
- Mother Nature - environment.

A more detailed analysis of each factor gives a diagram that resembles a fish bone as seen in Figure 2.

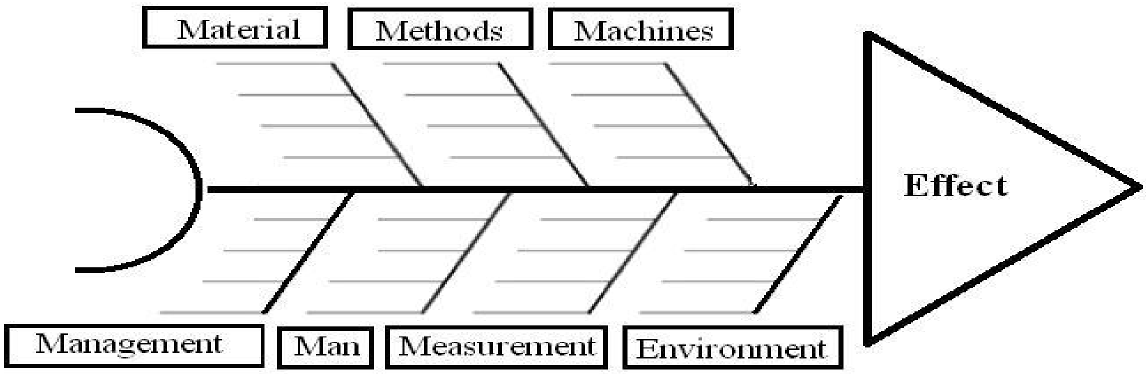


Fig. 2 *Fish bone 7M diagram*

Histogram

Histogram is a perfect tool for visualization of the frequency of the wathced phenomenon in process. It is a bar chart made from number of categories, showing their splitting. Customer tolerance can be added (LSL, USL) to watched process.

Pareto Diagram

Pareto diagram is a bar chart for discrete data, indicating the frequency of non digital data. These categories are arranged in descending order. The tool that allows determining the impact of input factors to an endpoint.

DMAIC

It is the common option for the model of improving the process based on Deming's circle PDCA (Plan-Do-Check-Act). DMAIC (Define-Measure-Analyze-Implement-Control) is in the Six Sigma metodology being used as the standart routine for planning and implementation of the project. The abetment for Six Sigma projects is displayed in Figure 3.

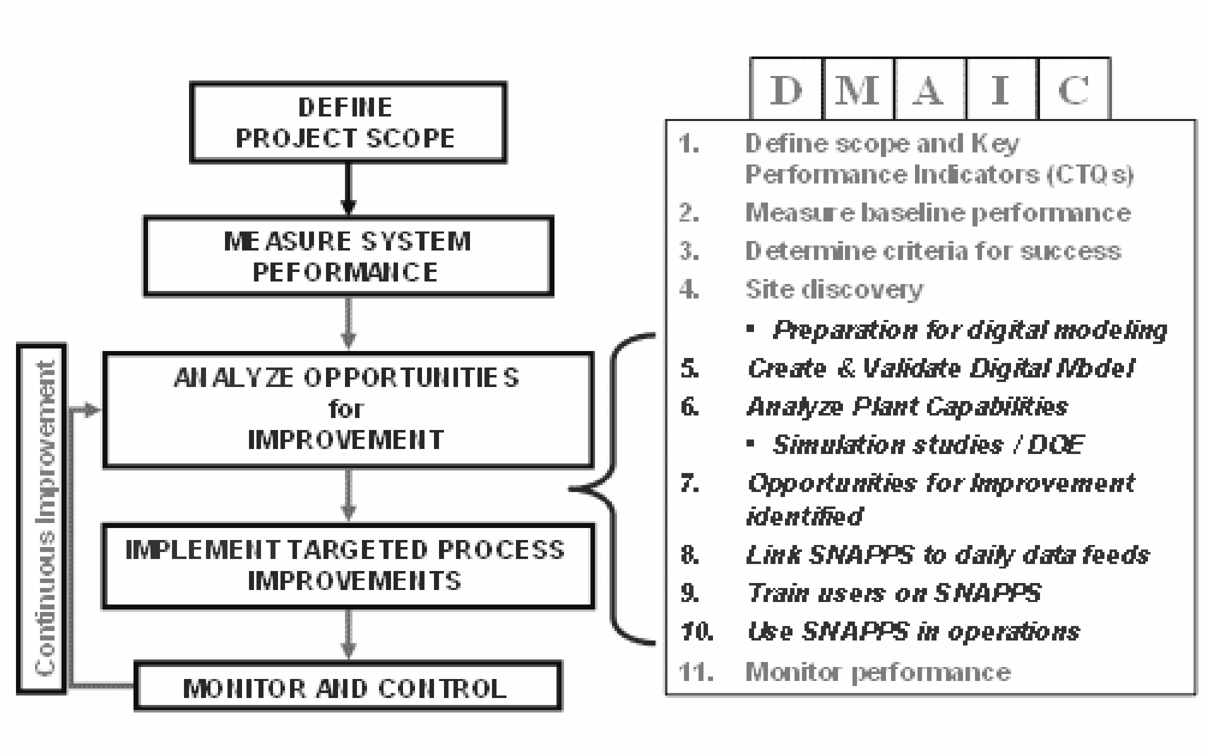


Fig. 3 *The ab-etment for Six Sigma projects*

Implications for Environmental Management

The Six Sigma method could be applied to EMS design because it has been successfully implemented in many large corporations in order to improve the quality of products and business processes. The company noted that while Lean Six Sigma projects focused on improving the operational efficiency and product field, direct reductions in energy use, air emissions, waste reduction, greenhouse gas emissions, and other environmental impacts also coincided. The implication of environmental performance lines to reduction of the overall environmental impacts [4].

Potential benefits: By eliminating variation, production processes are less-defect. A reduction in defects can, in turn, help eliminate waste from processes in three fundamental ways:

- fewer defects decrease the number of products that must be scrapped;
- fewer defects also mean that the raw materials, energy, and resulting waste associated with the scrap are eliminated;
- fewer defects decrease the amount of energy, raw material, and wastes that are used or generated to fix defective products that can be re-worked.

Six Sigma is the tool which helps focus attention on reducing conditions that can result in accidents, spills, equipment malfunctions, reduce the solid and hazardous wastes (e.g., contaminated rags and adsorbent pads) resulting from spills and leaks, and their clean-up. This method is focused on product durability and reliability, and increase of the life cycle of products.

Potential disadvantagies: Lack of technical capacity to effectively utilization of Six Sigma tools can potentially decrease the effectiveness of the strategy, and/or result in unexpected waste if incorrectly applied.

Conclusion

The fundamental idea of Six Sigma is that if performance is improved, quality, capacity, cycle time, inventory levels, and other key factors as reduction waste, energy sources and environment will also improve. Thus, when these factors are improved, both the provider and the customer experience greater satisfaction in performing business transactions.

One of the major tools used in practice especially abroad is Six Sigma, whose implementation has been gradually promoted in business also in Slovakia.

The paper is a result of the research within the frame of ***National grant No 3/7422/09 Creating the research conditions for preparation of a modern university textbook***.

References:

[1] SAMUELSON, P.A., NORDHAUS, W. D. *Economy*. Bratislava: 2000, 822 p., 339 p. ISBN 80-8044-059-X

[2] SAUER, P., LIVINGSTON, M. *Environmental economy and ecology police*, Prague: 1996, 203 p. ISBN 80-902168-0-3

[3] KOZÁKOVÁ, Ľ., ZELEŇÁK, F. : *Wastes and their disposal.* Košice: WILLCOM, 2007. 125 p. ISBN 978-80-8073-849-5

[4] KRÁLIKOVÁ, R., PAULÍKOVÁ, A. Modelling and diagnosing of mechanical engineering life cycle production process. In *Chemické listy*, 2008, Vol. 102. ISSN 0009-2770

[5] The RIGHT source for Six Sigma learning and application. [on-line] Available on - URL: >http://benchmark.groupsite.com/discussion< [cit.: 2011-01-19]

[6] Efektívny prístup k zlepšovaniu procesov. FBE Bratislava. [on-line] Available on - URL: > http://www.sixsigma.sk/< [cit.: 2011-01-23]

[7] Six Sigma Training from the Source [on-line] Available on - URL: >http://www.pyzdek.com/ < [cit.: 2011-01-09]

[8] SixSigma opportunity for your organization. [on-line] Available on - URL: >http://www. adamssixsigma.com/< [cit.: 2010-12-16]

Reviewers:

Milan Piatrik, Professor, Ph.D. - Faculty of Natural Sciences, Matej Bel University, Tajovského 40, SK-974 01 Banská Bystrica, Slovak Republic

Ivana Tureková, Assoc. Professor, Ph.D. - Institute of Safety and Environmental Engineering, Faculty of Materials Science and Technology, Slovak University of Technology in Bratislava, Botanická 49, SK-917 24 Trnava, Slovak Republic

RESEARCH PAPERS
FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA
SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

2011 Number 30

DETERMINING THE TOTAL DISPERSION ZONE FOR MICROMETER S_M MEASURING EQUIPMENT

Katarína LESTYÁNSZKA ŠKŮRKOVÁ, Jozefína KUDIČOVÁ

Abstract

The aim of the total dispersion zone for measuring equipment S_M is to define if three workers A, B, C can achieve the same values of measurement using the same measuring equipment. Before estimating the total dispersion zone for measuring equipment $S_{M.}$ the calibration of the micrometer was carried out. The values were obtained by measuring the width of clip anchor. It is necessary to calculate the average values $\overline{X}_A, \overline{X}_B, \overline{X}_C$ and to calculate standard deviations $s_{\Delta A}, s_{\Delta B}, s_{\Delta C}$ for three workers. Finally, the total dispersion zone S_M will be calculated and the results will be interpreted.

Key words

measuring equipment, average value, standard deviation, dispersion zone

Introduction

Requirements for quality have been lately widened to such a degree where they become a significant factor in company management. To manufacture some quality products, it is necessary to detect not just the capability of processes or the production facilities but also the capability of the measuring equipment.

The aim was to prove the capability of a micrometer and to meet the given requirement for the measuring system of the pressing process.

The capability of measuring equipment predicates of the operational capability of measuring tools and considers also the influence of the operators and the place of use [1].

Katarína Lestyánszka Škůrková, Ph.D., Jozefína Kudičová, Bc. - Institute of Industrial Engineering, Management and Quality, Faculty of Materials Science and Technology, Slovak University of Technology in Bratislava, Paulínska 16, 917 24 Trnava, Slovak Republic, e-mail: katarina.skurkova@stuba.sk, jozefina.kudicova@azet.sk

The functionality of measuring tools is expressed by indexes C_{gm} and C_{gmk}

- Index C_{gm} is the ratio 0.2 x sign tolerance T to six times of standard deviation repeated measurements s_w.,
- Index C_{gmk} is the ratio 0.1 x sign tolerance T to three times of standard deviation s_w , taking into account the position $\overline{X}_a$ measured by the tools.

Implementation:

The examination of measuring tools has to be done on the assumed place of use. Before the examination, it is necessary to calibrate the measuring tools. Normally the measurement has to be performed in the same place and the same position. At least 25 repeated measurements have to be done; the values are recorded in a form.

Defining the total dispersion of measuring tools S_M

Procedure:

Before the examination, the operator has to calibrate the measuring tools. Ten serial manufactured products, which have to be numbered, and measured twice, in the same order and place like before, have to be used. The measurement will be done by the operator A; 10 equivalent products will be measured by operators B and C. Values are recorded in the form. The differences between lines 1 and 2 will be calculated.

Materials and methods

As requested by MEVIS Slovakia s.r.o., Insize micrometer was used for total dispersion zone of measuring equipment $S_{M,}$. The monitored feature – the width of the clip anchor with dimensions 7.5 ± 0.2 mm – was measured using this measurement tool. Three workers conducted the measurements, each of them measured 10 products, while the measurement was conducted twice.

Identification of measuring tool: Micrometer INSIZE 3104-80
Range of measuring tool: 50 - 80 mm
Product name: LEGRAND
Measured feature: width of handles
Feature value: 7.500 mm
Tolerance: USL = 7.700 mm
LSL = 7.300 mm
Real value: Xr = 7.500 mm
Operating staff: 3 workers
The amount of measured products: 10.

Before starting the examination of total scatter S_M it is necessary to prove the capability using the index $C_{gmk,}$ the value of which has to be $C_{gmk} \geq 1.33$ [3]. If the index $C_{gmk} <1.33$; afterwards will be proposed corrective measures, which will eliminate the cause of the detected non-compliance or other unwanted situations (changes in the surrounding temperature, adjust production equipment, collection of products, used material, human factor…).

$$C_{gm} = \frac{0.2.T}{6.s_w} \tag{1}$$

C_{gmk} = lower value from

$$C_{gmk} = \frac{(X_r + 0.1.T) - \overline{X}_a}{3.s_w} \tag{2}$$

or

$$C_{gmk} = \frac{\overline{X}_a - (X_r - 0.1.T)}{3.s_w} \ , \tag{3}$$

where: s_W - standard deviation,

$\overline{X}_a$ - average value,

X_r - conventional true value,

T - sign tolerance.

Evaluation according to the methods s

Average values $\overline{X}_A, \overline{X}_B, \overline{X}_C$ and standard anomalies $s_{\Delta A}, s_{\Delta B}, s_{\Delta C}$ for each operator will be calculated.

Total scatter area S_M will be calculated as follows:

- average standard deviation of the measuring device

$$\overline{s}_\Delta = (s_{\Delta A} + s_{\Delta B} + s_{\Delta C}).\left(\frac{1}{3}\right) , \tag{4}$$

$$\overline{s} = \frac{\overline{s}_\Delta}{\sqrt{2}} \ , \tag{5}$$

- standard deviation s_v caused by the operators and calculated from of three average values $\overline{X}_A, \overline{X}_B, \overline{X}_C$
- total scatter zone of the measuring device S_M:

$$S_M = \sqrt[6]{\overline{s}^2 + s_v^{\ 2}} \ , \tag{6}$$

$$S_M\,\% = \frac{S_M}{T}.100 \ , \tag{7}$$

where: T – sign tolerance.

We regard S_M% as follows:

S_M% = 0 to 20 % good.
S_M% = 21 to 30 % limited usable.
S_M% = more than 30 % unacceptable [2].

EVALUATION OF THE TOTAL DISPERSION ZONE S_M (according to method s)

Table 1

MEVIS SLOVAKIA, s.r.o.	**Form for evaluation of total dispersion zone S_M (according to method *s*)**		**Method 2** **Level Nr: 1/1**
Nr. of facility M 13458	Measuring equipment MICROMETER INSIZE 3104-80	Year of production	

Data about product	**Data about normal line**	**Data about product**
Name: Legrand	Name: standard	Cgm: 1.93
Sign: width of clip anchor	Nr: 15	Cgmk: 1.87
Real value: 7.500 mm	Real value: Xr = 7.500	Prepared: Kudičová
USL = 7.700 LSL = 7.300		Date: 20.02.2011

Measurement conditions:

Measuring data : **Measure**: mm **Value deviation**:

Worker	**A**			**B**			**C**		
Product	Line 1	Line 2	(1-2)	Line 1	Line 2	(1-2)	Line 1	Line 2	(1-2)
1	7.499	7.498	0.001	7.499	7.501	0.002	7.500	7.499	0.001
2	7.497	7.498	0.001	7.499	7.500	0.001	7.499	7.499	0.000
3	7.501	7.499	0.002	7.498	7.498	0.000	7.497	7.498	0.001
4	7.498	7.498	0.000	7.500	7.500	0.000	7.499	7.499	0.000
5	7.496	7.497	0.001	7.501	7.500	0.001	7.501	7.500	0.001
6	7.498	7.499	0.001	7.501	7.500	0.001	7.500	7.501	0.001
7	7.500	7.501	0.001	7.497	7.499	0.002	7.498	7.499	0.001
8	7.500	7.500	0.000	7.497	7.498	0.001	7.499	7.498	0.001
9	7.502	7.499	0.003	7.499	7.499	0.000	7.498	7.497	0.001
10	7.502	7.501	0.001	7.500	7.501	0.001	7.498	7.498	0.000

$s_{\Delta A}$ = 0.000831 $s_{\Delta B}$ = 0,0007 $s_{\Delta C}$ = 0.000458

$\overline{X}_A$ = 0.0011 $\overline{X}_B$ = 0.0009 $\overline{X}_C$ = 0.0007

1. Average standard deviation of measuring equipment $\overline{s}$:

Average standard deviation of difference Measure: mm

$$\overline{s}_\Delta = (s_{\Delta A} + s_{\Delta B} + s_{\Delta C}).(1/3) = 0.000662973$$

$$\overline{s} = \overline{s}_\Delta / \sqrt{2} = 0.000468793$$

2. Standard deviation s_v of average values $\overline{X}_A$, $\overline{X}_B$, $\overline{X}_C$ (handling effect)

s_v = 0.0001632993

3. Total dispersion zone of measuring equipment S_M

$$S_M = 6.\sqrt{\overline{s}^2 + \overline{s}_v^2} = 0.079180207$$

S_M % = (S_M /T).100 = **19.79 %**

4. Results	**S_M 0 – 20 %** **(good)**	21 – 30 % (delimited)	> 30 % (deficient)

Remark: Date: 20.02.2011 Department: Q Name: Kudičová

Results and discussion

The first worker performed two consecutive measurements of one screw and then measured other nine products in the same way. Other two workers measured the same ten pressings in the same way as the first worker.

Revised screws were numbered and each worker carried out the measurements in the same order and the same place in the production hall. Measured data ($s_{\Delta A}$, $s_{\Delta B}$, $s_{\Delta C}$) were recorded in Table 1 for evaluation of the total dispersion zone of the measuring equipment S_M. Twenty values were measured for each worker. From these values were calculated: medium values $\overline{X}_A = 0.0011\ mm$, $\overline{X}_B = 0.0009\ mm$, $\overline{X}_C = 0.0007\ mm$ and further standard deviations for each worker $s_{\Delta A} = 0.000831\ mm$, $s_{\Delta B} = 0.0007\ mm$, $s_{\Delta C} = 0.000458\ mm$. Basically were calculated average medium standard deviations $\bar{s} = 0.000468793\ mm$ and handling effect deviation $s_v = 0.0001632993\ mm$. Finally, the total dispersion zone for micrometer $S_M = 19.79\ \%$ was calculated. If this value was in the zone from 0 to 20 %, the measuring equipment was qualified as good. All measured data as well as the calculated values are shown in the form for the evaluation of the total dispersion zone S_M in the Table of the total dispersion zone S_M (Table 1).

Summary

Determining the total dispersion zone for measuring equipment S_M according to the method *s* proved that the measuring equipment can be qualified as good because the value was in the zone from 0 to 20 %. (S_M = 19.79 %).

Similarly, the values of capability indexes C_{gm} = 1.93 and C_{gmk} = 1.87 proved that the measuring equipment, a micrometer, is capable. Based on these data, we can calculate their capability indexes and evaluate the process capability. This information signals the organisation a necessity of quality improvement, and simultaneously provides an evidence for a customer about the stability of production conditions.

References:

[1] HRUBEC, J., VIRČÍKOVÁ, E. *Integrovaný manažérsky systém*. Nitra: SPU, 2009. 543 s. ISBN 978-80-552-0231-0

[2] LESTYÁNSZKA ŠKŮRKOVÁ, K. Determining of the total dispersion zone for measuring equipment - profiloprojector Sm. Chapter 3. In *Toyotarity. Structure of control elements importance.* Dnipropetrovsk: Publisher Yurii V. Makovetsky, 2010, pp. 40-47. ISBN 978-966-1507-40-0

[3] STĘPIEŃ, K., BORKOWSKI, S., ULEWICZ, R. Chapter 9. *R&R Repeatability and Reproducibility Analysis with Use of Average and Range Method in Measurement of Electrolytic Coatings Thickness*, W: *Quality of Materials and Products*, Ed. and scientific elaboration Stanisław Borkowski, Peter Palcek. Saint-Petersburg: Wyd. Publishing and Press Association of Universities Russia, 2008, pp. 59 – 64.

Reviewers:

Maroš Korenko, Assoc. Professor, Ph.D. – Faculty of Engineering, Slovak University of Agriculture in Nitra

Helena Vidová, Assoc. Professor, Ph.D. – Institute of Industrial Engineering, Management and Quality, Faculty of Materials Science and Technology in Trnava, Slovak University of Technology Bratislava

RESEARCH PAPERS
FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA
SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

2011 Number 30

THE PROCESS CAPABILITY STUDY OF PRESSING PROCESS FOR FORCE CLOSED

Katarína LESTYÁNSZKA ŠKŮRKOVÁ, Jozefína KUDIČOVÁ

Abstract

Objective of the statistical assessment process is to determine whether all major manageable causes of instability of the process have been removed. The basis for statistical regulation is management of production processes. If a process operates a large number of random effects, the resulting distribution has the character of a normal distribution. Processes are considered as eligible if the indexes Cp and Cpk are greater than 1.33.

Key words

process, stability, normality, capability

Introduction

Objective of the statistical assessment process is to determine whether all major manageable causes of instability of the process have been removed. It is necessary, that average value of observed reference of quality and its variability have been constant over time. It can be managed through control charts and forms in the preparatory stage of statistical control.

The basis for statistical regulation is management of production processes. Production process is considered to be managed when only accidental impacts are active. If a process operates a large number of random effects, the resulting distribution has the character of a normal distribution. (3)

Currently, the process capability is assessed by the indicators of process capability Cp (characterizes the scattering process) and Cpk (characterizing the position of the tolerance field process). Processes are considered as eligible if the indexes Cp and Cpk are greater than 1.33.

Katarína Lestyánszka Škůrková, Ph.D., Jozefína Kudičová, Bc. - Institute of Industrial Engineering, Management and Quality, Faculty of Materials Science and Technology, Slovak University of Technology in Bratislava, Paulínska 16, 917 24 Trnava, Slovak Republic, e-mail: katarina.skurkova@stuba.sk, jozefina.kudicova@azet.sk

Input data which should be necessary to known prior to the survey process capability are:
- manufacturing conditions of mass production,
- capable measuring equipment,
- capable manufacturing facility
- statistically managed process,
- assess normality,
- technical and other specifications accurately reflecting the requirements of the customer,
- nominal value of the proposal is in the middle of the tolerance field.

By using this method, it is important that information and knowledge from previous observations of the process are considered and applied.

Materials and methods

Description of the pressing process

Operating step: pressing cross valve type B on the injection press
Mark*:* force required to close the valve
Rating value: 25±10 N
Lower Specification limit (LSL): *15 N*
Upper Specification limit (USL): *35 N*
Check centre: universal material tester Loyd Instruments LF*PLUS* 1455 with precision 0.5%
Production device: *injection press DEMANG*
Volume of subgroup: *N = 125 pressings*
Measure of subgroup: *n = 5 pressings*
Interval of taking: *every 60 minutes*
Number of subgroups: *k = 25*

Criteria for valuation of competence indicators are Cp and Cpk.

In terms of product specification, the force necessary to close the valve the range of 25 ± 10 N is considered a critical sign. The force necessary to close the valve is measured using a digital tester with an accuracy of ± 0.5% and proven capability of measuring equipment. In regulating the process, we will use Shewhart's control chart for average and range ($\overline{X}$, R). In the process of molding/ pressing is used injection molding/pressing equipment facility Sumitomo DEMANG.

Calculation of specification limits

Regulation charts work with the data from the manufacturing processes at approximately regular intervals (in hours or quantities). Each subgroup consists of the same product or service. Each subgroup obtains one or more characteristics of the subgroup.The Shewhart's control chart is a graph of values of the characteristics of the subgroups compared to subgroup number. It consists of a central line (CL) located in the reference value of visualization features. In evaluating whether the manufacturing processes are or are not in statistically managed state, the reference value is usually considered the average value. Control chart has two statistically established regulation limits, one on each side of the central line, called the upper regulation limit (UCL) and lower regulation limit (LCL). They are at the distance of 3σ on each side of the central line, where σ is standard deviation of the monitored statistics for the file [1].

Average range in subgroups

$$\overline{X_i} = \frac{1}{n}\sum_{j=1}^{n} X_{ij} \ , \tag{1}$$

i = 1, 2 ....k and j = 1, 2 ...n,

X_{ij} *– measured value in i- subgroups*
J – serial number of measured value in i- subgroups
K – number of subgroups
N – file size.

Span in subgroups

$$R_i = MAX(X_{ij}) - MIN(X_{ij}), \tag{2}$$

i = 1, 2 ... k and j = 1, 2 ...n
MAX (X_{ij}) and MIN(X_{ij}) is maximum and minimum value in i-th subgroup.

Average of process

$$\overline{\overline{X}} = \frac{1}{k}\sum_{i=1}^{k} \overline{X_i} \ , \tag{3}$$

$\overline{X_i}$ *- average of j – th subgroup*

Average of span

$$\overline{R} = \frac{1}{k}\sum_{i=1}^{k} R_i \ , \tag{4}$$

R_iX_i are spans and averages in *i*-th subgroups (*i*=1, 2, ...*k*). $\overline{R}$ and $\overline{\overline{X}}$ in quality control charts are central lines (*CL*).

Calculation of specification limits

$$UCL_R = D_4 \,.\, \overline{R} \ , \tag{5}$$

$$LCL_R = D_3 \,.\, \overline{R} \,, \tag{6}$$

$$UCL_{\overline{X}} = \overline{\overline{X}} + A_2 .\ \overline{R} \,, \tag{7}$$

$$LCL_{\overline{X}} = \overline{\overline{X}} - A_2 .\ \overline{R} \,, \tag{8}$$

where D_4 ,D_3 and *A_2* are constants moving in dependence on volume of subgroups *n,* in our case n = 5: $D_3 = 0.000$, $D_4 = 2.114$, $A_2 = 0.577$.

Qualification of pressing process

$$C_p = \frac{USL - LSL}{6.\hat{\sigma}} = \frac{T}{6.\hat{\sigma}} \;, \tag{9}$$

$$C_{PK} = \frac{USL - \overline{\overline{X}}}{3.\hat{\sigma}}, \tag{10}$$

$$C_{PK} = \frac{\overline{\overline{X}} - LSL}{3.\hat{\sigma}}, \tag{11}$$

USL – Upper Specification limit,

LSL – Lower Specification limit [2].

Results

In pressing process, we obtained the values for 25 subgroups. Characteristics $\overline{X}$ and R are applied in quality control charts. The following regulation limits are valid for quality control charts ($\overline{X}, R$):

UCL_X = 28.0428 N UCL_R = 9.3016 N
LCL_X = 22.9652 N.

General average $\overline{\overline{X}}$ = 25.504 N, average span $\overline{R}$ = 4.4 N. The process is considered as eligible, indexes C_p and C_{pk} are greater than 1.33. **Cp = 2.07** a **Cpk = 2.00**.

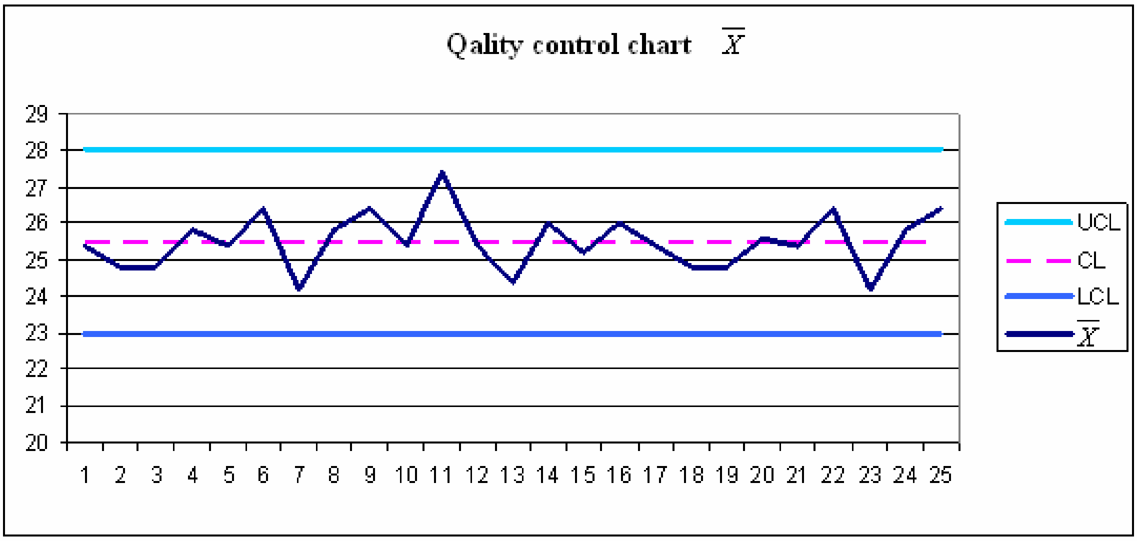


Fig. 1 *Quality control chart* $\overline{X}$

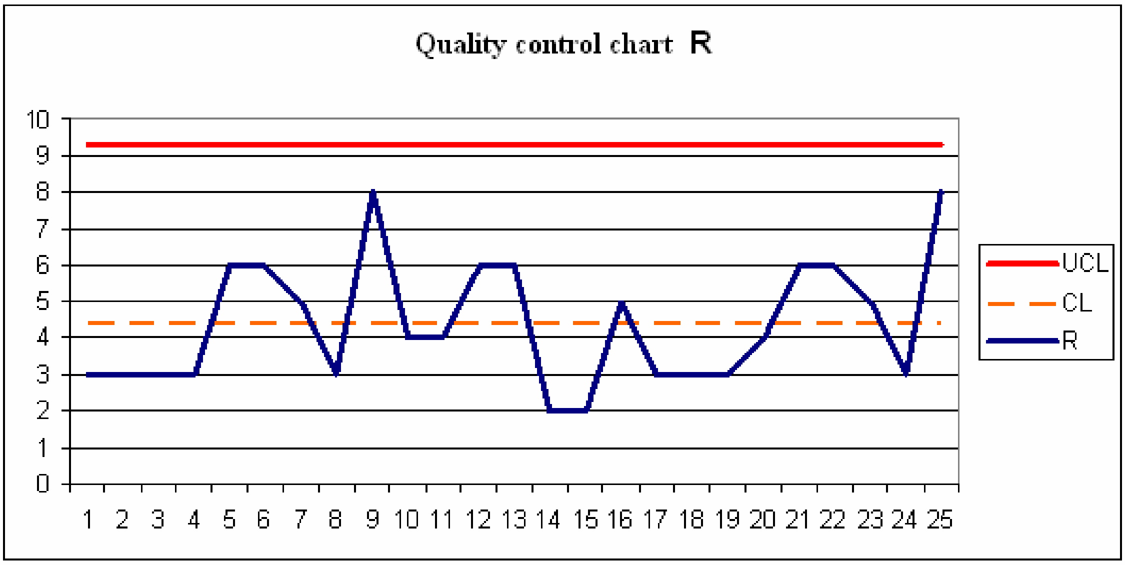


Fig. 2 Quality control chart R

We can see the process variance in histogram (Fig.3), where the position of the process was appreciated, variability and figure compared to tolerance zone. Based on the bell-shaped histogram, we note the confirmation of normality; the process runs at constant conditions. All measured values are inside the tolerance zone and moving around the median value of 25 N. All results are illustrated in protocol of process capability (Fig. 4).

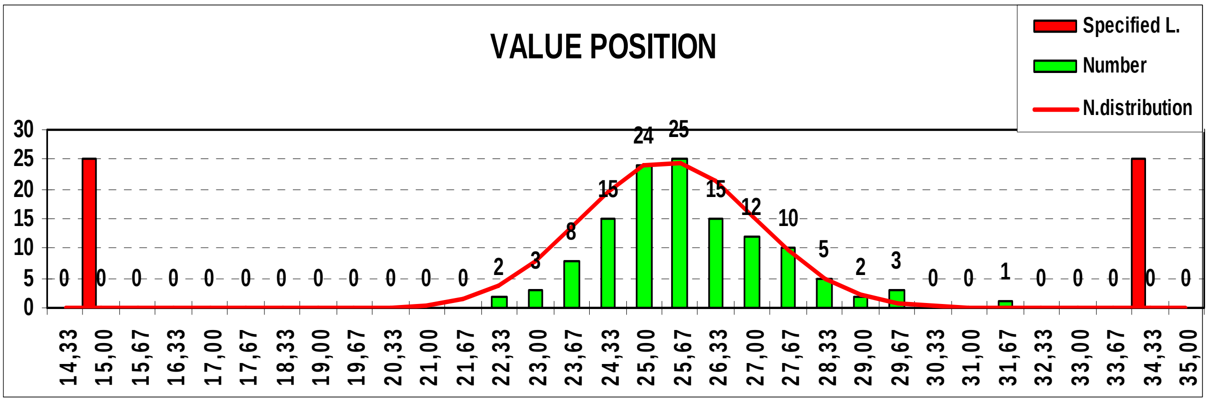


Fig. 3 Histogram

PROCESS CAPABILITY CALCULATION

Knudsen Plast

Process Capability Study for Force Closed

Main data

Product:	**Cross Valve B**
Batch no.:	**1254665**
Specification:	**125456 ver.1**
Nominal value acc to spec.:	**25**
Parameter:	**Operation Force**
Designation:	**N**

Specifications

Upper specified limit (USL):	**35**
Lower specified limit (LSL):	**15**
Target:	**25**
Allowable tolerance range	**20**

Calculations

Completed by	**Jozefina Kudičová**
Date for capability study	**2011.02.22**
No measured	**125**
Average	**25**
Max	**31**
Min	**22**
Range	**9.3**
Standard deviation	**1.6**
6 x St dev range	**9.7**
Number of test outside Upper limit	**0**
Number of test outside Lower limit	**0**
Cp	**2.07**
Cpk	**2.00**

Fig. 4 *Protocol of process capability*

Summary

The capability of pressing process in Knudsen Plast s.r.o. showed that the process provides the products that meet the claimed quality criteria. Values of a potential process capability C_p = 2.07 and a real process C_{pk} = 2.00. These values are higher than the rate 1.33 and the process is able to provide the products in compliance with the tolerance zones.

References:

[1] HRUBEC, J. *Riadenie kvality*. Nitra: ES SPU, 2001, s. 203. ISBN 80-7137-849-6

[2] ŠKŮRKOVÁ, K., ŠESTÁK, M. The capability of turning process by screws production. In *Production engineering.* Novosibirsk: Novosibirsk State Technical University, 2009, pp. 49-56. ISBN 978-5-7782-1165-0

[3] ULEWICZ R., BORKOWSKI S. The Quality System According to the Norm QS-9000, W: MT'01. *The Third International Conference*. Mechanical Engineering Technologies, Sofia, 2001, p.III.70.

Reviewers:

Maroš Korenko, Assoc. Professor, Ph.D. – Faculty of Engineering, Slovak University of Agriculture in Nitra

Helena Vidová, Assoc. Professor, Ph.D. – Institute of Industrial Engineering, Management and Quality, Faculty of Materials Science and Technology in Trnava, Slovak University of Technology Bratislava

RESEARCH PAPERS
FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA
SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

2011 Number 30

SELF-STUDY AND COOPERATION OF PUPILS IN PROJECT BASED INSTRUCTION

Jan KOSTELNÍK, Veronika HORŇÁKOVÁ

Abstract

This paper is focused on the use of cooperative and individualized concepts of instruction in project based learning. Part of the paper includes partial results of the questionnaire survey carried out within the grant project KEGA No. 031-035 SUT – 4 "Project models of teaching at the secondary vocational schools".

Key words

individualized instruction, self-study, cooperative instruction, cooperation, project based learning

Introduction

One of the serious contradictions at secondary vocational schools is a contradiction between frontal teaching and the individual character of learning. Vocational schools usually fail to teach their graduates everything what will be needed in their professional and personal lives, yet they should teach them to think, learn and work independently. On the other hand, the disadvantage of individualized concepts of teaching is that they do not sufficiently develop social and communicative competences of the learners. The companies employing the graduates of secondary schools require them to be ready for teamwork. Therefore, it is important to find optimal proportions of individualized and cooperative teaching approaches at secondary vocational schools. This also should be applied for the integration of independent work and cooperation of pupils in project based learning. Participation in a theoretical or practical, individual or social action during project work is an important way of pupils´ personal development. It bridges and connects school situations and real life with the practical development of pupils´ experience based on their active relation to the natural and social environment [1].

Jan Kostelnik, Assoc. Professor, Ph.D., Veronika Horňáková, MSc. Eng. - Institute of Engineering Pedagogy and Humanities, Faculty of Materials Science and Technology, Slovak University of Technology Bratislava, Paulínska 16, 917 24 Trnava, Slovak Republic, e-mail: jan.kostelnik@stuba.sk, veronika.hornakova@stuba.sk

Individualized instruction and independent work of pupils

Individualization and internal differentiation are needed for effective instruction; it means to take into account physical, psychological, social and experiential specifics and opportunities of the learners, e.g. by taking into account an individual pace of work and differentiating the difficulty of tasks for each pupil according to his/her knowledge and abilities. Individualized concepts of instruction include the Dalton plan, Winet system, programmed instruction, open learning, mastery learning and others. Actually, the permanent and entire individualization of instruction is not suitable for organizational and pedagogical reasons; it is therefore necessary to find the optimal proportions between the different social forms of teaching and individual work of the pupils [2].

Independent work of pupils means their theoretical or practical activity which is relatively independent from the direct management of the teachers. Independent work aims to objectives of the instruction based on their own efforts. We distinguish independent school work (e.g. independent problem solving of tasks and exercises, programmed work, individual work in laboratories, etc.) and extra-curricular work (e.g. home study from textbooks, preparation to exercises, essay writing, etc.) Extra-curricular individual work of pupils takes place without the personal presence of the teacher; individual school work of the pupils takes place with personal presence of the teacher, but without immediate management and control. In each developmental stage of the personality, the optimal intensity, scope and methods of individual work are different. The period of secondary education is a very important period in the development of personal independence and the development of study and work skills and habits. It is not only due to this fact that the secondary curriculum is more difficult for memory learning, but also because workshop, laboratory, engineering, computing and other tasks are requiring a certain level of independent work of pupils [2].

Cooperative instruction and pupils´ team-work

When group teaching, small groups of usually 3-5 pupils are formed, which is typical for cooperation in solving difficult tasks or problems. Pupils’ work within groups can be *undifferentiated*, where each pupil works on the solution to a common task, or *differentiated*, where each pupil solves a part of the group task or processes using an individual method. According to the pupils’ efficiency, it is possible to generate *homogeneous* groups in which pupils have approximately the same knowledge and capabilities, and *heterogeneous* groups in which pupils have different knowledge and capabilities [3].

Increased activity of pupils, development of social, communication and organization capabilities, responsibility for work results, partial possibility to choose the pace of work etc. can be considered the advantages of group work. The disadvantages of group work include the fact that it is time consuming, there are problems with discipline and noisiness, imbalanced load on particular pupils, and increased demand on assessment and organization skills of the teacher. The division of pupils into groups does not however guarantee the cooperation among the pupils. The cooperative vision of instruction is based on full-value cooperation of pupils in achieving the objectives. The group of pupils benefits from the activities of individuals, while the results of individuals are based on the activities of the whole group. Cooperative learning is characterized by cooperation and mutual support. It is necessary to arrange a positive mutual dependence and good contact of the group members to assure effective cooperative learning, and to invigorate personal responsibility of individual members for group work and its results. The way of cooperative instruction depends not only on the objectives and level of the pupils´ capabilities, but also on the organizational and management skills of the teacher [4].

Project-based instruction

Project based instruction is based on the solution of complex multi-subject theoretical or practical problems by pupils, and stems from an assumption that it is not suitable to split cognition and activity. The participation in theoretical or practical, individual or social activity is an important means to develop pupils´ personality. Well-prepared projects, often designed in cooperation between the teacher and pupils, lead to actual results and strong inner motivation. Projects link school and practical life, they give the possibility to step outside the classes and school and connect learning with pupils' life experience [1].

Project based instruction enables pupils to understand the whole structure of activities, i.e.: to participate in the selection of the project topic and its specifications, to determine the activity objectives, to plan the project solution, to carry out partial processes and suggest changes (corrections), get feedback on procedures, to present the results of activities and evaluate the whole project. Benefits of project work are also pupils' experience resulting from the cooperation and overcoming obstacles and the feeling of responsibility for one's own activity as well. Project based instruction is therefore of a huge educational importance. Projects can be suggested by pupils, teachers or both. The teachers' role in projects is that of organizer, facilitator and supervisor. According to the objective, projects can be divided into problem, drill (e.g. focused on development of the capabilities to search and analyse information), structural, evaluative and others [5].

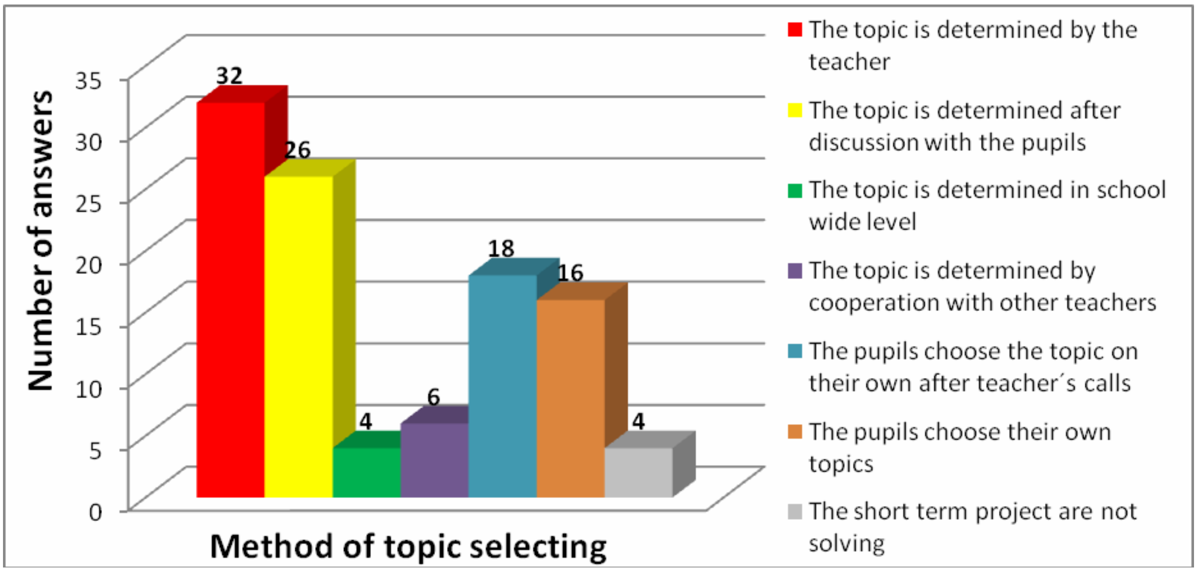
A usual policy of project based instruction includes the choice of a particular life situation or practical problem by the teacher together with pupils. At the beginning, it can be a freely formulated idea or topic – for example water quality of the Danube, alternative energy resources, healthy food, etc. Together with pupils, the teacher then discusses possible solutions to the situation or problem. The tasks, which the pupils will deal with either individually or in groups, are formulated. The required form of the result is defined. Then, individual work of the pupils and cooperation in groups start. Pupils gather and analyse necessary information, collect and assort material, measure, experiment, account, compare, make, etc. In the end of project based instruction, pupils present and evaluate results of their own individual work or cooperation [1].

In terms of the number of project team members and the instruction objectives, there are individual and group projects. The key question is, whether we want to develop independence or social-communication capabilities of the pupils. In individual projects, a pupil does all basic activities on his own, including the inquiries and analysis of the information and presentation of the output. His/her capabilities of thinking, learning and solving complex tasks independently are developed. In group projects based on cooperative instruction principles, pupils learn to cooperate and communicate, argue and accept ideas of the others solve human and work conflicts etc. Suitable integration of individual and group projects at secondary vocational schools can be an effective, authentic and motivating way of instruction [6].

Partial results of the questionnaire research

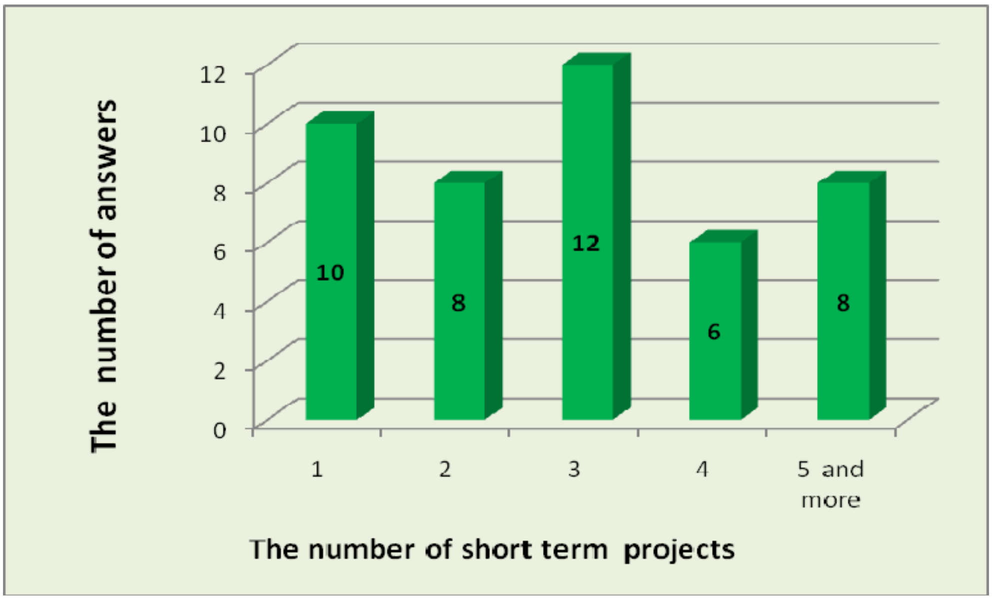
In 2010, we carried out a questionnaire research focused on project based instruction at fifteen secondary vocational schools. The questionnaire included 28 items, which were responded by 116 teachers of technical subjects. The number of respondents in each item varied. This paper illustrates only the answers to three items, namely the method of topic selection for short term projects (lasting one lesson, a double lesson up to one school day), number of short term projects solved during the school year in one class and determination of tasks and processes of work in short term projects.

In the item focused on the method of short term project topic selection, respondents could choose or add one or possibly more of the offered answers. There were 60 respondents. As Graph 1 clearly shows, the topic of short term projects is most often determined by the teacher (53.3% responds) or teacher in cooperation with the pupils (43.3% responds). Less frequent responds were that the topic is chosen by the pupil after teacher's challenge (30% responds) or the pupils themselves address the teacher with their own idea for a topic (26.7% responds).



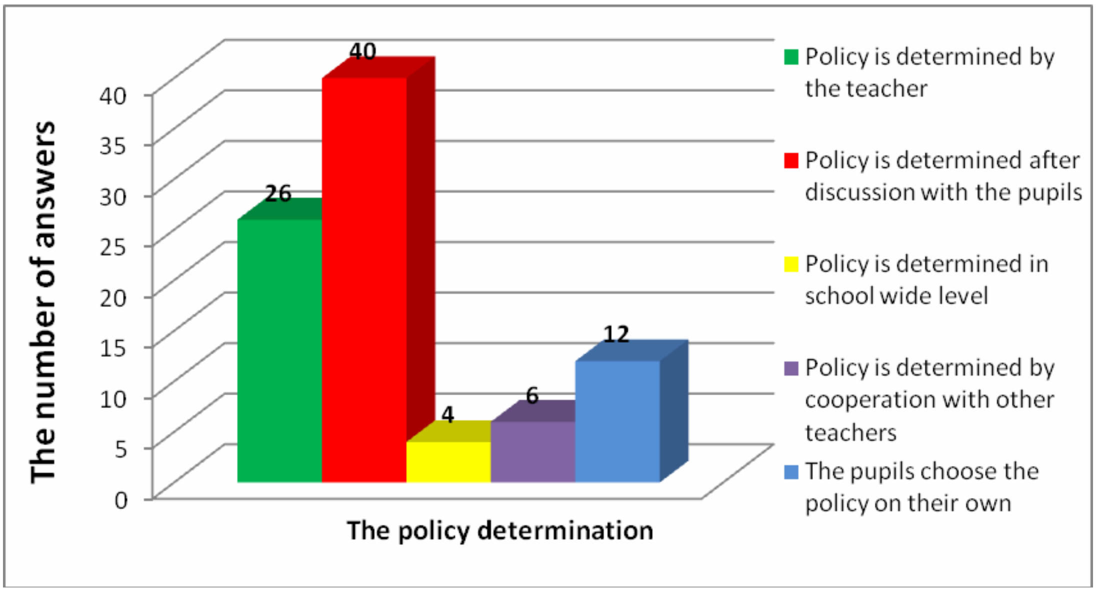
***Graph 1** Method of short term project topic selection*

In the next questionnaire item, respondents were asked about the number of short term projects solved by pupils in one class during the school year. There were 44 respondents who could choose or match just one response. Responses are shown in Graph 2. The most frequent (27.3% responds) responses state that pupils in one class solve three short term projects during the school year. The second most frequent respond was that pupils in one class solve only one short term project per school year.



Graph 2 *The number of short term projects in one class during the school year*

We were also interested in the determination of the policy for short term projects. There were 56 teachers of vocational technical subjects at secondary schools who responded to this item. Respondents could choose or add one or more from the offered options. In our opinion, the way of the policy determination is a cooperative decision of both teacher and pupils. This answer was chosen by most respondents (71.4%). The number of responses is shown in Graph 3.



Graph 3 *Determination of the policy of short term projects*

Conclusion

The advantages of individualized instruction involve the fact that pupils learn to think and work independently. Their ability to rely on their own abilities and their responsibility for their own actions is developed. The teacher can effectively use didactic principles of proportionality and individual approach, the pupils can choose, to a certain extent, their own pace of the work. The advantages of cooperative instruction also include the development of social, communicative and organizational skills of the pupils. Positive mutual dependence of each member of the group leads to mutual responsibility for the results of common work. In our contribution, we presented not only advantages, but also disadvantages and limitations of the above-mentioned concepts of instruction. Generally, a universal concept of instruction suitable for all didactic situations does not exist. The teacher always has to consider the objectives and content of instruction, readiness and motivation of the pupils, the time allotted etc. This applies also for the optimal proportion of integrating the independent work and cooperation of pupils in project based instruction at secondary vocational schools.

References:

[1] SKALKOVÁ, J . *Obecná didaktika*. *General didactics.* Praha: Grada Publishing, 2010. ISBN 978-80-247-1821-7

[2] KOSTELNÍK, J. *Riadenie samostatnej práce študentov stredných a vysokých škôl*. *Directing independent work of students of secondary schools and universities*. Bratislava: Vydavateľstvo STU, 1998, p. 59. ISBN 80-227-1043-1

[3] MAŇÁK, J., ŠVEC, V. Výukové metody. *Methods of instruction*. Brno: Paido, 2003. ISBN 80-7315-039-5

[4] KASÍKOVÁ, H. *Kooperativní učení, kooperativní škola*. *Cooperative instruction, cooperative schol.* Praha: Portál, s.r.o., 2010. ISBN 978-80-7367-712-1

[5] TUREK, I. *Didaktika*. *Didactics*. Bratislava: IURA Edition, 2010. ISBN 978-80-8078-322-8

[6] PASCH, M. et al. *Od vzdělávacího programu k vyučovací hodině. From educational programs to class.* Praha: Portál, s.r.o., 1998. ISBN 80-7178-127-4

Reviewers:

Pavel Krpálek, Assoc. Professor, Ph.D. - Institute of Education and Communication, Czech University of Life Sciences, Prague

Roman Hrmo, Assoc. Professor, Ph.D. - Institute of Engineering Pedagogy and Humanities, Faculty of Materials Science and Technology SUT, Trnava

RESEARCH PAPERS
FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA
SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

2011 Number 30

QUALITY AND DYNAMIC CHARACTERISTICS OF CONTROL SYSTEM VISUALIZATION IN CONTROL WEB

German MICHAĽČONOK, Maximilián STRÉMY, Andrej ELIÁŠ

Abstract

Progress of information technologies and their applications create the necessary need to explore the analysis of techniques to estimate the impact of architecture control system on dynamic characteristics of control. Major impact factors on dynamics and quality of visualization, control modes selection and impact analysis are described in the article.

Key words

Visualization, Control Web, Modicon, control, real-time

Purpose of the article

Progress of information technologies and their applications create the necessary need to explore the analysis of techniques to estimate the impact of architecture control system on dynamic characteristics of control. Major impact factors of dynamics and quality of control are described in the article.

Experimental control system & program

Experimental structure of control and visualization complex consisted of Modicon Micro 612 programmable controller and computer which carried out functions of the tasks control and process visualization in Control Web. Models for the system analysis were created in Matlab.

The visualization program carried out the following functions:
- signal output of the task to the monitor,
- generation of the sine wave signal of the task (with virtual driver),

German Michaľčonok, Assoc. Prof., Ph.D., Maximilián Strémy, Ph.D., Andrej Eliáš, Ph.D. – Institute of Applied Informatics, Automation and Mathematics, Faculty of Materials Science and Technology, Slovak University of Technology Bratislava, Hajdóczyho 1, 917 01 Trnava, Slovak Republic, maximilian.stremy@stuba.sk

- signal output of the task through the Modbus channel 100 to the port COM2,
- reception and process of input signals from COM2 port through the Modbus channels 121 and 305 into the software visualization,
- signal output to the screen from COM2 port.

Control Web program ran on a Windows platform and represented the real time program with the sample period T_C=0.05 sec. The size of the program and the architecture of the computer did not allow us to reduce the sample period [1].

The set point value represented by the digital signal from the Control Web was transformed by the analogue/digital (A/D) converter and transferred to the Modicon Micro 612. The control program in the Modicon was really simple to ensure the opportunity of the dynamic characteristic tracking. Program processed the signal from the output of A/D converter and redirected it on the input of 12 bit D/A converter, and the signal returned through COM2 port and channel 305 of the Modbus driver to the visualization in Control Web. The program also contained SUB function for matching of digital codes on an input and an output of the controller. The matching result was read out by Control Web program on the channel 121 of the Modbus drivers. Cycle time of the controller was set up by the timer with period T=0.001s.

Block scheme of the control and visualization complex is shown in Fig. 1

.

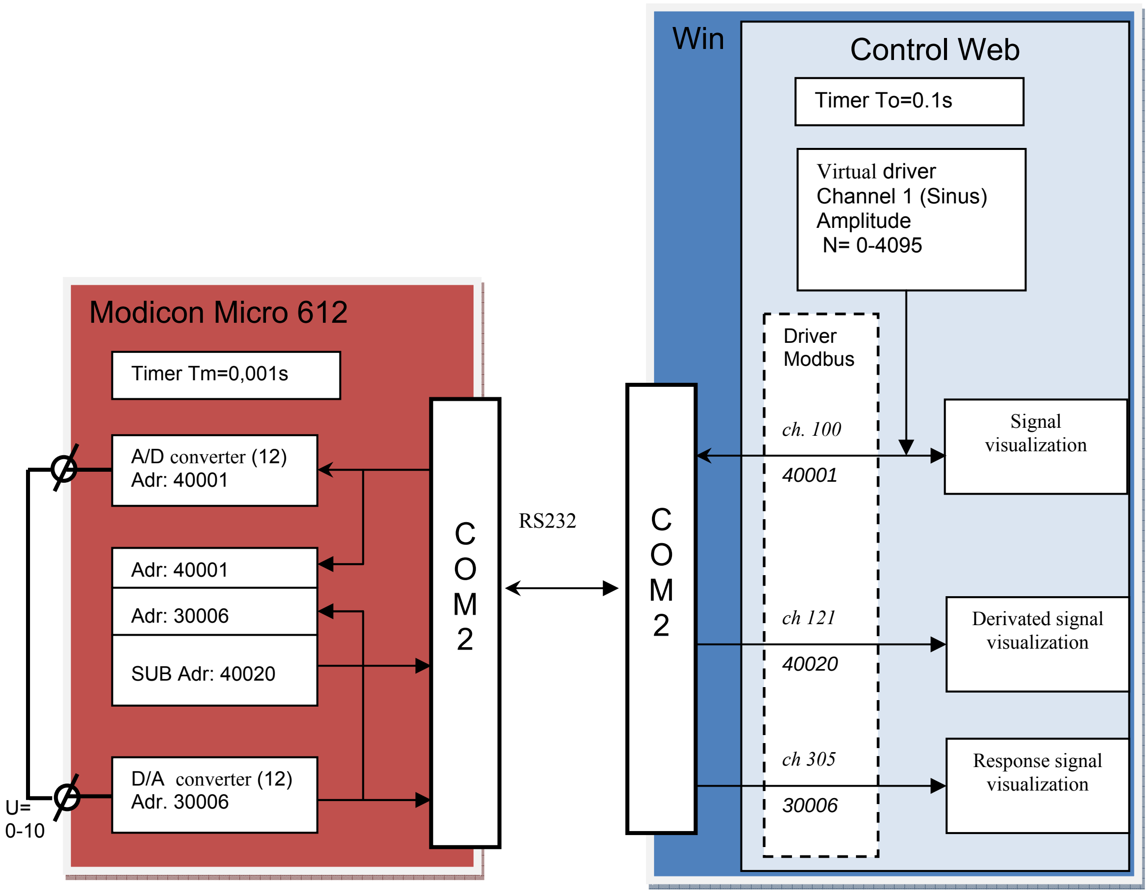


***Fig. 1** The block scheme of the complex*

The given structure practically allowed us to explore dynamic and interfering characteristics of such combination of hardware and software.

Control mode

There are two ways of how to organize the cycle of the control program:

1. Real-time mode - determination of hard cycle time of the program.
2. Control mode by the dataflow – processing the program instructions based on interruptions system which reacts to inquiries of separate units of a control system.

The first way assumes pre-computation of the maximum sum of temporary (in many cases stochastic) delays of the individual program routines. Thus, we can receive constant period of regulation and may calculate the characteristics of regulators in the control system. Disadvantage of such process is e.g. not optimum loading of the processor, depending on the event state in the system and the conditions of regulation. Examples of real-time mode application:

- direct digital regulation of the continuous processes,
- simulation of control systems in real time,
- visualization of a control system with exact binding on real time / necessities to follow the communications between both entry and output equipment.

The second way provides the variable period of the cycle, duration of which is automatically adapted to real needs of the control system and processing of the generated events in system. This approach also provides optimized processor loading, but there can be problems e.g. in time-critical processes with the precise timing. Dataflow control mode may be used e.g. if there is a necessity to provide only state visualization of the object or the technological process. Such necessity arises when the majority of control functions is carried out at the level of microcontroller, and the computer is used only for process visualization or like a human machine interface (HMI).

Impact analysis

Control Web program is used also for setting up the desired/required values of the controlling system as well as for the measurement of the deviations and quality or noise analysis. If the control is defined as the function of the time, there is a question of correct determination of maximum frequency and accuracy of the control [2]. At the given accuracy, it is possible to define necessary number bits count or, on the contrary, to determine limiting accuracy of the control at the given number bits. For example, both converters (D/A and A/D) of the microcontroller Modicon 612 have 12-bit resolution. Relative precision (RP) of the convertors and corresponding signal is:

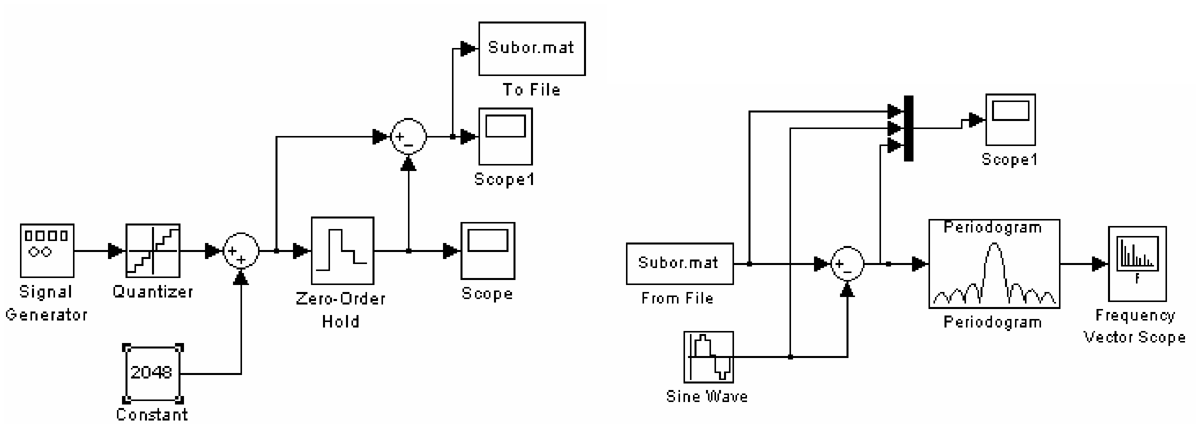
$$RP = 100/2(N-1) = 100/2(4096-1) \approx 0.01\ . \qquad (1)$$

If the period of the cycle is known, it is possible to determine maximum frequency of the signal at given amplitude A_N:

$$\varpi = \frac{1}{A_N T_C} \qquad (2)$$

So, in our case, Control Web program should not exceed 0.005 radian/sec at complete amplitude frequency of the harmonic signal. This value provides maximum dynamic accuracy of the control system. In practice, such accuracy is usually not required. It is therefore possible to increase frequency of the control system considering that the controlled object usually has a property of a low-frequency filter.

We have to consider a noise signal (generated by the quantization) and its spectral characteristics. To display its impact, we created a model in MATLAB using SIMULINK tools. Figure 2 shows the models for generation of quantization noise (a) and for a spectral analysis of a noise signal (b).



a) b)

Fig. 2 *Models of generation(a) and the analysis (b) of quantization noise/signal*

Noise signal $A_V(t)$ for $f_C = 1/T_C$ can be described by the following expressions:

- in an interval $0 \le \omega_S \times t \le \pi$:

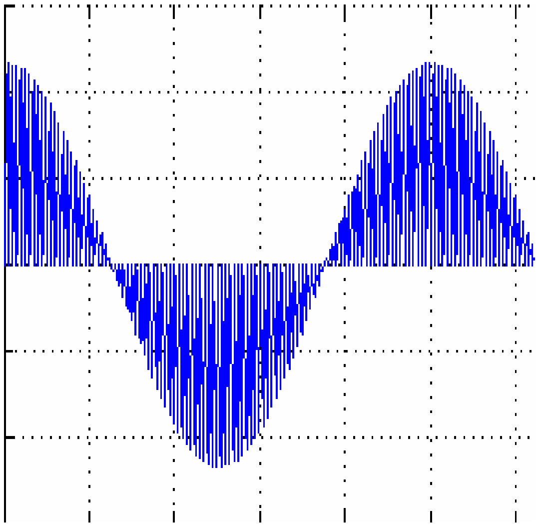
$$A_V(t) = A_S \times \omega_S \times T_C \times \{\pi - 2[\frac{Sin(2\pi f_C \times t)}{1} + \frac{Sin(4\pi f_C \times t)}{2} + \frac{Sin(6\pi f_C \times t)}{3} + ...]\} \times Sin(\omega_S \times t);$$

- in an interval $\pi \le \omega_S \times t \le 2\pi$:

$$A_V(t) = A_S \times \omega_S \times T_C \times \{-\pi + 2[\frac{Sin(2\pi f_C \times t)}{1} + \frac{Sin(4\pi f_C \times t)}{2} + \frac{Sin(6\pi f_C \times t)}{3} + ...]\} \times Sin(\omega_S \times t);$$

The following parameters were used in the simulation:

$$A_S = 2048; \quad \omega_S = 0.628\sec^{-1}; \quad T_C = 0.1\sec; \quad f_C = \frac{1}{T_C} = 10Hz;$$



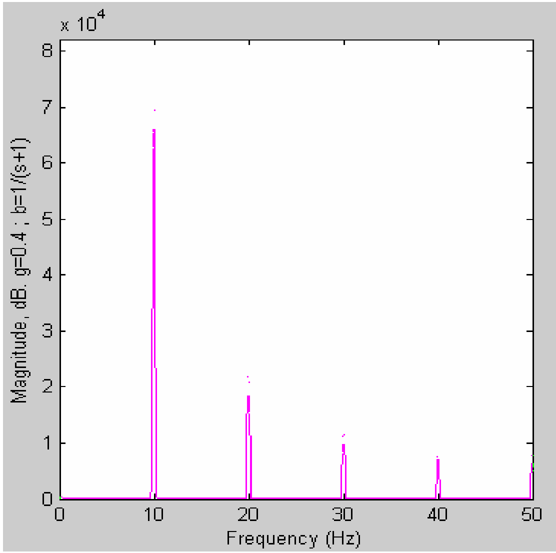


***Fig. 3** Parsed signal and its spectrum after discharge of harmonic modulation*

The model scheme of the spectral analysis contains an auxiliary unit for compensation of low-frequency modulation of a researched signal $Sin(\omega_S \times t)$. Such compensation helped us precisely to allocate high-frequency making a noise signal. The amplitude of the first harmonic noise signal at simulation made 128 units, that coincided with the designed value.

Conclusion

Based on the obtained results, we can conclude:

- By using software products such as Control Web as a controlling or regulating unit of the technological process, it is necessary to take into account its low dynamic characteristics.
- By the visualization of the state of the objects or technological processes, control mode by the dataflow should be preferably used.
- The detailed analysis of behaviour of the architecture of the computer and the operating system is necessary to exactly define the possible temporary delays of software of visualization of processes.
- By the exact definition of control system behaviour and its visualization, there is a possibility of program compensation of measurement errors.

References:

[1] BÍLÝ, R. 1999. *Control Web 2000*. Praha: Computer Press, 1999.
[2] ŠIMON, M. IT security in process control systems. In *Infokommunikacionnye technologii v nauke, proizvodstve i obrazovanii : tretja meždunarodnaja naučno-trechničeskaja konferencija*. Časť I. - Stavropol': Severo-Kavkazskij Gosudarstvennyj Techničeskij Universitet, 2008, pp. 94-100. ISBN UDK 004 (06)

[3] TRNKA, A. 2010. Six Sigma Methodology with Fraud Detection. In *Advances in Data Networks, Communications, Computers : 9th WSEAS International Conference on Data Networks, Communications, Computers (DNCOCO`10)*. University of Algarve, Faro, Portugal, November 3-5, 2010. [b.m.v.]: WSEAS Press, 2010, pp. 162-165. ISBN 978-960-474-245-5, ISSN 1792-6157

Reviewers:

Pavel Važan, Assoc. Professor, Ph.D. - Institute of Applied Informatics, Automation and Mathematics, Faculty of Materials Science and Technology in Trnava, Slovak University of Technology Bratislava

Anton Kachaňák, Assoc. Professor, Ph.D. – Faculty of Mechanical Engineering, Slovak University of Technology Bratislava

RESEARCH PAPERS
FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA
SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

2011 Number 30

ACOUSTICAL SPECIFICATION OF NEW EQUIPMENT WITH RESPECT TO NOISE POLICY

Miroslav RUSKO[1], Monika BIĽOVÁ[2], Ervin LUMNITZER[3]

Abstract

Increasingly, the Slovakian and European occupational health and safety legislation requires designers, manufacturers and suppliers of industrial plants and equipment to minimise hazards, such as excessive noise associated with their products, and to provide information about potential hazards. Even so, noise is still often overlooked with the result that the working environment is needlessly noisy. The purpose of this paper is to:

- *provide guidelines for the preparation of noise specifications;*
- *show how to calculate the maximum acceptable noise level for new equipment;*
- *show how to interpret noise information provided by suppliers.*

Key words

noise policy, noise manager, acceptable noise level, noise information

Introduction

A noise policy is a document laying down the general rules the organisation intends to follow in dealing with its noise problems. The most serious of these problems is the presence of hazardous noise (sufficient to cause hearing damage) in working areas. Noise can, of course, cause problems even when it does not pose a threat to hearing (for example, it can

[1]Miroslav Rusko, Ph.D. - Institute of Safety and Environmental Engineering, Faculty of Materials Science and Technology, Slovak University of Technology in Bratislava, Botanická 49, SK-917 24 Trnava, Slovak Republic, e-mail: >miroslav.rusko@stuba.sk<
[2]Monika Biľová, Ph.D. - Department of Environmental Studies and Information Engineering, Faculty of Mechanical Engineering, Technical University in Košice, Park Komenského č.5, SK-041 87 Košice, Slovak Republic
[3]Ervin Lumnitzer, Professor, Ph.D. - Department of Environmental Studies and Information Engineering, Faculty of Mechanical Engineering, Technical University in Košice, Park Komenského č.5, SK-041 87 Košice, Slovak Republic, e-mail: >ervin.lumnitzer@tuke.sk<

create difficulties in communication or concentration in office areas or provoke complaints from the organisation's neighbours), but these problems are outside the scope of this paper.

The organisation's noise control goals should be specified, for example, as follows:

- to ensure that no employee's 8-hour average noise exposure level ($L_{Aeq,8h}$) exceeds 90 dB(A) in 2011 and 85 dB(A) by 2013; and
- to ensure that no employee is exposed to impulse noise with a level exceeding 140 dB (lin) Peak.

The noise policy of an organisation also determines the roles and responsibilities of its employees. We will highlight the positions of noise managers and production engineers and give guidelines for improving the acoustical situation within a company by proper noise specification, determination of maximum acceptable noise levels and usage of a supplier's noise information.

Roles and responsibilities of production engineers and noise managers

The respective roles of the production engineer and noise manager will vary from organisation to organisation but typical roles are described below:

Production engineer

The production engineer should:

- establish the need for new equipment;
- question whether a quieter process could be substituted; and
- participate in the ultimate decision to order equipment.

Production engineer in association with noise manager

The production engineer should, in association with the noise manager:

- specify the maximum acceptable noise level;
- participate in the decision to order equipment;
- negotiate with suppliers for additional noise control as necessary;
- where required, arrange for noise measurements for evaluation and acceptance purposes; and
- participate in the decision to formally accept delivery of equipment.

Noise manager

The noise manager should coordinate the implementation of the noise policy program with overall budget planning and with other parts of an organisation's noise management program, especially the plant maintenance and replacement program.

Acoustical specification

It is necessary to specify the maximum acceptable noise level at a specified position (or positions) when the machine is operating under specified operating and acoustical conditions.

Noise level

The basic noise level to specify is the equivalent continuous A weighted sound pressure level ($L_{Aeq,T}$) measured over a complete operating cycle (or the average of several cycles). For the equipment which is likely to emit high-level impulse noise (explosive-powered tools, impact devices such as presses), it may also be necessary to specify a maximum value of linear (unweighted) peak sound pressure level.

Position

The position usually specified for noise measurements is the operator's position. However, for some machines (such as a machine for which there is no fixed operator position or a machine with a built-in operator's enclosure) it may be important to know the noise levels at other points around the machine so that exposure of the operator and the effects on others in the workplace can be properly assessed. In these cases, noise should be measured at the points around the machine at a height of 1.5 metres above the floor and/or access platform(s) and 1.0 metre from the machine itself, ignoring small projections.

Operating conditions

Specification of the operating conditions depends on the nature of the machine and its intended use, and includes such factors as speed, load, tooling, material being processed and feed rate.

Acoustical conditions

The acoustical conditions may be specified in three ways:

- The first option is to specify that the noise of the machine is to be measured under agreed conditions in an environment similar to the proposed installation site. In practice, the manufacturer's or supplier's workplace will often meet this requirement.
- The second option is to specify that the maximum acceptable noise level is not to be exceeded when the machine is installed and operating in the workplace.
- The third option is to specify that the noise of the machine is to be measured in a standard acoustical environment, such as one of those defined in a relevant international standard for machine noise measurement.

Specification of noisy items

While specific items will vary from industry to industry, quiet procedures should apply to all potentially noisy equipment. Even powered hand tools are important because they are a significant source of excessive noise in many workplaces. If the size of the organisation warrants it, consider compiling a specific list of the potentially noisy items in the industry.

Maximum acceptable noise level

Fundamentally the maximum acceptable noise level will be determined by the noise exposure level the organisation sets as its goal for working areas. In order to keep the workplace noise below a certain limit, the noise output of individual pieces of machinery will usually need to be well below that limit.

Flow chart 1 (see Figure 1) outlines a step-by-step procedure for calculating the maximum acceptable noise level for a given installation site. The following comments refer to the lettered points in Flow chart 1.

(a) In Box 1 enter the noise exposure goal [$L_{Aeq,8h}$] that the organisation has set for working areas.

(b) In Box 2 enter the present noise exposure level [$L_{Aeq,8h}$] at what will be the operator position of the new machine, measured when the machine it is to replace is not running.

(c) If the value in Box 1 exceeds the value in Box 2 (which means the present noise in the area is below the goal), use the "Subtracting Decibels Table" on the flow chart to subtract the level in Box 2 from the level in Box 1 and enter the result in Box 4.

(d) For example, if the level in Box 1 is 85 dB(A) and the level in Box 2 is 80 dB(A), by using the "Subtracting Decibels Table" the level to be entered in box 4 is 83 dB(A). If the value in Box 2 exceeds the value in Box 1, the present noise in the area is above the goal, and therefore needs to be reduced. Estimate the level that will exist in the area after feasible engineering controls have been installed and enter it in Box 3.
   - (d1) If the value in Box 3 is lower than the value in Box 1 (that is, anticipated engineering controls will reduce the noise in the area below the goal), use the "Subtracting Decibels Table" to subtract the value in Box 3 from the value in Box and enter the result in Box 4. The result is the maximum noise exposure level that can be introduced into the treated noise environment without causing the noise goal to be exceeded.
   - (d2) If the value in Box 3 is higher than the value in Box 1 (that is, after the installation of feasible controls the noise in the area will still exceed the goal), reduce the value in Box 3 by 10 dB(A) and enter the result in Box 4. This will ensure that after feasible controls have been introduced, installation of new equipment will have a minimal effect (the increase will be less than 0.5 dB(A)) on the noise exposure level in the area.

(e) Subtract 0, 3 or 5 dB(A) from the value in Box 4, depending on whether 1, 2, or 3 or more machines respectively will be installed either now or in the future, and enter the result in Box 5. This correction allows for the additive effects of noise from adjacent sources.

(f) The value in Box 5 is the maximum level that can be tolerated from an individual machine over its working lifetime.

(g) Since the noise emitted by a machine normally increases with wear and tear, it is desirable to specify for a new machine a somewhat lower limit than the calculated maximum acceptable value. A correction of 2 dB(A) allows a small margin for wear and tear and produces the final result in Box 6.

(h) This is the maximum acceptable noise level to specify for a new machine.

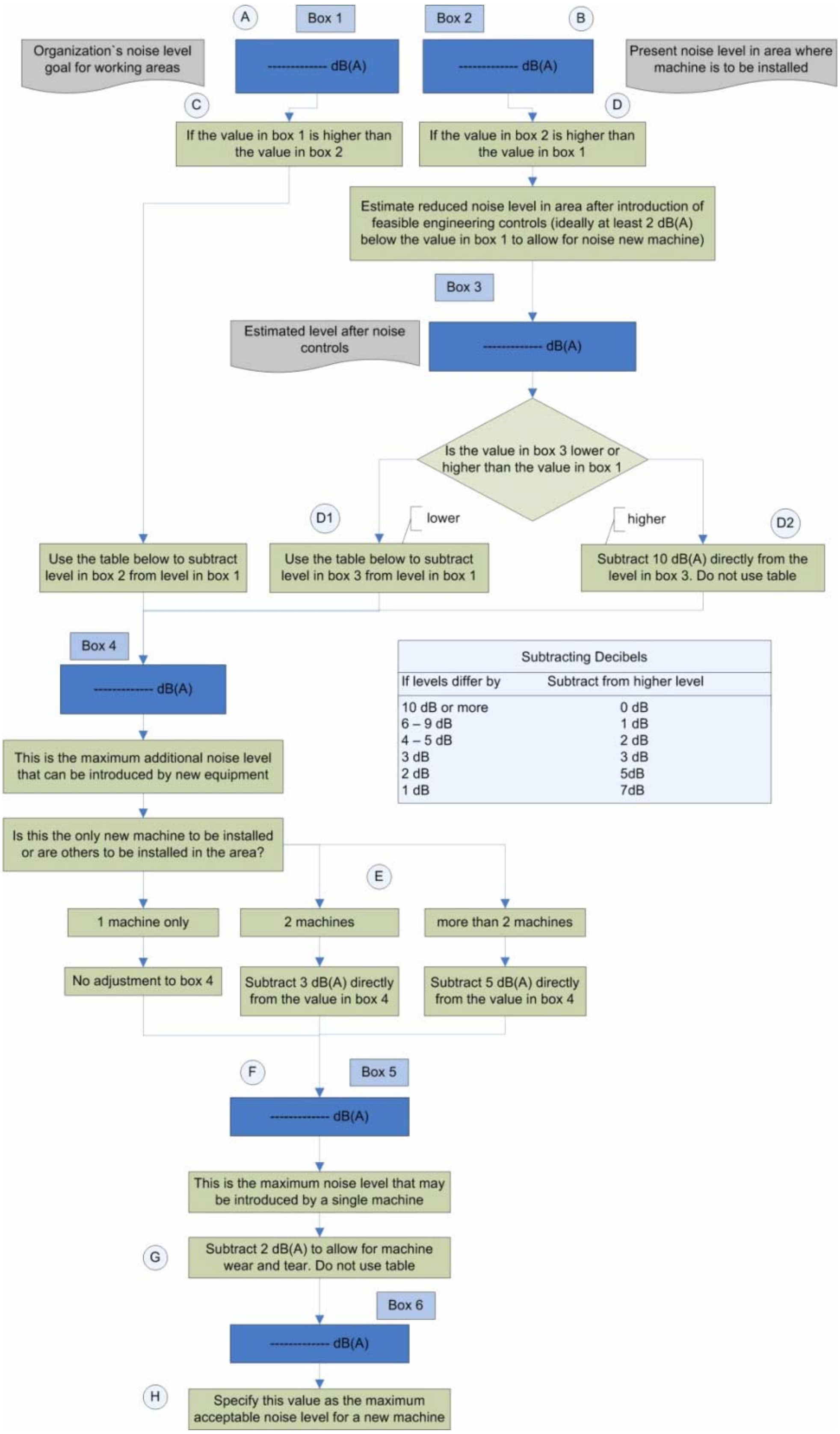


***Fig. 1** Calculation of maximum acceptable noise level for a new machine*

The calculation method in Flow chart 1 ensures that the new machine can be used for up to 8 hours per day without causing the noise exposure goal to be exceeded. If it is certain that the machine will be used for fewer hours every day, higher noise levels, calculated according to the 3 dB rule, could be tolerated without infringing the noise exposure goal. For example, if the machine will never be used for more than 2 hours a day, a maximum acceptable noise level 6 dB(A) higher than the value calculated in Box 6 (for 8 hours) would be tolerable.

Generally, in cases where a machine will be used (or people will be exposed to its noise) for less than 8 hours a day, we should consider specifying a range of acceptable noise levels encompassing its expected actual use and its potential daily use. If the value in Box 6 is 78 dB(A), but the machine will probably never be used for more than 2 hours a day, we should specify 78 dB(A) as the maximum preferred level, thus allowing for increased use/exposure at some time in the future, say as a result of expansion, and 84 dB(A) as the maximum acceptable level.

When comparing noise emission levels quoted by suppliers with the maximum acceptable noise level, we should check the conditions under which the supplier's noise measurements have been obtained. Noise levels appearing in a supplier's data sheet may have been measured under non-representative conditions (for example, a light to medium load on a machine installed in non-reverberant surroundings). At the workplace, it is more likely that the surroundings will be reverberant and that the machine will be run at full load. To allow for these effects, 4 dB(A) should be added to the supplier's noise measurements unless it is clear that they were made under typical working conditions.

Using suppliers' noise information

International standard methods are now available for measuring and describing the noise emission of industrial machines. It is best if suppliers' noise data have been measured according to one of these standards. Measurements made according to other procedures may, however, be acceptable if performed by a competent person according to a clearly defined procedure.

Flow chart 2 (see Fig. 2) presents a method for using supplier's noise information to estimate the amount of noise a given machine will introduce into the workplace:

(a) Enter the supplier's noise measurement result in Box 1.

(b) Refer to the supplier's noise information sheet to determine whether the noise was measured as a sound pressure level or a sound power level.

(c) If measured as a sound pressure level, make no adjustment. However, if supplier's sound pressure level data are for positions at larger distances than the operator's location, seek expert advice.

(d) If measured as a sound power level, subtract 8 dB(A) from the value in Box 1 and enter the result in Box 2.

(e) Refer to the supplier's noise information sheet for a description of the conditions under which the noise measurement was made.

(f) If the test conditions appear to have been representative of typical working conditions (for example, machines are installed in reverberant surroundings, have suffered some wear and tear and are run fully loaded), no adjustment is necessary.

(g) If the test conditions are not representative (for example, the test machine is in new condition and is run on less than full load in non-reverberant surroundings) add a 6 dB(A) correction to the value in Box 2 and enter the result in Box 3. If the test conditions are partially, but not fully, representative of the working conditions, select an appropriate correction between 0 and 6 dB(A).

(h) The value in Box 3 is the estimated noise level the machine will introduce into the area in which it is installed. This value is an estimate and that variations of 5 dB(A) are possible.

(i) The noise introduced by the new machine will combine with the noise already present in the area. To calculate the new noise level in the area, enter the present noise level in the installation area in Box 4, then use the "Adding Decibels Table" to combine the levels in Boxes 3 and 4. For example: if a machine with a noise level of 78 dB(A) is introduced into an area where the existing noise level is 80 dB(A), by using the "Adding Decibels Table" the new noise level in the area will be 82 dB(A).

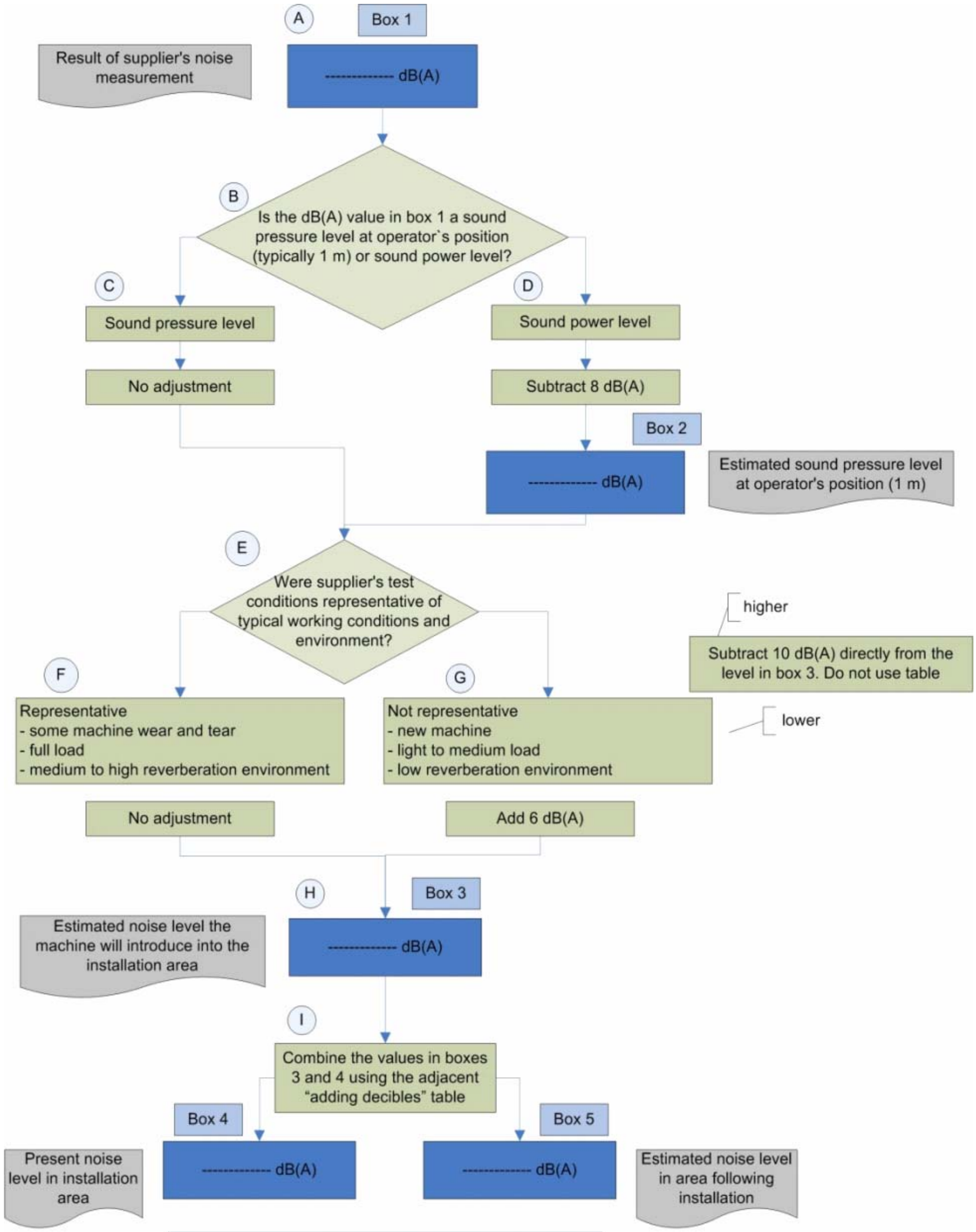
Lack of supplier information

It may be possible to arrange for noise measurements to be made of the same model of machine already installed elsewhere or of a machine set up in the supplier's workshop. The supplier may be prepared to meet or at least share the cost of having the measurements made since the information would be useful in relation to future product promotion and sales.

Failure to meet noise specifications

As a matter of policy, plant which fails to meet the noise specification should be accepted only with the written approval of a senior manager who should check that:

- efforts have been made to locate alternative suppliers;
- negotiations have been held with tenderers to determine the feasibility of additional noise control work on their products and the availability of noise-reducing accessories;
- the equipment is to be supplied with the maximum affordable amount of noise reduction treatment in order to minimise noise emission in the workplace;
- consideration has been given to the design of the area in which the new equipment is to be installed to ensure that operator exposure levels will be as low as workable.



Adding Decibels	
If levels differ by	Add to higher level
0 - 1 dB	3 dB
2 - 3 dB	2 dB
4 - 9 dB	1dB
10 dB or more	0dB

Fig. 2 *Estimation of the amount of noise a given machine will introduce into the workplace*

Conclusion

The relevant noise manager(s) and production/engineering staff should be able to:

- identify which machines or tasks contribute most to the overall noise exposure of operators;
- estimate how much noise reduction is required;
- compare the effectiveness and cost of various treatment options; and
- select the most cost-effective treatment, taking account of significant non-noise factors such as other health and safety considerations and productivity.

Acknowledgement

This paper was supported by KEGA project No. 3/7426/09

References:

[1] BRUCE, R.D., TOOTHMAN, E.H. *Engineering Controls*, in Berger, EH et al. (Eds), Noise and Hearing Conservation Manual, 4th edition, American Industrial Hygiene Association, Ohio, 1986.

[2] MIDDLETON, A. How to specify quieter machinery. In *Works Management*, 1984, vol. 37, No. 1, pp. 28-9.

[3] PINDER, J.N. *Noise specifications for industrial plant and equipment - avoiding shortcomings*. Noise and Vibration Control Worldwide, 1982, pp. 292-5.

[4] Bruel and Kjaer Ltd, Noise Control - Principles and Practice, Bruel and Kjaer Ltd, Denmark, 1986.

[5] National Occupational Health and Safety: Commission Control Guide Mmanagement Of Noise At Work: Canberra, Commonwealth of Australia 1991. ISBN 0 644 12866 6

[6] BIĽOVÁ, M., LUMNITZER, E. Nové trendy v oblasti merania a hodnotenia hluku. In *Zem v pasci? 2008 : Analýza zložiek životného prostredia* : 2. ročník medzinárodnej vedeckej konferencie. Zvolen: TU, 2008, s. 106-112. ISBN 978-80-228-1848-3

[7] LUMNITZER, E., BADIDA, M., BADIDOVÁ, D., BIĽOVÁ, M. Simulation utilize for increasing effectiveness of the integrated production. In *AEI '2009 : International Conference on Applied Electrical Engineering and Informatics*. Genoa 2009. Košice: FEI TU, 2009, pp. 63-65. 1 elektronický optický disk (CD-ROM). ISBN 978-80-553-0280-5

[8] BADIDA, M., LUMNITZER, E., BIĽOVÁ, M., FIĽO, M. The uncertainties of environments parameters measurements as tools of the measurements quality improvement. In *Quality Festival 2008 : 2nd international quality conference.* Kragujevac: Univerzitet u Kragujevcu, 2008, 5 p. ISBN 978-86-86663-26-9

Reviewers:

Milan Piatrik, Professor, Ph.D. - Faculty of Natural Sciences, Matej Bel University, Tajovského 40, SK-974 01 Banská Bystrica, Slovak Republic

Ivana Tureková, Assoc. Professor, Ph.D. - Institute of Safety and Environmental Engineering, Faculty of Materials Science and Technology, Slovak University of Technology in Bratislava, Botanická 49, SK-917 24 Trnava, Slovak Republic

RESEARCH PAPERS
FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA
SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

2011 Number 30

SIZE AND RETURN PERIODS OF EXTREME DISASTERS

Miroslav RUSKO[1], Dana PROCHÁZKOVÁ[2]

Abstract

Extreme disasters occur rarely and altogether occasionally, and therefore, the determination of maximum possible size or maximum expected size of natural and other disasters is important for the safety management and for the insurance domain, and considerable attention is paid to it. Systematic methodology development has been supported by professional papers since 70s of the last century or so. At present, the extreme value methods based on the great numbers of law, fuzzy sets etc. are used. The example shows the high differences in the extreme values existing in the application of old concepts and new methods. By use of the extreme value methods, it is also possible to calculate the return period of extreme disasters. The example showing return periods for different disaster sizes is given.

Key words

disasters, hazard, extreme impacts, extreme disaster size

Introduction

From of old long, the humans suffer from natural and other disasters (further only “disasters”). Far off it is also known that for each phenomenon (disaster) management or defence against it we must know its cause, size and return period. Therefore, the measurement of disaster size is important. Generally, we can measure the size or magnitude of disaster itself using an objective quantity (the energy or any other measure seems to be optimal) or we can determine its size by measuring or classifying its impacts. There are disasters, for which both accesses have been historically developed, e.g. earthquake, wind, industrial accidents.

The fundamental function of the state is to ensure the existence and sustainable development of human society (i.e. theoretically human system), which is not possible

[1] Miroslav Rusko, Ph.D. - Institute of Safety and Environmental Engineering, Faculty of Materials Science and Technology, Slovak University of Technology in Bratislava, Botanická 49, SK-917 24 Trnava, Slovak Republic, e-mail: >mirorusko@centrum.sk<

[2] Dana Procházková, Assoc. Professor, Ph.D., D.Sc, Institute of Security Technologies and Engineering, Faculty of Transport Sciences, Czech Technical University, Praha, Czech republic, e-mail: >prochazkova@.fd.cvut.cz<

without ensuring the safe space for human society. It is necessary to define three basic terms for safety management tool that has been used to this aim. These terms represent integral terms, the definitions of which correspond to the English professional terminology and generalised meanings traditionally used in the Czech language. There are:

- protected interests (assets) of human system are components that are necessary for its safety and sustainable development,
- an impact is an adverse effect (influence) of phenomenon (disaster) at a given site and time of human system on protected interests,
- a disaster is each phenomenon in human system that has or can have impacts on protected interests of the human system, i.e. it threatens or can threaten from a given size or at given conditions the safety and sustainable development of human system.

The safe space, i.e. safe human system is a space in which the security is acceptable and in which sustainable development is guaranteed. With regard to the present knowledge, the safety must be mainly considered in integral sense and with regard to the protected (safeguard) interests that are:

- human lives, health and security,
- environment,
- property and welfare,
- technologies and infrastructures, mainly critical ones.

The extreme (beyond design/severe) disaster size plays a principal role in the human system safety, because the protective system creation, i.e. measures for averting or mitigating disasters and their impacts, depends on it.

Summarised knowledge on disasters

Disasters are divided into several groups according to the process types being in motion inside and outside the Earth like the Planet which causes them. Therefore, they originate at different sites and have different characteristics. With regard to present knowledge, their possible size depends on regional processes and their impact size on both, the regional and local conditions. Their causes and characteristics are generally incommensurable. From the protected interests' viewpoint, they have some common features, namely their ability to destroy, i.e. to cause harm and damages [1-3].

The number of disaster types increases; it is related to developed technologies and infrastructures. According to [4], we know that we must minimally take into account the following disasters:

- in and out of the Earth: natural disasters (earthquake, floods, drought, strong wind, volcanic activity, land slide, rock slide etc.); epiphytic; epizootic; land erosion; desertification; fundament liquefaction; ocean spreading etc.,
- in human body, behaviours and in human society divided to:
  - unintentional: illnesses; epidemic; involuntary human errors etc.,
  - intentional: robbery; killing; victimization; religious and other intolerance; criminal acts; terrorist attacks; local and other armed conflicts etc.,

- connected with human activities: incidents; near miss; accidents; infrastructure failures; technology failures; loss utilities etc.
- reactions of Planet or environment to human activities: man-made earthquakes; disruption of ozone level; greenhouse effect; fast climate variations; contaminations of air, water, soil and rock; desertification caused by human bad river regulation; drop of diversity of animal and vegetal variety; fast human population explosion; migration of great human groups; fast drawing off the renewable sources; erosion of soil and rock; land uniformity etc.
- connected with inside dependences in human system and its surrounding separated to:
  - natural: stress and movements of territorial floes; water circulation in environment; substance circulation in environment; human food chain; planet processes; interactions of solar and galactic processes;
  - human established: human society management; flows of raw materials and products; flows of energies; flows of information; flows of finances etc.

The listing shows that disasters are of different nature: physical, chemical, economic, biological, social and cyber, and, measures and activities for negotiation must therefore respect this fact.

The occurrence of disaster is accompanied by chains of undesirable phenomena (impacts, consequences) of external and internal character, primary and secondary, which affect negatively protected interests of human system with different intensity and at different time moments. The local vulnerability and pertinent faults in human behaviour or management on all levels play the substantial role.

To put the originated emergencies under the control, it is necessary to understand disaster impacts and to know all links and flows in human system that escalate or suppress disaster impacts. Interdependencies across the human system or across infrastructures that can under special conditions create undesirable couplings play a big role. Sources of such interdependencies are information networks, management tools, finance flows and electric energy networks etc. [3 and 4].

At present, there are technical standards and norms for technology vulnerability reduction, health standards for human population vulnerability reduction, environmental standards for environment vulnerability reduction and legal rules for human society vulnerability reduction. It is necessary to note that the standards for cyber infrastructure (IT) vulnerability reduction have not been qualified yet. The emergency plans contain rules for putting emergency situations under control [3].

From the viewpoint of human security, it is necessary to take into account that standards and norms ensure the human system safety only to a given disaster size. The disaster with the size greater than the given size is denoted as extreme / severe / beyond design disaster. It has extreme impacts and a lot of secondary impacts that are caused by links and flows going across the human system [3]. The Figure 1 shows that, owing to the IAEA and the NEA / OECD long-term effort, only nuclear technologies are protected from such disaster sizes.

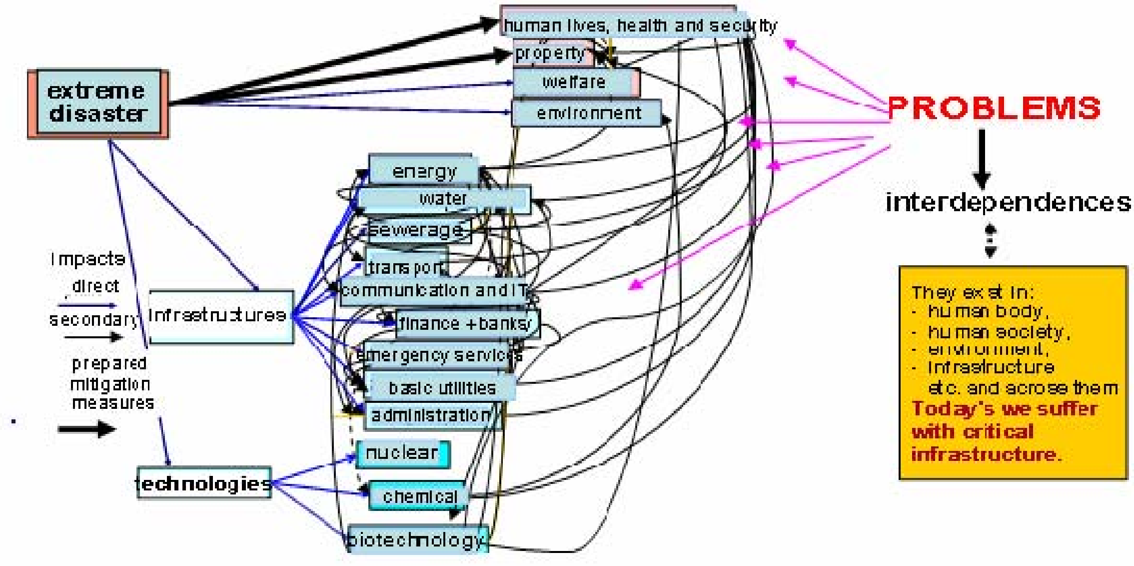


***Fig. 1** Extreme disaster impacts with denotation of impact categories classified according to preparedness of response measures*

The arrows in Figure 1 denote severe disaster impacts that lead to relevant detriments, harms, losses and damages. Bold black ones show relevant impacts, where countermeasures mitigating them are prepared. Dark blue ones show relevant impacts, where there are no the mitigation measures prepared in advance; they are solved ad hoc (welfare, environment, infrastructures and technologies). Thin black ones denote the impacts that have not been systemically solved yet (infrastructures vs. human lives and health, property, environment etc.). These interdependencies in human system escalate as a rule the disaster impacts on human lives, health and security, since they cause secondary impacts and elongate the emergency, i.e. they mean a great danger.

Pursuant to analyses of pieces of knowledge and examples in works [1-3, 6 and 18] it is clear that extreme disasters occur seldom and ate considerably random. In case of their occurrence, the common statistic laws applied to representative data files do not work. It is necessary therefore to take into account historical data [5-13], which are, from the objective reasons, incomplete, inhomogeneous (i.e. their accuracy depends on their size or on time of their occurrence), non-stationary and in addition heavy-laden by odd errors, the distribution function of which cannot usually be determined. In the case of historical data, data from observation, mostly non-instrumental and non-repeatable in sense of data obtained at physical experiments, are at disposal. With regard to it, to judge the dependencies and tendencies among those quantities, it is necessary to strictly distinguish formal mathematic-statistic accuracy of a given operation with data (numbers) and a real result reliability, which depends on the quality of input data set. We e.g. distinguish uncertainties and indeterminateness.

Development methodology for extreme disaster size determination

The analysis performed and quoted in papers [1-3] show that extreme disasters seldom occur. The task dealing with determination of maximum possible or maximum expected disaster [19-21] is of principal importance for both, the safety management and the insurance domain. Therefore, the attention has been paid to this domain for a long time. The methodology development in time progressed in accordance with the knowledge development roughly in this way [13and 19-21]:

- size of the maximum disaster in historical period,
- size of the maximum disaster in historical time + certain correction on the indeterminateness or on the reality that extreme disaster has not had to occur yet. The correction always depended on experience and knowledge of assessor,
- frequency occurrence vs. disaster size curve (mainly its intersection with disaster size axe). Challenges to this method mainly consisted in reality that results of such extreme assessments were physically impossible in some cases,
- methods for extreme value determination [14-17,19-21]. Applications of such method for extreme value determination for earthquakes and other disasters [17] for nuclear power plant site locations are in safety documentation of these power plants and a model example in [6], too.

Example

Development in the field of methodology led to the fact that, e.g. despite the earthquake in the Central Moravia ranging from 4.5° MSK-64 in 1980 up to 7° MSK-64, an industrial plant (industrial buildings and their equipment) has been built, though the intensity of site is 6.5° MSK-64 [8]. From the economic analysis regarding the earthquake it roughly follows that when increasing the resistance against earthquake by about one degree, the financial expenses roughly double.

Ground of methods for extreme values determination

The computation is started from the relationship between the cumulative frequency disaster occurrence and disaster size. In contradiction to common statistics, the summation starts at big disasters (see example of earthquake in [6]).

Starting relation of extreme value theory is the algorithm [17], which determines the probability of disaster occurrence with the I_o size, that is not smaller than disaster with the I_{oi} size in time t

$$\mathbf{R_t (I_o \geq I_{oi}) = 1 - \{T / [\ T + t\ .P\ (I_o \geq I_{oi})]\}^{n+1},}$$

where T is the time period of documented disaster occurrence (i.e. the observation time for disaster), n is the number of observed disasters and P is the function defined by the formula.

$$\mathbf{P\ (I_o \geq I_{oi}) = [\ \exp(-\ \beta\ I_{oi}) - \exp(-\ \beta\ I_{omax})\ ] : [\ \exp(-\ \beta\ I_{omin}) - \exp(-\ \beta\ I_{omax})\ ].}$$

In both formulas, the I_{omin} denotes the smallest disaster size from the disaster catalogue i.e. it determines the database homogeneity limit, the I_{omax} is the maximum possible disaster size in a given area, $I_{omin} \leq I_{oi} \leq I_{omax}$. The β parameter $\beta = b \ln 10$, where b is the slope of the frequency graph $\log N_c = a - b I_{oi}$ and N_c is the cumulative occurrence frequency. In other words $R_t (I_o \geq I_{oi})$, it is probable that the disaster size Io does not exceed the I_{oi} value in time interval t and $P (I_o \geq I_{oi})$ is the probability, that the disaster size I_o exceeds the I_{oi} value [10]. The results are in Figures 2 and 3.

From the example in Fig. 2 (numerical values are in work [10]) it follows that when we take into account earthquake with intensity 8°MSK-64, so we get for the time interval t = 50 years the probability of non-exceedance 0.42704 and only for time interval t = 1000 years the probability is equal to 0.99998 = 1. For earthquake with intensity 9°MSK-64, for time interval t = 50 years we obtain the probability of non-exceedance 0.10355, for time interval t = 100 years the probability of non-exceedance 0.19635 and for time interval t = 1000 years the probability of non-exceedance 0.88661 and only for the time interval t = 10 000 years the probability of non-exceedance is equal to 0.91794, i.e. it is close to 1. The probability of non-exceedance of earthquake intensity 10.5°MSK-64 exceeds the value 0.05 only in time interval of 1000 years.

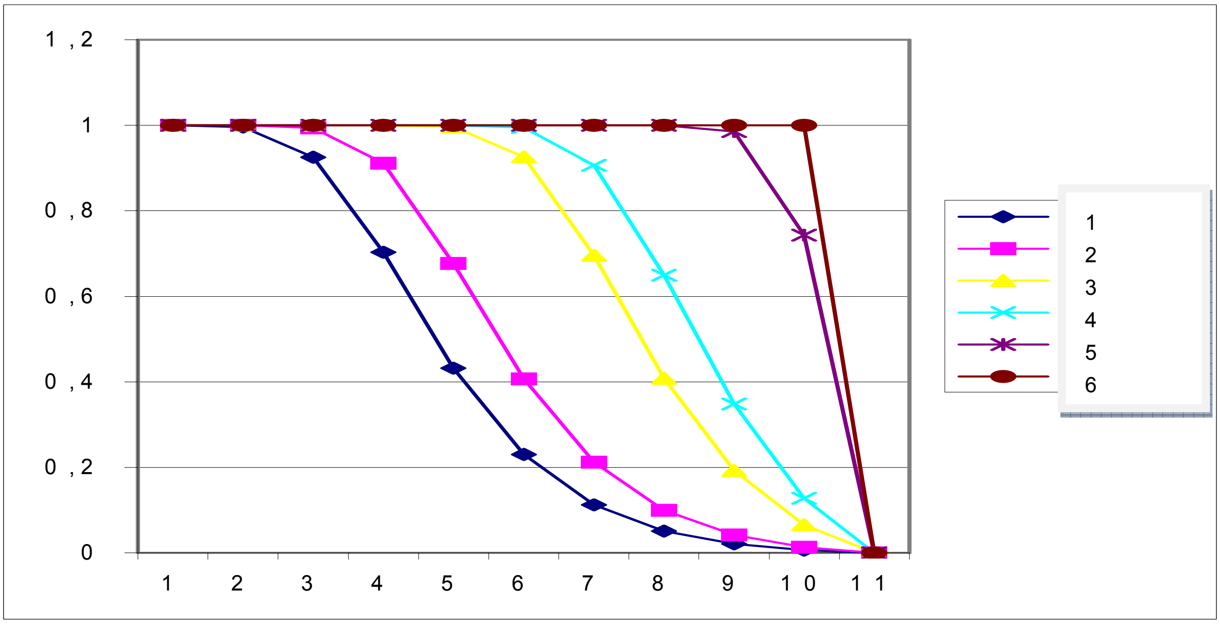


Fig. 2 *Probabilities of earthquake occurrence expressed by curves of non-exceedance R_t $(I_o \geq I_{oi})$ in dependence on time interval length for given site. P – the probability of occurrence of earthquake with intensity I_o and R_t $(I_o \geq I_{oi})$ are probabilities, which mean, that in the time interval t the value I_{oi} will not be exceeded [10]; time 1-50, 2-100, 3-200, 4-500, 5-1000, 6-10000 years*

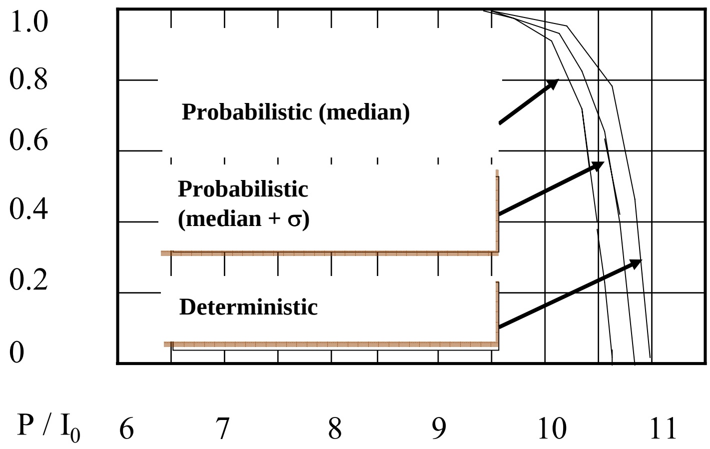


***Fig. 3** Marginal probabilities and median of 81 variants for earthquake occurrence in form of curves of non-exceedance $R_t (I_o \geq I_{oi})$ of given earthquake size in time interval of 10 000 years in given southern Bohemia site [6, 10]*

By help of extreme value theory, we can calculate the return period. It starts from the algorithm given in [17 and 19-21] and from the equation for probable error. Pursuant to it for a given disaster size Ioi the mean return period is τ_i . For each τ_i I = 1, 2, ….n it holds the equation $R_\tau = 0.633$. It means that to one I_o there is one τ value that fulfils given equation. The mean return period for earthquake with intensity I_{oi} is τ_i and every value τ_i for I = 1, 2, ….n is defined by equation $R_{\tau i} = 0.633$ and it is given in Table 1. The Table suggests that for I_{oi} = 9°MSK-64 in region of site under account approximately the mean return period is 460 years. It means that, in the followed site, the earthquake impacts corresponding to intensity 6°MSK-64 will occur once 460 years taking into account the attenuation of earthquake impacts with distance for given case. These impacts cannot damage buildings and equipment respecting the Czech technical norms and standards, because buildings in the CR are built so that they withstand such impacts, while the requirements for nuclear facilities are even much stricter [8 and10].

MEAN RETURN PERIODS τ_i FOR EARTHQUAKE WITH INTENSITY I_{oi} IN SITE REGION [5] Table 1

I_{oi} [°MSK-64]	τ [years]
6	4.20
6.5	9.17
7	19.30
7.5	41.38
8	90.08
8.5	199.76
9	459.33
9.5	1148.33
10	4568.37
10.5	7373.51

Conclusion

The analyses show that natural and other disasters will originate in the human system, because they are an inherent phenomenon of this system. The purpose of sapient human is to adapt to this situation and to create tools for its management, which in other words means to build complex safety contributing to sustainable development of the whole human system. Hazards from natural and other disasters cannot be eliminated, because they are inherent disaster properties, i.e. they constitute the potential of disaster to cause impacts on safeguard interests, harms, damages and losses on property and infrastructure. By reasonable safety management, it is possible to diminish the occurrence frequency of some disasters (e.g. accidents), or it is possible to prevent their undesirable impacts or at least mitigate them.

To ensure the safety and sustainable development, it is necessary to monitor and to evaluate disasters, i.e. to investigate the extreme disaster size, and systematically perform the measures to avert them, and to avert or mitigate their impacts.

References:

[1] PROCHÁZKOVÁ, D. *Teoretický rozbor problému – část 1 a Metodiky 1 – 4*. Odborná zpráva č. 2. Projekt MMR 28/04. Knihovna MMR ČR Praha, 2005.

[2] PROCHÁZKOVÁ, D. Živelné a jiné pohromy. In *Sborník „Požární ochrana 2004"*, (editor: doc. Dr. Ing. Michail Šenovský) CD-ROM. Ostrava: VŠB – Technická univerzita Ostrava, Fakulta bezpečnostního inženýrství. ISBN 80-86634-39-6

[3] PROCHÁZKOVÁ, D. *Řízení pro podporu lidské bezpečnosti a udržitelného rozvoje*. Zpráva pro Ministerstvo vnitra č. 1. CITYPLAN spol. s r.o., Praha, 2005, 350 p.

[4] PROCHÁZKOVÁ, D. *Strategické řízení bezpečnosti a organizace.* Praha: ČVUT, 2011, v tisku, 400 p.

[5] PROCHÁZKOVÁ, D. *Teoretický rozbor problému – část 2, metodiky 5 – 8 a publikovaná sdělení výsledků projektu*. Zpráva č. 3 k projektu 28/04 smlouva, č. WB 28200452, Č.j.: 24512/2004-52, CES 3010. CITYPLAN spol. s r.o. Praha, 2005, 258 s.

[6] PROCHÁZKOVÁ, D. *Seismické inženýrství na prahu třetího tisíciletí*. Monografie. Praha, 2002, 28 s. ISBN 80-238-8661-4

[7] UK: *COMAH Safety Report Assessment Manual*: UK- HID CD2, London, 2002, 570 p.

[8] IAEA: *Safety Guides and Technical Documents*. IAEA, Vienna.

[9] ASCE: *Global Blueprints for Change – Summaries of the Recommendations for Theme A „Living with the Potential for Natural and Environmental Disasters",Summaries of the Recommendations for Theme B „Building to Withstand the Disaster Agents of Natural and Environmental Hazards",Summaries of the Recommendations for Theme C „Learning from and Sharing the Knowledge Gained from Natural and Environmental Disasters*". ASCE, Washington 2001.

[10] PROCHÁZKOVÁ, D. Seismické ohrožení lokality na střední Moravě. In *Bezpečnostní dokumentace pro Energoprůzkum*, s.r.o. Archiv Energoprůzkum. Praha, 2010, 456 s.

[11] KRINITZSKY, E. L., SLEMMONS, D. B. eds: *Neotectonics in Earthquake Evaluation*. Am. Geol. Soc., Boulder 1980, 125 p.

[12] US RG 1.70: *Regulation Guide 1.70.* Revision 3. Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants. LWR Edition, November 1978. Office of Standards Development, U.S. Nuclear Regulatory Commission 1978.
[13] PROCHÁZKOVÁ, D. *Analýza zemětřesení ve Střední Evropě*. Doktorská disertační práce. Praha: GFÚ ČSAV, 1984, 486 s.
[14] EPSTEIN, B., LOMNITZ, C. *A Model for the Ocurrence of Large Earthquakes*. New York: Pergamon Press, 1966.
[15] NORQUIST, J. M. Theory of Largest Values Applied to earthquake Magnitudes. In *Trans. Am. Geoph. Un*., 1945, 26, 29.
[16] GUMBEL, E. *Statistical Theory of Extreme Value and Some Practical Applications*. New York: S. J. Gumbel, 1954.
[17] KIJKO, M. Sellevoll: *Estimation of Earthquake Hazard Parameters for Incomplete Data Files*. Incorporation of Magnitude Uncertainties. Seismolog. Obs. Univ., Bergen, 1988, 1-23.
[18] PROCHÁZKOVÁ, D., ŘÍHA, J. *Krizové řízení*. Praha: MV-GŘ HZS ČR, 2004, 225 s. ISBN 80-86640-30-2
[19] LUCK, P. H. *Schweizer Rueck – Sonderrisiken*. Zuerich: Swiss Re Publishing, 1998, 23 p.
[20] MUELLER, S. et al. *Safety Culture – a Reflection of Risk Awareness*. Zuerich: Swiss Re, 1998, 45 p.
[21] ZIMMERLI, P. *Natural Catastrophes and Reinsurance*. Zurich: Swiss Re, 2003, 46 p.

Reviewers:

Ervin Lumnitzer, Professor, Ph.D. - Department of Environmental Studies and Information Engineering, Faculty of Mechanical Engineering, Technical University in Košice

Ivana Tureková, Assoc. Professor, Ph.D. - Institute of Safety and Environmental Engineering, Faculty of Materials Science and Technology, Slovak University of Technology in Bratislava

RESEARCH PAPERS
FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA
SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

2011 Number 30

STUDENTS RELATIONSHIPS AND TEACHER´S AUTHORITY AS AXIOLOGICAL, ETHICAL, PEDAGOGICAL, SOCIAL AND PSYCHOLOGICAL PROBLEMS

Silvester SAWICKI

Abstract

The paper is focused on the research into the problems of education regarding the relations between students (bullying, competiveness and cooperation) and the decreasing teacher's authority in schools and society. We found that relations between pupils and students of elementary and secondary schools show several negative tendencies including harming each other, reduced rate of mutual sensitivity and preference of rivality to cooperation. Authority of teachers is permanently decreasing not only with pupils and students, but with parents and society, too. Society, parents and students much less value study results and wisdom, and these issues consequently influence the decreasing teacher's status. On the other hand, this behavior leads to decreasing the interest in semantic learning. The roots of these problems can be found in the postmodern crisis of Western culture, associated with severe deficiencies of the political system and market economy as well as one-sided rational orientation of Western society at the expense of the spiritual needs of man.

Key words

education, society, authority, problems, teacher, students, postmodern

Introduction

Educational process at schools has always been and will be closely monitored by society, experts in pedagogy and educational psychology, teachers, students, parents, politicians, sociologists, but also business sector, churches, doctors and so on. Such deep interest is good news on the one hand, since a massive multidisciplinary discourse can bring the quality of ideas, resources and active support, cooperation, but on the other hand, it is also bad news because the broad interests and too many "players in the game" hardly result in acceptable consensus.

Silvester Sawicki, PhDr., MSc., Ph.D. - Institute of Engineering Pedagogy and Humanities, Faculty of Materials Science and Technology in Trnava, Paulinska 16, 917 24 Trnava, Slovak Republic

It is only natural, on the one hand, that on these processes challenge a broad and diverse social discourse which will actually never stop, but on the other hand, we should realize that it is just a lay discourse signalling the feelings and needs of society to the scientist and educators.

Theoretical and cultural context of education

Education and training always have cultural and ideological context. With its scientific, cultural and ideological apects, Pedagogy provides answers to society's needs, which are always culturally and ideologically contingent. It is logical, because education serves mainly to hold the state together and develop it in terms of its ideals and cultural values. Opinions and attitudes of teachers (as well as the other debater) are always theoretically and ideologically grounded in the culture and its values. In recent decades, the Western countries and we have ideologically been under the influence of neo-liberalism, democracy and market economy. Under this approach, we have noticed a tendency to leave education to family, subcultures and multicultural segments of society. The state is, de facto, unwilling to take responsibility for the future generation. The result is that the diversion of increasing values and subcultures results into inadequate social tensions and antagonism. This causes the gradual disintegration of the spirituality with all the consequences, as it can be seen in practice.[1]

The question is, whether to strengthen the philosophy of pupils' individualism, which is the core idea of democracy and market economy. Market economy is successful when it produces a self-centered generation of individuals able to win in competition. Cooperation and a sense of belonging to society of other individuals do not develop wolf-like individuals. On the other hand, cooperation, sense of partnership and prioritization of "we" to "I" creates the pre-conditions for tightening and developing social relationships, which is the foundation of a healthy society. Individualistic and self-centered eneration is inattentive to nature and ecology, as well as to society, state and other people. Such a philosophy in practice, however, leads to the collapse of social relations that are fundamental to the functioning of any human community, not excluding the State. Western society will need to undertake serious and open discourse on this subject, unless it wants to commit its gradual internal disintegration. In the same direction, here is the restoration of ancient issues (dilemmas) of Erich Fromm, "to have" or "to be". Do we want to be more materially rich or spiritually (morally) rich? Clarify the substance of these priorities for schools, because they are preparing future generations. The next generation will be just as good as its education and training. What values, ideas and its virtues are present in it. In Slovakia, yet few are aware of the abovementioned ideological and theoretical context and the related discourse is missing.

[1] This is particularly the decline of values and negation of existing, loss of common goals and motives of self-development, open ideological struggle of different groups (subcultures) Disfunction of social processes and functions of the state and the subsequent apathy in the form of increasing social pathologies - crime, drug and alcohol dependency, gambling, promiscuous and shallow way of life, increased depression, loss of sense of being, suicide and etc.

Research and its results

In the next section, we present the results of our investigations aimed at solving the following problems in the educational process:

1 Relationships among students (bullying, competiveness and cooperation)
2 Decrease in teacher's authority in schools and society.

The research was conducted in the years 2006-2010 via qualitative methodology with a critical focus using the methods of observation, group interviews and critical analysis. The research results were analyzed and compared with quantitative and qualitative research of other authors.

Students' relationships

We found that relationships of students pose a serious problem in our schools. Mainly bullying is common in primary and secondary schools. It severely affects not only the mental health of students, but also the process and results of teaching. Similar findings were achieved by by other researchers.

Bieliková and Bošňáková (2006) in their research conducted in primary and secondary schools noted 21.0% of bullied students. In further research of Havlínová and Kolar (2001), 41% of pupils and students claimed they were bullied. A similar result were reported by Fojtíková, a Czech scientist (45.3% bullied pupils, 2000) and Diaz Kohout, a French scientist (42.3% bullied pupils), who compared the state of bullying in the Czech and French schools. Various studies show the rates of bullying only about 14-15% (Diaz Kohout 2007), which is considered very much in France. Despite these facts, the issue of bullying in Slovakia is being dealt with insufficiently and formally. There is no relevant concept of serious analysis regarding bullying and anti-bullying, which would be binding for all schools, while effectively, sanctioning bullying in particular According to Michele Elliott (1995), the causes of bullying in schools may include: underestimating, ignoring and poosponing arising problems, roots in tensions, authoritarian approach in school education and misconcepts in teaching. We can also supply other indicators such as increasing aggressiveness in the society, global disruption of social relations in society, an emerging need to dominate over the other, uncontrolled concept of education of children in families and schools, mainly due to failure to cope with emotions, too benevolent education, non-acceptance that children should clearly define the boundaries of behavior and punish them for non-compliance and the like. The abovementioned indicates three main factors of bullying:

1 failure to deal with this problem in the Ministry of Education,
2 serious disruptions of relations in society, which is reflected in the education of children in families (cultural aspect),
3 wrong philosophy and practice of educating children both in from families and schools.

Children undoubtedly need to be educated with love, so that to become strong personalities with confident and positive relationships to each other, but unfortunately we forget that[2] in addition the child needs clearly set up standards and limits, strict requirements

[2] Today's neo-liberal times, unfortunately, brings about the naive and harmful ideas that the child should be both limited and punished.

for compliance and effective punishment for non-compliance. Another problem concerning the ethics and values of students' coexistence and relationships concerns the question of rivalry in schools. In this regard, we found that pupils and students prefer competition to cooperation. Similar findings were confirmed by other authors.

Kusá studied eighth-graders and found "... high degree of rivalry is rooted the pupils'shyness and caginess". In her research, there was the lowest rate of friendship motivation (1992, p. 360). Focusing on individual success impedes spontaneous development of cooperative forms of behavior." (Kusa, 1992, p. 362). The researchers also noted that "for most students, the emphasis on the results in the learning process is a negative emotional and stressful factor. Learning and schools are associated especially with a sense of fear of failure" (1992, p.526).

Some degree of rivalry among pupils and students is probably beneficial in the psychological and social context particularly that promotes motivation, assertiveness, self-realization, self-development and positive self-evaluation. However, socio-psychological studies clearly point to the fact that rivalry, especially if it is dominant in the psychological sense, results in the failure, loss of motivation, reduced self-esteem and self-image and self-realization. This leads to frustration, dissatisfaction and other negative psychological and health consequences in social terms; in turn, competitive preference leads to a reduction in pupil's positive relationships, the indifference of another, to the reduction of altruism and social sensitivity and empathy. In other words, it supports the dominance of individualism and self-centeredness and well weakens social ties, social values, social participation, which ultimately leads to inoperable society. This, in our view, necessarily leads to social isolation of individuals (and hence to their overall mental decline) and degradation of social ties, which are most important to everyone in every culture, state and society.

Teacher's authority

The authority of teacher has two fundamental dimensions: the ability of teachers to become an authority, and the pupils and students' willingness to accept authority, respectively. Using critical-interpretative analysis in our research we found that the problem in our primary and secondary schools and universities concerns mainly the second dimension. The problem of teacher authority has several levels. Perhaps the most significant is the postmodern value orientation of the western culture that is characterized by liberalism (impeaching traditional values, moral order), plurality (everyone is entitled to do and get anything), multiculturalism (right to preach any values and ideas) and strengthening individualism. In this socio-cultural-political environment, where everything is relative and everyone is entitled to have their own subculture, no authority can succeed, as the importance and meaning of authority is linked to the mediation and acceptance of values and norms of society as a whole. Reinforcing the idea of individualism associated with the values of democracy and market competition, young people develop the false impression that they are not subordinated to the authority other than their own.

Furthermore, we found that our school students reported decrease of meaningful learning. This is manifested mainly in cognitive learning site, lack of understanding ability textbooks, analyze and apply it in solving practical problems. Problems are also reflected in students' ability to open the new knowledge and develop their knowledge. Thus, we refer to the qualitative aspects of learning.

As for the the ability to be open to new knowledge and develop it, we refer to the qualitative aspects of learning. As a result of reduced acceptance (sometimes non-acceptance) of authorities (teachers, society, parents), self-centralism and liberal philosophy of individualism, ego of today's pupils and students is so large that it has the effect of closing the learning in terms of reluctance to assume the values and knowledge from teachers. Today's students acquire the knowledge and values usually only formally without mastering and acceting them, just to obtain marks (credits) and complete the education. Some students literally believe that they themselves know everything best. Without the authority of teachers and schools, no student can learn semantic knowledge and values mediated by school and society (culture).

M. Slaninka (2009) says: "The teacher has the authority resulting from hi knowledge of the world. This is what addresses his pupil, who is to be introduced into the world freely”.

Slaninka is right, that the world (the internal and external) can be recognised only via the the authority of the teacher (and other real authorities). Bečvař highlights: in conditions of dominating undispicpline, teaching and learning fail. Current schools and teachere do not have effective means of retaining their respect, however. Today a teacher dares not criticise their students without being blamed and endangered by parents and all-powerful media.

Today’s school (primary, secondary) and teachers are clueless in terms of education, values and respect and decency standards by pupils. The current Czech minister of education says that the growing aggressiveness in school and disregard of the teacher authority must be urgently deat with (2010). Diaz Kohout (2007) in her comparative research of school climate in the Czech Republic and France found that indicated strong rawness and aggression against teachers, claimed by 61% of surveyed students and teachers in the Czech schools only 15.2% of surveyed students and teachers in France, where similar behaviour is considered typical. Yet, according to D. Kohout, the Czech school applies punishment quite rarely, as indicated by 36.6% of students surveyed, compared to 57.7% in France. The research confirmed that the low rate of punishment in the Czech Republic is due to the teachers’ effort to avoid conflicts with parents. This idea is supported by Prokop (2003), who explains the context of education in the market environment.

Conclusions

Our research confirmed that the students’ relationship in the elementary and secondary schools show several negative tendencies: harming each other, reduced rate of mutual sensitivity, increased rate of egoism and selfishness, preference of rivality to cooperation. Authority of teachers keeps decreasing, not only with pupils and students, but with parents and society, too. Society, parents and students do not value learning results and wisdom, and these issues consequently influence the decreasing teacher status, which leads to the decreased students’ interest in semantic learning. Learning is becoming more formal and superficial, and teachers cannot stop this trend. The current situation is rooted in cultural, political and economical phenomena of the market economy and one-way rational preference of western culture to the spiritual dimension and people’s needs. Low social status of teachers is due to the low moral and financial evaluation of the teacher in society. The value of education has sbeen degraded.

Possible improvement in the above-mentioned trends may be due to the change of axiological, ethical and rational-material priorities of today's postmodern western society. These changes may be feasible only when the whole society is convinced about the important role of school education and training objectives.

References:

[1] BIELIKOVÁ, M., BOŠŇÁKOVÁ, M. Šikanovanie žiakov v základných a stredných školách. In *Prevencia*, 2006, Roč. 5, č.1.

[2] ELLIOT, M. *Jak ochránit své dítě*. Praha: Portál, 1995.

[3] FOJTÍKOVÁ, M. Nebezpečná epidemie. Cyklus o šikaně s dr. Kolářem. In *Rodina a škola*, 2000, 12, č. 3.

[4] GÁLIK, S. *Duchovný rozmer krízy súčasného človeka.* Brataislava: Iris, 2010.

[5] HAVLÍNOVÁ, M., KOLÁŘ, M. Sociální klima v prostředí základních škol České republiky. Praha: M©MT ÈR, 2001.

[6] KOHOUT DIAZ, M. Klima a násilí v českých školách: neslušné chování žáků vůči učitelům. In *Pedagogická orientace* 2007, č. 2, s. 47, 52. ISSN 1211-4669

[7] DOBEŠ, J. Učitelé budou moci trestat děti. In *Lidové noviny*, 19.července 2010.

[8] KUSÁ, D. Školská úspešnosť a súperivé správanie žiakov. In *Pedagogická revue*, 1992, 44, č. 5, s. 356-363.

[9] OLWEUS, D. *Gewalt in der Schule*. Bern, Göttingen, Toronto 1997, Seatle, Hans Huber.

[10] PROKOP, J. Kritika a mýty současné školy. In *Chráska, M., Tomanová, D., Holoušová, D. (Ed.) Klima současné české školy*. Brno: Konvoj, 2003, s. 46, 62.

[11] SLANINKA, M. *Učiteľ ako autorita, autorita ako učiteľ.* Paideia: philosophical e-journal of charles university, Issue/Volume/Year: 3–4/VI/2009 ISSN 1214-8725

[12] RAJSKÝ, A. *Nihilistický kontext kultivácie mladého človeka. Filozoficko-etický pohľad*. Bratislava: Veda, 2009.

[13] VALIŠOVÁ, A. *Autorita ve výchově:vzestup, pád, nebo pomalý návrat*. Praha, 1999.

[14] WEDLICHOVÁ, I. Poruchy osobnosti a chování. In *Kol.: Vybrané psychologické aspekty terénní sociální práce*. Ústí nad Labem: Acta UP, 2006.

Reviewers:

Slavomír Gálik, Professor, Ph.D. - Faculty of Philosophy of UKF, Nitra
Andrej Rajský, Assoc. Professor, Ph.D. – Faculty of Pedagogy, University of Trnava, Trnava

RESEARCH PAPERS
FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA
SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

2011 Number 30

EVENT PROCESSING AND VARIABLE PART OF SAMPLE PERIOD DETERMINING IN COMBINED SYSTEMS USING GA

Maximilián STRÉMY[1], Pavol ZÁVACKÝ[2], Martin JEDLIČKA[3]

Abstract

This article deals with combined dynamic systems and usage of modern techniques in dealing with these systems, focusing particularly on sampling period design, cyclic processing tasks and related processing algorithms in the combined event management systems using genetic algorithms.

Key words

events, sample period, genetic algorithms, combined dynamic systems

Purpose of the article

This article deals with combined dynamic systems and usage of modern techniques in dealing with these systems, focusing mainly on sampling period design, cyclic processing tasks and related processing of the control algorithms in the combined control dynamic systems using genetic algorithms.

Combined dynamic systems

The fusion result of time-driven and event activated systems are combined dynamic systems, called also hybrid systems. Since the notion "hybrid system" is used also in connection e.g. between distributed control system and programmable logical controllers, neural networks, genetic algorithms and fuzzy logics, or in combination of electric and

[1] Maximilián Strémy, Ph.D. – Institute of Applied Informatics, Automation and Mathematic, Faculty of Materials Science and Technology, Slovak University of Technology Bratislava, Hajdóczyho 1, 917 24 Trnava, Slovak Republic, e-mail: maximilian.stremy@stuba.sk
[2] Pavol Závacký, Ph.D. – Division of Communication and Information Systems, Faculty of Materials Science and Technology, Slovak University of Technology Bratislava, Paulínska 16, 917 24 Trnava, Slovak Republic, e-mail: pavol.zavacky@stuba.sk
[3] Martin Jedlička, Ph.D. – University of SS, Cyril and Methodius in Trnava, nám.Jozefa Herdu 2, 917 01 Trnava

mechanical power units, the concept of "combined dynamic system" was introduced in order to better predict and better identify the time-driven and event activated systems.

If the change is dependent on events occurring at discrete time moments, we talk about discrete event dynamic systems. In case the conditions change is dependent from periodic processing, monitoring and system evaluation in discrete time moments, we talk about discrete time-driven systems. Since it is management of real time systems, it is very important to set up right sampling time. By time-driven systems, events are processed through cyclic monitoring, processing and evaluating inputs and system states. In discrete event dynamic systems, this part is implemented by calling internal interrupts by occurrence of any event. Given the sampling period, we classify combined dynamic systems into two groups:

a) Constant sampling time – by setting up, it is necessary to determine the ratio of event component T_P and time-driven system component T_R.
b) With varying sampling time – it is necessary to determine the impact, respectively relationship between T_R a T_P.

Dynamic control system works with sampling time T_0 (of cycle processing), corresponding to Shannon-Kotelnik theorem of time, needed to process all processes in each cycle of execution.

Generally in dynamic systems, sampling period T_0 is considered constant and includes only time T_R processing of all necessary control and cyclically recurring processes in the system. On the other hand, combined dynamic systems means a sampling period, no matter whether constant or varying, enlarged of event time constant T_P, needed to carry out random events in the system.

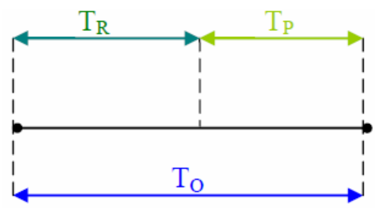


Fig. 1 *Sampling time T_0*

To determine the time T_P, and in order to carry out servicing routines of random events in the cycle, I used statistical evaluation of emerging events and their probability estimate, and determined the most probable time constant T_P, using one of the probability distribution.

Generally, we may suppose that time T_A needed to process all events in a combined dynamic system is [1]:

1. $T_A<T_0$ – less then total sampling period T_0, while
   a) $T_R>>T_A$ – constant of time-driven system T_R is much bigger than time needed to process all events T_A, then this time T_A is negligible,
   b) $T_R \approx T_A$ – constant of time-driven system T_R is approximately equal to time needed for processing all events T_A,
   c) $T_R << T_A$ – time T_A needed to process all events is much bigger then constant T_R of time-driven system.

2. $T_A > T_0$ – is much bigger then total sampling period, than minimal number of steps K_{min} needed to carry out services; it is determined by the equation $K_{min} \geq T_A/T_P$, or $T_P = T_A/K_{min}$, while $T_A = T_{A1} + T_{A2} + ... + T_{AK}$.

According to the abovementioned approach, the total time needed to carry out all servicing routines lies in the number of cycles according to the value of step K_{min}.

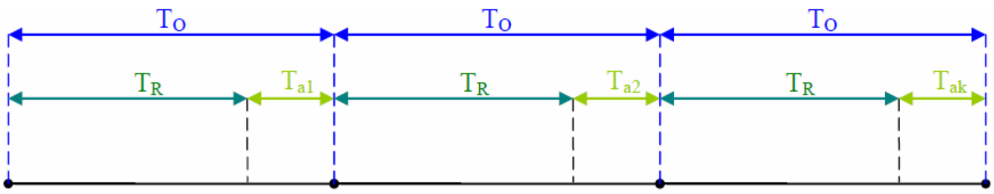


Fig. 2 *Decomposition of T_A into several steps with respect to T_P*

This article describes an appropriate part of control algorithm that can process generated events and also determine which of the events will be processed in a given cycle and which ones in the next cycle according to the rules based on GA. This is important when sum of times needed to process all events in the system is bigger than value T_0 and we need minimum steps K_{min}. In this case, it is necessary to select those events which should be processed in the current cycle time, and to process as many events as possible in the specified time.

Genetic algorithms

Algorithm begins with solving group (represented by chromosomes) also called population. Solutions from one population are selected and used to create the new population. This is motivated by the fact that new population will be better that the old one. Solutions, which are later selected to form a new population, are selected on the basis of their suitability. The more convenient they are, the greater the likelihood of reproduction. This is repeated until the fulfilment of any conditions. Flowchart of GA is illustrated in the following Figure:

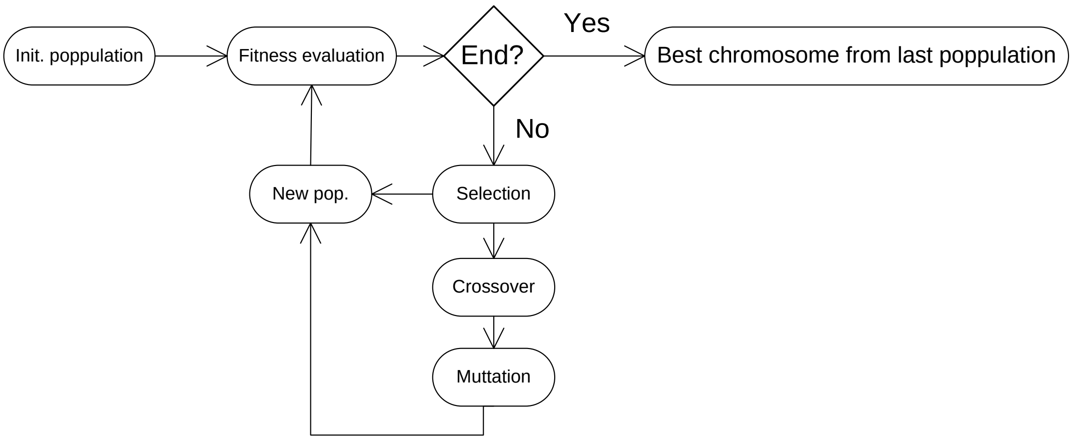


Fig. 3 *Flowchart of GA*

The idea is to select better parents in the hope that better parents will create better offspring. The process of natural evolution is simple, but very powerful and robust, universally valid for simple and complex. There is no feedback to it. The organisms are able to get out of the local extremes and move to global optima. Searching is carried out simultaneously in several directions. They do not need information on the development of solutions such as gradient of objective function [2]. They want only to assess the objective function at each point area [3]. They are able to solve optimization problems with hundreds of variables within the most challenging time solutions.

Genetic algorithm in control algorithm

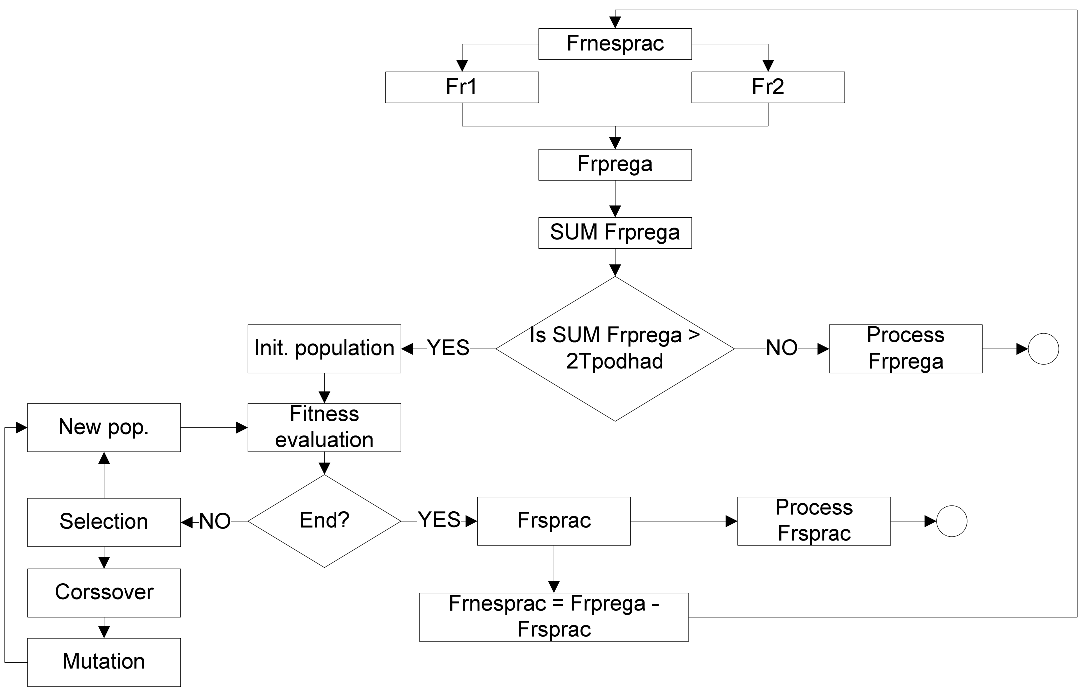


Fig. 4 *Flowchart of GA, part of draft algorithm*

The proposed algorithm uses two main queues (F_{r1} and F_{r2}) to which emerging events are collected [1]. In actually inactive queue, there are events which occur in the system and should be processed in the next cycle.

In actually active queue, accumulated events are processed. The choice of the event to be processed is based on the genetic algorithm. It is necessary for the 1st population to create a queue with the events from actually an active queue, and events which were not processed before by the GA. Given that the algorithm is a variant designed to perform all statistical forecast of the events in the system, the maximum sampling period is determined by the equation:

$$T_{0max} = T_R + 2T_{Podhad} . \quad (1)$$

Queue F_{rprega} contains all the raw events from the previous cycle, and all events of the currently active event queue, regardless of whether the time required to perform all the abovementioned events is bigger or smaller then $2T_{Podhad}$. When the switch between active and inactive queues comes on, this queue is read-out and processed by the genetic algorithm.

Before the GA processing occurs, sum of all individual times required for processing the events is created. If the sum is less than $2T_{Podhad}$, queue F_{rsprac} is automatically filled and the events in the queue are processed. If the sum is more than $2T_{Podhad}$, it is necessary to select the events with GA, which should be processed. The main goal is to process as many events from the queue F_{rprega} as possible in maximum time $2T_{Podhad}$.

This means that each chromosome is a solution, and each gene in chromosome is one event, respectively the time required for its processing. Lengths of chromosomes are generated randomly, and also events occurring in different genes are generated randomly. The fitness function will be applied to evaluate the new chromosomes:

$$fitness = \frac{number\ of\ genes\ in\ chromosome}{\sum time\ in\ each\ gene} \cdot 100\% \tag{2}$$

The fitness function was chosen on the basis that our aim is to handle the largest number of events in the shortest time, but not longer than $2T_{Podhad}$. The function comprises also an integrated classification to order the events from the view of the time requirements - from the largest to the smallest – while using genetic operations like selection, crossover and mutation. The selection will be based on elitism, the set % of the best individuals will be automatically transferred to the next generation. Applying crossover operations, two situations can occur:

- one event in chromosome can occur multiple times,
- one event in chromosome can occur only once.

By genetic operation mutation, we will mutate individual chromosomes in a way that we add or remove genes in each chromosome. If total length of chromosome is not bigger then $2T_{Podhad}$, we will add random event; on the other hand, if it is bigger than $2T_{Podhad}$, we will remove unnecessary genes.

Thus after a set number of generations, the chromosome which best suits our needs and individual events contained in this chromosome will be placed in queue F_{rsprac} to be processed. Raw events are transferred to the queue $F_{rnesprac}$ which will be included once again in the queue of events F_{rprega} to start. If the queue $F_{rnesprac}$ is empty, the whole cycle of the algorithm is processed, but if this front is not empty, the value Count is set-up. If this value Count is bigger than the declared value N, redetermination of time event component T_{Podhad} occurs and sets a new sampling period of the controller. The actual value of the sampling period in this control process is fully dependent on the number of generated events in the system and related service routines.

Conclusions

The proposed control algorithm part of combined dynamic systems should be tested. Testing and simulation of the proposed algorithm will be made in Matlab / Simulink and the toolboxes SimEvents for generating stochastic events in random times and GAToolBox for operations with genetic algorithm. It is necessary to determine how many populations are needed to find a suitable solution, and it is also necessary to test the overall functionality and accuracy of the proposed solutions. The solution presents a new approach to organizing the combined event dynamic systems, since the algorithm handles all the events generated in the system, when time needed to their processing is not bigger than the allowed time to process all stochastic generated events in the system and to avoid undesirable conditions such as rejection or failure events, which could lead to emergency situations.

References:

[1] STRÉMY, M. *Combined discrete dynamic systems*. Trnava: AlumniPress, 2010. ISBN 978-80-8096-113-8

[2] HURAJ L., SILÁDI, V. Authorization through Trust Chains in Ad hoc Grids. In *Proceedings of the 4th ACM EATIS annual international conference on Telematics and Informatics: New Opportunities to increase Digital Citizenship (EATIS '09)*. Prague: 2009, pp. 68-71. ISBN 978-1-60558-398-3

[3] TANUŠKA, P. et al. The Proposal of Step Stress Testing Automation. In *International Journal of Computer Theory and Engineering*, 2010, Vol. 2, No 6, p. 860. ISSN 1793-8201

Reviewers:

Pavol Tanuška, Assoc. Professor, Ph.D. - Institute of Applied Informatics, Automation and Mathematic, Faculty of Materials Science and Technology, Slovak University of Technology Bratislava

Anton Kachaňák, Assoc. Professor, Ph.D. – Faculty of Machining, Slovak University of Technology Bratislava

RESEARCH PAPERS
FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA
SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

2011 Number 30

FIVE YEARS OF RESEARCH INTO TECHNOLOGY-ENHANCED LEARNING AT THE FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY

Štefan SVETSKÝ, Oliver MORAVČÍK, Dagmar RUSKOVÁ, Karol BALOG, Peter SAKÁL, Pavol TANUŠKA

Abstract

The article describes a five-year period of Technology Enhanced Learning (TEL) implementation at the Faculty of Materials Science and Technology (MTF) in Trnava. It is a part of the challenges put forward by the 7th Framework Programme (ICT research in FP7) focused on "how information and communication technologies can be used to support learning and teaching". The empirical research during the years 2006-2008 was focused on technology–driven support of teaching, i. e. the development of VLE (Virtual Learning Environment) and the development of database applications such as instruments developed simultaneously with the information support of the project, and tested and applied directly in the teaching of bachelor students.

During this period, the MTF also participated in the administration of the FP7 KEPLER project proposal in the international consortium of 20 participants. In the following period of 2009-2010, the concept of educational activities automation systematically began to develop. Within this concept, the idea originated to develop a universal multi-purpose system BIKE based on the batch processing knowledge paradigm. This allowed to focus more on educational approach, i.e. TEL educational-driven and to finish the programming of the Internet application - network for feedback (communication between teachers and students). Thanks to this specialization, the results of applications in the teaching at MTF could gradually be presented at the international conferences focused on computer-enhanced engineering education. TEL was implemented at a detached workplace and four institutes involving more than 600 students-bachelors and teachers of technical subjects. Four study programmes were supported, including technical English language. Altogether, the results *have been presented via 16 articles in five countries, including the EU level (IGIP-SEFI).*

Štefan Svetský, Ph.D. - Detached workplace Dubnica n.V., Oliver Moravčík, Professor, Dr. - dean of FMST, Dagmar Rusková, Ph.D. - Institute of Engineering Pedagogy and Humanities, Karol Balog, Professor, Ph.D. - Institute of Safety and Environmental Engineering, Peter Sakál, Professor, Ph.D. - Institute of Industrial Engineering, Management and Quality, Pavol Tanuška, Assoc. Professor, Ph.D - Institute of Applied Informatics, Automation and Mathematics, Faculty of Materials Science and Technology, Slovak University of Technology Bratislava, Paulínska 16, 917 24 Trnava, Slovak Republic, e-mail: stefan.svetsky@stuba.sk, oliver.moravcik@stuba.sk, dagmar.ruskova@stuba.sk, karol.balog@stuba.sk, peter.sakal@stuba.sk, pavol.tanuška@stuba.sk

Key words

Technology Enhanced Learning, Computer Assisted Learning, Batch Knowledge Processing

Introduction

The beginning of TEL development is linked with teaching at the detached workplace in Dubnica nad Váhom in the period of the Slovak Republic's EU-accession. It was necessary that time to incorporate the new EU environmental legislation, as well as the legislation for occupational hygiene and safety into the bachelor study programmes. For these purposes, the database application "Zápisnik" (Writing Pad) was used. It was proven in industry to promote technological activities. The application was used to produce additional electronic textbooks for courses of Introduction to Environmental Science, Occupational Health and Safety and Final Semester Projects. Course materials were prepared in two versions - for use on personal computers, and on the Internet for online environment. Students who did not have Internet access at home were thus able to access the information via the use of USB keys containing e-textbooks which could be then viewed on their home computers.

The database application called "Zápisník" was originally programmed to work with the *data.* The university modification of this program was needed in order to work with *information* and *knowledge*. For these purposes, in the first phase of the program, the *Virtual Learning Environment* (VLE) started, providing enough informatics tools for off-line and on-line teaching support. As a model of systematic technology enhanced learning support, *Mayes conceptualization cycle* was used. All these activities were presented at the eLearning Conference ICETA 2007-2008 [1, 2]. The training materials developed were also presented.

A breakthrough in the further development of TEL was the invitation to the international consortium of twenty partners, which was connected with the Partner Search brought to the Brokerage event in Warsaw [3]. MTF participated in the project proposal of the "*Knowledge Enhanced Proactive Learning Library*" (KEPLER) within the FP7-IST call "*Digital libraries and technology-enhanced learning*" [4]. One of the tasks of the MTF was the *batch processing* of "*knowledge keywords*" according to technical standards and classifications. Although the project was not accepted, MTF started a systematic research of TEL, based on the strategy of *knowledge automation* as an essential element that defines teaching and learning, respectively, acting in educational theories. From the informatics aspect, this resulted in programming the editor for *batch processing of information and knowledge* (BIKE - Batch Information and Knowledge Editor). With the help of this system, several applications in education described below were carried out.

Principles of technology enhanced learning

In real life, a teacher simultaneously needs to perform a large number of sub-educational, administrative and other activities. Moreover, this relates to various *professional contents*, different *pedagogical approaches* and *teaching concepts*. This variability and diversity of the human mind and mental processes makes the technology support very complicated. In terms of computer support (enhancements), the problem is the fact that teachers and students work with *unstructured* information and knowledge.

Another problem is that there is *no universal informatics format*, and a specific problem is *how to concentrate the large amounts of specialized content in a small screen area* while the number of possible solutions and further outputs is increasing enormously. In other words, software algorithms must be written for data, information and procedures that are *not fixed in advance*, i.e. are *variable* and usually *unknown* at that time. This is the fundamental difference, when compared e.g. to writing programs for accounting, where accurate structures, procedures and calculations are stated by the legislation.

Current approaches to the application of digital technologies for learning

Technology enhanced learning is, of course, complicated because it is an interdisciplinary field. Education has its own *distinct content* (curriculum, course of study, syllabus, engineering content) and its *educational* and *teaching practices* taking place in *real environment* (class, teaching space, library). The digital technology has its own *Internet and communication technologies* and *informatics tools* (hardware, software, and the Internet).

Success or effectiveness of technology-enhanced learning always depends on the alignment of education and technology (informatics) components, i.e. on *integrating informatics tools in learning activities*. Unfortunately, computers were not invented for education, so this area represents a major challenge for the Internet and communication technologies. The relationship between *education, digital technology, technology-enhanced learning* and *learning (educational) activities* is shown schematically in Fig. 1.

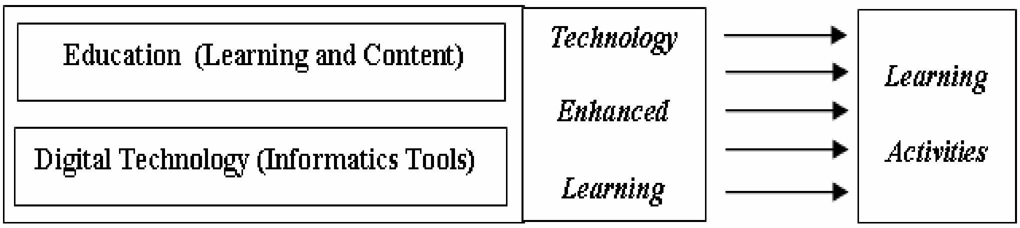


Fig. 1 *Principle of interplay between the educational component and informatics tools for TEL*

For these reasons, the technological support has undergone several stages. The related terms are such as *Computer aided instructions* (CAI), or attributes like *computer assisted / based / aided / supported learning.*

In the EU research programs, the 7th Framework Program in particular, this topic which is now called *Technology Enhanced Learning* (TEL) dominates [5]. Its definition is very broad, because it "*refers to the support of any learning activity through technology*". Deferring from that of eLearning, TEL usually confuses many people. According to Wikipedia [6] and Answers.com [7], *learning activities* can be described in terms of the *learning resource, actions, context, roles, and learning objectives*. The focus in TEL is on the *interplay* between these *activities* and respective *technologies*. *Learning management systems* (LMS), *learning content management systems* (LCMS), *learning repositories* or *managing the learning process of learners with technical means* (e.g., tools for self-directed learning, etc.) shall be appointed as *technological tools for TEL* allowing the access from educational resources to systems.

This informative description suggests that it is a preferred *technology-driven* approach even though it mentions that learning activities "*can follow different pedagogical approaches and didactic concepts*". The above-mentioned requirement of the alignment of education and technology (informatics) parts is disrupted because *technology-driven* approach is superior to the *educational-driven* approach. This fact has been recently criticized in several scientific publications stressing that the educational-driven approach should be prioritised [8, 9, 10]. This stems from the fact that teacher, and not a computer, plays a key role in the learning process.

Technology-enhanced learning approach at MTF

The basis of the theoretical outcome for the TEL approach at MTF is the idea presented at the Brockerage event in Warsaw, where MTF was looking for a project leader support [3]. This idea is based on the needs of the practitioners involved in *research* and *development* or *working with information and knowledge*, denoted as "*R&D staff*" including *researchers, teachers, librarians and students* who, in their daily practice, perform various activities requiring the processing of large amounts of knowledge and dynamic information flow. This is why "they should be equipped with information tools (digital technology) just as today's soldiers are armed with high-tech".

It should be noted that learning activities performed by teachers are much larger than those placed on the sites for TEL, i.e. as mentioned in the previous section [Cordis/ICT, Wikipedia, Answers.com]. Being a teacher, one must *study* the case itself to know how to *explain it well* and to be able to *create* a *well-construction* of *new knowledge*. Teachers at universities are also required to *publish, deal with projects, correct and mark tests, handle administration matters, communicate* with AIS (university LCMS) and alike. The TEL approach is thus based on the fact that all these activities *should be automated,* and digital technology is a *teacher's* "*partner*". In optimum cases, teacher or user needs *one universal software* that automates *everything what is possible* at the given time and space,. Such an "*all-in-one*" system was developed in the period of 2007-2010 and tested in teaching bachelor students. The working version of this system or rather the universal database application is named *BIKE* (Batch Information and Knowledge Editor). As its title suggests, it allows bulk work with information and knowledge, what IT scientists call "*batch processing*". The paradigm of work is described more closely in [12, 13]. If we correctly understand Saljö [11], the BIKE can be categorisedas so called "*Mindware*" group, i.e. software is "*linked with our body and mind*".

In principle, the BIKE editor works so that the knowledge is defined in the "informatics way" allowing the *concentration of information and knowledge at a given time and space* and is used according to the *instant need* of a certain *activity carried out* by a teacher or student. This *activity* may involve *designing* educational materials, *teaching* in a classroom with computers, *creating* eLearning configurations, *conducting* Internet retrieval, *managing the* knowledge, *marking* tests, etc. This "*bottom up*" method of work takes the user as an individual, encouraging one's mental activities such as *knowledge structures, knowledge retention, repetition and decision-making*. Thus, the software is versatile and can do what otherwise would have to be done with dozens of current software packages. With some exaggeration we can say that it works "like a chip" connected to our brain. According to current theories of learning approaches, it acts as a social memory of an individual (teacher, student, and customer) [11]. Such an approach to the application of digital technology in education is in a very good compliance with the learning theories, both based on simple *behaviourism* or *cognitive* and *constructive* approaches. This compliance is assured by the possibility to create knowledge structures, while knowledge is constructed by using optional menu of BIKE. It only up to the user if he performs "simple things", creates sophisticated knowledge, or knowledge clusters on his computer.

It should be noted that computers were not developed to educate and most of common approaches are *mechanically applied* to support teaching and learning. However, the TEL approach based on the BIKE editor is being developed and tailor-made for individuals who work with knowledge. It does not handle new algorithms or semantic structures, but it uses the power of existing database technologies and common programming. The TEL approach at the MTF is based on *empirical* research coming out of the fact that the matters are dealt directly in teaching and technology is adapted to what one needs in a certain (educational / learning) situation. This approach thus respects the synergy of teaching content (e.g. engineering curricula), educational activities and technologies as shown in Fig. 1. The key feature in the educational process is either *teacher* (teacher-centred process) or *student* (student-centred process) and the technology is *integrated into their activities* according to how they run it and not vice versa.

Such understanding and implementation of TEL approach allows the functions to be used as technology support for all possible types of learning e.g. *self-directed learning, distance learning, blended learning, active learning and life-long learning*, ... (some applications are described below). Therefore, the BIKE editor can be used for various specific purposes and can be further developed as a *"never-ending story*". Although BIKE is characterized in this paper as a tool/software for TEL, it can be included in the category of software for so called TPACK framework [14, 15] – it is a complex interplay of three primary forms of knowledge: Technology (T), Pedagogy (P) and (A) Content (C) Knowledge (K).

Applications of technology-enhanced learning at the MTF

As mentioned above, in the initial phase of implementing TEL at the MTF, the *technology - driven* approach predominated due to the fact that it was first necessary to develop a set of information tools the teacher can choose from according to particular learning activity. In this stage, the activities were focused on the development of a knowledge base, i.e. on generating educational materials in the form of html files. These were placed in computers in classrooms and on the Internet. Gradually, as the programming environment of BIKE was growing, other types of programs have been applied to enhance blended learning, active learning, language support, batch Internet retrieving, creating a virtual library and interactive and self-evaluation tests [16-20]. At this stage, the *educational-driven* approach begun to dominate, where the teacher decides what is needed to support the daily activities.

Figure 2 shows some examples of computer screen output from teaching the subject of Introduction to Environmental Science. The Figure shows that the set of educational materials includes various types of educational output elements (navigational template for entering the e-textbooks, a sample of written semester paper, the scheme for photosynthesis, an explanation of pH, and photos of matriculation). During this time, students cannot recognize whether it is a link from the Internet, home computer or the MTF server.

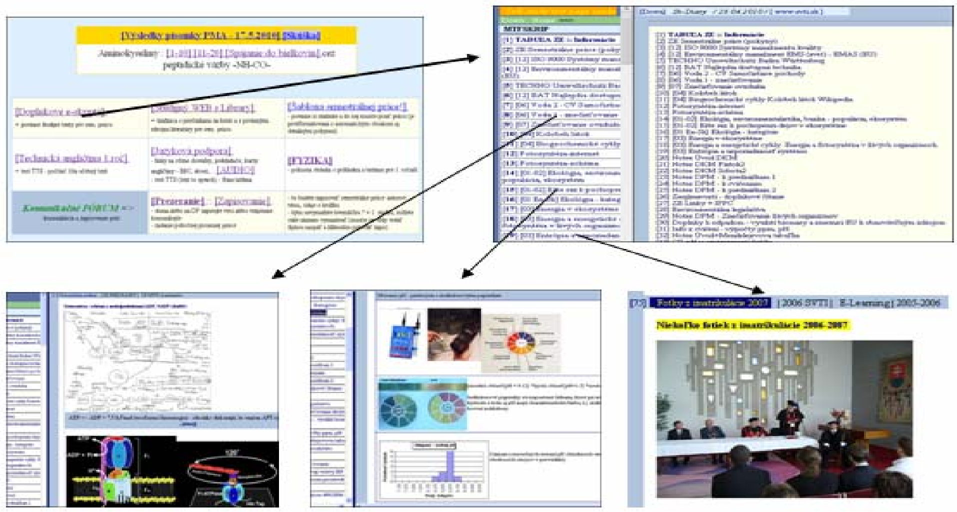


***Fig. 2** Sample of technological support for teaching the subject - Introduction into Environmental Science*

Fig. 3 shows an example of modelling a study-room for Blended Learning with pop up menu (see output to manual for semester project and a study area in the classroom).

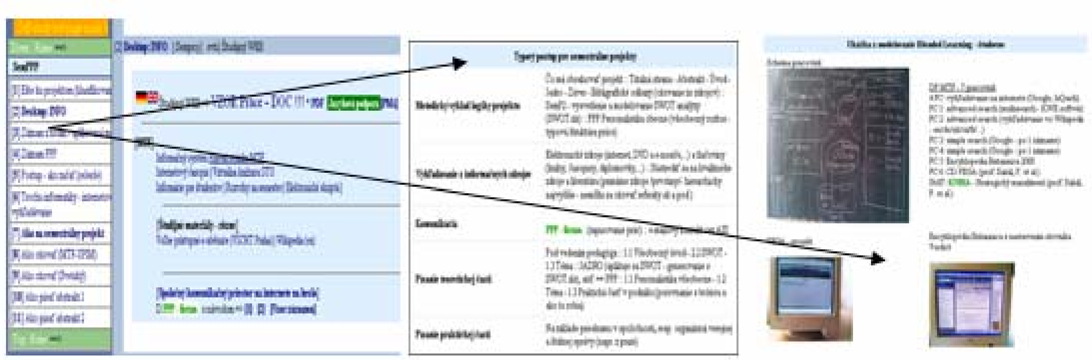


***Fig. 3** Example of modelling the study- room for Blended learning for semester project (Svetský, Sakál)*

A breakthrough in the implementation of TEL at the MTF was collaboration with the language department (Reháková and Rusková). In phase 1, a universal support site containing the links to language translators, dictionaries, the BBC course of Slovak Radio, model sentences with prepositions used in technical German and sample sentences for writing English and German abstracts for term papers and projects were developed [21, 22]. Phase 2 was cooperation with external software for Text-To-Speech (the machine says the English written text) which supported the teaching of technical English [23, 24].

Fig. 4 illustrates a popup menu which is displayed when you click on multilingual translators Google (left), Systran (centre), and scanned passive sentences (right) from the book ”Angličtina pre vedeckých pracovníkov - Dušeková, L., Bubeníková, L., 1971”.

Fig. 4 *Sample of technology-enhanced multilingualism*

Conclusion

The article presents the history of five-year implementation of *technology-enhanced learning* at the Faculty of Materials Science and Technology. The principles of technology-enhanced education from the point of current approaches in the world and TEL approach at MTF are explained. The Application of digital technologies for learning requires the alignment of *technology* (ICT tools) and the *educational component* (content of knowledge). The TEL approach chosen at MTF solves this issue by developing its own software - BIKE programming environment, which serves as a tool to automate the processing of knowledge to all possible kinds of learning activities that are undertaken.

The state-of-the-art in TEL is characterized by technology-driven approach. It is characterized by top-down testing of the approved software fit for education by assuming a universal indefinite content. The TEL approach at MTF comes out directly from the nature of knowledge as an essential element of education and is based also on educational theories and the fact that knowledge, respectively its structures, are not only managed but also created and constructed (they are transmitted e.g. via instructions from the tutor to the student). From an informatics point of view, it is solved on the basis of the paradigm of the batch processing of a knowledge flow concentrated in a certain time and space (class, virtual learning space). From a pedagogical point of view, information and knowledge are processed especially for conditions of blended and active learning, but also for self-directed and informal learning.

This TEL approach allowed the universal use of the database BIKE application in several study programmes, including language (see the preview of applications). As a technological enhancement, it has so far brought benefit to over 600 students from several MTF institutes. The results of the TEL approach in teaching were presented in 16 publications in Slovakia and abroad (Europe, North and South America, Australia). The further development aims to support more sophisticated educational applications, which will require new approaches and the programming of further textbooks, together with their verification in teaching (these are partially elaborated, e.g. advanced search, natural text marking, batch processing of chemistry calculations and social mini-network with retrievals for undergraduates).

References:

[1] SVETSKY, S. Modelling of Multilingual e-Learning and Virtual Learning space for R&D Staff. In *ICETA 2007 : 5th Int. Conference on Emerging e-Learning Technologies and Applications*. Košice: Elfa, 2007, pp. 1-4. ISBN 978-80-8086-061-5

[2] SVETSKY, S., MORAVCIK, O., TANUSKA, P., REHAKOVA, A., RUSKOVA, A. Modelling of Multilingual e-Learning and Virtual Learning space for R&D Staff. In *ICETA 2008 : 6th International Conference on Emerging e-Learning Technologies and Applications*. Košice: Elfa, 2008, p. 347. ISBN 978-80-8086-089-9

[3] SVETSKY, Š. *Multilingual self-E-learning in support of sustainability*. Online. ATVN-EU-GP-Warszaw [cit. 2011-02-15]. Available at <http://www.atvn-eugp.pl/broker/resource/ stefan_svetsky.pdf>.

[4] SVETSKÝ, Š, MORAVČÍK, O., TANUŠKA, P., SCHREIBER, P., ŠUJANOVÁ, J. *Vedomosťami podporované vzdelávanie v e-aktívnych knižniciach : Záverečná správa k prípravnému projektu 7. rámcového programu APVV - PP7RP-0054-09*. Trnava: MTF STU, 2009.

[5] TeLearn - European research on technology-enhanced learning [online]. ICT Research in FP7 - Challenge 8: ICT for Learning and Access to Cultural Resources. [cit. 2011-02-15] Available at <http://cordis.europa.eu/fp7/ict/telearn-digicult/telearn_en.html>.

[6] Technology-enhanced learning [online]. From Wikipedia, the free encyclopedia [cit. 2011-01-11]. Available at < http://en.wikipedia.org/wiki/Technology-Enhanced_Learning>

[7] Technology-enhanced learning [online]. Answers.com® [cit. 2011-01-11] Available at <http://www.answers.com/topic/technology-enhanced-learning#ixzz1D1tPmHuD>**.**

[8] Laurillard, D. (2008), Technology Enhanced Learning as a Tool for Pedagogical Innovation. Journal of Philosophy of Education, 42: 521–533. doi: 10.1111/j.1467-9752.2008.00658.x

[9] VUORIKARI, R., BERENDT, B. *Study on contexts in tracking usage and attention metadata in the field of multilingual Technology Enhanced Learning*. [online]. Portál people.cs.kuleuven.be. [cit. 2011-01-11]. Available at <http://people.cs.kuleuven.be/~bettina.berendt/Papers/TEL_context_attention_vuorikari_berendt.pdf>.

[10] DERRY, J. Technology-Enhanced Learning: A Question of Knowledge. In *Journal of Philosophy of Education*, 42: 505–519, 2008. doi: 10.1111/j.1467-9752.2008.00638.x

[11] SALJÖ, R. Digital tools and challenges to institutional traditions of learning: technologies, social memory and the performative nature of learning. Journal of Computer Assisted Learning. Special Issue: 'CAL'– Past, Present and Beyond. Volume 26, Issue 1, pp. 53–64, 2010. DOI: 10.1111/j.1365-2729.2009.00341.x

[12] SVETSKÝ, Š., MORAVČÍK, O., SOBRINO, D. R. D., ŠTEFÁNKOVÁ, J. The Implementation of the Personalised Approach for Technology Enhanced Learning. In *WCECS 2010 : Proceedings of the World Congress on Engineering and Computer Science 2010*. Volume I. San Francisco, 2010. - Hong Kong : International Association of Engineers, 2010, pp. 321-323. ISBN 978-988-17012-0-6

[13] SVETSKY, S., MORAVCIK, O., TANUSKA, P. Some aspects of the technology enhanced learning in engineering education. In *Proceedings of the Joint International IGIP- SEFI Annual Conference 2010*.

[14] TPCK - Technological Pedagogical Content Knowledge – TPCK [online]. Portál tpck.org [cit. 2011-03-11]. Available at http://www.tpck.org/tpck/index.php?title=Main_Page>.
[15] MISHRA, P., KOEHLER, M. Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. [online]. Michigan State University, 2006. [cit. 2011-03-11]. Available at <http://punya.educ.msu.edu/publications/journal_articles/mishra-koehler-tcr2006.pdf>.
[16] DIVJAK, B., BEGIČEVIČ, N., MORAVČÍK, O., SVETSKÝ, Š. Bilaterial collaboration for ICT support in engineering education. In *Proceedings of the Joint International IGIP-SEFI : Annual Conference 2010.* Diversity unifies - Diversity in Engineering Education, 19th - 22 th September 2010. Trnava, Slovakia. - Brussel: SEFI, 2010. ISBN 978-2-87352-003-8
[17] SVETSKÝ, Š., SAKÁL, P., HRDINOVÁ, G. Nové prístupy k riešeniu automatizácie činností výskumníkov, pedagógov a manažérov pri spracovávaní a manažmente informácií a vedomostí. In *Fórum Manažéra*, 2010, č. 1, s. 9-12. ISSN 1336-7773
[18] MORAVČÍK, O., SVETSKÝ, Š., HORŇÁK, F., SOBRINO, D. R. D., ŠTEFÁNKOVÁ, J. Experiences with the Personalised Technology Support for Engineering Education. In *21st Annual Conference of the Australasian Association for Engineering Education & 2010 Fall CDIO Collaborators´ Meeting*. Sydney: University of Technology. *The 21st Annual Conference for the Australasian Association for Engineering Education : Proceedings of the 2010 AaeE Conference*. Australia. Sydney: The Faculty of Engineering & Information Technology, University of Technology, 2010, pp. 532-538. ISBN 978-0-646-54610-0
[19] SVETSKÝ, Š., PAULÍKOVÁ, A., BALOG, K., MORAVČÍK, O., REHÁKOVÁ, A., TUREKOVÁ, I., TANUŠKA, P. Modelovanie technologickej podpory vzdelávania pre oblasť integrovanej bezpečnosti. In *Environmentálne a bezpečnostné aspekty požiarov a havárií : Konferencia s medzinárodnou účasťou.* Trnava: AlumniPress, 2009, s. 239-250. ISBN 978-80-8096-080-3
[20] SVETSKÝ, Š., BALOG, K., ŠENOVSKÝ, P. Informačná podpora integrovanej bezpečnosti. In *1. medzinárodná vedecká konferencia Policajnej, zabezpečovacej, hasičskej a záchranárskej techniky*. Trenčín: Trenčianska univerzita Alexandra Dubčeka v Trenčíne, 2009, s. 1-6. ISBN 978-80-8075-398-6
[21] REHÁKOVÁ, A., SVETSKÝ, Š. Modelovanie foriem viacjazyčnej podpory výučby s podporou IKT. In *Modernizace výuky cizích jazyků pro zvýšení konkurenceschopnosti absolventů VŠ* : Mezinárodní seminář pořádaný 16.září 2009 v rámci IX. mezinárodní konference "Liberecké ekonomické fórum 2009". Liberec: Technická univerzita v Liberci, 2009. ISBN 978-80-7372-501-3
[22] SVETSKÝ, Š., REHÁKOVÁ, A., RUSKOVÁ, D. Cudzie jazyky v technickej praxi. In *Strojárstvo – Strojírenství,* 2009, roč. 13, č. 7-8, s. 79-8. ISSN 1335-2938
[23] REHÁKOVÁ, A., SVETSKÝ, Š. IKT podpora pri výučbe jazykov. In *Transfer*, 2009, roč.1, č. 3, s. 15. ISSN 1337-9747
[24] REHÁKOVÁ, A., RUSKOVÁ, D., SVETSKÝ, Š. Modeling multilingual support systems for trainee teachers of technical branches via the use of ict. In *Problemy doksztalcania i doskonalenia zawodowego nauczycieli.* Radom: Instytut Technologii Eksploatacji, 2009, pp. 219-223. ISBN 978-83-7204-851-6

Reviewers:

Eduard Kostolanský, Professor, Ph.D. – Faculty of Natural Sciences, University of SS, Cyril and Methodius in Trnava

Anton Kachaňák, Assoc. Professor, Ph.D. – Faculty of Machining, Slovak University of Technology Bratislava

Pavel Važan, Assoc. Professor, Ph.D. - Institute of Applied Informatics, Automation and Mathematic, Faculty of Materials Science and Technology, Slovak University of Technology Bratislava

RESEARCH PAPERS
FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA
SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

2011 Number 30

INFLUENCE OF RETARDANTS TO BURNING LIGNOCELLULOSIC MATERIALS

Ivana TUREKOVÁ, Jozef HARANGOZÓ, Jozef MARTINKA

Abstract

The paper deals with monitoring retardant changes of lignocellulosic materials. Combustion of lignocellulosic materials and fire-technical characteristics are described. In assessing the retarding effect of salt $NH_4H_2PO_4$, fire-technical characteristics as limiting oxygen index (LOI) were measured, and by using thermoanalytical TG and DSC methods. High-temperature process of cellulose degradation at various flame concentrations was studied.

Key words

burning, fire-technical characteristics, limiting oxygen index, thermal analysis

Introduction

The aim of the testing was to assess the impact of retardants to flame and flameless burning propagation of cellulose. Retarding effect of salt $NH_4H_2PO_4$ by thermoanalytical methods was observed. The advantage of research is that the changes in biopolymer materials were recorded by increasing temperature. The thermogravimetry and the differential scanning calorimetry were carried out by testing of concentrated samples of different significant results. For evaluation of retarding effects of TG and DSC methods were used to assess the retarding effect on the process of burning, while the changes were recorded in reaction enthalpy (DSC), the maximum rate of active degradation (DTG), resistant residue at 600 °C (TG), the starting temperature of active decomposition (TG) and impact of oxidation of the atmosphere on the course of thermal decomposition (DSC, TG).

Ivana Tureková, Assoc. Professor, Ph.D., Jozef Harangozó, MSc. Eng., Jozef Martinka, Ph.D. - Institute of Safety and Environmental Engineering, Faculty of Materials Science and Technology, Slovak University of Technology in Bratislava, Botanická 49, 917 24 Trnava, e-mail: >ivana.turekova@stuba.sk<, > jozef.harangozo@stuba.sk <, > jozef.martinka@stuba.sk<

As a result of biochemical processes of plants, wood is a complex of substances with distinct chemical and physical properties. To give an idea of the complex substance, it is necessary to research the structure of macromolecules of wood parts. It is important to know the character and properties of substances. Particular wood substances cannot be observed separately; it is therefore important to focus on the perspective of interaction and reciprocal connection. When we separate one of the main substances, there are such important changes in the wood that we cannot talk about the same substance as in the natural wood [1].

This also applies in the case of thermal degradation of wood respectively wood substances. Considering all these facts, the processes of wood heat degradation will depend on:

- chemical properties (chemical content),
- physical properties (humidity, thermal conductivity, specific heat),
- mechanical properties (decreased solidity properties caused by cracks),
- environmental atmosphere (the concentration of fouling, speed and direction of air flux),
- antipyrenne wood treatment [2].

The theory of wood burning comes from the general burning theory of solid substances. The issue of wood combustibility, in wooden or other materials, is based on a determination of present conditions and factors that influence the burning process. Combustibility is not a physical unit; it only characterizes the value of substance behaviour by certain conditional factors. When comparing the combustibility of materials, we compare the changes in chemical content and the changes in the physical and mechanical properties, caused by the thermo-oxidizing reaction. [3].

Wood is a biopolymer because of its base, which has high energetic potential, mostly in covalent bonds of polysaccharides and lignin. The electrons of covalent bonds are excited to the higher energetic level due to a sufficient supply of energy (heat). Thus, the excited covalent bonds can be split and react with other reactive substances.

The most important component of wood is cellulose. Pure cellulose is an unbranched homopolymer with repeated cellobiose components. Cellulose is a basic structural component of cell walls in wood. Cellulose consists of two β - D anhydroglucopyranosis units links which are connected in positions 1→4-β- D by a glucosidic bond. The neighbouring units are connected to one another and turned by 180 ^{o} (Fig. 1) [4, 5].

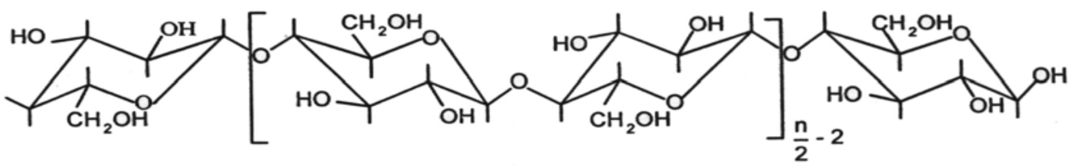


Fig. 1 *Structural formulla of the cellulose macromolecule[3]*

Fire-technical characteristics

Substances are characterized by physical-chemical properties and fire-technical characteristics. The physical-chemical properties have a character of parameters of substance defining. The fire-technical characteristics are the common values depending on the whole group of factors including the way of their determination. The fire-technical characteristics can be defined as the numeral values, which reflect the behaviour of substances or materials by the initiation and process of burning to its termination. These characteristics relate to certain partial process phases of ignition and combustion, as ignition, time to flame forming, rate an time of burning, flame propagation rate, amount of formed heat and smoke, amount and kind of gas products of burning, mass reduction, amount and properties of carbonized rest after burning and others. A certain set of fire-technical characteristics is needed for a complex evaluation of fire danger of a substance, material or product [6, 7].

Principle of fire retardation

During the process of fire retardation, it is necessary to affect those events that cause the termination of burning. In fact, these influence the rate of formation (intake) or rate of heat removal from the reaction zone of fire. Flame fire of chemical reactions takes place in the gas phase, but all the process passes through several intermediate stages of combustion (Figure 2) [6, 8, 9].

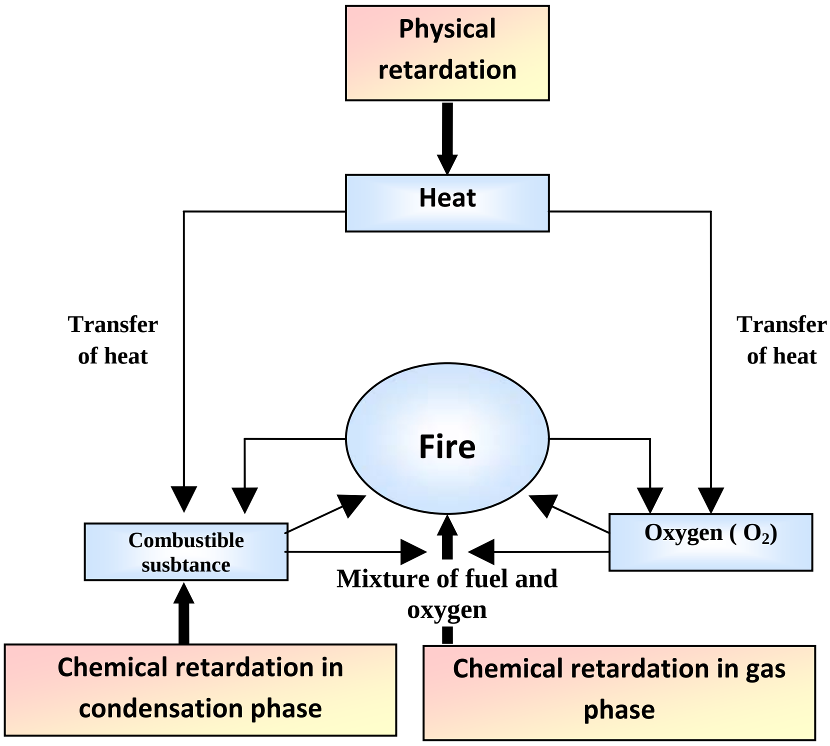


Fig. 2 *The scheme of three fire elements and possible retardation*

Fire retardants change the process of active thermal decomposition of cellulose-based materials by catalyzing the reactions by lower temperatures and limiting the rate and extent of the main decomposition reaction.

Assessing thermal stability of protected and unprotected cellulose

Sample preparation

FILTRAK 389 quantitative filter paper was used as cellulosic material in the experimental measurements. It is a filter medium fast filtering, ash-free. The cellulose samples (they were prepared according to the test method) conditioned in desiccators for 24 hours at 20 ± 1 °C and then weighed on an analytical balance. The $(NH_4)\ H_2PO_4$ was used as a retardant for testing and applied to cellulose by inserting it to solutions of different concentrations.

Testing protected and unprotected cellulose

The methods that were applied for material testing are described below:

1. The method of thermal analysis TG and DSC that characterize the material behaviour by high-temperature degradation. We used METLLER Toledo thermo analyzer (Switzerland) to measure DSC TG 20 or 50, together with Grapheware TA - 72.2/5 evaluation software. The thermoanalytic methods belong to the methods of elementary research.
2. The method of limited oxygen index, which defines combustibility and rate of burning.

Thermogravimetric analysis (TGA)

TGA is the most important thermo analytic method, which we used in the study of thermoanalysis process and biopolymer burning. The heating rate in testing was 10 $^oC.min^{-1}$. The thermo gravimetric analysis was performed at the temperature of 600^o C. According to the results of measurements in dynamic air atmosphere, various intermediate grades of decay, mass reduction and temperature by maximum reduction rate were carried out (Table 1).

THERMAL CHARACTERISTICS OF PARTICULAR DISINTEGRATION OF PROTECTED AND UNPROTECTED CELLULOSE $NH_4H_2PO_4$ by TG METHOD Table 1

Quantity **$NH_4H_2PO_4$** [$g.m^{-2}$]	**Integrates of disintegration**	**Temperature interval** [^oC]	**Mass reduction** [%]	**Temperature by max. reduction rate** [^oC]
pure cellulosis	I. grade	277.3 – 353.0	79.60	333.7
	II. grade	353.0 – 495.4	15.24	480.7
44.08	I. grade	166.2 – 292.4	33.82	263.7
	II. grade	292.4 – 600.0	34.98	.
22.15	I. grade	176.3 – 288.4	35.06	259.0
	II. grade	288.4 – 600.0	36.81	.
10.72	I. grade	183.4 – 282.3	40.61	252.0
	II. grade	282.3 – 600.0	42.36	495.2
5.25	I. grade	185.4 – 308.5	46.18	266.0
	II. grade	308.5 – 600.0	41.98	495.2

In Figures 3 - 7, there are thermograms of protected and unprotected cellulose with different quantity retarder. On the basis of the thermoanalytical measurements, we can conclude that fire resistance of the examined lignocellulose material increases with the amount of $(NH_4)H_2PO_4$ applied. The increasing amount of retarder influenced also the process of flameless combustion of cellulose, where thermal maximum was not observed in the case of lower concentrations of flame.

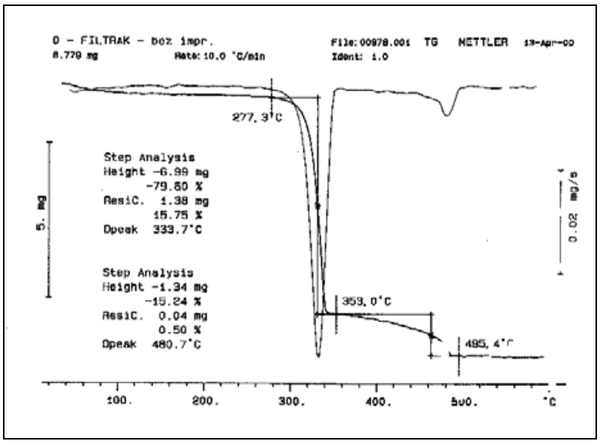


Fig. 3 TG record of unretarded cellulose

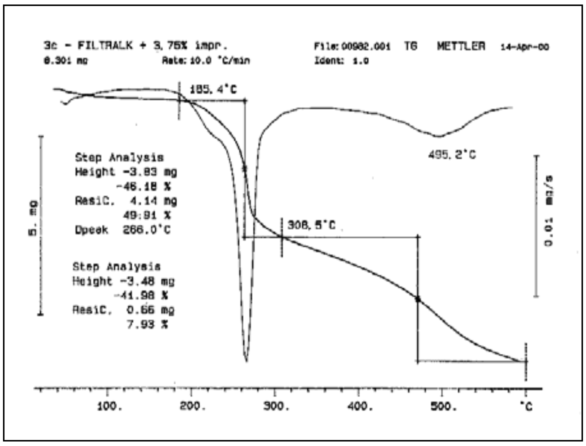


Fig. 4 *TG record of retarded cellulose with retardant amount* $NH_4H_2PO_4$ *5,25* $g.m^{-2}$

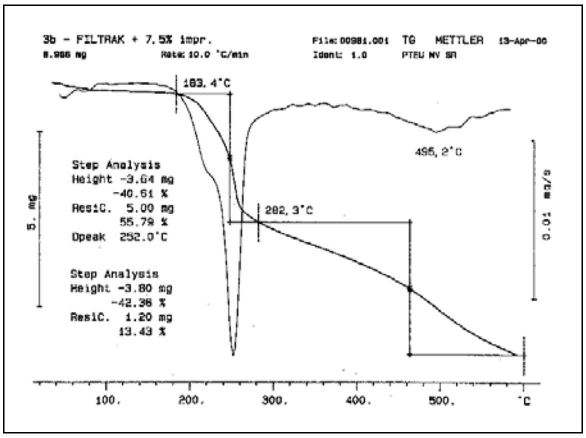


Fig. 5 *TG record of retarded cellulose with retardant* $NH_4H_2PO_4$ *10.72* $g.m^{-2}$

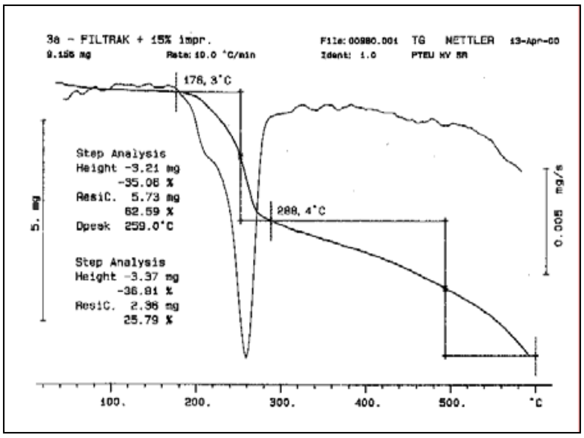


Fig. 6 *TG record of retarded cellulose with retardant* $NH_4H_2PO_4$ *22.15* $g.m^{-2}$

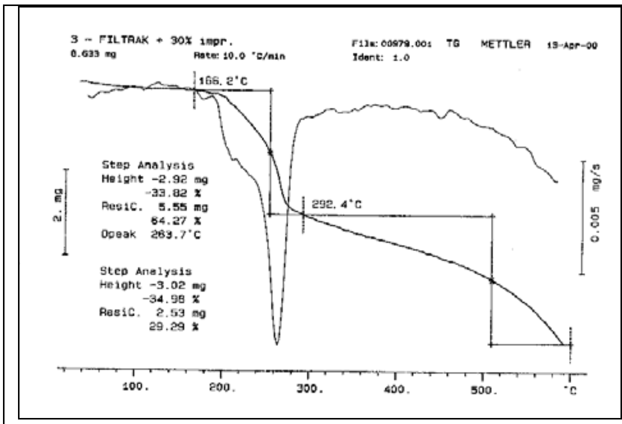


Fig. 7 *TG record of retarded cellulose wit retardant $NH_4H_2PO_4$ 44,08 g.m^{-2}*

Diferencial scanning calorimetry (CSC)

DSC method was used to measure the changes in reaction enthalpies of fuel- forming thermal generation processes by thermal disintegration of testing samples. The reaction heats in the selected interval of exothermic (endothermic) reactions were determined, and the maximum rate of heat formation was characterised by the maximum temperature of exothermal peak on the thermoanalytical curve between 25 - 600 ^{o}C in dynamic air atmosphere. In this way, the determined changes of reaction enthalpy are not identical with the enthalpic measurements in a calorimetric bomb, but they do provide better information about the heat released by thermal degradation. They also provide information about thermal colour reaction in the individual grades of thermal disintegration in testing sample.

CORRELATION OF CHANGE PROCESS BY REACTION ENTHALPY OF PURE CELLULOSE AND CELLULOSE PROTECTED WITH $NH_4H_2PO_4$ METHOD DSC

Table 2

Quantity $NH_4H_2PO_4$ [g.m^{-2}]	**Temperature interval [^{o}C]**	**Change of reaction enthalpy [J.g-1]**	**Temperature by max. peak [^{o}C]**
pure cellulosis	35.0 – 122.1	- 121	79.3
	311.2 – 555.1	5966	350.8 (506.0)
44.08	186.8 – 244.2	-1170	204.2
	244.2 – 280.0	462	266.9
22.15	185.6 – 228.0	- 411	200.2
	228.0 – 579.0	14 942	307.4 (502.7)
10.72	183.6 – 224.1	- 182	198.2
	224.1 – 593.1	18 854	305.4 (508.9)
5.25	222.0 – 598.5	25 848	310.5 (520.0)

Generally, we can say that the larger the area of endothermic peaks by fire retardants is, the more efficient they will be in the protection of polymeric materials against high-temperature degradation.

These results characterize the retardation efficiency of salts dihydrogen phosphor, which are applied in cellulose and describe the behaviour of these materials in the process of high-temperature degradation. The change of each parameter in measurement can cause the changes in the determined characteristics.

The method of limiting oxygen index (LOI)

The LOI method was used in testing the retardation efficiency of fire retardants, too. LOI is defined as the lowest concentration of oxygen mixed with nitrogen, expressed as volume fraction of oxygen in 100 parts by volume mixture of N_2 and O_2, in which the sample keeps burning at the conditions defined by test. This feature characterizes the ability of the material to burn even at reduced oxygen concentration, especially in the conditions of developed fires in buildings where the air supply to the area is very limited [10].

The sample is ignited on the upper end and the flame spreading in the opposite direction of the flowing oxidizing agent is observed in the interval of 180 seconds at minimum. The rate of gas flow (usually a mixture of oxygen and nitrogen) is 4 ± 1 cm.s^{-1}. The equipment can be combined also with a set for heating a flowing mixture of oxygen and nitrogen. This modification enables the observation of the influence of temperature on the change LOI.

The equipment for determining LOI also allows us to provide the linear rate of flame spread along the surface, as well as to develop a model of the non-flame process of propagation (Fig. 8). The concentration of oxygen and nitrogen is mostly determined by flowmeters, which is the latest equipment, and paramagnetic analyzers of oxygen. The results of the LOI retarded cellulose are shown in two vertical and horizontal configurations in Table 3.

Fig. 8 *Equipment of combustibility determination by the method of oxygen index (vertical modification)*

LIMITING OXYGEN INDEX OF RETARDANT AND NON-RETARDANT CELLULOSE $NH_4H_2PO_4$

Table 3

Amount of applied retardant $NH_4H_2PO_4$	**LOI [vol. % O_2]**	
	Vertical distribution	**Horizontal distribution**
Pure cellulose without retardation	17	21
10.1	34	34
19.7	45	77
32.1	66	68
39.2	66	76

A modification of counter-flow testing of vertical and horizontal distributions provided different LOI results. In the case of pure and retarded cellulose, the results of fire initiations in the vertical position were lower. The LOI value in retarded samples increased with increased retardant concentration in samples. The amount of applied retardant, 31.1 g.m^{-2} significantly affected the limit LOI which is an evidence of high substance efficiency of $NH_4H_2PO_4$ functioning as a cellulose retardant.

Discussion and conclusion

If to compare the effectiveness of various retarding substances, it is necessary to ensure the same standard conditions as heating rate, atmosphere, amount of sample and its pre-treatment), and to have enough knowledge about quantity of retardant. Testing the cellulose of different of $NH_4H_2PO_4$ concentrations by using DSC and TG methods showed that the best results were achieved at the value of 44.08 g.m^{-2} wt. of pure $NH_4H_2PO_4$ retardant in the sample.

Retardant properties showed high efficiency of the flame. It was proved that pro-degradation effect caused by dehydration reactions shifts the beginning of the reaction to lower temperatures than in the case of pure substances. To apply these retardants on wood, other factors such as the size and value of the active surface and method of application of the sample impregnation should be considered in further research. It was confirmed that $NH_4H_2PO_4$ salt is one of the basic substances which, when applied to materials, will be subject to further research. Research confirmed that optimum interface concentration of salt is 10.8 % wt. – 3.31 % wt., where an important retarding effect on cellulose was proved.

The LOI method is a suitable method for comparison of a fire retardant's efficiency, but the visualisation of fire is advantageous in terms of searching for new testing methods. This advantage provides valuable information about the influence of external conditions on the real process of material burning.

References:

[1] MELCER, I. a kol. *Analytická chémia dreva*. Bratislava: ALFA, 1977.

[2] BUČKO, J., OSVALD, A. Rozklad dreva teplom a ohňom. Zvolen: Drevárska fakulta TU, 1997.

[3] POŽGAJ, A. a kol. *Štruktúra a vlastnosti dreva*. Bratislava: Príroda, 1997. 486 s.

[4] KAČÍKOVÁ, D., KAČÍK, F., LAUROVÁ, M. Selected structural characteristics of beech wood lignin. In *Cellulose Chemistry and Technology*, 38, 3-4, pp. 157-163, 2004.

[5] KAČÍK, F., MARKOVÁ, I., OSVALD, A. The changes of lignin in burning process of spruce wood. In *Cellulose Chemistry and Technology*, 33, No. 3-4, 1999, pp. 267-275.

[6] BALOG, K., TUREKOVÁ, I. Limitné kyslíkové číslo a rýchlosť odhorievania celulózových materiálov. In *Vedecké práce MtF STU*. Bratislava: Vydavateľstvo STU, 1999. ISBN 80-227-1292-2

[7] YOUMING, Y., XICHANG, S., RUIRONG, Z. Flame Retandancy Behavior of Zinc Borate. In *Journal of fires Sciences*, 1999, vol.17, pp. 355 –361.

[8] TUREKOVÁ, I, BALOG, K. Termoanalytické štúdium vplyvu rýchlosti ohrevu na priebeh aktívneho rozkladu a zmien aktivačnej entalpie retardovanej celulózy. In *Požární ochrana*, 2002, s. 377 –383. ISBN 80-86634-07-8

[9] CALLUM A. S. HILL. *Wood Modification: Chemical, Thermal and other proceses.* John Wiley & Sons, 2006. ISBN 0-470-021172-1

[10] STN EN ISO 45889-1: 2001. *Plasty: Stanovenie horľavosti metódou limitného kyslíkového čísla.* Bratislava: SÚTN, 2001.

Reviewers:

Milan Oravec, Professor, Ph.D. – Institute of Safety and Quality and environmental Science, Faculty of Mechanical Engineering, Košice

Danica Kačíková, Assoc. Professor, Ph.D. – Department of Fire Protection, Faculty of Wood Sciences and Technology, Technical University in Zvolen

Faculty of Materials Science and Technology in Trnava. Issued as a special publication of FMST in Trnava by the Publisher of SUT Bratislava.

VEDECKÉ PRÁCE

MATERIÁLOVOTECHNOLOGICKEJ FAKULTY

SLOVENSKEJ TECHNICKEJ UNIVERZITY

V BRATISLAVE

SO SÍDLOM V TRNAVE

ČÍSLO 30

2011

RESEARCH PAPERS

FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY

SLOVAK UNIVERSITY OF TECHNOLOGY IN TRNAVA

NUMBER 30

2011

Contributions were edited for linguistic accuracy.
1. Edition. 40 copies printed.

ISSN 1336-1589

Registered with the Ministry of Culture SR under EV 3562/0

Name	:	Research Papers Faculty of Materials Science and Technology, Slovak University of Technology in Trnava, year 2011, number 30
Publisher	:	Publisher SUT in Bratislava
Editor	:	Publisher AlumniPress, Faculty of Materials Science and Technology in Trnava
1st Edition	:	2011
Volume	:	19
Copies printed	:	40 pieces