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CONTENT

ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING.
FASCICULE 3 [JULY – SEPTEMBER]. TOME II. 2009

Abstract:
In the article methods of vibroacoustic diagnostics of the high-power toothed gears are described. It is shown below, that properly registered and processed acoustic signal or vibration signal may serve as an explicitly interpreted source of diagnostic symptoms. The presented analyses were based on vibration signals registered during the work of the gear of a rolling stand working in Huta Katowice (Katowice Steel Plant) (presently one of the branches of Mittal Steel Poland JSC).

Abstract:
Economical effectiveness of manufacturing systems is one of decisive indicators of prosperity and firms competitive ability and is influenced through more factors.
Also technological parameters of manufacturing system have significant influence on it. The article presents results of experimental research on the manufacturing system with technology AWJ.
The article describes economical effectiveness of steel HARDOX cutting and technological parameters of manufacturing system on the basis of numerous experiment results. The utilization areas and main contributions also are mentioned.

Abstract:
The analytical model has been derived for description of the abrasive water jet cutting efficiency. Several material parameters are included in the model and the investigation of their influence on both the qualitative and quantitative cutting results is the topic of the contribution. The theoretical equation has been prepared for description of the dependence of the angle between the tangent to the striation curve and the impinging jet axis, called the declination angle, on the depth of jet into material penetration. Tilting of the cutting head reducing negative phenomena can be evaluated from this theory. The levels describing depth-dependent surface quality of cutting walls has been introduced and the experimental methods for quality evaluation were prepared. The so-called "geometrical model" describing the negative consequences of water jet delay inside the cutting kerf was prepared. Comparison of the theoretical investigation and experimental data is discussed.

Abstract:
The paper deals with diagnostics of hydraulic drive dynamics with hydraulic motor. Flow and speed of the hydraulic motor are controlled by proportional distributor. There are measured and evaluated time-response characteristics of pressures before and behind the hydraulic motor and time-response characteristics of speeds of the hydraulic motor with the inertial mass on control voltage step change. This voltage is brought to card of the proportional distributor at the same time. The dynamic behaviour of the drive with the hydraulic motor and the inertial mass at ramp change of the control voltage on the card input of the proportional distributor is subsequently measured and evaluated.

ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering, Fascicule 3 [July-September] *is a volume dedicated to* ***THE 9TH INTERNATIONAL SCIENTIFIC CONFERENCE – NEW TRENDS IN TECHNICAL SYSTEMS OPERATION 2009****, organized in Presov, SLOVAKIA.*
Fascicule 3 [July-September] *includes papers which will be presented in the Conference's sections.*

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ACTA TECHNICA CORVINIENSIS
BULLETIN OF ENGINEERING

[1.] Henryk KRAWCZYK, [2.] Marcin BARYLSKI

ARCHITECTURE OF REQUEST/RESPONSE AND PUBLISH/SUBSCRIBE SYSTEM CAPABLE OF PROCESSING MULTIMEDIA STREAMS

Abstract:
On-the-fly analysis of multimedia flows, containing high quality voice and video data, is still a challenge.The paper depicts an architecture of a system capable of processing real-time multimedia streams with distributed compontents working in both Request/Response and Publish/Subscribe manner, taking advantage of Java Multimedia Framework (JMF). The system is secured with IPSec (Internet Protocol Security) and SSL (Secure Socket Layer) protocols that impact the performance but are fully recompensed with increased system overall security. Seven testing measurement points are defined on the system critical path – the results are going to be applied to multidimensional approach to quality analysis of distributed applications working in public-private network infrastructures.

Keywords:
architecture, multimedia streams, processing, request/response, publish/subscribe

INTRODUCTION

On-the-fly analysis of multimedia flows, containing high quality voice and video data, is still a challenge. Firstly, a system designed to such a target requires wide infrastructure of reliable multimedia stream sources, then network (wired or wireless) capable of secure data high-bandwidth transmission to the system headquarters where stream are analyzed, classified, and quick but correct decision process is performed. Secondly, there is a group of interest that would like to receive the results of the multimedia streams processing but with certain level of reliability, if possible without need of human assistance, without false alarms.

On the other hand application of such analysis and classification is strongly demanded by many business needs. It covers observation of manufacturing processes, security monitoring, detection of fire, flood, or any natural disasters, potential crime scene monitoring, traffic measurements, and so on. Such a system is irreplaceable to support mass entertainments, including sport events, able to detect hooligan behavior, glass break, smoke, fire, shout for help in many languages, and more.

This paper will present the architecture of multimedia streams processing system, with components working in Request/Response (R/R) and Publish/Subscribe (P/S) architectures (Krawczyk H., Barylski M. 2009) The middleware layer will be secured with the use of IPSec and

HTTPS. Furthermore the required implementation steps are discussed.

SYSTEM CONCEPT

From high-level perspective the proposed system is build from 3 main components: Web Cam Client Network (WCCN), Multimedia Flow Processing Engine (MFPE), and End-Client Network (ECN) (Fig. 1).

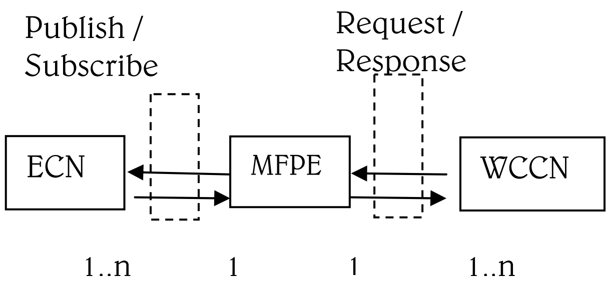

Fig. 1. System overview

WCCN consists of a set of Web Cam Clients (Fig. 3), organized as a group of small Private Networks capable of capturing voice and video data in runtime, reporting the results over Public Network to non-stop listening MFPE services. The Clients cooperate with the MFPE in R/R manner – the multimedia flows are captured by the Web Cam Clients, initially processed (flow standardization to multimedia format recognized by MFPE) and transmitted as a sequence of subsequent requests to MFPE. MPFE acknowledge the successful reception of each flow piece by short response messages. Lack of acknowledgement means the corresponding data must be retransmitted.

ECN is a network of thin end-clients, strongly interested in MFPE processing results, communicated to them over Public Network by Apache Tomcat + JSP. The Clients act in P/S architecture (Krawczyk H., Barylski M. 2009) (Farooq U., Majumdar S., Parsons E. 2007) – they register for certain results of multimedia flows processing (e.g. detection of fire) that are published by MFPE as soon as the multimedia flow classification produces output.

MFPE is a supercomputer capable of fast-enough and accurate classification of multimedia flow received from WCNN, constantly updating the final results matrix available to ECN, stored in data repository (JDBC + MySQL) with Web Services infrastructure. MFPE must be equipped with multimedia processing queue able to store the received data without loss. Unquestionably MFPE needs to be a powerful, multithread and multicore processing unit. MFPE is based on Java Media Framework (JMF) that enables the playback and transmission of Real Transfer Protocol (RTP) streams through the APIs defined in the javax.media.rtp, javax.media.rtp.event, and javax.media.rtp.rtcp packages (Fig. 2).

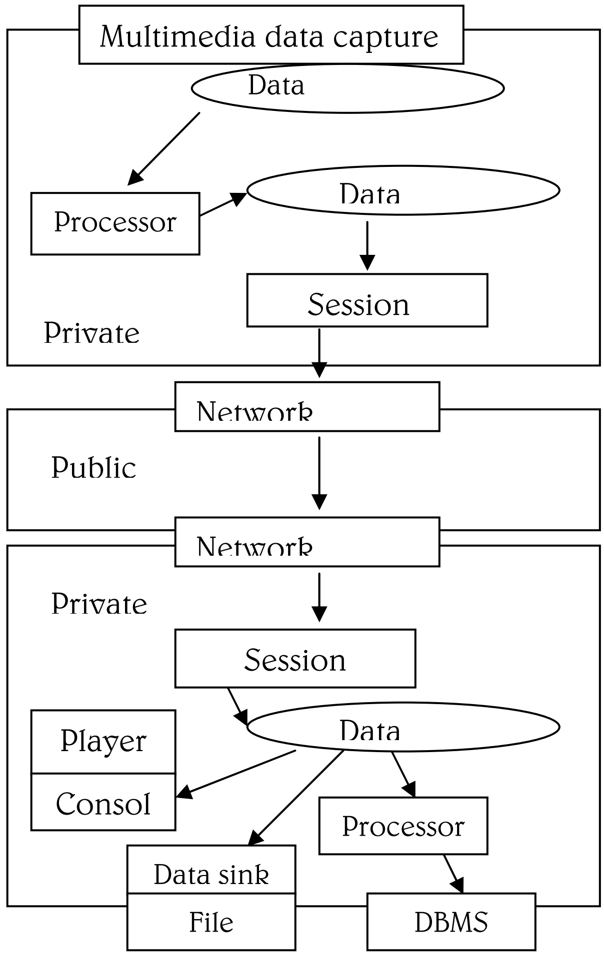

Fig. 2. RTP multimedia streams transmission and reception

The JMF RTP APIs are designed to work seamlessly with the capture, presentation, and processing capabilities of JMF. Players and processors are used to present and manipulate RTP media streams just like any other media content. Media streams that have been captured from a local capture device using a capture DataSource or that have been stored to a file using a DataSink can be transmitted. Similarly, JMF can be extended to support additional RTP formats and payloads through the standard plug-in mechanism. SessionManager is used to coordinate an RTP session. The session manager keeps track of the session participants and the *streams that are being transmitted. It maintains the state of the session as viewed from the local participant. In effect, a session manager is a local representation of a distributed entity, the RTP session. It also handles the RTCP control channel, and supports RTCP for both senders and receivers.*

The SessionManager interface defines methods that enable an application to initialize and start participating in a session, remove individual streams created by the application, and close the entire session. Several RTP-specific events are defined in javax.media.rtp.event. These events are used to report on the state of the RTP session and streams. The streams within an RTP session are represented by RTPStream objects. There are two types of RTPStreams: ReceiveStream and SendStream. Each RTP stream has a buffer data source associated with it. For ReceiveStreams, this DataSource is always a PushBufferDataSource. The session manager automatically constructs new receive streams as it detects additional streams arriving from remote participants. New send streams are constructed by calling createSendStream on the session manager. To implement a custom packetizer or depacketizer, JMF Codec interface is implemented.

ANALYSIS OF R/R COMPONENTS

In the R/R architecture one program is asking the other for any new information that has arrived since the last time it asked by sending a request message and expecting a corresponding response message (Krawczyk H., Barylski M. 2009). The main advantage of R/R is simplicity what directly causes that a chance of potential defect is lower. On the other hand it causes high mean communication channel utilization - every message exchange between client and server must be initialized by a request message. It causes that the performance of the R/R model is not optimal from application point of view.

WCCN is a set of Web Cam Clients. Each Web Cam Client is built from the camera HW and firmware, able to continuously capture, pack to appropriate encoding format and transmit the results to its destination end-point (Web Cam Server = MFPE) as soon as possible. A piece of WCCN may consist of one or more Web Cams. The transmission from WCCN to MFPE happens over Public Network (Ethernet + IPv4 + TCP), insecure, available to eavesdroppers, tractable to forgery, data manipulation, open to hackers and DoS attacks. To secure the communication IPSec ESP (Kent S. 2005) (Barylski M. 2007) + IKEv2 mechanism is incorporated.

The edge of WCCN is equipped with IPSec Gateway (GW) (Frankel S., Kent S., Lewkowski R., Orebaugh A. 2005) with appropriate Security Policies Database (SPD), maintaining the Security Associations (SAs) within Security Association Database (SAD) (Kent S., Seo K. 2005), handling SA lifetime, SA expiration events, SA SN (Sequence Number) overflow, SA renegotiation via two-phased IKEv2. On the opposite communication side (MFPE) stands the IPSec GW able to capture and decrypt the received flows from WCCN. SPD and SAD on both end-point must be synchronized by IKEv2. For the security reasons, to protect the data, a pair of HMAC-SHA1 + AES-CBC256 algorithms is used, with setkey infrastructure incorporated.

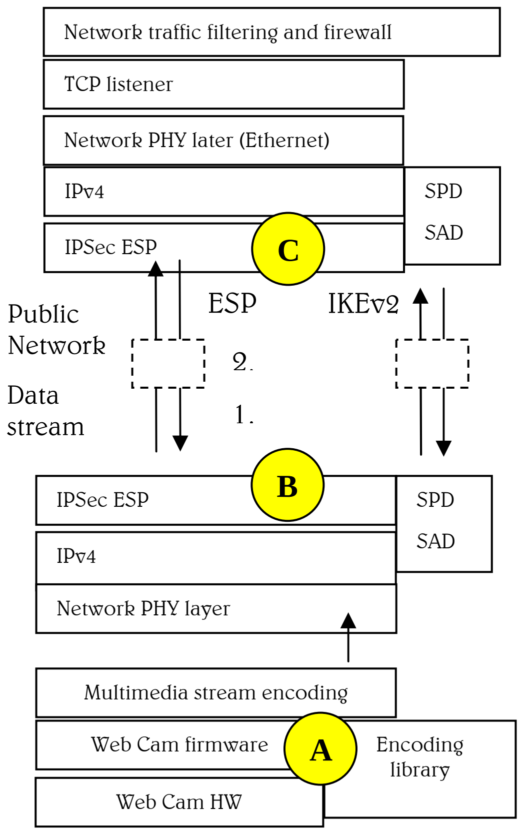

Fig. 3. System R/R components with measurement points

For R/R the overhead of IPSec and IKEv2 is as follows: need of SA renegotiation via two-phased IKEv2 if previous SA has expired (SA lifetime expiry, SA kilobytes expiry or SA sequence number overflow), additional bytes of ESP *header and recommended HMAC-SHA1 authentication at the end of the datagram. In comparison to the IP traffic over Ethernet without IPSec it is obvious that less application data is sent over the wire for the same Ethernet frame length (Kim O., Montgomery D. 2003). However if both client and server incorporate IPSec with AES-CBC-256 encryption and HMAC-SHA1 authentication algorithms with long keys known to these parties only the communication security increases significantly.*

ANALYSIS OF P/S COMPONENTS

The P/S approach expands and optimizes the communication channel utilization in comparison to R/R (Krawczyk H., Barylski M. 2009). The Client (Subscriber) registering an interest in certain data with a server program and Server (Publisher), asynchronously sends new information to the subscriber each time it is ready.

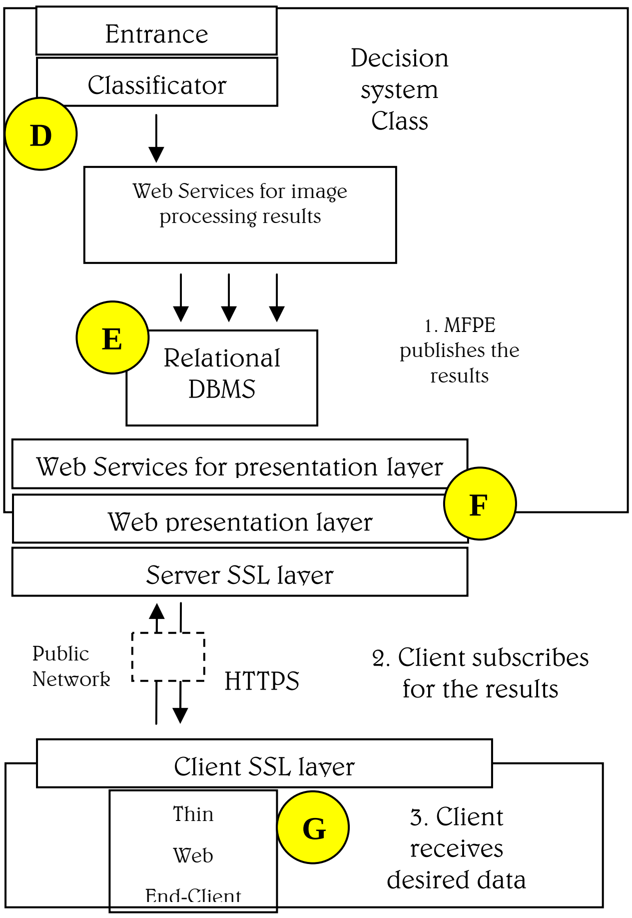

Fig. 4. System P/S components: deployment diagram with 4 measurement points

The main advantage of the P/S cooperation model is significant reduction of bandwidth requirements; Subscriber is no longer constantly asking for new data. Publisher only sends data changes for a specific point to those clients that have registered for exceptions on that point. The data is not delayed by polling cycles. IP multicast can decrease network traffic by sending the data from the publisher to the subscriber with a single message on the wire.

HTTPS used in P/S approach incorporates benefits of SSL (Secure Socket Layer) which allows managing accessibility by certificates and PKI (Public Key Infrastructure). It slows down the browsing of WWW resources - additional datagrams must be sent - but makes it harder to steal HTTP session variables or fool user authorization mechanisms over network.

LOCALIZATION OF MEASUREMENT POINTS

Implementation of the system is essential part of research related to verifying the testing model, based on security and performance testing, for improving quality of distributed applications working in public-private network infrastructures (Barylski M., Krawczyk H. 2009). Model fundamentals are the security and performance metrics gathered at the system critical points.

There are seven critical points (Tab. 1) identified in the discussed system architecture that should monitored, situated on a process flow from the multimedia stream source to system end-client presentation. Point A is the Web Cam Client who is open to intensive HW resources consumption. Then there is IPSec GW of WCCN (Point B), responsible for securing the data, with the IPSec ESP and IKEv2 processing tasks (Barylski M. 2008). On the opposite side of ESP tunnel there is point C: the destination IPSec GW that handles a bunch of IPSec connections – efficient SPD and SAD processing is required there. Point D is the multimedia stream processing layer, the backbone of the system.

The results of analysis are placed in the distributed data repository with appropriate Web Services layer exposing the available methods – point E. Then results are published, being available to the subscribers – point F – the latency from the time of happening to the time of results published. Point G, the last one, is the *thin-end-client, able to assess the system performance from the end-user point of view.*

Tab. 1. Testing points with adequate metrics

	Performance metrics	Security metrics
A	▪ Average CPU time usage [%] ▪ Operational memory average usage [MB]	▪ # of system malfunctions ▪ Area covered by the observation [m2]
B	▪ # of frames dropped due to missing SA ▪ Data throughput [Mb/s] ▪ IPSec throughput [Mb/s]	▪ # of SA rekeyed per second [SA/s] Ciphering strength
C	▪ Peak # of open connections ▪ IPSec throughput [Mb/s] ▪ Average CPU time usage [%] ▪ Operational memory average usage [MB]	▪ # of SA rekeyed per second [SA/s] ▪ IPSec IKE latency [ms] ▪ IPSec SA latency [ms] ▪ # of replayed IPSec packets/s [packet/s]
D	▪ Correctness of stream classification [%]	▪ # of system malfunctions
E	▪ Average DB query response time [ms]	▪ # of DB deadlocks per second [deadlock/s]
F	▪ System latency [ms]	▪ # of SQL injections ▪ # of exceptions ▪ time of system availability [%]
G	▪ HTTPS response latency [ms]	▪ # of exceptions

SUMMARY AND FUTURE WORK

The paper presents the architecture of a system capable of processing real-time multimedia streams, with decomposition to R/R and P/S components. Implementation details, based on Java framework, are discussed. Multimedia streaming is supported by JMF, able to transmit RTP traffic through public network. Communication over public network is secured with IPSec ESP + IKEv2 between IPSec Gateways (R/R components), and HTTPS (P/S components). Seven important measurement points are defined on the main application flow path.

The results of experiments will be used against multidimensional approach to quality analysis based on security and performance testing, presented in (Barylski M., Krawczyk H. 2009). Inputs to the testing model are the numerical values of the metrics.

Presented solution is a part of work sponsored by project Mayday Euro 2012: Supercomputer Platform for Context Analysis of Multimedia Data Streams to Identify Specialized Objects or Dangerous Events (POIG.02.03.03-00-008/08).

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ACTA TECHNICA CORVINIENSIS
BULLETIN OF ENGINEERING

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PROCESS OF COOLING INJECTION MOULD AND QUALITY OF INJECTION PARTS

Abstract:
Injection mould cooling to an important way influences both technology and economy of production cycle. Main requirement given onto cooling system of injection moulds is quick and homogenous heat removal from injection part. Because of these reasons are in engineering practice quite often used methods which support commonly active cooling device, i.e. circulating medium in cooling ducts. The aim of this paper is refer to possibilities of hest removal from shape part of mould by heat pipe or by using highly thermal conductive materials (for production of shape inserts of mould) and namely with regard to properties and quality of injection part.

Keywords:
Cooling system, Heat-pipe, Ampcoloy, Polypropylene

INTRODUCTION

Quality and properties of injection parts are to a great extent given by chemical and molecular structure of polymer and by additives elements. Very important is however also supramolecular structure (morphology of polymer) which is created during processing of plastic melt into final injection part namely during its cooling and solidification. Morphology of polymeric injection part is so given not only by structure possibilities but also by its processors: i.e. cooling conditions for injection part – it means injection mould temperate, cooling time and used cooling medium – or more precisely cooling system of mould.

Size of morphological shapes influences final properties of injection part and depends on running (temperature) of cooling and are created during solidification of parts from melt [1]. Conditions of solidification are not however same for all areas of injection part and from the structure point of view is created non-homogenous, anisotropic material with specific structure which differs in core of part and onto its surface (so-called skin-core structure, see fig. 1). This is because in consequence of shear and temperature gradient in mould cavity which differs along cross-section and length of flow line of polymer´s melt [2]. Individual layers of injection part structure: surface layers, shear and center one differ from the flow intake their thickness, shape, morphology also crystallinity and influence also final properties of injection part.

From the technological point of view is clear that for cooling system of injection mould (which must enables quick and homogenous heat removal from shape part of mould) have to be given not only side-attention because it is not only connected with heat removal from mould (economical point of view) but also to a great extent influences processing process (melt flow properties) [3] and injection part quality – i.e. for example surface quality, physical-mechanical properties, size of shrinkage [4], anisotropy of properties [5], residual stress [6] etc.

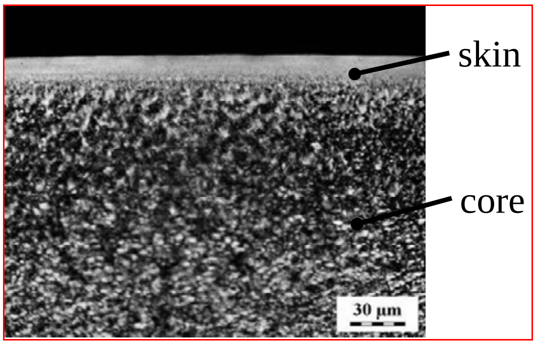

Fig. 1 Characteristic micro-structural elements of injection part thickness cross-section

COOLING SYSTEMS OF INJECTION MOULDS

Conception of cooling system in mould is given by design of injection mould, shape solution of part and requirements pose onto cooling itself. Common and in engineering practice mostly using cooling system consists of cooling and control section, couplers and cooling ducts in injection mould in which circulates cooling medium (most often water or oil). Frequently is however this active cooling system (which is heat source directly in mould) added or entirely replaced by passive cooling devices which contribute to increase heat removal intensity from shape part of mould, namely in areas of injection part where is difficult to design common cooling system, e.g. by using of heat pipe, application of highly thermal conductive material etc.

HEAT PIPE

Heat pipe is device which works as an excellent heat conductor enables very intensive heat transfer from the area with higher temperature to the area with lower temperature namely on the base of cooling medium phase conversion inside pipe. Principle of heat pipe is closely described e.g. in [7]. Advantages of heat pipes are their small diameters that is why are in the branch of polymers injection using namely for injection of thin and often also rugged shape parts which would other required difficult cooling ducts. Accordingly they have found application for cooling of long punches where is not possible to ensure circulation of water towards to its peak.

Heat pipe is device which with proper conception enables highly intensive heat removal from shape parts of moulds, but is necessary to take into account that in dependence on cooling course there can be change of injection part morphology and thus also its utility properties. On the base of experimental measurements carried out during cooling of injection parts from polypropylene by heat pipe capillaries (which replace cooling of core by so-called partition system with circulating water – see fig. 2), which is placed in drilled part of core and its wetting part flows into main cooling ducts with circulation water (see fig. 3), was identified that by application of heat pipe is possible not only to make heat removal from mould quicker, but also can influences microstructure of injection part (see table 1) and thus also can change of mechanical properties (see table 2).

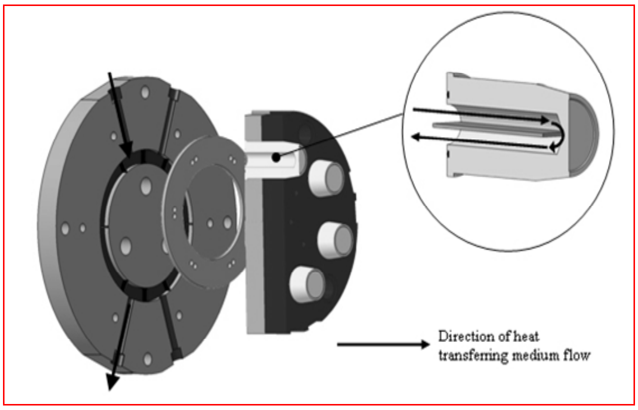

Fig. 2 Scheme of moveable mould parts and cooling of punch by partition system with circulation water

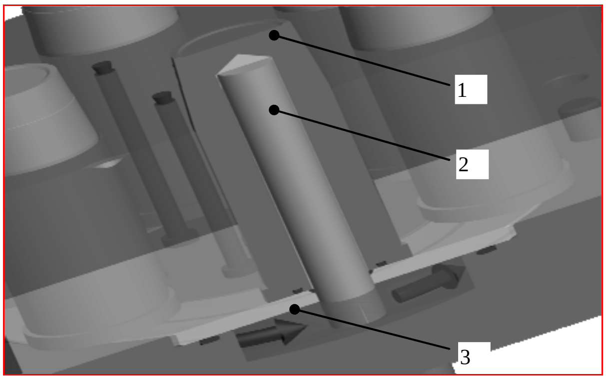

Fig. 3 Cooling of core by heat pipe.
1- core; 2 – heat pipe;
3 – main cooling duct with water

Influence of cooling medium onto so-called skin-core structure is in table 1 shown by change of whole surface layer thickness which was measured onto microtome samples of injection parts under polarized light, including shear layer (transition layer). From obtained experimental results is possible to further state that degree of crystallinity depends only on mould temperature (with higher mould temperature also increases degree of crystallinity and thus also e.g. flexure modulus of injection part) and not on used cooling medium (table 3).

Table 1 Surface layer of micro-structure polypropylene parts

Skin layer thickness [μm]			
Cooling system	Temperature of moulds		
	30 °C	45 °C	60 °C
Circulating Water under canal of core	92 μm	61 μm	45 μm
Heat pipe	80 μm	45 μm	52μm

Table 2 Mechanical properties of polypropylene injection parts in dependence on cooling system

Tensile and Flexure properties [MPa]			
Cooling system	Temperature of moulds		
	30 °C	45 °C	60 °C
Circulating Water under canal of core			
Tensile strength	34,3±0,3	34,7±0,8	34,5±0,4
Flexure strength	62,8±2,4	68,9±2,2	72,8±1,7
Flexure modulus	1549,2±48,3	1617,1±43,7	1632,9±86,5
Heat-pipe			
Tensile strength	34,5±0,2	34,7±0,2	34,9±0,4
Flexure strength	64,7±0,8	65,8±1,6	73,5±0,4
Flexure modulus	1615,8±70,2	1649,6±49,8	1749,2±69,1

From table 2 is clear that the same flexure modulus which was achieved for injection parts cooled by water under mould temperature 45 °C, resp. 60 °C, is with application of heat pipe possible to achieve already under mould temperature 30 °C resp. 45 °C. This enables reduction of injection part cooling time and thus reduction of process cycle time.

By using heat pipe was for polypropylene injection parts and mould temperature 30 °C and 45 °C observed thickness reduction of whole surface layer of injection part and increase of flexure modulus. Under mould temperature 60 °C there was however increase in surface layer thickness which is because by different behavior of heat pipe in different temperature intervals, resp. lower time delay in start of working (continuous heat removal) heat pipe under mould temperature 60 °C.

Table 3 Degree of crystallinity of polypropylene injection parts determined by diffusion method of X-radiation in dependence on cooling system

Degree of crystallinity [%]			
Cooling system	Temperature of moulds		
	30 °C	45 °C	60 °C
Circulating Water under canal of core	42 %	44 %	47 %
Heat pipe	41 %	43 %	46 %

USING OF HIGHLY HEAT CONDUCTIVE MATERIALS

Highly heat conductive materials are not real cooling medium, however in design of injection mould are using e.g. for shape inserts to heat removal from such areas of injection part which are difficult for cooling [8]. Heat is thus transferred to areas where is possible to ensure further heat removal by common ways – most often with help of cooling ducts with circulation of water.

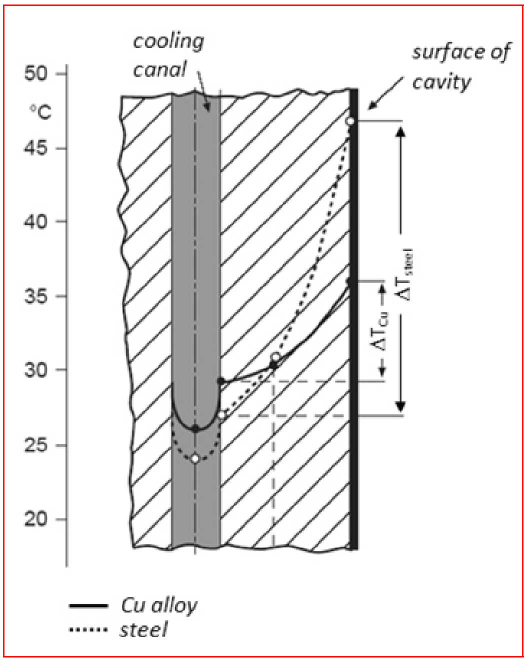

Fig. 4 Temperature outline in cross-section of mould during injection part cooling

Highly heat conductive materials – copper alloys (e.g. Ampco, Ampcoloy, Moldmax etc.) ensure not only highly intensive heat removal (see fig. 4 and fig. 5) but also prohibit non-homogenous *heat loading of mould and injection part (see fig. 5) with all of its consequences (e.g. non-homogenous properties, high eigenstress etc.). Disadvantages coming from using of such alloys are namely their low hardness which however can be solved by newly patented technology Mecobond [9].*

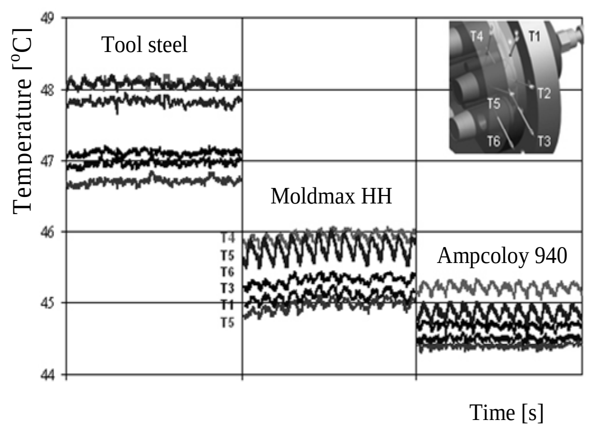

Fig. 5 Field of temperature in injection mould in the area of shape core in dependence on core´s material under cooling by circulation of water in ducts

Table 4 Surface layer of micro-structure polypropylene parts

Skin layer thickness [μm]			
Material of core	Temperature of moulds		
	30 °C	45 °C	60 °C
STEEL	92 μm	61 μm	45 μm
AMPCOLOY 940	94 μm	75 μm	51μm

Table 5 Mechanical properties of polypropylene injection parts in dependence on material of injection mould core

Tensile and Flexure properties [MPa]			
Material of core	Temperature of moulds		
	30 °C	45 °C	60 °C
STEEL			
Tensile strenght	34,3±0,3	34,7±0,8	34,5±0,4
Flexure strenght	62,8±2,4	68,9±2,2	72,8±1,7
Flexure modulus	1549,2±48,3	1617,1±43,7	1632,9±86,5
AMPCOLOY 940			
Tensile strenght	33,6±0,4	33,7±0,4	34,2±0,3
Flexure strenght	65,9±0,7	68,5±0,9	68,7±0,9
Flexure modulus	1663,8±157	1578,5±185	1751,2±78

Table 6 Degree of crystallinity of polypropylene injection parts determined by diffusion method of X-radiation in dependence on cooling system

Degree of crystallinity [%]			
Material of core	Temperature of moulds		
	30 °C	45 °C	60 °C
STEEL	42 %	44 %	47 %
AMPCOLOY 940	41 %	44 %	46 %

From results of experimental measurement with using copper alloy Ampcoloy 940 for production of injection mould shape core (cooled by water, partition system – see fig. 1 and replacing steel core) is possible to state that there is increase of whole surface thickness in injection part structure (see table 4) as a consequence of rapid heat removal and cooling of injection part surface. From measured mechanical properties is not possible with regard to measured values variance make any clear conclusions about surface layer influence onto such properties. Concerning influence of copper alloys onto measured polypropylene injection parts degree of crystallinity (under different mould temperature) is from results possible to state that by using copper alloys there is influence only surface layer of injection part structure and there is not influence of final degree of crystallinity of injection part (see table 6) which is influenced only by mould temperature.

CONFORMAL COOLING OF INJECTION MOULDS

Increase intensity of heat removal from injection part is possible to ensure not only by application of heat pipe and highly heat conductive materials in design of injection mould but also by alternative methods for production of shape cores of mould and its cooling systems – i.e. for example "conformal cooling". This is method which uses standard methods of circulation water in cooling ducts but however contrary of common cooling method follows shape circumflex of mould cavity (see fig. 6). Shape insert with cooling ducts is produced very quickly and effective layer by layers with the help of method Direct Metal Laser Sintering (DMLS, see fig. 7), whereas with regard to achieve maximal cooling effect is possible to optimize size, shape and cross-section by the help of simulation programs [10], [11].

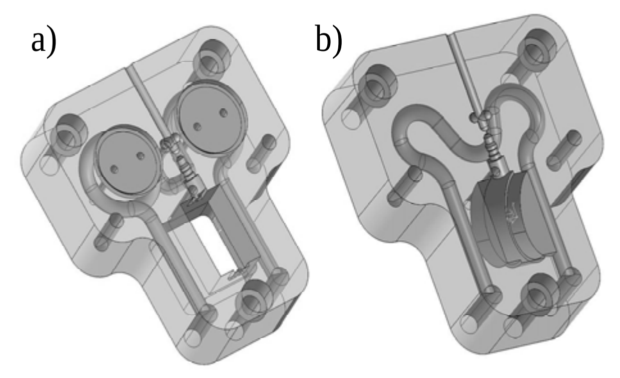

Fig. 6: Insert board of injection mould
a) moveable part of mould b) fixed part of mould

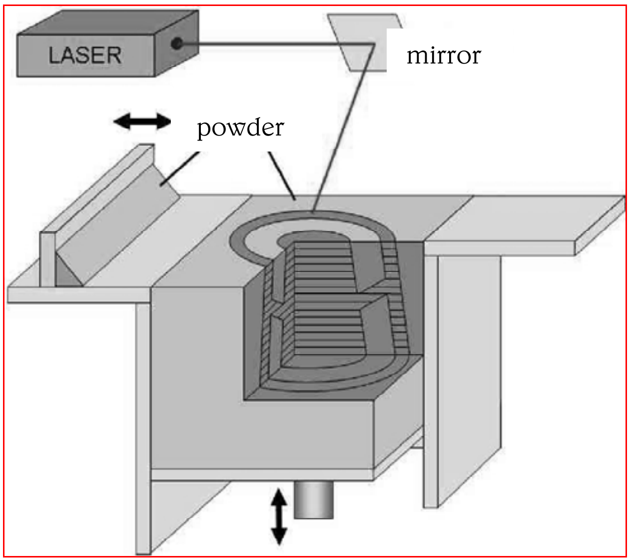

Fig. 7: Scheme of DMLS method /11/

CONCLUSION

From written examples and results of experiment is clear that cooling system of injection moulds and course of injection part cooling influences not only process quality, dimensional and shape accuracy of injection part (by means of rapid and homogenous heat removal from shape cavities of mould) but also its final properties (through changes in morphological structure).

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ACTA TECHNICA CORVINIENSIS
BULLETIN OF ENGINEERING

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APPLICATION OF SIMULATION CONTROL IN BUILDING ENERGY SYSTEM

Abstract:
Advances in real-time data collection, data transfer and increasing computational power are bringing simulation assisted control closer to reality. The contribution deals with the development and testing of a prototype simulation assisted controller, in which a simulation program is embedded in realtime control decision making. Results from an experiment in a full-scale environmental test facility prove the feasibility of predictive control using thermal simulation program.

Keywords:
Simulation assisted control, predictive control, building energy management systems

INTRODUCTION

The most of recent developments in Building Energy Management Systems (BEMS) have applied the advances made in computer and information technology. Significant developments have been made in the standardisation of communication protocols [1] and in web-enabled controllers [19]. There has been less focus on the development of new concepts in control, particularly in the built environment. Despite this, some important advances of building control techniques have been made.

The concept of predictive control, which uses a model in addition to measured data in order to predict the optimum control strategy to be implemented, could assist in the more efficient operation of BEMS. This results in lower energy consumption and more comfortable buildings. Work has been done on predictive controllers using stochastic models [14, 15]. Both short term (10-20 min.) and long term (days) prediction errors lay within acceptable ranges both in terms of temperature and humidity control. Prediction errors were found to be within 1°C and 1.5% relative humidity.

Other advancements include the use of fuzzy logic control [6] and the use of neural networks [2]. The basic idea behind fuzzy logic control is to incorporate the experience of a human process operator in the design of the controller: this unfortunately requires good quality experiential knowledge and data about the controlled system's operating conditions. A neural network is a control mechanism based on the operational principles of the human brain. It can be described as a set of linked units that connect an input to an output. These units interact with each other by means of weighted connections. The network requires training by giving the related output to a given input, resulting in *certain weights being assigned to particular connections. An apparent drawback with the use of neural networks in control is the requirement for extensive training data.*

Controllers incorporating self-learning algorithms in control systems are now quite common, for example in optimum start of heating plant [18]. The aim is to achieve the defined zone conditions at the desired time of arrival of the occupants in the shortest possible time. However, the International Energy Agency (IEA) Annex 17 research work [13] showed that these learning algorithms can initially take days to predict the correct optimum start time and have difficulty dealing with unusual conditions such as long shutdown periods, exceptional weather conditions and changes in building operation. Even the best trained self-learning controller cannot extrapolate beyond its range of experience.

The controlled entity is basically a nonphysical "black-box model". There are inherent limitations in the black box approach to control as the controller has no knowledge of the cause and effect relationships between the elements of the controlled system and external excitations such as climate and occupant interaction. With passive buildings employing natural resources such as daylight and free cooling, control actions become convoluted due to these interactions between the elements of the controlled system (e.g. glare requiring blind repositioning, causing luminaire actuation, leading to increased cooling loads). Such interactions can be represented in a physically-based model in which all the elements are in interactions [4]. Building simulation programs can provide such a model.

CONTROL ASSISTED BY SIMULATION

Nowadays, detailed simulation programs are playing significant roles in this areas:

Emulators: Emulators replace a building and its HVAC (heating, ventilation, air-conditioning) systems and use a computer program to simulate their response to the BEMS commands. Emulators can also be used for control product development, training of BEMS operators, tuning of control equipment and imitating fault situations to see how the BEMS would cope [11]. Collaborative research work on emulation was carried out by the IEA under Annex 16 and Annex 17. Six different emulators were developed: three used HVACSIM+ and three used TRYNSYS. One of the best-known emulators developed within the framework of Annex 17 was SIMBAD (SIMulator for Buildings And Devices), which uses both the TRNSYS and HVACSIM+ simulation software. The early versions of SIMBAD had difficulty simulating dynamic conditions, the creation of HVAC models was tedious and the user interface was not user friendly. In order to address these difficulties CSTB are currently developing a toolbox of models of HVAC components and plant for the design and testing of control systems. Johnson Controls and the National Institute of Standards and Technology in the US have developed a low cost PC based emulator [3]. The company is now using this for the purpose of testing new control products.

Simulation models play a similar role in the development of fault-detection and diagnosis (FDD), a technique which aims to detect and locate faults or predict the presence of faults in energy management systems [12]. FDD uses a model of the correctly operating system to supplement the conventional feedback loop, the model acting as a reference for correct behaviour of the controlledsystem. Test results [20] on an air handling unit serving a dual duct air conditioning system show that the use of FDD improved the control performance and achieved good results in detecting leakage of a control valve on a cooling coil and the sticking of a return air damper.

Evaluators: In this role, simulation programs can be used to test the efficacy of possible control strategies. In this case a detailed model of the building/HVAC system is established, and various control strategies are evaluated in terms of comfort acceptability and energy efficiency [13].

The objective of this research was to investigate a possible third use for simulation programs: their encapsulation within the BEMS system in order to provide simulation assisted control. The research, undertaken in collaboration with Honeywell Control Systems, involved executing the simulation program as part of the control task in order to evaluate several possible control scenarios and make a selection interms of some relevant criteria. Although this possibility had been suggested previously, it was dismissed at the time as being "beyond the capabilities of the detailed simulation programs" [10]. The premise *of the present study is that simulation program capabilities and BEMS flexibility are now sufficiently advanced for simulation assisted control to be feasible.*

Although there are potential difficulties associated with simulation assisted control (e.g. the need to make and calibrate a model of the system, particularly when dynamic variations due to airflow and solar radiation are important; the difficulty of parsing from complex result sets to simple actions), physically-based models offer the following benefits over "black-box" models:

- *they are able to address cause and effect scenarios such as outlined previously;*
- *they can adapt to the impact of changing building use or operation (provided that the change is incorporated into the model);*
- *they potentially offer better control through calculation of interactions and can identify the factors that result in particular building performance;*
- *they provide the possibility of comparing options for different control strategies by testing them on the building model.*
- *Simulation assisted control is likely to be of most use in the following circumstances:*
- *when significant look-ahead times are involved (hours, rather than minutes);*
- *for high-level supervisory control, e.g. load shedding, where several alternatives and their implications for environmental conditions (particularly occupant comfort) may need to be evaluated;*
- *where interaction is high, e.g. blinds/lighting/cooling; and*
- *where the building use varies or changes (e.g. large variations in occupancy) and where this variation is known in advance.*

Table 1 lists those plant systems that have been identified as presenting opportunities for simulation assisted control. In addition, where integrated control is emphasised, a BEMS system would likely benefit from explicit simulation of the interactions within the building.

The primary objective of this pilot project was therefore to investigate the possibility of integrating simulation within real-time BEMS operation to provide a prototype control decision-making capability. The envisaged system is depicted in Fig. 1. This shows the usual BEMS control structure - inputs are obtained from climate and building state sensors, and an internal control algorithm decides on the appropriate control action for switching heating, cooling etc. The new elements are the simulator, which models the building/HVAC using sensed data as boundary conditions, and an evaluator, which scans the simulation results to suggest an appropriate control action to the main simulation assisted controller.

Tab. 1 Applications suitable for simulation assisted control [4]

Application	Controlled Component	Output to be optimised
Optimum start/stop	Heating/ cooling system	Start/stop time
Night-time cooling	Fans	Hours of operation
Optimum set-back temperature	Heating system	Set-back temperature
Boiler sequencing	Boilers	Heating system efficiency
Load shedding	Heating system	Priority for heating
Combined heat and power	CHP engine	Hours of operation
District heating	Heating system	Forecasting of heat demand
Underfloor heating	Heating system	Hours of operation
Mixed mode ventilation systems	Fans	Start/stop time
Charging of ice storage	Refrigeration	Hours of operation
Night operated ground water source heat pumps	Water pump/compressor	Start time
Optimum control mode	Various	Control mode selection

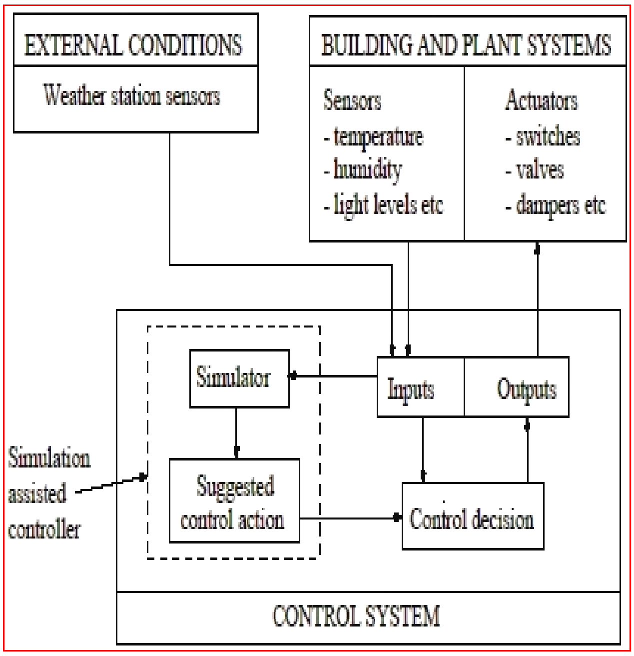

Fig.1 Simulation assisted control [4]

The study investigated whether real-time simulation could be introduced as shown in Fig. 1. In view of the many practical interface issues that would be inherent in using a BEMS system directly, as demonstrated in the development of the SIMBAD emulator [9], it was decided to use LabVIEW as a BEMS replacement and the dynamic simulation program ESP-r [5] for *control scenario appraisal. LabVIEW is used widely in industry for SCADA (Supervisory Control and Data Acquisition) applications, and for prototype development it offered the necessary flexibility without being tied to a particular BEMS protocol. The ESP-r system was used as it is a detailed simulation program with explicit representation of all heat and mass transfer processes and includes an extensive array of control capabilities.*

The research had the following elements.

a] The identification of control functions of current BEMS that might benefit from simulation assistance.

b] The creation of LabVIEW routines for data acquisition and control actuation.

c] The development of the real-time linking of these routines to ESP-r to permit scenario appraisal, selection and enactment.

d] A testing of this linked system in realistic scale experiments.

APPLICATION AND EXPERIMENT

The application of a prototype simulation assisted controller required the following elements:

a] A calibrated model of the building and HVAC system.

b] Sensors to measure all critical boundary conditions (external temperature, solar radiation, etc) and internal conditions (temperature, humidity etc); the data must be collated in the BEMS (i.e. within LabVIEW).

c] A mechanism for transferring data to the simulator.

d] A routine within the BEMS for initiating the simulation(s) against a predefined control strategy.

e] A simulator to predict internal conditions and ascertain parameters (start time, plant output, etc) to meet some user-defined criterion.

f] A controller to make decisions based on modelling outputs.

g] A mechanism for transferring control data back to the BEMS (LabVIEW).

h] Actuators controlled by the BEMS to initiate the control action.

i] A structure to allow iteration and updating of control actions.

An independent software module was developed that, together with LabVIEW and ESP-r, forms the prototype simulation assisted controller. The software module combines several of the elements outlined above. The function of these three programs, and the developments required in each case are described in the following paragraphs.

ESP-r

The main use of the ESP-r system is for design decision support. Several changes were required to cope with the novel aspects of real-time simulation. The most important of these were the transfer of acquired data into ESP-r databases, and the subsequent use of this measured data to maintain the correct model state until the current time, after which the specified predictive controller was invoked.

LabVIEW

In its role as a surrogate BEMS, LabVIEW is the controlling entity. Programs were therefore written in LabVIEW's in-built G programming language to collect sensor data, to display and store this data in a format suitable for import to ESP-r's databases, to commission simulations, to receive the suggested control action and to initiate that action.

BEMS to ESP-r link

This new interface module operates on the basis of a control definition file containing the following information:

- *the type of control simulation to be conducted (e.g. winter: heating, summer: cooling);*
- *designated controlled spaces;*
- *control action type(s) to be investigated (e.g. optimum start/stop, night ventilation);*
- *available plant capacity for each space;*
- *control strategy end time;*
- *target set-point for each space;*
- *target time at which set-point is to be attained.*

The interface module is controlled by the BEMS system (LabVIEW), and is passed a file containing LabVIEW's monitored climate and internal temperature data. The module then performs the following tasks:

[1.] Simulation Synchronisation: The required start and stop dates for the simulation are determined, based on the time-stamped data contained within the file provided by LabVIEW. The program also calculates a simulation frequency (time step) based on the sampling rate of the monitored data.

[2.] Climate Prediction: The LabVIEW data file is read and its climate information used to predict weather conditions for the next 24 to 48 hours. At this stage, only a structure for short-term climate prediction has been implemented with a simple algorithm: further work will be required to develop this function.

[3.] Control Strategy Preparation: Based on the control action type specified in the control definition file, the interface module develops a suitable control strategy for use in the ESP-r simulation.

Firstly, the controlled space temperatures are held to those contained in the monitored data passed by LabVIEW until time tc, the last monitored time in the file, after which the simulation evolves freely (with predicted climate data) until time t_p.

Secondly, the module determines the plant action start time: this is either advanced or retarded based on the progress of the predictive simulation. Plant action is made according to a defined plant control strategy until time te, the specified shut down time.

[4.] Simulation Commissioning: Based on the calculated simulation start and stop dates, simulation frequency and user defined control strategy, the interface module commissions n simulations (where $n = (t_{stop} - t_{start}) \times 1/\text{frequency}$). In each of these simulations a control parameter (e.g. plant start time) is changed by a fixed increment. The parameters for the simulation are passed to the simulator in the form of a control definition file and a simulation parameter file (defining the period over which the simulation is to be run and the time step of the simulation).

[5.] Results Interpretation: At each iteration, the interface module examines the simulation output and compares the value of the controlled space variable reached at the target time with that specified in the control definition file. If the controlled value is not acceptable then another simulation is commissioned with the plant action time tp advanced or retarded by one time increment depending on the type of simulation being conducted. If the controlled value is within bounds then the sequence of simulations is stopped and the time and/or value which meets the control criteria reported back to LabVIEW.

As a result of these developments, it is possible to implement the functions listed in Table 1. For the purposes of this project, one commonly used function was tested - optimum start control. The following section describes one experiment that was set up within a test room environment.

The environmental test facility consisted of two realistically dimensioned rooms surrounded by temperature controlled voids. The constructions used in the test rooms are as would be found in a real dwelling (insulated cavity walls, with double glazed windows). Each room is heated by a central boiler, with two low-temperature hot water radiators in each room. Two dedicated PCs running LabVIEW monitor heating system temperatures, room air temperatures and void temperatures.

An ESP-r model of the test rooms was developed using geometrical and construction data supplied by Honeywell. This model, along with ESP-r itself, was installed on the PC monitoring test room 1. The LabVIEW programs described previously were modified and linked to the existing test room data acquisition program.

The ESP-r model was firstly calibrated using data from a heating sequence conducted on test room 1: the room was heated at full power (using one radiator) for two hours and allowed to cool for 3 hours. This sequence was repeated twice. The same heating sequence was simulated with the ESP-r model and predicted room temperature were deemed to be sufficiently close to that of the real room for the purposes of the experiment.

The main experiment involved using simulation assisted control to predict the optimum start time for the test room 1 heating system. Data collection was at 1 minute intervals. At the start of the experiment, the test rooms were left in a free-floating state for 24 hours. The surrounding voids remained unconditioned throughout the experiment, while the adjacent test room (being used for another experiment) was maintained at 24°C. The simulation controller was set to determine the switch-on time required to bring the room to a temperature of 25°C with a nominal 1200 W heat input.

In the preceding 24 hours the room temperature floated at around 21° C. Given a 25° C set-point and target of 11:00, ESP-r predicted a heating system switch on time of 10:20. Note that the room temperature was not at exactly 25°C at this time as the simulated temperature was compared to the set-point with a tolerance of ±0.5°C. When the test room heating was switched on, the room reached 25°C at 11:06. The room temperature coincided with the ESP-r room temperature prediction at 11:02. It is clear that ESP-r slightly overpredicts the response of the test room to heating, with the prediction leading the actual room temperature. However, given the rudimentary calibration of the model, the predictive performance of the simulation assisted control tool was encouraging. Measured and simulated temperatures coincided with a temporal error of 5%, maximum error in temperature prediction was around 1°C and the actual set-point was reached 6 minutes later than predicted but within the time interval of one simulation time increment (10 minutes).

CONCLUSION

This research was conducted to test the feasibility of using simulation to enhance the control capabilities of BEMS. Building and plant control functions amenable to simulation assisted control were identified.

Modifications to the ESP-r system were undertaken to allow real-time simulation (i.e. simulation using data as it is gathered and which returns control actions for real-time implementation). This paper described an experiment undertaken with the prototype control system in full scale rooms within Honeywell's test facility, demonstrating how such a system could be used to generate optimum start times. On a realistic scale experiment, it was shown that it is feasible to include simulation in control decision making. Typically, the simulation time (for a total of about 6 different simulations of the Honeywell test facility) was about 1 to 2 minutes on a low-end Pentium PC. Although only optimum start was demonstrated, the structure is in place for other applications [4].

Further research is necessary to develop the idea further. This should focus on testing on a full scale building subject to external climate variation, integrating improved short-term climate prediction algorithms into the simulator, testing different control strategies, replacing LabVIEW with a modern BEMS system, developing the link to ESP-r or other simulators with BEMS standard protocols and developing calibration.

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DIAGNOSIS OF INDUSTRIAL GEARBOXES CONDITION BY VIBRATION ANALYSIS

Abstract:
In the article methods of vibroacoustic diagnostics of the high-power toothed gears are described. It is shown below, that properly registered and processed acoustic signal or vibration signal may serve as an explicitly interpreted source of diagnostic symptoms. The presented analyses were based on vibration signals registered during the work of the gear of a rolling stand working in Huta Katowice (Katowice Steel Plant) (presently one of the branches of Mittal Steel Poland JSC).

Keywords:
gearbox, diagnosis, vibroacoustic

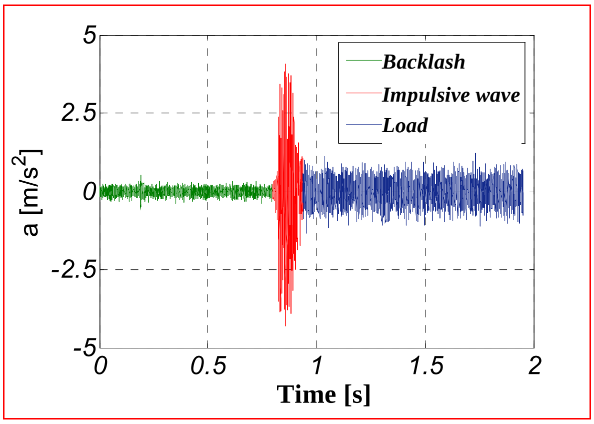
INTRODUCTION

Residual phenomena are inseparable phenomena during the work of a technical object, and among them there are vibrations and noise. The evaluation of the technical condition on the basis of research is known under the name of vibroacoustic diagnostics. The basis for the research on the use of vibroacoustic signals in the diagnostics of the object technical condition is the creation of symptoms measures, which will enable to define the condition precisely. Vibroacoustic diagnostics uses, as source of information about the condition of the tested object, not the static parameters, as it happens in other technical diagnostics methods, but the dynamic parameters, describing the appearance and the propagations of the vibroacoustic disturbance both in a tested object and in the outer environment [1-10]. Because of the fact that the changes in the condition of the diagnosed object may influence broadly the structure and the size of the vibroacoustic signal, the diagnostic information included in it may have a heterogeneous shape. The vibroacoustic signal includes both information required about the processes in progress in a technical object and the unnecessary information from the point of view of diagnostic aim, the, so called, information noise. A very important issue here is the right reconstruction of the information model of a given object condition, being the basis to treat it as the information carrier. In paper [2] the author points out the bigger sensitivity of the vibration signal on the changes of the object work condition of than the acoustic signal sensitivity. It is so due to the fact, that the vibration signal may be distorted only by the movement of close kinematic pairs and by the signal of other damages in that area. The acoustic signal will additionally include *unnecessary information coming from the measuring surrounding. In paper [1] authors compared the vibration signals and the acoustic signals taking into account their damage orientation. In vibration diagnostics of the power transmission system the most often used are the vibration acceleration converters, placed in various points of the casing and the no-contact methods used to measure the perpendicular vibration speeds of the rotating shafts. The use of no-contact measurement method of vibrations decreases the amount of information noise included in the measured signal. It results directly from the shortening of the signal path generated by the appearing damage.*

RESEARCH OBJECT

Tests were conducted on 10 single-stage and double stage gears with additional meshing of the roll cage [3,7]. In the power transmission system of the cages the asynchronous engines with the power of 200 [kW] were applied. The rotational speeds of the input shafts are constant for each gear and are included in the range from 380 to 800 [rotation/minute]. In the course of research the measurements of vibration accelerations in three directions were conducted and the impulse signals were registered, consistent with the rotations of the input shaft which served for synchronic averaging. The measurements of the gearbox vibrations were conducted during idle running and with a load during rolling. Diagnostic signals were processed in the Matlab-Simulink environment. The applied measurement method enabled the synchronic averaging of the vibration signals with the rotations of the input shafts. The changes of the diagnosed gearboxes condition have significant influence on the structure of the vibroacoustic signal. The example registered courses of the vibration accelerations in time of idle running and under load, for two different consumption conditions are presented in fig. 1.

The registered vibroacoustic signals should be processed with the use of proper signal measures so that they would serve as symptoms showing the intensity or advancement of the consumption. The right signal processing in time domain and/or frequency domain enable the definition of the level and type of the carrying signal modulation, which will finally enable the diagnosis of the technical condition of the object. One of the methods is the statistic analysis of the signal received after preliminary processing in frequency domain.



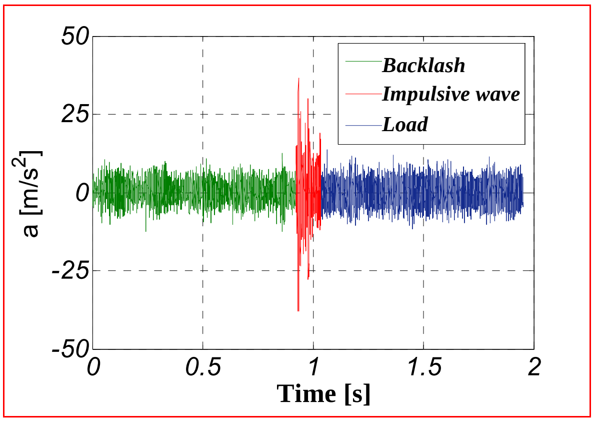


Fig. 1 Registered vibration signals of toothed gears of the rolling stand drives, a – gear in general good dynamic condition (cage k4), b – gear classified for repair (cage k12)

VIBROACOUSTIC SIGNALS ANALYSIS METHODS

In the vibroacoustic diagnosis of the technical objects lots of various signal analysis methods are used. The vibroacoustic signal, registered from a technical object includes in it information significant from the point of view of the analysed phenomenon and the unnecessary information, distorting the readability of the diagnostic information included in the signal [4,6,10]. Noise component comes from the side phenomena accompanying the object functioning and from the measuring system. In order to get the carrying signal, including the maximum amount of useful information, the synchronous averaging and signal filtration are used as preliminary analyses in the diagnostics of the power transmission systems.

Synchronous averaging eliminates the random component from the signal. It is based on marking the medium signal in time corresponding with the given number of periods. In diagnostics of the toothed gears the averaging with rotation period of pinion and wheel is used, and the period of tooth connection cycle repetition. A very important stage in this method is the precise synchronisation of the reference signal with the angular position of the diagnosed rotating elements. Filters are comfortable and simple tools used for elimination of noise constituents included in some frequency bands. It should be remembered, however, that each decision concerning the use of filters must be justified with the predominance of the benefits of their use over the information distortion, which is to be used in diagnosis of the technical object condition. An important problem here is the choice of the right filter and its accommodation to the defined diagnostics requirements [5]. A particularly interesting, commonly and successfully used filtration method was proposed for the first time in paper [9]. It helps to find the wide-band vibration signal modulation caused by the impulse stimulation, which is a situation that is observed by appearance of a local damage of gear teeth. In this paper it was proposed to remove those bands from the spectrum which include the rotation constituents of the wheel shafts and their harmonics ($i \cdot f_o$), as well as frequency constituents and their harmonics ($i \cdot f_z$). Later application of the reverse Fourier transform IFFT helps in getting the signal in time domain, known as the residual signal r(t). In literature one can also find the residual signal, defined as a filtration result based on removal of only meshing frequency constituents and their harmonics. Another commonly used filtration method is the one which leads to the achievement of time signal, known as the differential signal d(t). Such signal is received similarly to the residual signal, but the removed bands around the meshing frequency and their harmonics are wider and include the sidebands connected with the rotational frequencies of the toothed wheels.

After the application of preliminary methods of vibroacoustic signal preparation for diagnostic purposes (averaging, filtration), the next stages, serving to improve the extraction of the useful features, are the signal analysis methods in time domain, frequency, time-frequency, time-scale, frequency- frequency.

ANALYSIS OF SIGNAL ENVELOPE

The damages appearing in the power transmission system influence the change of parameters describing the shape of vibroacoustic signal, and in case of appearance of amplitude modulation, describing the changes in envelope parameters. As the author states in [8], this dependence may be the basis to define a set of diagnostic parameters built on the basis of both the signal and its envelope. Signal amplitude modulation may be caused by modulating phenomena in the form of impacts of elements in bearings, gears and clutches. The extraction of the diagnostic information from a signal modulated in such a way enables the application of amplitude demodulation that is the use of the signal envelope:

$$x_{obw}(t) = \sqrt{x^2(t) + x^2_{Hilbert}(t)} \quad (1)$$

where:
$x_{obw}(t)$ *– vibroacoustic signal envelope,*
$x(t)$ *– tested vibroacoustic signal,*
$x_{Hilbert}(t)$ *– vibroacoustic signal after the application of Hilbert transform.*

Time signal after application of the Hilbert transform is displaced 90° in phase in respect of the tested time signal. It enables marking the constituent amplitude of variables without the necessity to find the current phase of the tested time signal.

SPECTRAL ANALYSIS

Each moving part of the technical object generates by movement the vibroacoustic processes included in a given frequency band. The analysis of the frequency composition of those processes can be used in diagnosis processes of the object condition. The representation of the time signal in frequency domain is achieved by the application of Fourier transform:

$$X(f) = \int_{-\infty}^{+\infty} x(t) \cdot e^{-j2\pi ft}\, dt \quad (2)$$

In literature, the most common algorithm is the Fast Fourier Transform (FFT), which enables to mark the spectrum in a fast and computationally easy way. The stages of the damage development cause the modulation of the bands around the given carrier frequencies, and at the same time they change the frequency structure quality of the signal. Depending on the damage type the change in frequency structure differ. In literature one can find given frequency bands characteristic for given damage type, that is:

- 0,4 f_o to 3 f_o – backlash in shaft bearing mounting or rotor bearing mounting, instability of the oil film, unbalancing, axial backlash of the shaft and its lack of co-linearity,
- several to over a dozen f_o – damages in rolling bearings, defects appearing by the flow of working medium,
- over a dozen to several dozen f_o – characteristic for machines with toothed gears,
- 20 do 60 [kHz] – characteristic for surfaces rubbing one another in stroke pairs, rotating pairs and acoustic emission.

In toothed gears the development of the crack stage at the tooth base happens with the presence of changes in the modulated bands around the meshing frequency. The pitting, however, happens with the noise in wider and wider frequency band. This phenomenon is particularly visible in frequency range from 0 to f_z. An example picture of vibration signal spectrum of a toothed gear in rolling stand in various stages of consumption is presented in fig.2. Another method which enables the identification of the periodicity is the product spectrum. For a given frequency f_p a product of their successive harmonics $i \cdot f_p$ is marked in the range of the whole spectrum ΔF. The range of the given frequencies is limited to the frequencies $\frac{\Delta F}{3}$. The product spectrum is marked according to dependence:

$$I_w(f_p) = \sqrt[N]{\prod_{i=1}^{N} G_{uu}(i \cdot f_p)} \quad for \quad f_p \in \left(0, \frac{\Delta F}{3}\right) \qquad (3)$$

where: $G_{uu}(f)$ – power spectral density.

An example of product spectrum application is presented in fig. 3, achieved on the basis of vibration signal in toothed gears of rolling stand drives in rolling time. Changing in formula (3) the product sign to sum sign, and the root sign to division sign by number of sum elements, we get the formula for poly-harmonic spectrum:

$$P_w(f_p) = \frac{1}{N}\sum_{i=1}^{N} G_{uu}(i \cdot f_p) \quad for \quad f_p \in \left(0, \frac{\Delta F}{3}\right) \qquad (4)$$

Poly-harmonic spectra received from a vibration signal of toothed gears in rolling stand drives in rolling time are shown in fig.4 .

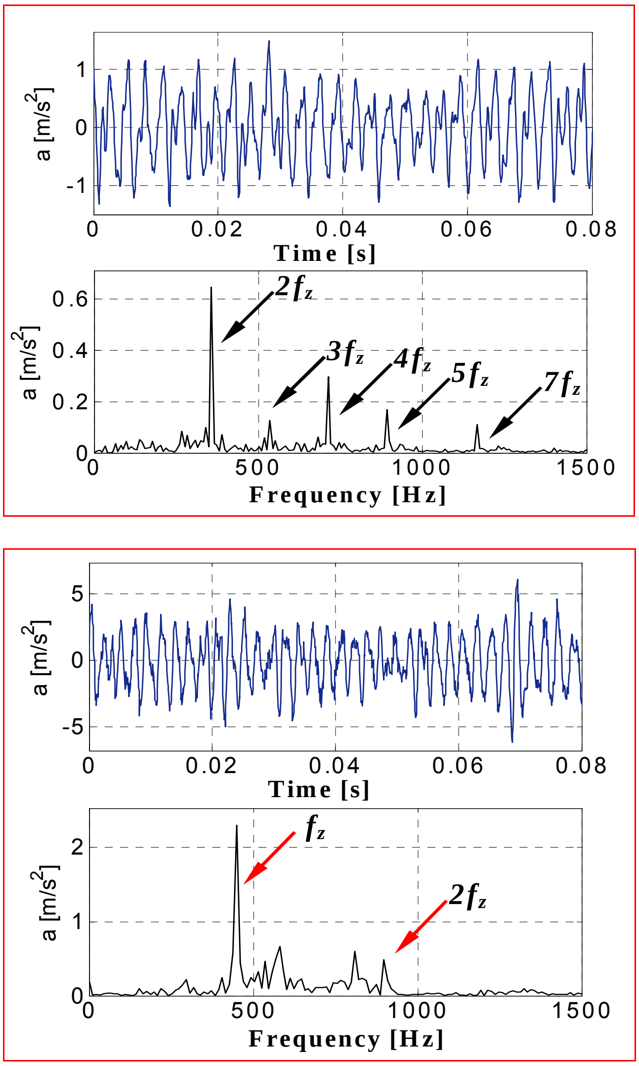


Fig. 2 Time runs and vibration signal spectra of the toothed gears in rolling stand drives in rolling time a – gear in general good dynamic condition (cage k4), b – gear classified for repair (cage k12).

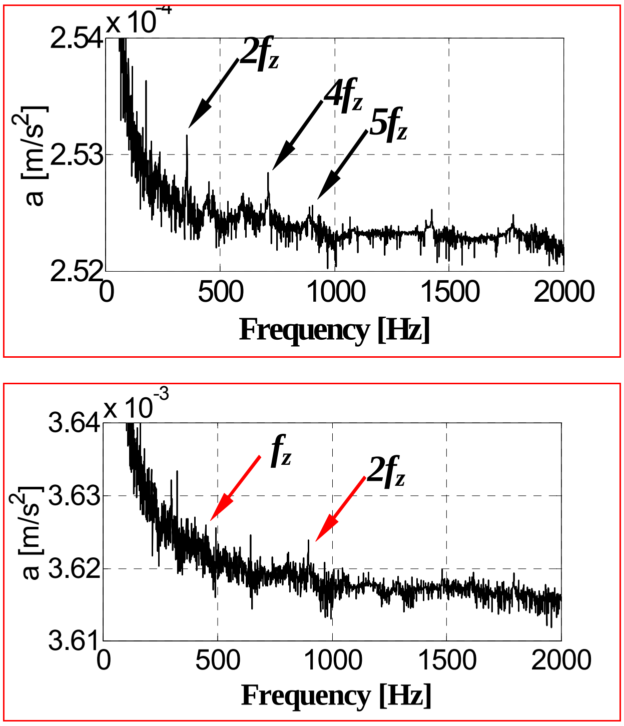


Fig. 3 Product spectra of toothed gears vibration signals in rolling stand drives in rolling time a – gear in general good dynamic condition (cage k4), b – gear classified for repair (cage k12).

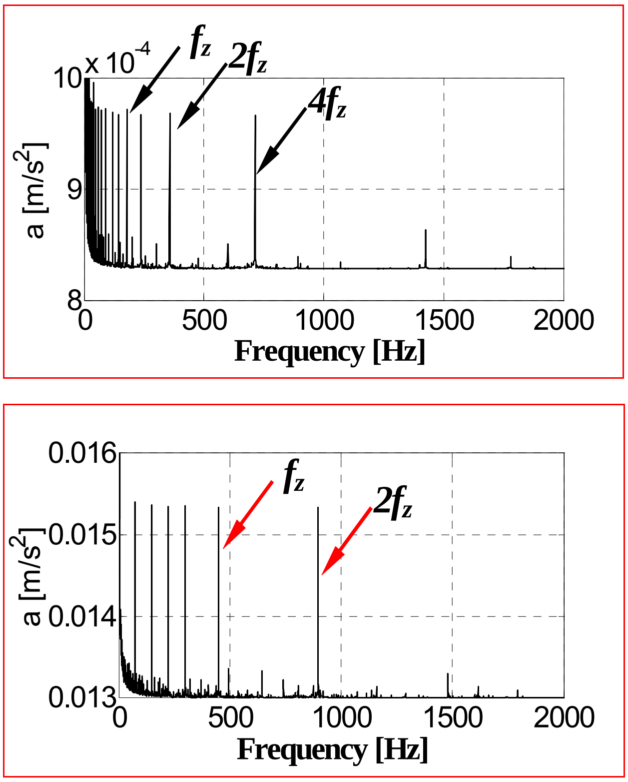


Fig. 4 Poly-harmonic spectra of toothed gears vibration signals in rolling stand drives in rolling time a – gear in general good dynamic condition (cage k4), b – gear classified for repair (cage k12).

CONCLUSION

From the number of vibroacoustic signals analysis methods applied in diagnostic practice only some are presented in this paper in reference to the analysis methods of frequency domain. Those analyses are the starting point in defining the diagnostic measures for particular diagnosed cases [1-10]. The damage descriptors of particular elements of power transmission systems built on their basis are used in forming the complete diagnostics systems. The most recently designed diagnosis systems work according to methods of artificial intelligence [3,5].

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ACTA TECHNICA CORVINIENSIS
BULLETIN OF ENGINEERING

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SOME POSSIBILITIES OF STEEL HARDOX CUTTING ECONOMICAL EFFECTIVENESS INCREASE TECHNOLOGY AWJ IN RELATIONS ON TECHNOLOGICAL PARAMETERS

Abstract:
Economical effectiveness of manufacturing systems is one of decisive indicators of prosperity and firms competitive ability and is influenced through more factors.
Also technological parameters of manufacturing system have significant influence on it. The article presents results of experimental research on the manufacturing system with technology AWJ.
The article describes economical effectiveness of steel HARDOX cutting and technological parameters of manufacturing system on the basis of numerous experiment results. The utilization areas and main contributions also are mentioned.

Keywords:
economical effectiveness, manufacturing system, technological parameters, main contributions

INTRODUCTION

Economical effectiveness of manufacturing systems is one of decisive indicators of prosperity and firms competitive ability and is influenced through more factors.
Also technological parameters of manufacturing system have significant influence on it. The article presents results of experimental research on the manufacturing system with technology AWJ. Influence of technological parameters, cutting head movement speed „v“, pump pressure „p“ and mass flow of abrasive „m_A“for cutting time „t“ is researched. On the foundation of experiments evaluation principles and recommends for firms working manufacturing systems with technology AWJ are formulate.

EXPERIMENTS

The set of experiments enabling to formulate as follows recommends for cutting process effectiveness increase and also manufacturing system working economical effectiveness with technology AWJ was performed in framework technological parameters influence research and quantification on cut area quality parameters with technology AWJ. On the foundation of experiments planning theory knowledge experiment with three factors and three levels of factors (three technological parameters with three values for every researched technological parameter) i.e. 27 (3^3) combinations of technological parameters values was side dimension 40 mm and cut areas number 27.

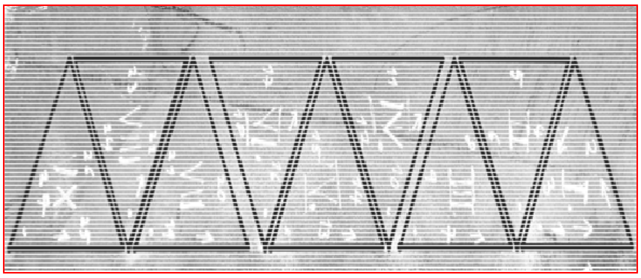

Figure 1 represents Method of samples designation and numbering

EXPERIMENTS EVALUATION AND DISCUSSION

Cutting times for single of three technological parameters v, p, m_A number values combinations are calculated from cutting speed and course given by sample sizes and led into table 1.

Table 1 Measured values of cutting time

Sample thickness h					
Sample Identification		Technological Parameters			
No. of sample	No. of sample cutting surface	m_A [g/min]	p [MPa]	v [mm/min]	cutting time t [s]
I	1	170	300	10	240
	2	170	300	15	160
	3	170	300	20	120
II	4	170	340	10	240
	5	170	340	15	160
	6	170	340	20	120
III	7	170	380	10	240
	8	170	380	15	160
	9	170	380	20	120
IV	10	220	300	10	240
	11	220	300	15	160
	12	220	300	20	120
V	13	220	340	10	240
	14	220	340	15	160
	15	220	340	20	120
VI	16	220	380	10	240
	17	220	380	15	160
	18	220	380	20	120
VII	19	270	300	10	240
	20	270	300	15	160
	21	270	300	20	120
VIII	22	270	340	10	240
	23	270	340	15	160
	24	270	340	20	120
IX	25	270	380	10	240
	26	270	380	15	160
	27	270	380	20	120
$\sum t$ [min]					78

We see from the table that cutting head movement speed increase lowers expressively cutting time. Changes of pump pressure and mass flow of abrasive in researched range of their values did not cause change of cutting time. At speed growth 100 percent (from 10 on 20 mm/min) cutting time was shortened on a half (from 240 on 120 minutes).

NEW KNOWLEDGE AND RECOMMENDS

For cutting process economical effectiveness increase it is possible to recommend cutting speed increase. The cutting speed increase has however expressively unfavourable influence on cut area quality increasing with cut material thickness. This unfavourable influence of speed on quality it is possible to appease with increase of pump pressure and mass flow of abrasive. From authors las measurement on Working-place of liquid jet on Technical University in Ostrava resulted that with increase of pump pressure from 300MPa on 380 Mpa at constant speed 20mm/min and constant mass flow of abrasive 170 g/min lowers unfavourable value of jet deviation at cutting head high speed (20 mm/min) from value 30,1 on 21,2 degree almost by a third. Analogously at mass flow of abrasive with increase of its value from 170 g/min on 270 g/min abd at constant pump pressure 300 Mpa unfavourable value of jet deviation at high cutting head speed (20mm/min) is lowered from value 30,1 on 18,3 degree then more than by a third. At simultaneous increase of pressure from 300 Mpa on 380 Mpa and also mass flow of abrasive from 170 on 270 g/min it is possible to lower unfavourable value of jet deviation at high cutting head speed (20 mm/min) from value 30,1 on 14,6 degree then on less than a half.

REGIONS OF UTILIZATION AND MAIN CONTRIBUTION

Knowledge in the article will be a contribution for increase of economical effectiveness and competitive ability of firms working manufacturing systems with technology AWJ. Their contribution shows mainly in objectiveness and exactness increase at determination of number values of technological parameters, in programming time shortening but mainly in cutting time shortening (with finding suitable numbers values of technological parameters) at *in lowering cut area surface quality. They can serve also as foundations for research aimed at working manufacturing systems and AWJ optimalization.*

CONCLUSION

The article busies with actual and for firms working manufacturing systems with technology AWJ acute problematics of technological parameters influence on cutting time and as follows on manufacturing systems working economical effectiveness with technology AWJ at considering cut area surface quality. On basis of evaluated experiments conclusions and recommends are elaborated and concrete examples shown. The solution forms one of foundations for modelling and simulation of technological parameters influence on manufacturing systems with technology AWJ working economical effectiveness. It is possible to utilise methods of solution exercised in the article in the form of analogy also for further especially relative jet technologies.

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The contribution presents the part results of the task VEGA 1/0544/08 solution

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ACTA TECHNICA CORVINIENSIS
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INFLUENCE OF IMPACT ANGLE ON ABRASIVE WATER JET CUTTING QUALITY

Abstract:
The analytical model has been derived for description of the abrasive water jet cutting efficiency. Several material parameters are included in the model and the investigation of their influence on both the qualitative and quantitative cutting results is the topic of the contribution. The theoretical equation has been prepared for description of the dependence of the angle between the tangent to the striation curve and the impinging jet axis, called the declination angle, on the depth of jet into material penetration. Tilting of the cutting head reducing negative phenomena can be evaluated from this theory. The levels describing depth-dependent surface quality of cutting walls has been introduced and the experimental methods for quality evaluation were prepared. The so-called "geometrical model" describing the negative consequences of water jet delay inside the cutting kerf was prepared. Comparison of the theoretical investigation and experimental data is discussed.

Keywords:
abrasive water jet; cutting; declination angle; striations; surface quality

INTRODUCTION

The abrasive water jet has been investigated since the end of seventies of the twentieth century. Many researchers are dealing with this topic all over the world. A small group of researchers has been dealing with the problem also in our country since the middle of eighties. The theoretical approach based on the law of conservation of energy and the law of conservation of momentum was presented in the beginning of nineties. Thenceforth, the model has been continually improved and updated. The efforts of the improvement of the CNC cutting machines started the new stage of a deeper interest in theoretical and experimental investigation of the process. Some recent approaches and results are presented in the paper.

PRESENT STATE-OF-THE-ART

One of the earliest models and experiments in the branch were performed in the beginning of eighties of the last century. They were improved many times and many new elements were introduced into them extending their use and validity range (e.g. Hashish 1989, Zeng and Kim 1996). Further investigations were aimed at 3D abrasive water jet machining (Kovacevic and Yong 1996a, b) or the cutting quantity (Hlaváč 2001, Chen et al. 2003, Henning and Westkämper

2006, Monno et al 2006). The most often situation is, however, that the own theoretical bases not easily interchangeable or addible are developed. Published experimental data are non-comparable for some important information being omitted many times.
The theoretical approach of Hlaváč has been used in this work, especially his description of the abrasive water jet interaction with material (Hlaváč 2001). His model was enhanced implementing the declination angle relationship on the cutting depth (Hlaváč 2009).

THEORETICAL APPROACH

Theoretical description of the cutting process is based on the energy conservation law (Hlaváč 1998). The resulting set of equations enables to calculate the limit depth of penetration of the abrasive water jet into the material with known parameters for implicit cutting parameters. The modification of the traverse speed from the limit value to the one assuring the selected quality even on the worse part of the cutting wall was derived from the five-step kerf evolution process fully described in 2009 (Hlaváč 2009). The declination angle of the jet axis in the cut is in a direct relationship with the respective wall quality in a certain depth. Declination angle Θ is measured between the tangent to the striation curve in the depth h and the impinging jet axis. It is determined by equation

$$\theta = arctg\left(\frac{df(h)}{dh}\right) : h^{1.5} \qquad (1)$$

The basic equations used in a subsequent experimental work were derived and presented by Hlaváč (2009). They enable calculation of the declination angle respective to certain depth in material or respective to the traverse rate. Inverse calculation of the appropriate traverse rate v_P for selected declination angle Θ is possible from Eq. 2

$$v_P = v_{P\,lim}\left(\frac{\theta}{\theta_{lim}}\right)^{\frac{2}{3}} \qquad (2)$$

v_{Plim} is the limit traverse rate and Θ_{lim} is the respective limit declination angle for given material thickness H.

EXPERIMENTAL PROCEDURE

The experiments were performed with the following invariable parameters:

Pressure inside the pumping system	*400 MPa*
Water orifice diameter	*0.25 mm*
Stand-off distance	*2 mm*
Focusing tube diameter	*1.02 mm*
Focusing tube length	*76 mm*
Abrasive mass flow rate	*225 g/min*
Abrasive material average grain size	*0.275 mm*
Abrasive material type	*Australian garnet*
Basic angle of impact	*0 rad*

Firstly the linear cuts were performed and later on the circular cuts were done. The differences in the radii on the top and on the bottom of the kerf were analyzed. Several steals and copper were investigated to prove the supposed relationships between the individual material parameters and respective declination angles measured according to Hlaváč et al. (2009). These relationships are inherently included in the theoretical base (Hlaváč 1998, 2001).
The Eq. 2 was used for calculation of the traverse speeds for the appropriate declination angles by the exit of the jet from material. Some results are presented in Tab. 1. The variable H is the material sample thickness, V_{Pt20} is the traverse speed determined from the theory for the declination angle 20°. Similarly, the quantity V_{Pe20} is the experimentally determined traverse speed for the declination angle 20°. Tilting of the cutting head should improve the quality of the walls in kerf (especially delay of the jet) as it is demonstrated in Fig. 1 for tilting 10°.

Tab. 1. Some experimental results and their comparison with presented model

steels	H	V_P	Θ	V_{Pt20}	V_{Pe20}
CSN EN	mm	mm/min	(°)	mm/min	mm/min
11523	10	100	11.4	146	140
12050	10	100	16.5	116	115
14220	10	100	13.7	128	125
15142	10	100	17.9	105	105
17246	10	100	16.6	116	110
19437	10	100	23.6	93	90

Fig. 1. Plate from Hardox™ 500 15 mm thick cut with tilted cutting head (angle 10°, traverse rate calculated from Eq. 2)

The radii of the curves on the inlet surface and on the outlet surface are different for curved trajectories when all material and jet parameters are constant. It is supposed that this difference is caused by a geometrical variable directly chained with the radius of the trajectory curvature called the trailback, demonstrated in Fig. 2.

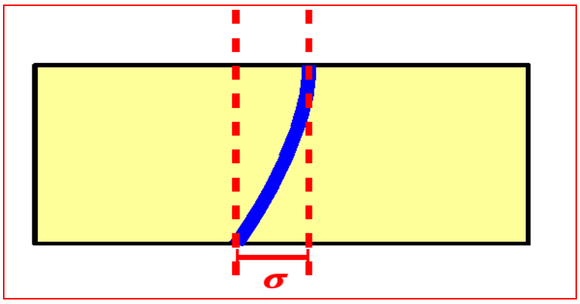

Fig. 2. Trailback σ the blue line demonstrates striation line being the trace of the jet penetrating through material

In the case of curved trajectory the jet delays inside the cut in the plane given by the jet axis and tangent to the jet trace trajectory on the material surface. This situation is graphically outlined in Fig. 3.

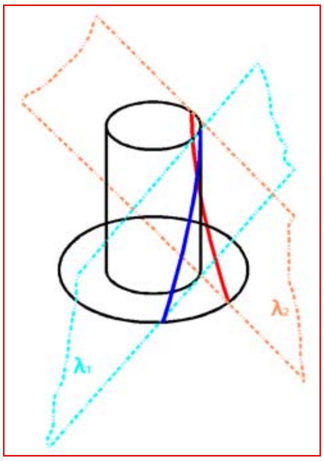

Fig. 3. An example of planes λ_1, λ_2 determined by jet axis and respective tangents to the required cutting curve

It is evident from the Fig. 4 that knowledge of the trailback σ for given material and depth is fully sufficient for determination of the relationship between the radii R_1 and R_2 of the conically disturbed column shape. It is evident that the maximum deviation Δ_σ from the required curve radius is determined from the equation 3.

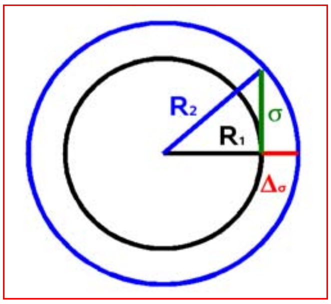

Fig. 4. Deviation Δ_σ from the required curve radius R_1

$$\Delta_\sigma = \sqrt{R_1^2 + \sigma^2} - R_1 \qquad (3)$$

R_1 is a required radius of the cutting trajectory and σ is the trailback. Equation 3 describes the influence of the cutting curvature radius on deviation from the required dimension for a constant trailback σ that includes material and cutting parameters. The trailback enables to determine the deviations Δ_σ of the radii of curves during the cutting process. The model can be generalized using Eq. 2. Trajectory of the jet can be described as a function of jet and material parameters included in a previously derived theoretical base (Hlaváč 2001). Introducing the knowledge from Eq. 2 into Eq. 3 the maximum deviation from the required shape is expressed as Eq. 4

$$\Delta_\sigma = \sqrt{R_1^2 + \left[\frac{2}{5} H \, tg\left[\Theta_{lim}\left(\frac{v_P}{v_{P\lim}}\right)^{\frac{3}{2}}\right]\right]^2} - R_1 \qquad (4)$$

Equation 4 is a function of important variables like the sample thickness H, traverse rate v_P and the cut curvature radius R_1. Information about liquid pressure, abrasive mass flow rate, the stand-off distance and material parameters is included in the limit traverse rate v_{Plim} and the limit declination angle Θ_{lim}. The submitted model was compared with data obtained from measurement of the radii of experimental rings with various diameters (an example of rings is presented in Fig. 5). The graph in Fig. 6 shows the typical comparison of results calculated from the model and the ones measured on rings.

Fig. 5. An example of rings cut in steel plate

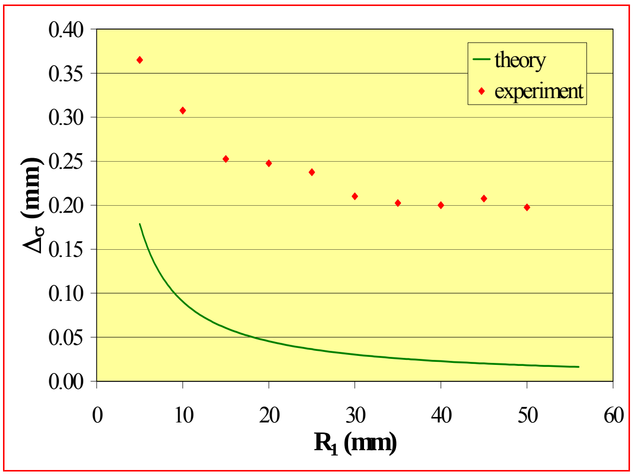

Fig. 6. An example of rings cut in steel plate

It is evident that some shift is needed for a theoretical model to correlate it with experimental results. Therefore, it can be supposed that the model should consist of two independent parts – the one related to the radius of cutting curvature R_1 and the one independent on the curvature. It is supposed that this second part is closely related to the jet divergence or convergence inside the cutting kerf (see the scheme in Fig. 7).

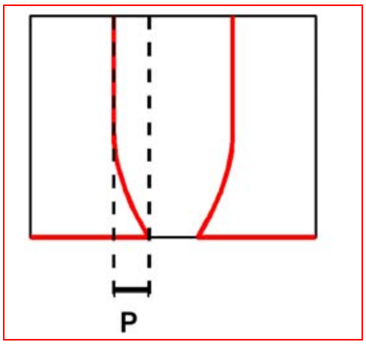

Fig. 7. Finding of the constant parameter P

As the shift is to be independent on curvature radius, it can be found out from the linear cut similarly to the parameter σ. The cross profile of the cut enables to determine the shift (Hlaváčová et al. 2008), because for the traverse rate higher than the optimum one the bottom part of the sample is not cut in the same width as the upper part like at the scheme in Fig. 7. The taper of the cut P is identical for both linear and curved cuts. The deviation from the normal projection of the upper edge of the cut to the output sample surface characterizes the convergence of the cut and it is the parameter P being searched for.

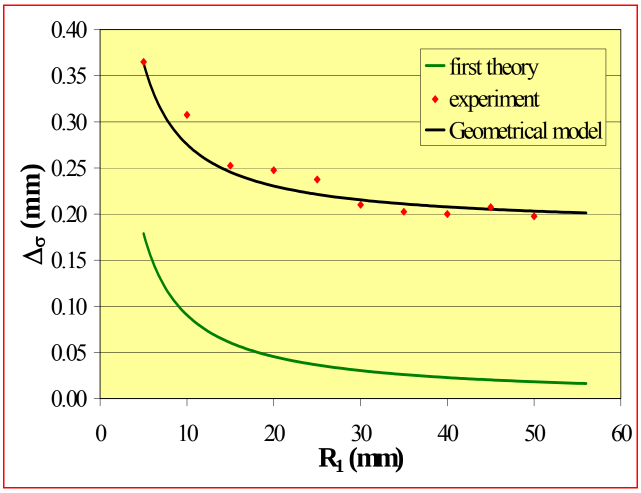

Fig. 8. Comparison of the Geometrical model with experiments

The theoretical model improved by implementation of the parameter P is named the Geometrical model. It is in a good correlation with experimental data (Fig. 8). This model is fully applicable and describes the relationship of the deviation of the real dimension of the work-piece from the required one when cutting in curvature. Application of this model in practice is possible through this equation

$$\Delta_\sigma = \sqrt{R_1^2 + \left[\frac{2}{5} H \; tg\left[\theta_{lim}\left(\frac{v_P}{v_{P\,lim}}\right)^{\frac{3}{2}}\right]\right]^2} - R_1 + P \qquad (5)$$

Δ_σ is the deviation of the cut shape, R_1 is the curvature radius, H is the sample thickness, v_P is the traverse rate, v_{Plim} is the limit traverse rate and Θ_{lim} is the limit declination angle.

DISCUSSION

The theoretical model was used for calculation of the respective traverse speeds for declination angle 20° and several materials. Subsequently, the experiments were performed verifying the hypothesis that tilting of the cutting head into the half value of the declination angle should result in such a deformation of the striation lines that the jet penetrating the material exits it approximately along the normal to the material surface created at the point of jet axis entry. The tilting of the cutting head to the half value of the respective declination angle should minimize the typical defects caused by the abrasive water jet deflection when the cut starts, ends, changes direction in the corners and curved parts of trajectories.

The presented theory and experimental data imply that the changes of the impact angle through the tilting of the cutting head can be used for modification of the cutting surface quality.

CONCLUSION

The declination angle between the tangent to the striation and the impinging abrasive water jet axis can be used for calculation of the required traverse speed or the tilting angle of the cutting head. Tilting of the cutting head can be utilized for reduction of the shape deviation in the case of curved cuts. It is demonstrated that the theoretical model can be used for prediction of cutting variables. The power of the model is demonstrated in comparison with experimental results and it is proved that it is usable for calculation of the cutting head tilting respective to the traverse speeds and their changes.

ACKNOWLEDGMENT

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ACTA TECHNICA CORVINIENSIS
BULLETIN OF ENGINEERING

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DIAGNOSTICS OF DRIVE DYNAMICS WITH HYDRAULIC MOTOR AND INERTIAL MASS

Abstract:
The paper deals with diagnostics of hydraulic drive dynamics with hydraulic motor. Flow and speed of the hydraulic motor are controlled by proportional distributor. There are measured and evaluated time-response characteristics of pressures before and behind the hydraulic motor and time-response characteristics of speeds of the hydraulic motor with the inertial mass on control voltage step change. This voltage is brought to card of the proportional distributor at the same time. The dynamic behaviour of the drive with the hydraulic motor and the inertial mass at ramp change of the control voltage on the card input of the proportional distributor is subsequently measured and evaluated.

Keywords:
hydraulic motor, inertial mass, time – response characteristics, ramp change

INTRODUCTION

Proportional distributors [5] are applied in hydraulic applications to continuous control of flow. The size and direction of flow corresponds to inlet control electric signal. The hydraulic motor with inertial mass controlled by the proportional distributor forms an oscillating system with the eigenfrequency f. The eigenfrequency of the rotary hydraulic motor depends on its geometric volume, moment of inertia of rotating masses, liquid volume and bulk modulus of liquid [1], [3]. The recommended time of the ramp function for run up and run down is calculated in order to reduce unfavourable dynamic effects.

MEASURING EQUIPMENT

The hydraulic drive with the rotary hydraulic motor is controlled by the proportional distributor [2]. The inertial mass is realized by steel discs. The hydraulic pump with constant pressure control is used as the source of pressure liquid. The tank with the volume of 160 dm^3 consists of air filter, thermostat, water level sensor, cooler and low pressure filter. The flow size and direction of liquid are controlled by the proportional distributor with its external control card. Mineral oil [4] was used as the working liquid. The source of control voltage uv is the stabilized voltage source with the potentiometer for step voltage change uv and the functional generator to control ramp function of voltage uv.

Rotating axial piston motor with rotating inclined plate was used as the output consumer. The moment of inertia of rotating masses (i. e. of the rotary hydraulic motor, two rotating discs, brake disc, shaft and mechanical coupling) is $J_M = 6.10^{-2}$ $kg.m^2$ [3] in this case. The hydraulic motor is connected to the proportional distributor by high-pressure hoses with the inner diameter of 0.012 m and the length of 1.6 m. The hydrostatic drive is shown in Fig. 1 [2]. The auxiliary view of the hydraulic motor is displayed in Fig. 2.

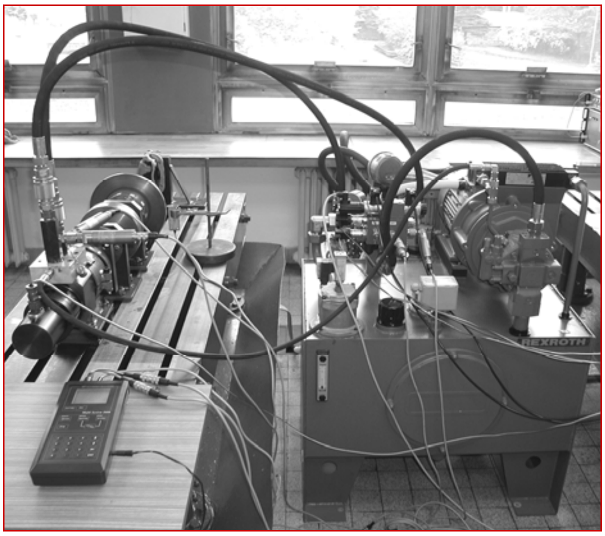

Fig. 1 Measuring equipment

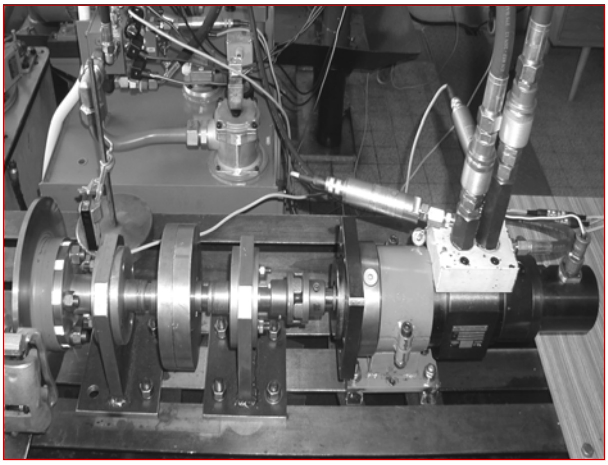

Fig. 2 Auxiliary view of hydraulic motor

The time-response characteristics of the pressure pB on the inlet to the hydraulic motor, the pressure pA on the outlet from the hydraulic motor and the voltage uTD of the tachogenerator were experimentally measured in this case. The time-response characteristics were measured for option of the hydraulic motor with inertial mass realized by steel discs and for option without the discs. The responses of the pressures pA and pB and the voltage uTD to control input signal ramp function were measured for option with the inertial mass. The measurement was realized by the measuring system M 5050 Hydrotechnik. The pressures pA and pB were measured by pressure sensors Hydrotechnik (range (0 ÷ 200) bar) with the measurement accuracy ± 0,5 %. The voltage of the tachogenerator uTD was measured by the voltage sensor Hydrotechnik. The course of speed for the hydraulic motor can be determined from the measured voltage of the tachogenerator uTD (i. e. 16 V = 1000 rpm).

TIME-RESPONSE CHARACTERISTICS OF DRIVE WITH HYDRAULIC MOTOR LOADED BY MASS DISCS

The time-response characteristics of the drive for the hydraulic motor with the mass discs were measured for the control voltage step change uv = (0 ÷ 5) V. The time-response characteristics of the inlet pressure pB and the outlet pressure pA of the hydraulic motor and the voltage uTD of the tachogenerator after the control voltage step change uv = (0 ÷ 5) V are demonstrated in Fig. 3. The measured responses show a vibrating course with significantly damped dynamic processes. The maximal instantaneous pressure pB = 108 bar on the inlet of the hydraulic motor during the first amplitude is considerably higher in comparison with the steady-state value pB = 34 bar. It is possible to determine the vibration period T of the pressure between the 3rd and the 4th response oscillations:

$$T = 37.345 - 37.1 = 0.254 \text{ s} \quad (1)$$

The corresponding system eigenfrequency f is subsequently given by the formula:

$$f = \frac{1}{T} = 4.1 \text{ Hz} \quad (2)$$

The significant maximum of the pressure pB = 97.4 bar in comparison with the steady-state pressure pB = 26 bar was measured after the control voltage step change uv = (0 ÷ 4) V. The maximum of the pressure pA = 122.5 bar on the outlet of the hydraulic motor at the first pressure oscillation from the steady-state value pA = 24 bar was measured at the control voltage step change uv = (5 ÷ 0) V. The pressure pA was subsequently reduced to the value pA = 0 bar at the hydraulic motor stop.
The significant maximum of the pressure pA = 82.4 bar in comparison with the steady-state pressure pA = 18 bar was measured in the hydraulic motor outlet after the control voltage step change uv = (4 ÷ 0) V.

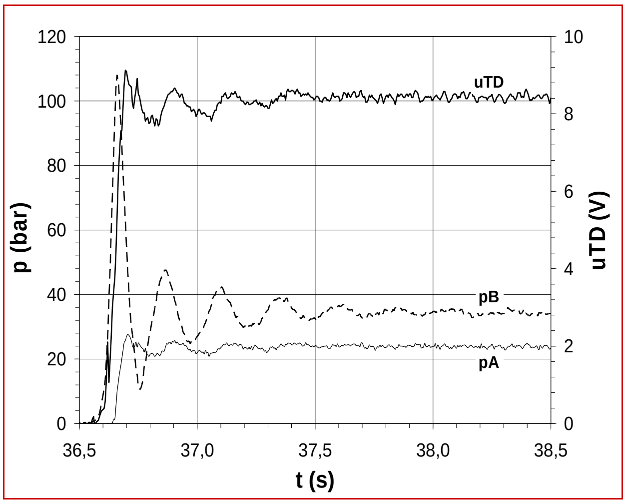

Fig. 3 Time-response characteristics of pA, pB, uTD, uv = (0 ÷ 5) V, with inertial mass.

TIME-RESPONSE CHARACTERISTICS OF DRIVE WITH HYDRAULIC MOTOR WITHOUT INERTIAL MASS

The time-response characteristics of the drive for the hydraulic motor without the inertial mass were measured for the control voltage step change uv = (0 ÷ 5) V. The time-response characteristics of the inlet pressure pB and the outlet pressure pA in the hydraulic motor and the voltage uTD of the tachogenerator after the control voltage step change uv = (0 ÷ 5) V are displayed in Fig. 4. The run up of the hydraulic motor is smooth (see Fig. 4).

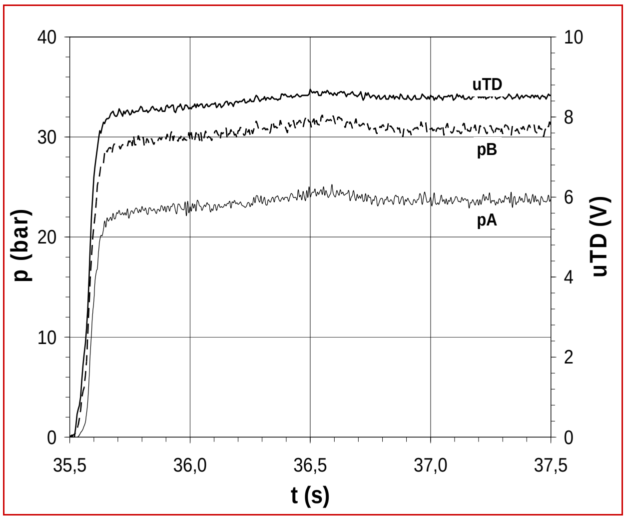

Fig. 4 Time-response characteristics of pA, pB, uTD, uv = (0 ÷ 5) V, without inertial mass

RESPONSE OF DRIVE WITH HYDRAULIC MOTOR LOADED BY MASS DISCS ON RAMP FUNCTION

The responses of the drive with the hydraulic motor loaded by mass discs on the control voltage linear ramp functions uv = (0 ÷ 4) V and uv = (4 ÷ 0) V were also measured. The time of the linear ramp function was T = 2 s in this case. The responses of the quantities pA, pB and uTD during the ramp function uv = (0 ÷ 4) V for the time T = 2 s are displayed in Fig. 5 [2]. From Fig. 5 is evident that there is not significant pressure peak due to slow run up of the ramp function of the control voltage. The peak pressure on the hydraulic motor inlet is only pB = 33.1 bar, while in the case of the steady-state is the pressure pB = 26.5 bar. Similarly, the responses of the quantities pA, pB and uTD during the ramp function uv = (4 ÷ 0) V for the time T = 2 s are displayed in Fig. 6 [2].

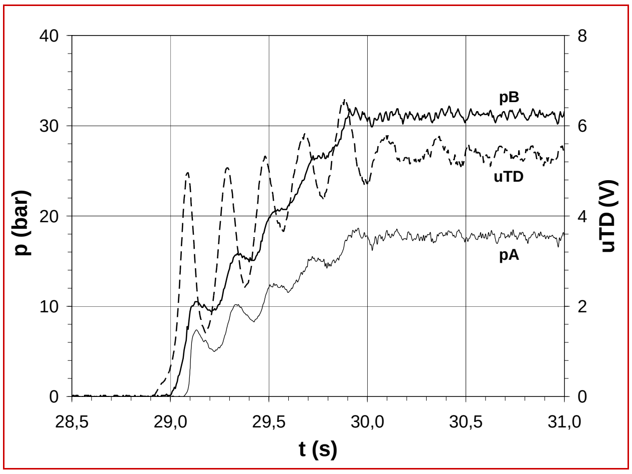

Fig. 5 Responses of pA, pB, uTD, ramp function uv = (0 ÷ 4) V, T = 2 s, with inertial mass

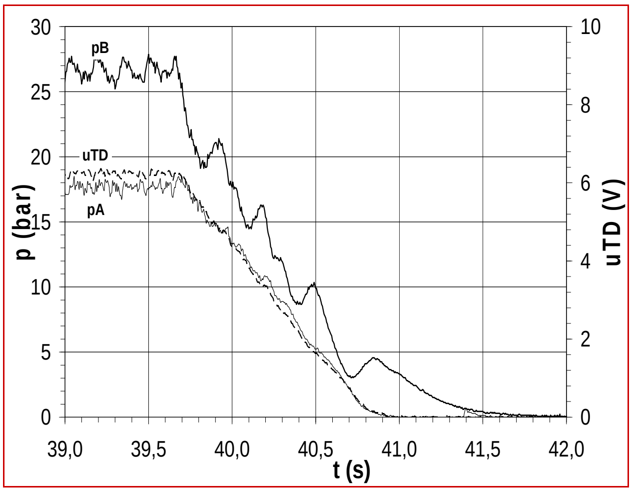

Fig. 6 Responses of pA, pB, uTD, ramp function uv = (4 ÷ 0) V, T = 2 s, with inertial mass

CONCLUSION

The effect of the inertial mass on significant pressure overshoot (during the run up) on the hydraulic motor inlet and significant growth of pressure (during the braking) on the hydraulic motor outlet are evident from the measured time-response characteristics of the investigated drive with the hydraulic motor. The elimination of pressure peaks in the hydraulic motor during the run up and the braking is evident from the measured responses at the control voltage uv of ramp functions of the investigated drive with the hydraulic motor.

There is evident the influence of the time behaviour of the control voltage uv on the course of the pressure pB on the hydraulic motor inlet at its start with the inertial mass. For the step change of the control voltage uv (0 ÷ 5) V, the response of the pressure pB has the expressive first maximum pB = 97.4 bar at the first oscillation in comparison with the response of the pressure pB at the small ramp function (see Fig. 5) of the control voltage uv (0 ÷ 4) V. The time behaviour of the control voltage uv on the time dependence of the pressure pA on the hydraulic motor outlet is similarly evident at its stopping with the inertial mass from the measuring data. The pressure response at the step change of the control voltage uv = (4 ÷ 0) V has the expressive first maximum pA = 82.4 bar at the first oscillation in comparison with the pressure response on the small ramp function (see Fig. 5) of the control voltage uv = (4 ÷ 0) V.

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INFLUENCE OF CUTTING TOOL FORM ON MORPHOLOGY MACHINED SURFACE AT STAINLESS STEEL Cr20Ni8Ti

Abstract:
This article presents conclusions of quality tests on austenitic stainless steels Cr20Ni8Ti and describes appropriate parameters for the machined surface at drilling. The paper present of real experimental results. The authors would like to thank in words the VEGA grant agency at the Ministry of Education SR for supporting research work and co-financing the projects: Grant work VEGA #01/0406/2003 and Grant work VEGA #01/3173/2006 and Grant work KEGA #3/7166/2009

Keywords:
machined surface, cutting zone, cutting tool, drilling

INTRODUCTION

Deformation behaviour of material during cutting expresses the evaluation and knowledge of material properties changes during the course of cutting deformation process. It enables to understand and to control this process. In the contribution are analysed the sources of stability and instability of deformation process and their influance on the chip shape and on the tool loading.

This paper is concerned with the topic of drilling. It will be of importance to teachers of Industrial Technology, those involved in machining research, and industrialists with an interest in process monitoring.

This paper will describe the machined surface morphology of Cr20Ni8Ti stainless steel. Stainless steels are often considered to be poorly machinable materials; materials with high elasticity are also difficult to machine. In drilling stainless steel with a pseudo-elastic coating material, machinability difficulties are caused by the high strength and work hardening rate of steel and the pseudo-elastic properties of the coating material, [2], [8], [9], [16]. The deformation effects were studied by analyzing HSCo steel drills.

The interface between stainless steel was examined with SEM (Scanning Electron Microscopy). Drilling is one of the oldest and most common machining operations. The tools themselves have not changed much over the centuries, but the cutting materials and machine tools that employ them have. However, for its simplicity and commonality, the cutting geometries in drilling are extremely complicated and the process is terribly inefficient.

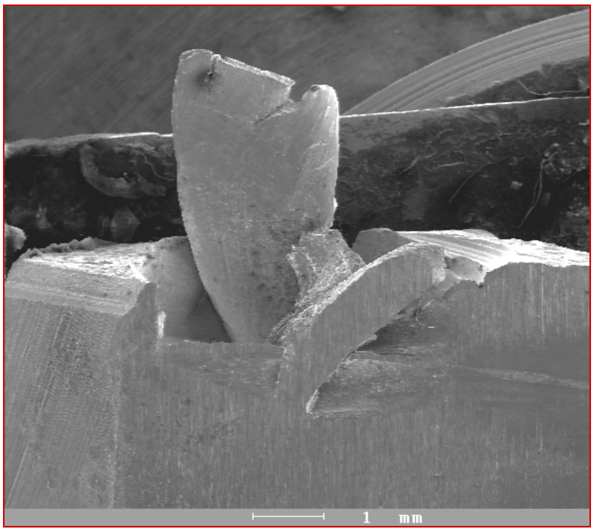
The effect of feed rate on chip formation was analyzed. The cutting tests indicated that cutting speeds of 50 m/min, a feed 0,08 mm/rev, and material HSCo drills can be applied, from a machinability standpoint. When effective cutting *speeds and feed rates were utilized, optimal tool life was achieved without several decrease in coating properties.*

CHARACTERISTIC OF PRODUCT MATERIAL AND CUTTING PROCESS

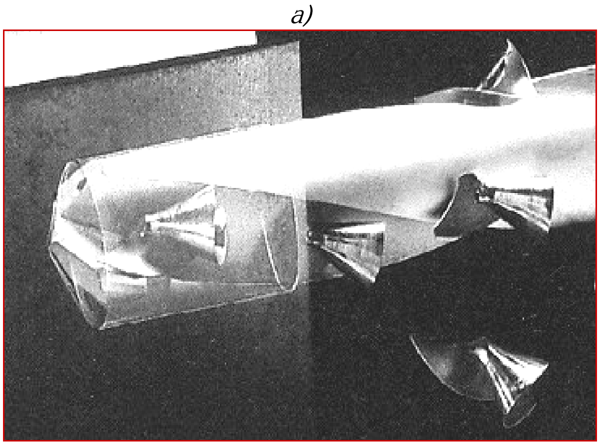
Wear is the result of interaction between tool, workpiece material and machining conditions. The main load factors are: mechanical, thermal, chemical, abrasive. Apart from the static components of mechanical load, there are various dynamic ones from the chip forming process itself, as well as more emphasized ones from varying cutting depth, interrupted cuts and mill. The partly because of the mechanical loads with varying cutting depth and feed rate: abrasive wear in the form of flank and crater wear, BUE oxidation forming a notch, plastic deformation and fatigue with risk of fracture.Stainless steel predominantly contains high levels of chromium and nickel, typically 18Cr-8Ni wt%. Additional elements may be added to enhance performance, but the benefits and side effects are sometimes hard to understand. However, various parameters will be examined such as dislocations, stacking faults, grain size, solid solution and precipitation hardening. Corrosion resistance, ductility, good weldability and resistance to high and low operating temperatures are some of the many reasons for the use of austenitic steels. Chromium is the main deterrent to corrosion through a process called passivity, where chromium combines with oxygen in the atmosphere to form a protective oxide layer [20]. This is especially useful when the metal is scratched, as the oxide layer re-forms quickly, hence protecting it from corrosion. However, chromium is a ferrite stabiliser. To counteract this, nickel is added as an austenite stabiliser, so that the microstructure at ambient temperature is austenitic. The basic properties of stainless steel have been studied and can be found in the materials the strain-rate effect plays an important role in plastic deformation of materials, several investigators have focused on the strain-rate effect for stainless steel at low rates. Over the past decades, many researchers have indicated that the plastic deformation of materials under dynamic loading is very different from that under static loading. Dynamic plastic behavior is often found during the metal-forming process, vehicular accidents, and unexpected foreign impacts. Products made from stainless steel are not infrequently subjected to dynamic loading. Although some investigators [1], [4], [6], have studied the impact and shock-loading behavior of stainless steel is dynamic plastic deformation, mechanical behavior, and associated microstructural evolution are still insufficient. Abrasion wear is caused by the action of sliding chips in the shear zone, as well as by friction generated between the tool flank and workpiece. This wear is compounded by the part's hardness and strength properties, which also dictate appropriate machining speeds. Chemical wear is caused by a reaction between the tool and workpiece materials. Thermal wear refers to breakdown caused by temperature cycling of the tool's cutting edge between heating and cooling stages of the machining process, [3], [5], [7], [10], [11], [12], [19]. Impact wear is breakdown of the tool's cutting edge that occurs when mechanical loading exceeds the physical properties of the tool material, [2], [15], [18]. Optimum process of machining is a precondition of effective employing of optimal working conditions. When deciding on cutting conditions of various materials it is necessary to take into consideration the characteristics of material properties and cutting conditions. Machinability is one of such characteristics. In the current market there is a demand for high quality products of corresponding properties. Only materials with specific physical, chemical, mechanical and other properties can meet the criteria of resistance to various aggressive environment, thermal and heat influence and high mechanical load. When the conditions for either adhesive wear or abrasive wear coexist with conditions that lead to corrosion, the processes interact synergistically to produce corrosive wear. As described earlier, surface fatigue wear is a wear phenomenon associated with curved surface in rolling or sliding contact, in which subsurface cyclic shear stresses initiate micro-cracks that propagate to the surface to spell out macroscopic particles and from wear pits. Deformation wear arises as a result of repeated plastic deformation at the wearing surface. Producing a matrix of cracks that grow and coalesce to from wear particles. Deformation wear is often caused by severe impact loading. Impact wear is impact-induced repeated elastic deformation at the wearing *surface that produces a matrix of cracks that grows in accordance with the surface fatigue description just given. The complexity of the wear process may be better appreciated by recognizing that many variables are involved, including the hardness, toughness, ductility, modulus of elasticity, yield strength, fatigue properties, and structure and composition of the mating surface, as well as geometry, contact pressure, temperature, state of stress, stress distribution, coefficient of friction, sliding distance, relative velocity, surface finish, lubricants, contaminants, and ambient atmosphere at the wearing interface. Tool wear is the product of a combination of load factors on the cutting edge. The life of the cutting edge is decided by several load, which strive to change the geometry of the edge.*

EXPERIMENTAL PART

Drilling tests were carried out using a vertical machining centre equipped with 10 000 rpm, 16 kW spindle. The tests used and TiCN-coated high speed steel with cobalt (HSCo) drills with a diameter of Ø 6 mm, at a cutting speed of 50 m/min and feed 0,08 mm/rev were used without coolant. All experiments was realizated in practice by product in firm from Cr20Ni8Ti steel. Cutting zone is a summary term from the region during cutting To properly describe the cutting zone it is necessary to describe the regions and test parameters. Primary plastic deformation zone (primarily an examination of phenomena associated with the creation and formation of chips, with the effect of the components of cutting force-the state of strain deformation, the location of the angle of the shear level, chip compression, the temperature field, chip shape, chip formation and separation, the effect of the components of cutting force). Secondary plastic deformation zone (primarily an examination of phenomena associated with friction and cutting wedge wear, and also with the generation of heat and temperature-the location of the grain angle, the contact length of the cutting wedge and the face plate, friction stress and scab creation (BUE), friction, the generation of heat and temperature, the mechanism of tool wear). Tertiary plastic deformation zone (primarily an examination of the phenomena associated with the shaping creation of the machined surface, its profile, morphology, qualities and inherited traits-contact of the machined surface and the worn side plate). Cutting surface, its properties and integrity. The gradually-deformed region of the cut layer. Researching the cutting zone (the interaction between the instrument, the work piece, and the cuttings) is to capture its state at the moment of the creation of the cutting (the so-called root of the chip), shown in Figure 1.



a)



b)

Fig.1 Cutting zone at drilling
a-chip root, mag 19x,
b-material destruction in front of cutting wedge

The process of cutting is the mutual interaction between the instrument and the work piece, which is controlled by many phenomena, which creates a synergistic effect. An understanding of the phenomena and domains involved arises from cutting zone experiments [13], [14]. It is important to define the shear level in the cutting zone. Weber states, that the depth of the shear level follows the formula $0.05h \leq h_{SP} \leq 0.1h$*, where h is the thickness of the cut section and* h_{SP} *is the depth of the shear level. The size of this local* *region was determined through the help of electron microscope analysis, and the results. We observe elements from the cut layer in the shear layer that have been displayed (they melt the cutting wedge). The thickness of the cut layer continually varies chip thickness h_1. Chip formation is described by Hencky and Zorev through the theory of plasticity. The strain line field extended to the region of plastic deformation, the machined surface, and the cut layer (the chip). Strain lines (the so-called Lüders-Černov lines) represent an extensive high-intensity deformation. Models of chip formation have been created by Weber, Oxley, Lee-Shaffer and others based on the theory of plasticity and the use of strain lines. It is our opinion that chip formation most closely follows the method of Oxley, which even accounts for the element of time in chip formation. From the standpoint of temperature effects in the cutting process, the cutting zone comprises a thermodynamic system whose state changes through heat transfer as a form of energy transfer. Thermal conductivity $A[W/K]=[kg\ m^2\ s^{-3}\ K^{-1}]$ expresses the capacity to diffuse heat in a specific environment. The specific thermal conductivity $\lambda\ [W/K\ m]=[kg\ m\ s^{-3}\ K^{-1}]$ as a material quality (or constant) expresses the capacity to diffuse heat through convection. It is especially characteristic for austenitic stainless steels that they have rather low values of specific thermal conductivity. For example, for C45 steel, $\lambda = 60\ [W\ m^{-1}K^{-1}]$ and for austenitic stainless steels $\lambda=18.7$ to $22.8\ [W\ m^{-1}K^{-1}]$, so its conductivity is three times worse in comparison with the reference material (C45 steel), which is often used in actual work. The variable temperature field appears mainly in the formation of individual chips, whose deformation is not homogenously concentric in the individual pieces connected to the later of intensively deformed material. According to Dehlinger strain hardening, which arises are a result of the total amount of strain and external forces, tends to achieve marginal values towards the beginning of fatigue interruption. A variable load means that plastic deformations appear in small regions and fatigue cracks begin in the slip layers. For Oding, Cobkallo, Kuznetzova, Glikman and Techt strain hardening represents only the first measurable stage of the process of fatigue. Austenitic Cr-Ni steels are, as a result of their higher ductility, more prone to surface strain hardening, which compared to construction steel can be up to 1.5 times as great. In a non-deformed state austenitic steels are not as hard as C45 steel, but in cases of great deformation they are greatly harder than ferritic-perlitic steel. Low thermal conductivity has a large significance in austenitic stainless steel turning. It means the temperature which arises during the process of cutting on the touching plates of the cutting instrument is poorly dissipated, which results in an increase in temperature on the touching plates, lowering the instrument's resistance to wear, reducing its longevity. This makes itself most apparent in the use of cutting instruments made from high-speed steel, whose firmness and thus resistance to wear drops sharply at higher temperatures. Sintered carbide instruments are not as sensitive to temperature on touching plates as high-speed steel, and can be used to attain higher performance, but in this case they have greater pressure stress, which directly influences the process of adhesive wear. The micro geometry of the outer surface is characterised by micro geometric chipping. For evaluating the outer surface after drilling . and defining the cutting process conditions, the following parameters were used in the investigation: the outer surface roughness parameter Ra [μm] was measured on two measuring instruments, a HOMEL TESTER T 1000C and a HOMEL TESTER T 6 D, the hardness of the outer surface layer was evaluated following Brinnell [HB] with the help of a hardness tester, the micro hardness of the outer surface layer was evaluated following Vickers [HV] with the help of another hardness tester, increased tension and morphology of the outer surface after cutting were evaluated after careful analysis using an x-ray microscope. On the figure 2 and figure 4 are define characteristic the machined surface morphology at drilling.*

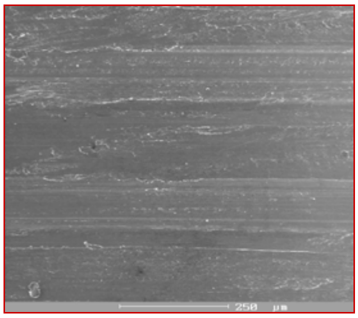


Fig.2 The machined surface morphology - the cutting tool HSCo, 8 % Co, mag. 90x, v_c=50 m/min, f=0,08 mm, steel Cr20Ni8Ti

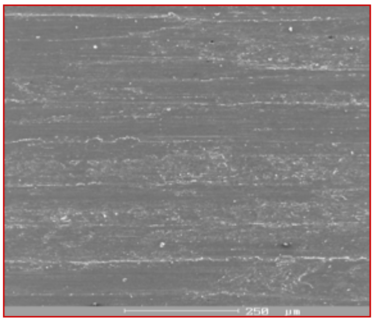


Fig.3 The machined surface morphology - the cutting tool HSCo, 8 % Co, TiN mag. 90x, v_c=50 m/min, f=0,08 mm, steel Cr20Ni8Ti

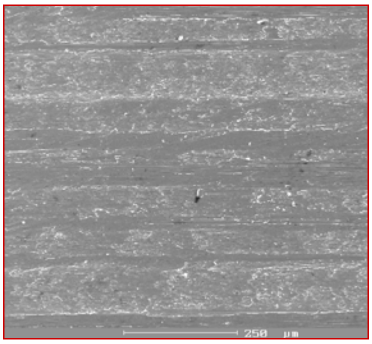


Fig.4 The machined surface morphology - the cutting tool HSCo, 8 % Co, TiAlN mag. 90x, v_c=50 m/min, f=0,08 mm, steel Cr20Ni8Ti

CONCLUSION

Machining is the world's most common manufacturing process, with 15 to 20% of the cost of all goods being attributed. Machining may either be the primary manufacturing process as in the aerospace industry, or a secondary process as in the machining of castings, forgings, and powder metals. Most automotive castings are liable to be machined on up to 30% of their surfaces. Also, machining can be an indirect manufacturing process as in the production of press tools used in the stamping of automotive body panels. In the education of both technologists and engineers the basic mechanics of machining are explored. However, due to its nature, students should have exposure to the many variables that change with both workpiece and tooling materials, as well as the actual shop floor variables. This is important since they affect not only tool life but surface finish, component performance and material removal rates. Drilling was selected because most students who do not have a machining background will be familiar with a standard "twist/jobber" drill.On the basis of experience, the authors recommend, for machining these types of steels, selecting criteria for automated production process based on the following order: For rough machining operations – in first position, forming of shavings, kinematic processes, dynamic processes and outer surface quality after cutting. For finished work, the criteria are set in the following manner: outer surface quality after cutting, forming of shavings, kinematic processes and dynamic processes. This article is the result or much research work on the part of the authors in this field and the article presents actual conclusions that are currently being successfully implemented in machine shops.

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THE INFLUENCE OF TOOL WEAR ON CUTTING PROCESS DYNAMICS AND CHIP FORMATION MECHANISM

Abstract:
The paper presents the survey of the experimental research of the chip forming mechanisms and chip types dependant on the tool wear process in turning. Based on the experimental research, the influence of tool wear on morphology and microstructural alterations in a chip has been analysed. Relating to tool wear, the modification in chip structure and the character of vibrations appearing in certain size of the medium-width band for tool wear and chip segments formation mechanism significant for cutting conditions definition have been monitored. The research in the paper aims at contributing to better understanding of mechanism, feature and chip lamella formation depending on the size of tool wear medium-width band in turning.

Keywords:
Vibrations, Tool wear, Signal processing

INTRODUCTION

In order to achieve satisfactory tool existence in modern production conditions, the research does not aim only to increase tool cutting characteristics in high temperatures in order to examine resistance to increased temperature and wearing. Understanding the correlation between chip formation mechanism and tool wear in the process of cutting hard and improved materials has an important role in revealing the friction influence at critical point during the cutting process, as well as in determining optimal cutting conditions. Generally, in conventional (slower) cutting speed the dominant wearing mechanism includes abrasive and adhesive wear, and in higher speed the diffusion and oxidation influences have a dominant role in tool wear appearance. Kopač and al. [1] emphasised that cutting in lower temperatures produces high pressure resulting in welding which in turn leads to layers on the cutting edge, while the increased cutting temperature due to high cutting speed increases the oxidation process distribution onto larger tool surface. Diffusion process, appearing between the chip and the tool rake face, results in crater wear, while the oxidation reaction to the environment produces alterations on the cutting edge [1]. In the conditions of high-speed machining, with high cutting speed and supplementary movements speed, at the contact points between the tool and the chip, there appears material merge in certain zones on the tool face, which can seize the entire surface, considering their large contact area and fast spreading. In this case, it would be hard for the coolants and lubricants to reach to the tool/chip *contact area. Increase in sliding, i.e. friction coefficient reduction at tool/chip contact area can be solved by applying certain coat types [2]. The aim of the paper is to present the influence of tool wear onto chip formation mechanism, i.e. to examine the measure in which tool wear development affects the chip formation and type.*

CHIP FORMATION DEPENDANCE ON THE DEGREE OF TOOL WEAR

In the several last decades, even the entire century, the studies on the chip formation process have been performed, though the problem has remained in the centre of attention. Chip shape emerging during turning can be classified as continual, discontinual, continual with wrinkled edges, sheared and segmented (continual with periodical variations in thickness) [4]. Generally, the chip formed in cutting hard and improved materials is in most cases continual with wrinkled edges and sheared. Currently, there are two theories in available literature data which define the origin and formation of sawtooth chip (with wrinkled edges). One theory is the "theory of fracture" and cracks, by which the appearance of a chip happens with the appearance of a crack on the free surface of the workpiece which is then quickly distributed to the tool cutting edge up to the certain length when the crack halts due to strong plastic deformations in the material influenced by cutting tool high pressure. The segment, chip lamella, occurring between the tool rake face and the chip, advances forward in the tool movement direction, while the material in the region beneath plastic deformation of the initial crack is expanded along the tool rake face in order to form the sawtooth chip type [1, 3, 4, 5]. The second theory of shearing occurrence in the primary cutting zone is the "adiabatic theory of chip formation", which states that thermoplastic material instability occurs inside the primary shear zone and it is the basis for material deformation mechanism appearing due to heat softening, so the material lamellae shear due to forces occurring with thermoplastic material strengthening outside the zone, as a consequence of high material strain in the shear zone [4, 5]. Adiabatic shearing can precede the occurrence of the initial crack and its expansion inside the non-cracked area of the primary shear zone, depending on the cutting conditions. Barry and Gerard [4] have examined the chip formation mechanisms in steel machining and concluded that the instability inside the primary shear zone during sawtooth chip formation is initiated by the adiabatic chip formation theory, with the dominance of the shearing stresses and their expansion towards the free area of the workpiece. Deformations of the upper region in the primary zone close to the chip free surface are the consequence of the both theories, "theory of fracture" and "adiabatic theory", depending on the cutting conditions. Hard conditions in material processing, like high stiffness material cutting using high cutting speed, cause material degradation by chip appearance of the so-called "ductile" fracture influenced by high plastic deformations. The increase in workpiece material hardness, cutting speed, cutting depth (non-deformed chip thickness) and tool wear band width, as well as negative value of the rake face angle, can result in the occurrence of the chip with sawtooth segments [1]. The research has shown that the deformed segment on the chip cross section area decreases with the cutting speed increase.

Cutting tool vibrations during machining appear due to friction on face and rear tool surface, wear on tool cutting edge, and corrugated (non-cylindrical) cutting, and they are also connected to the shearing gear wheels in the kinematical machine chain. The research has shown that the largest source of lathe knife vibrations in stable machining mostly occurs due to the friction between the tool rear and the workpiece. Basic tool vibration frequency is the resonant system frequency caused by friction on the cutting edge. Vibration acceleration is the best possible measure for the vibrations appearing in high frequencies. Considering that the cutting tool vibrations are in fact high frequency vibrations (i.e. above 1 kHz), tool accelerations have been selected as a parameter for tool wear monitoring [3].

EXPERIMENTAL RESULTS SURVEY

Segmentation of the Sawtooth Chip

Experimental research presented in the paper offers a clear insight into the basis of metallurgical instability responsible for the appearance of the sawtooth chip lamella on the free surface. Figure 1 shows a microscopic view *of the chip occurring in the machining of the low alloy carbon steel, thermally processed to the hardness of 45 HRC with a cutting speed of 200 m/min. It can be clearly observed that the lamella gear teeth in the cutting process are a cyclic process starting from the initial segment having considerate alterations due to physical tool action (or deformation due to high pressure of the tool tip). Likewise, grain elongations in the material structure, which, due to large elongation and stress, compress into the line extended from the primary shear zone, are visible on the cross section of the occurring chip, as in Figure 1. That such a shape is not a result of the sliding friction on the fracture segment is evident from the fact that the fracture force is maximal on the sliding area [4]. Instead of expanding the fracture crack downwards through the primary shear zone, the occurring deformation band is localized as a band formed due to adiabatic material sliding. This conclusion is based on the fact that its thickness is connected to the tool type, i.e. tool geometry and features, which assumes the appearance of shearing due to the influence of the cutting force and the expansion of the initial crack towards the tool cutting edge. The lack of the visible shear in the upper region of the material primary shear zone reveals that there is a deformation and stress decrease due to the influence of the thermal strengthening of the basic material, i.e. due to the machining material condition.*

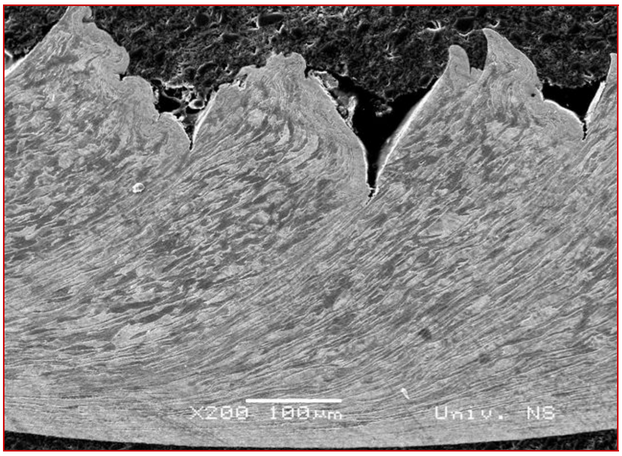


Fig. 1 Sawtooth chip segmentation

The band next to the chip edge in the contact with the tool shows shearing along the sample edge which is formed within the secondary cutting zone. The remaining traces of the elongated material structure grains are formed within the primary zone; however, it is evident that every appearance of cracks and initial chip segments in the basic shear zone forms a discrete segment. For the conditions in which the sample in Figure 1 is formed, the decrease in the improvement and the expansion of the initial crack in the lower segment of the primary shear zone (where lamella shearing localisation occurs) is observed. Within the observed chip segment, two chip formation segments can be identified in the primary shear zone in the formation of the lamella teeth of the sawtooth chip, which can be attributed to the sharp cutting conditions, and which can be observed through the longer time spent on the material removal and higher cutting speed due to thermal improvement of the material, as seen in Figure 2.

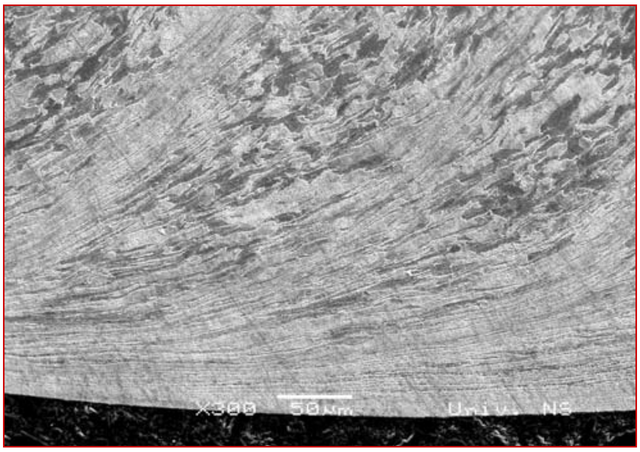


Fig. 2 The outlook of the zones of deformed and non-deformed material in chip formation

Segmentation of the Quazi Continual Chip Type

It is known that quazi continual chip type introduces obvious proofs for the occurrence of the lamella shearing in the primary cutting zone on the free surface, though, observed on the frequency scale, the frequency is for a size rate smaller than in the situation when sawtooth chip is formed [4]. A more significant difference in the nature of defining lamella shearing in the quazi continual and sawtooth chips is the relation between the distance of the cutting front D shown in Figure 1 and the d shown in Figure 3 on the undeformed chip thickness (cutting depth). On the free surface of the continual chip, the distance between the cutting front lamellae (equivalent to the lamella thickness) is largely independent of the undeformed chip thickness, and it is usually from 7 to 12 μm. Sawtooth chip, i.e. the distance between lamellae is similar in its size as the undeformed chip thickness and it is generally within the 50% of that thickness.

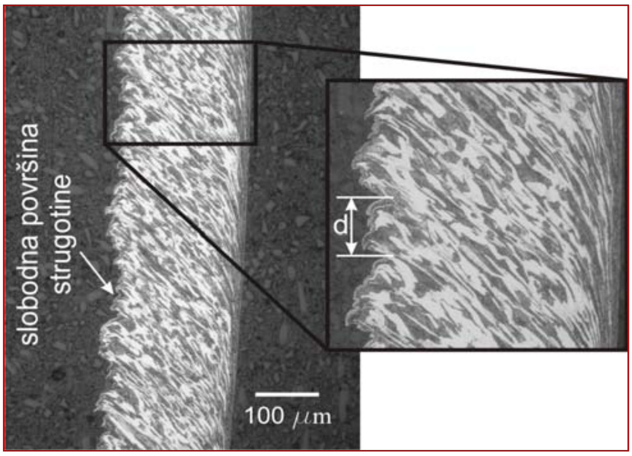


Fig. 3 Quazi-continual type of the occurring chip

Tool Rake Face Wear

The development of wearing on the tool rake face appears approximately only after 1/3 of the standard time in tool work after chip lamella breaks into the tool insert, after which it begins to grow progressively. Progressive wear development is connected to the temperature growth and friction on the rake face, and, as already stated, the insertion of the chip segment into the tool insert, thus removing the chemically less stable titanium nitrite together with the chip. The formed crater damages the cutting edge and in relation to the increased temperature leads to breakage and fracture of the tool insert tip.

The crater increase on the tool rake face has a very significant influence on the chip segment formation mechanism, as well as on the segmentation frequency and chip type. Crater wear is directly linked to the main initial structure in lamella formation which always aims to have a character of the continual uninterrupted chips. Chip interior in excessively growing crater formation leads to the beginning of the inlayer formation on the tool cutting edge. The sight of the chip free surface formed with the tool with the developed crater on the tool rake face and creation of the layers on the tool cutting edge is presented in Figure 4.

Localisation of the shearing within the basic and medium zone in chip formation appears as a key phenomenon controlling the wear progression, static cutting force and vibrations occurring in the cutting process.

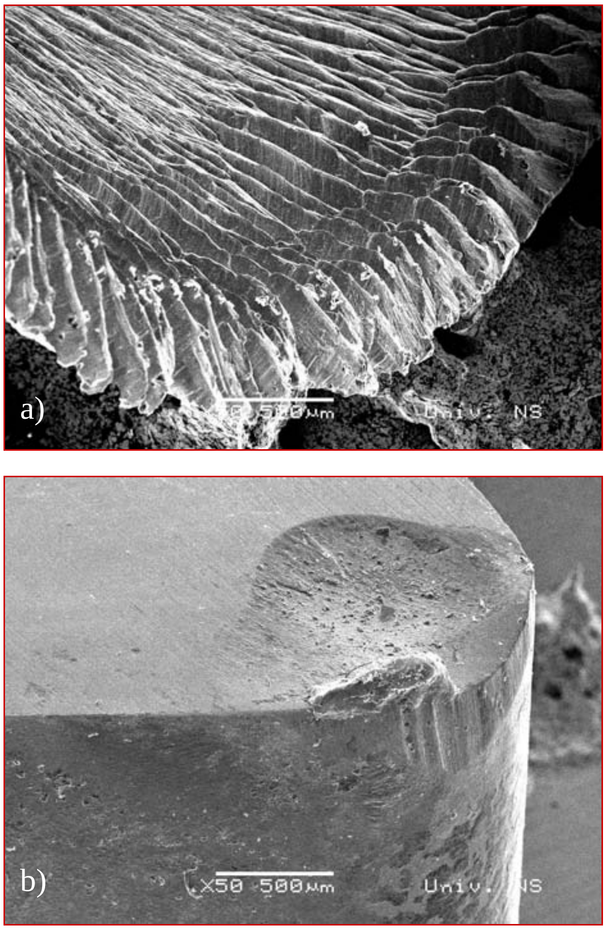
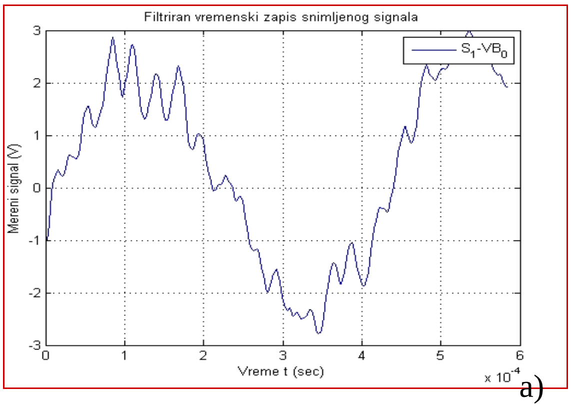


Fig. 4 Presentation of the a) chip free surface and b) rake face with the development of the crater wear on the cutting edge

The alteration in the chip shape caused by the alteration in the cutting wedge geometry leads to the alteration in lamella segmentation which then reflects the increase in signal content in high-frequency spectre segment. The alteration in the crater wear directly influences the chip type, which is in any case directly linked to the alterations in lamella formation and segmentation, which can be directly observed on the chip free surface.

Observing the lamella segmentation alteration, as well as the alteration in tool cutting geometry due to tool wear increase, Figures 5 and 6 present a comparative presentation of the time window of the recorded signal and microscopic shot of the cross section of the formed chip during the machining with the new tool and the tool with the certain degree of wear.



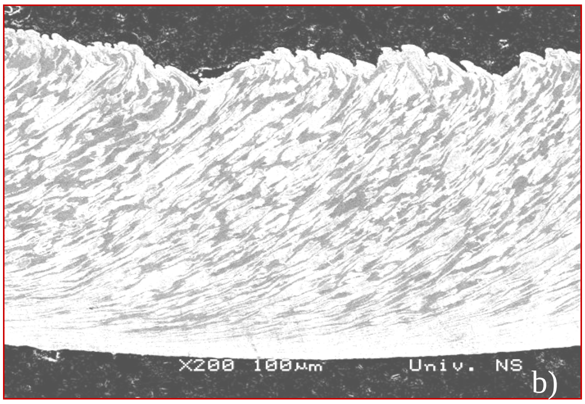
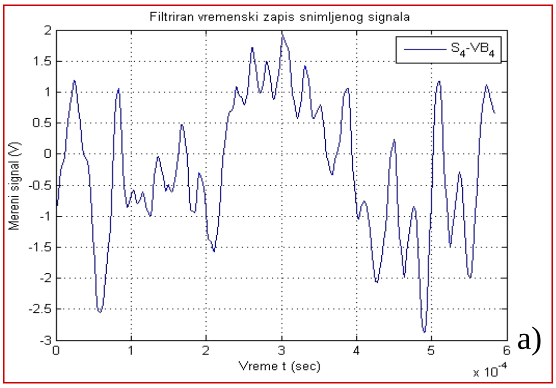


Fig. 5 Display of the vibration signal time window, a) cross section of the occurring chip, b) new insert



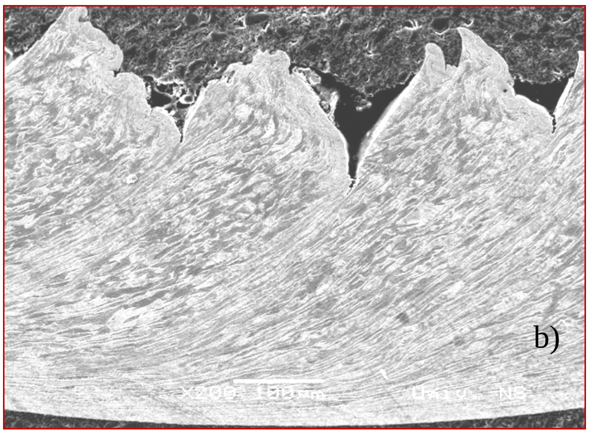


Fig. 6 Display of the vibration signal time window, a) cross section of the occurring chip, b) wear band 1mm

CONCLUSION

Considering the previous research, it can be concluded that the time limited observation of the vibration signal spectre presents "deviations" caused by the alternation in energy content due to the alternations of the chip segmentation type and features. The observed continual vibration signal measured on the lathe knife presents significant differences. Time limited short-term events appearing in the machining process can be identified by extracting significant parameters by the application of the appropriate methods for signal processing utilized to perform characteristic extractions from the basic signal content.

Identification of the tool rake face wear based on the alterations in the macroscopic and microscopic chip features is possible with the utilization of the adequate methods and techniques for vibration signal processing.

Common causes for the formation of statistic and frequently dependent characteristics for cutting processes are in correlation with the chip segmentation type and the development of the tool crater wear.

However, one should bear in mind that the wear process is performed simultaneously on both face and rear tool surface and hence the wearing process cannot be observed separately. Based on the trend of the growth of these influences on the amplitude and the signal spectre, identified influences will serve to recognize tool wear condition and classification. Vibration signal content is in any case directly dependant on the concrete cutting conditions, i.e. machining parameters.

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ACTA TECHNICA CORVINIENSIS
BULLETIN OF ENGINEERING

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APPLYING OF AHP METHODOLOGY AND WEIGHTED PROPERTIES METHOD TO THE SELECTION OF OPTIMUM ALTERNATIVE OF STOCK MATERIAL

Abstract:

In this paper, AHP (analytical hierarchy process) methodology and weighted properties method have been compared and applied to the selection of optimum alternative of stock material and manufacturing process. Three alternatives for the manufacturing of work piece are evaluated: rod, plate and tube. Six criteria were defined: stock material costs, stock material preparation costs, manufacturing costs, as well as material availability and purchase possibility, machinability and total material utilization. The criteria weights can be more precisely defined by the AHP methodology using the Saaty scale than using the digital logic method. However, subjectivity is playing a great role in both of methods. Subjectivity is included to the comparison of alternatives by the original AHP methodology, also. Contrary, by using weighted properties method there is no subjectivity concerned of alternatives comparisons because of dealing with transformed values of criteria. From the viewpoint of costs, the best alternative, calculated by both of methods is steel tube machining.

Keywords:

AHP methodology, weighted-properties method, criteria weights

INTRODUCTION

In this paper, three alternatives of stock materials for the same product are chosen and evaluated. Which one is optimal for the defined objective? This problem can be solved quantitative or qualitative. Qualitative approach is quite subjective, because it is based on assumptions and experience from the previous period. It is applied when the number of criteria and alternatives is small. Quantitative approach can be applied when the number of criteria, requirements and alternatives is quite large. Many quantitative methods exist, like operational research methods, decision making methods, as well as quantitative methods of materials selection which can be used to solve this problem.

Analytical hierarchy process methodology (further AHP methodology) is developed by Thomas Saaty [1, 2]. This method is widely applied in almost every field of human activity, for example economy [3], traffic [4], agriculture [5], information technologies [6], inventory control [7], materials selection [8] and many others.

Several quantitative methods of materials selection can be used [9-12]. The most important quantitative initial screening methods are as follows [9]: cost per unit property method, Ashby's material selection charts and Dargie's method. Pahl-Beitz method and weighted properties method represent the quantitative methods which can be applied to select the optimum solution between several combinations of materials and matching manufacturing processes. Sometimes in practice there is a reason for the substitution of one material with another, so the Pugh quantitative method and cost-benefit analysis [9] can be applied to compare properties and costs of used materials and new proposed materials.

In this paper, AHP methodology and weighted properties method are applied to the selection of the best alternative of stock material and manufacturing process concerning the following six criteria: stock material costs, stock material preparation costs, manufacturing costs, as well as material availability and purchase possibility, machinability and total material utilization.

DESCRIPTION OF THE USED METHODS

Analytical hierarchy process

AHP methodology is based on the decomposition of the defined decision problem to the hierarchy structure. The hierarchy structure is a tree-like structure which consists of the main goal at the top of the hierarchy (the first level), followed by the criteria and sub-criteria (also sub-sub-criteria) and finally by the alternatives at the bottom of the hierarchy (the last level), Fig. 1.

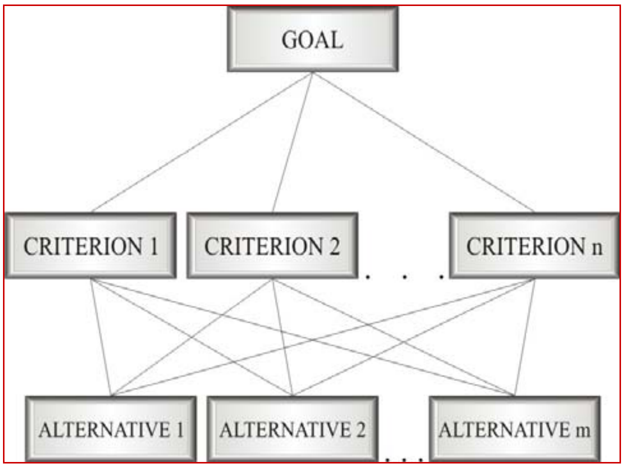

Fig. 1 AHP model with" n" criteria and "m" alternatives

The goal presents the optimum solution of the decision problem. It can be the selection of the best alternative among many feasible alternatives. Also, the ranking of all alternatives can be performed, by obtaining the priorities. Criteria (sometimes called objectives or attributes) are the quantitative or qualitative data (judgements) for evaluating the alternatives. If we compare the terminology of weighted properties method and AHP methodology, the term properties is equivalent to the term criteria. The weights of the criteria present the relative importance of each criterion compared to the goal. Finally, alternatives present the group of feasible solutions of the decision problem. Alternatives are evaluated against the set of criteria.

AHP methodology has three basic steps:

- *Decomposition of the defined decision problem to the hierarchic structure - building an AHP model with the overall goal, the evaluation criteria (sub-criteria) and alternatives.*
- *Pair wise comparisons of the criteria and alternatives based on the Saatys scale of numbers from 1 to 9, Table 1. The value 1 means equal importance of two criteria (alternatives), while the value 9 stands for extreme importance of one criterion (alternative) to another. Pair wise comparisons of the criteria are performed with respect to the goal or criteria at higher level. The weights of the criteria present the ratio of how much more important is one criterion than another, with respect to the goal or criterion at higher level. Pair wise comparisons of the alternatives are performed against each criterion and present the ratio of how much more important is one alternative than another, taking into account each criterion. The local priorities of alternatives are derived. Testing the consistency of subjective judgements is also performed.*
- *Synthesising the results by the calculation of the total priorities of alternatives. The total priority of each alternative is calculated by the multiplication of the local priority of alternative by the weight of corresponding criterion and then summing all the products for each criterion. Sensitivity analysis can be also performed and it gives the response of*

the alternative priorities to the change of the input data.

Tab. 1 Saaty's scale for pair wise comparisons.

Scale	Description of the importance
1	equal
3	moderate
5	strong
7	very strong
9	extreme
2, 4, 6, 8	intermediate values

Weighted Properties Method

This method is very useful when there are a lot of important criteria (properties) to compare and evaluate. Scaled value of the criteria (S_V) is multiplied by the weighting factor (B_i) (see the expression 1). The sum of multiplied scaled properties and weighting factors represents the performance index (V_r), see the Eq. (1). The combination of stock material and matching manufacturing process with the highest performance index is the optimum solution.

$$V_r = \sum_{i=1}^{k} B_i \cdot S_{Vi} \rightarrow \max. \qquad (1)$$

where:
- V_r - performance index
- B_i - weighting factor
- S_{Vi} - scaled property value
- k - number of properties

Weighting factor B_i represents the relative importance of the requirement according to the defined objective. This factor is determined by using the experience or the digital-logic method. Digital-logic method is based on the comparison of properties, where more important property has mark 1, and less important property has mark 0. After that, for every property the number of positive decisions is determined. Weighting factor for the property is the ratio of the number of positive decisions and the total number of decisions, Eq. (2).

$$\text{The total number of decisions} = \frac{k(k-1)}{2} \qquad (2)$$

where:
- k - number of requirements (properties)

Scaled values of the properties are applied because of more reliable comparison of the properties with different units of measurements. Eq. (3) represents the dimensionless scaled property value for the property where a lower value is desirable (for example costs, mass loss, etc.).

$$S_V = \frac{\text{Minimum value in the list}}{\text{Numerical value of the property}} \cdot 100 \qquad (3)$$

Equation (4) represents the dimensionless scaled property value for the property where a higher value is desirable (for example hardness, tensile strength, etc.).

$$S_V = \frac{\text{Numerical value of the property}}{\text{Maximum value in the list}} \cdot 100 \qquad (4)$$

All the properties data are transformed to the 0 - 1 scale. The property with the value 100 (or 1, without multiplying with 100, Eq.. 3 and 4) is the best property.

In AHP methodology, for a very large number of alternatives, making pair wise comparisons of alternatives, with respect to each criterion, can be time consuming and confusing, because the total number of comparisons is very big, too. Therefore, instead of pair wise comparisons, alternatives relative priorities can be obtained by the scaling (normalizing, transforming) the alternative data for each criterion. The data (qualitative or quantitative) can be transformed in such a manner described previously in weighted properties method. The sum of multiplied scaled criteria values and weighting factors across all of the criteria (so called weighted sum) presents the overall score for the alternative item (see and compare the expression 1, weighted properties method). The alternative with the maximum score is on the top, while the alternative with the minimum score is on the bottom of the ranking scale.

Analysis And Evaluation Of Variants

The following part of the paper illustrates the application of AHP methodology and weighted properties method for selecting the optimum combination between three combinations of stock materials to manufacture the connector (see Fig. 2) [13].

Three types of stock materials have been quantitatively analyzed. These are: rod, plate and tube made from material C45 (the material is assigned in accordance with the Euronorm EN

10027, classification by the chemical composition). Six requirements are included and calculated [13]:

- *stock material costs, $TR_{(o)}$ (calculated by multiplying the mass of work piece and the unit material price),*
- *material availability and purchase possibility, $O_{(rn)}$ (rated from 1 – poor to 5 – excellent),*
- *stock material preparation costs, $TR_{(PM)}$ (calculated by taking into account the quality control costs, storage costs and cutting costs),*
- *machinability, $O_{(ob)}$ (calculated according to experiment results by taking into account work piece material, tool material, processing conditions and cutting rate),*
- *manufacturing costs, $TR_{(p)}$ (calculated by considering the turning and milling machining costs, cooperation costs and additional costs)*
- *total material utilization, f (calculated from the stock over dimension losses, cutting losses, machining losses and fallout losses [14]).*

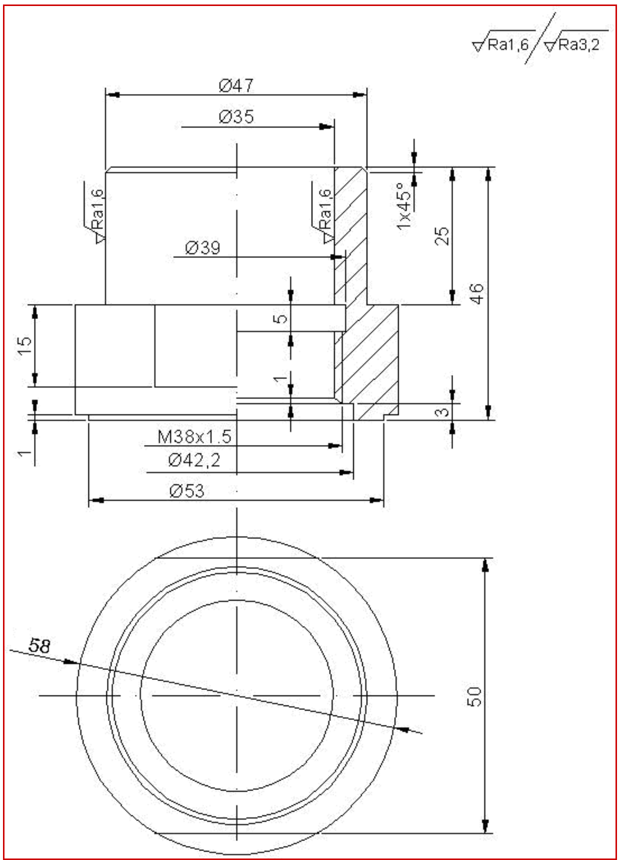

Fig. 2 Technical drawing of the connector

The selection of the optimum combination of stock material and manufacturing process is carried out by the application of the above mentioned methods.

Figure 3 presents the AHP hierarchy model of this problem with the overall goal, six evaluation criteria and three alternatives.

The criteria weights are calculated by the pair wise comparisons of criteria using the Saaty scale (Tab. 1), and their amounts are as follows: 0,197; 0,302; 0,133; 0,064; 0,197 and 0,107. The values of criteria weights are corresponding to the order of criteria in Fig. 3 (from left to right).

Local priorities of alternatives are calculated by the comparison of the alternatives in terms of each criterion using the Saaty scale (Tab. 1).

Using the criteria weights and local alternative priorities, the total priority of each alternative is calculated (0,246 – rod; 0,353 – plate and 0,401 – tube). The third alternative (tube machining) is the optimum solution for obtaining minimal total costs because of the highest total priority.

In the following part of the paper, weighted properties method is applied. Using the calculated values for six defined properties as well as calculated linearly scaled property values according to the Eq. (3) and (4), performance indexes for these three variants are derived, Eq. (1).

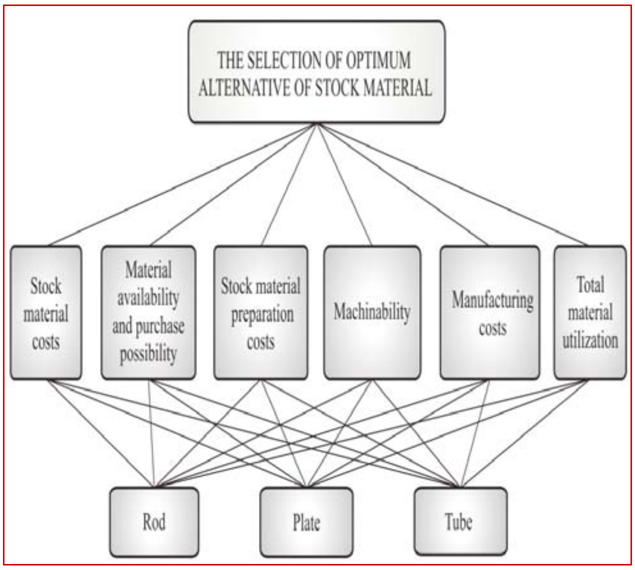

Fig. 3 AHP model

They are as follows: 83,39 – rod, 88,59 – plate and 89,964 – tube. Weighting factors are calculated using the digital logic method and their values are as follows: B_1=0,2, B_2=0,3333, B_3=0,1333, B_4=0, B_5=0,2667 and B_6=0,0667. The *values of criteria weights are corresponding to the order of criteria in Fig. 3 (from left to right). The third variant (tube machining) is the optimum solution for obtaining minimal total costs because of the highest performance index.*

CONCLUSION

On the basis of the above calculated results obtained by the application of AHP methodology and weighted properties method, the following conclusions can be made. In order to obtain minimal total costs, the third variant (tube machining) is the optimum solution because of the highest total priority (AHP method) and the highest performance index (weighted properties method).

It can be concluded that the criteria weights can be more precisely defined by the AHP methodology using the Saaty scale than using the digital logic method. A Saaty scale is larger scale (from 1 to 9) in comparison to digital logic method (only 0 and 1).

However, subjectivity is playing a great role in both of methods of comparison. Subjectivity is included to the comparison of alternatives by the original AHP methodology, also. Contrary, by using weighted properties method there is no subjectivity concerned of alternatives because of dealing with transformed values of criteria. However, the optimum solution obtained by the application of quantitative methods should be subjected to further analysis of an experienced decision maker.

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a maximum 100 words abstract will be written, simple spaced, in ***ENGLISH***

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The submitted manuscript must be content ***INTRODUCTIVE NOTES (INTRODUCTIONS)****, follow by the* ***METHODOLOGY****, the* ***PRELIMINARY RESULTS*** *or the* ***FINAL RESULTS****, and, in final, the* ***CONCLUSIONS*** *about the presented notes.*
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The conclusions must be clear, relevant and must be indicate some the empirical, theoretical, methodological or scientific aspects of the research, and the author's contributions, or the future preliminaries of our research. It will publish empirical, theoretical and methodological articles.

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Tables and Figures should be numbered, titled and the resource should be mentioned below them. Photographs in the text are preferable to be in black and white, but must be clear, with a high contrast. Under each figure there will be typed, centered, "Figure X. Name of the figure".
Tables will be part of the text, designed as "Table y. Name of the table", written above the table, centered.
The equations will be inserted in the text – left aligned – and will be numbered with Arabian figures, in round brackets, right aligned. Before and after the equation a blank line will be left.

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ACKNOWLEDGMENT

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[2] AUTHORS. YEAR. TITLE OF BOOK, EDITING HOUSE
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ACTA TECHNICA CORVINIENSIS
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SCIENTIFIC EVENT

The XIth INTERNATIONAL SYMPOSIUM "YOUNG PEOPLE AND MULTIDISCIPLINARY RESEARCH"

ISYPMR - 2009

12 - 13 NOVEMBER 2009
TIMISOARA, ROMANIA

ANNOUNCEMENT

The SYMPOSIUM will be organised by the NATIONAL R&D INSTITUTE FOR WELDING AND MATERIAL TESTING – ISIM TIMIŞOARA, ASSOCIATION FOR MULTIDISCIPLINARY RESEARCH (ACM-V), UNIVERSITY "POLITEHNICA" OF TIMISOARA under de aegis of MINISTRY OF EDUCATION, RESEARCH AND INNOVATION.

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The deadline for mailing the abstracts, in which, it will be showed the personal contribution of the authors and the interdisciplinary character: July 17th 2009.

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The publication in volume or on CD of the papers will be decided by the Scientific Committee following the analysis of the complete papers mailed in time, if these fulfill the technical-scientific criteria and the elaboration mode.

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ISYPMR - 2009

The XIth INTERNATIONAL SYMPOSIUM "YOUNG PEOPLE AND MULTIDISCIPLINARY RESEARCH"

ACTA TECHNICA CORVINIENSIS – BULLETIN of ENGINEERING

UNIVERSITY POLITEHNICA TIMISOARA
FACULTY OF ENGINEERING HUNEDOARA
5, REVOLUTIEI
331128 – HUNEDOARA
ROMANIA
http://acta.fih.upt.ro

SCIENTIFIC EVENT

9TH INTERNATIONAL SCIENTIFIC CONFERENCE NEW TRENDS IN TECHNICAL SYSTEMS OPERATION 2009

5TH – 6TH NOVEMBER 2009
PRESOV, SLOVAKIA

CONFERENCE AIMS

The aim of the ninth conference TSO '09 is to offer a space for information, exchange of experience and the latest scientific knowledge, to contribute actively to forming of development trends in manufacturing technology operation and technical systems and to contribute to an increase of intellectually demanding technical education standards.

PATRONAGE:

CONFERENCE WILL BE HELD UNDER THE PATRONAGE OF

- *NOVÁK - MARCINČIN Jozef, prof., Ing., PhD., DEAN OF FACULTY OF MANUFACTURING TECHNOLOGIES OF THE TECHNICAL UNIVERSITY IN KOŠICE WITH A SEAT IN PREŠOV*
- *HUDACKÝ Ján, Ing., Member of European Parliament, Committee on Industry, Research and Energy*
- *HAGYARI Pavel, JUDr., Mayor of the Prešov Town*

CONFERENCE CHAIRMEN:

FABIAN Stanislav, prof., Ing., PhD., head of Department of Manufacturing Processes Operation

HONORARY BOARD: (in alphabetical order):

ADAMCZAK Stanisław, prof. Dr hab. inż., Dr.h.c. Kielce University of Technology (PL)
BABULAK Eduard, prof., Dr.habil., PhD., PEng, SMIEEE, SMACM Fairleigh Dickinson University (CA)
MÁDR Vilém, prof., RNDr., PhD. VŠB TU Ostrava (CZ)
OSANNA Herbert Peter, Univ. Doz. Hofrat O.Univ.prof. prof.h.c. Dipl. Ing. TU Wien (A)
SONNTAG Herbert, prof. Dr. Ing. TFH Wildau (D)
UNGUREANU Nicolae, prof. univ. dr. Ing. North University of Baia Mare (RO)

LOCALITY:

Conference will be held in PREŠOV, the third beiggest town in SLOVAKIA.

TOPICS:

- *MANUFACTURING SYSTEMS OPERATION.*
- *OPERATION STATES DIAGNOSTICS OF MANUFACTURING SYSTEMS – NEW TRENDS AND INNOVATIONS.*
- *MANUFACTURING SYSTEMS AND PRODUCTS QUALITY AND RELIABILITY.*
- *MANUFACTURING SYSTEMS CONTROL AND COMPUTER AIDED MANUFACTURING.*
- *ENERGY ASPECTS OF MANUFACTURING SYSTEMS OPERATION.*
- *ENVIRONMENTAL ASPECTS OF MANUFACTURING SYSTEMS OPERATION.*
- *INNOVATION AND CREATIVITY IN MANUFACTURING SYSTEMS OPERATION.*

Technical fields application in progressive manufacturing technologies, metal die casting technology, and injection moulding are welcomed.

INTERNATIONAL SCIENTIFIC PROGRAMME COMMITTEE: (in alphabetical order):

ORGANIZING COMMITTEE:

MEMBERS:

RIMÁR Miroslav, assoc. prof., Ing., CSc. TU Košice (SK)
SKOK Peter, assoc. prof., Ing., CSc. TU Košice (SK)
STRAKA Ľuboslav, Ing., PhD. TU Košice (SK)
ULIČNÝ Andrej, Ing. TU Košice (SK)

CONTACT:

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TIBOR KRENICKÝ, RNDr., PhD.
DEPARTMENT OF MANUFACTURING PROCESSES OPERATION
FACULTY OF MANUFACTURING TECHNOLOGIES OF THE TECHNICAL UNIVERSITY IN KOŠICE
with a seat in Prešov
Štúrova 31, 080 01 Prešov, SLOVAK REPUBLIC
tel: +421-51-7723504, fax: +421-51-7733453
Email: tso.fvt@tuke.sk

CONFERENCE INFORMATION UPDATE:

All needed information about conference can be found in:
www.tuke.sk/fvtpo/tso2009

SHEDULE AND DEADLINES:

Application and paper annotation: MAY 30, 2009
Acceptation notification comments: JUNE 5, 2009
Print-ready contributios (PDF + Word) by e-mail: OCTOBER 10, 2009
Early registration deadline: SEPTEMBER 30, 2009
Conference TSO '09, PREŠOV, Slovakia: NOVEMBER 5 - 6, 2009

9TH INTERNATIONAL SCIENTIFIC CONFERENCE – NEW TRENDS IN TECHNICAL SYSTEMS OPERATION 2009

organized in:

EUROPEAN YEAR OF INOVATION AND CREATIVITY

by:

DEPARTMENT OF MANUFACTURING PROCESSES OPERATION, FACULTY OF MANUFACTURING TECHNOLOGIES, TECHNICAL UNIVERSITY OF KOŠICE WITH A SEAT IN PREŠOV

in cooperation with

REGIONAL ADVISORY AND INFORMATION CENTER PREŠOV,
SLOVAK MECHANICAL ENGINEERING SOCIETY
ZSVTS, BRATISLAVA,
EUROPEAN INFORMATIONAL CENTER SK 673,
CITY OF PREŠOV

ACTA TECHNICA CORVINIENSIS
BULLETIN OF ENGINEERING

SCIENTIFIC EVENT

1st CONVEEESH
INTERNATIONAL CONFERENCE ON ENGINEERING, ENVIRONMENT, ECONOMIC, SAFETY & HEALTH
&
10th SENVAR
INTERNATIONAL SEMINAR ON ENVIRONMENT & ARCHITECTURE
SCIENCE & ENGINEERING FOR BETTER LIFE
26 – 27 OCTOBER 2009
MANADO, INDONESIA

ORGANIZED BY:

Faculty of Engineering, Universitas Sam Ratulangi, Manado in Indonesia at the celebration of 45th Anniversary of Establishing the Faculty of Engineering

AIMS:

Sustainable development is one the key issues for modern society and requiring new ideas to advance the technologies and strategies currently in use. The main fields, which are the focus of many research efforts, are engineering, ecosystems, planning sustainability and many others. These and others aspects are the focus of the presentation and discussions that will be carrying out at the Conference.
The way in which our society exists, operates and develops is strongly influenced by the way in which sustainable development is applied and implemented. No function in sustainable development can be created without sufficient knowledge, and without sustainable development there can be no innovation on which the existence of modern society depends. However, this international Conference will focus on topics related to Sustainable Development in Engineering, Ecology, Ecosystems, Economics and Planning.

CONFERENCE TOPICS:

ARCHITECTURE
- *Indoor Comfort (Thermal, Light, Sound)*
- *Green Building/ Green Architecture*
- *Traditional & Vernacular Architecture*
- *Energy Efficient Architecture*
- *Waterfront Architecture/ Coastal Architecture*
- *Healthy & Convenience Living Space*
- *Smart Building*
- *Bioclimatic Architecture*
- *Role of Architectural Education in Sustainable Development*

TOWN PLANNING, HOUSING & REGION DEVELOPMENT
- *Ecological Coastal Planning*
- *Disaster Management*

- *Energy Efficient City*
- *Low-Cost & Healthy Housing*
- *Landscape & Townscape for Urban Sustainability*
- *Traditional Settlement & Cultural Heritage*
- *Rural Development*
- *Tourism Management*
- *Outdoor Comfort*

CIVIL ENGINEERING & INFRASTRUCTURE

- *Coastal Engineering*
- *Ecological Construction Material*
- *Construction Management & Work Safety*
- *River Management & Engineering*
- *Urban Electricity & Telecommunication System*
- *Urban Fire Safety Management*
- *Urban Drainage Engineering*
- *Traffic Management & Safety*
- *Road Engineering*
- *GIS, Remote sensing & Geo-mapping*
- *Soil science, Geotechnical & Underground Construction*

ENVIRONMENTAL SCIENCE & PUBLIC HEALTH

- *Governmental Policy in Climate Change & Global Warming*
- *Waste Management (re-use, reduction & recycling)*
- *Pollution Control Technology*
- *Urban Pollution & Health effects*
- *Environmental Education*
- *Environmental Impact Assessment Models*
- *Ecosystems analysis, Ecotoxicology and protection for the living environment*
- *Environmental economics*
- *Ecosystems analysis, Ecotoxicology and protection for the living environment*
- *Environmental economics*
- *Environmental Management, Restoration & Legislation*

MECHANICAL ENGINEERING

- *Ergonomics /Biomechanics*
- *Renewable Energy*
- *Automatic/ Robotic*
- *Energy Conversion Technology*
- *Refrigeration & Air Conditioning*
- *Industrial Management & Processing*
- *Applied Computational Fluid Dynamics (CFD)*
- *Material Properties & Durability*

ELECTRICAL ENGINEERING

- *Hydro electric technology*
- *Photovoltaic Technology*
- *Expert System*
- *Lighting Technology*
- *Electricity Forecasting*
- *System Stability, Analysis & Protection*
- *Power Plants technology & management*
- *Economic Evaluation of Power Systems and Utilities*
- *Informatics Technology*

CONFERENCE COMMITTEE:

CONFERENCE ADVISOR:

- *Professor Dr. Ir. Ellen J. Kumaat, Dean of Faculty of Engineering, Sam Ratulangi University, Manado,*

ORGANIZING COMMITTEE:

- *Professor Dr. Sangkertadi, Faculty of Engineering, Sam Ratulangi University,*
- *Prof. Dr. Doddy Sumajouw, Faculty of Engineering, Sam Ratulangi University,*
- *Dr. Linda Tondobala, Faculty of Engineering, Sam Ratulangi University*
- *Dr. Aristotulus E. Tungka, Faculty of Engineering, Sam Ratulangi University,*
- *Dr. Steenie Wallah, Faculty of Engineering, Sam Ratulangi University,*
- *Dr. Veronica Kumurur, Faculty of Engineering, Sam Ratulangi University,*
- *Dr. Tiny Mananoma, Faculty of Engineering, Sam Ratulangi University, Manado,*
- *Cynthia Wuisang, M.Sc, Faculty of Engineering, Sam Ratulangi University*
- *S T Gideon Kaunang, M.Eng, Faculty of Engineering, Sam Ratulangi University*
- *Kenny Lempoy, M.Eng, Faculty of Engineering, Sam Ratulangi University*

TECHNICAL CONFERENCE CHAIR:

- *Dr. Abdelnaser Omran Al Amroni, School of Housing, Building and Planning, Universiti Sains Malaysia.*

INTERNATIONAL SCIENTIFIC COMMITTEE MEMBERS:

- *Professor Ir. Dr. Mahyuddin Ramli, School of Housing, Building and Planning, Universiti Sains Malaysia, Malaysia.*
- *Professor Dr. Hamidi Abdul Aziz, Environmental Engineering, School of Civil Engineering, Universiti Sains Malaysia, Malaysia.*

- Professor Dr. Mariana Gavrilescu, Chemical and Environmental Engineering, "Gheorghe Asachi" Technical University of Iasi, Faculty of Cheemical Engineering and Environmental Protection, Department of Environmental Engineering and Management, Iasi, Romania.
- Professor Dr. Abdullah Mahmood, Project Management, College of Planning and Architecture, King Saud University, Saudi Arabia.
- Associate Professor Dr. Said Mohammed Al Abidi, Dental Science and Materials, Faculty of Medicine, Department of Dental, Garyounis University, Libya.
- Associate Professor Dr. Claudiu Chiru, Compute Sciences, University Spiru Haret, Costanta, Romania.
- Professor Dr. Ismail Said, Dep. Of Landscape Architecture, Faculty of Buklt Environment, Universiti Technology Malaysia, Skudai, Johor, Malaysia
- Dr. Odile Schwarz-Herion, MBA, Sustainable Development Consultant, Germany
- Dr. Julijana SILJANUSKA, Faculty of Administration and Management Information System, University of "St. Kliment Ohridski" – Bitola, Republic of Macedonia.
- Associate Professor Dr. Julaihi bin Wahid, School of Housing, Building and Planning, Universiti Sains Malaysia.
- Associate Professor Dr. KISS Imre, University Polytechnic Timisoara, Faculty of Engineering Hunedoara, Department of Engineering and Management, Romania.
- Prof.Dr.RM.Soegijanto, Bandung Institute of Technology (ITB), Bandung, Indonesia.
- Prof.Dr.H.M. Ramli Rahim, Hasanuddin University, Makassar, Indonesia.
- Prof.Dr.Prasasto Satwiko, Atma Jaya Christian University, Yogyakarta, Indonesia.
- Prof.Dr. Tri Harso Karyono, BPPT/Tarumanagara University, Indonesia
- Dr. Ing. Eka Setiadi Rasyad, Department of Architecture, Trisakti University, Jakarta, Indonesia.
- Dr. Egor Sidorov, Jan Evangelista Purkyne University, Usti nad Labem, Czech Republic.
- Associate Professor Dr. Macjei GORA, Faculty of Chemistry, Department of Organic Chemistry, Jagiellonian University, Kraków, Poland.
- Professor Dr. Elena Druica, Department of Economics, Faculty of Administration and Business, University of Bucharest, Romania.
- Dr. Violaine Mijno, Laboratoire de Géologie HydrASA, Limoges Cedex, France.
- Dr. Abdelhaq Kabbabi, Centre for Studies and Research Mineral Phosphate, Casablanca, Morocco.
- Assoc. Prof. Dr. Giovanni Dotelli, Department of Chemistry and Chemical Engineering "G. INSTM R.U. – Polimi, Politecnico di Milano, Milano Italy.
- Prof. Dr. Mohd. Hamdan Ahmad, Dept. of Architecture, Faculty of Built Environment, Universiti Teknologi Malaysia (UTM) Skudai, Johor, Malaysia

IMPORTANT DATES:

Deadline for Abstract submission 20 Aug 2009
Reply to Authors for Abstracts acceptance 31 Aug 2009
Full paper submission 10 Sep 2009
Reply to Authors with reviewer's comments 20 Sep 2009
Final paper submission 30 Sep 2009
Conference date 26-27 Oct 2009

INSTRUCTION TO AUTHOR:

An abstract should consist of 250-300 words, and the author should state the objective, theoretical framework, methodology, data sources, results, and applications in his/her paper.

Please write your name (s), affiliation (s), address (es), phone, fax, e-mail address at the end of the page.

Full Papers of not more than 14 pages, singled spaced with Times New Roman Font 10 (2.5 cm all margins) should reach the Technical Conference Chair not later than 10, September 2009. All the papers presented at the conference will appear in the proceedings. CD-ROM and abstracts will be distributed to the conference participants.

BENEFITS OF ATTENDING:

The conference will be of interest to planners, environmentalists, engineers, architects, ecologist, economists, policy makers and other governmental officials, researchers and academics involved in the field of the sustainability. However, attending this conference will benefit you as follows:

- *Keep up to date with the latest advances in the field.*
- *Present your research within a unique forum.*
- *Collaborate with experts from around the world.*
- *Your conference paper will be reviewed by members of the committee and other colleagues and best quality of the papers will be selected for publication in the JOURNAL OF ARCHITECTURAL, SCIENCE, URBAN SETTLEMENT AND ENVIRONMENT, ISSN 1858-1137. Dr. Aristotulus E. Tungka (matrasain@yahoo.com), the EDITOR-IN-CHIEF, will be in charge of the communication with the members of the international Scientific Committee and authors.*
- *Participants who presented papers at **CONVEEESH'09** conference will be considered for waiving their fees in the up-coming events of **CONVEEESH' 2011**.*

SECRETARIAT:

LAB. SAINS & TEKNOLOGI BANGUNAN,
FAKULTAS TEKNIK,
UNIVERSITAS SAM RATULANGI,
JALAN KAMPUS, BAHU, MANADO 95115, INDONESIA

SUBMISSION:

An abstract should consist of 250-300 words, and the author should state the objective, theoretical framework, methodology, data sources, results, and applications in his/her paper. Please write your name (s), affiliation (s), address (es), phone, fax, e-mail address at the end of the page.

Full Papers of not more than 12 pages, singled spaced with Times New Roman Font should reach the Technical Conference Chair not later than 10, September 2009. All the papers presented at the conference will appear in the proceedings. CD-ROM and abstracts will be distributed to the conference participants.

All professionals, environmentalists, researchers, and policy makers involved or interested in the area of the conference are invited to present papers relating to the conference topics. Authors are requested to submit abstracts, preferably by e-mail as a Word File attachment to the Technical Conference Chair (E-mail: naser_elamroni@yahoo.co.uk), by not later than August 20, 2009.

VIIth INTERNATIONAL CONGRESS "MACHINERY, TECHNOLOGY, MATERIALS" – INNOVATIONS FOR THE INDUSTRY

26. – 28.05.2010
SOFIA, BULGARIA

INVITATION

The SEVENTH INTERNATIONAL CONGRESS "MACHINERY, TECHNOLOGY, MATERIALS'10" will be carried out together with the EXHIBITION OF MECHANICAL ENGINEERING MECHTECH'10 in Inter Expo Center Sofia.

Together and collaborating these two events will form the industrial forum "MACHINERY, TECHNOLGY, MATERIALS – INNOVATIONS FOR THE INDUSTRY". We hope that in this way the Congress will become a bigger innovation mediator between scientific research and industry.

The program of the Congress offers you different ways to present the results of your research in front of you colleagues and the representatives of the industry. We invite you to take advantage of these opportunities.

*Beside the international congress **MTM'10** and MECHTECH'10 the INDUSTRIAL FORUM includes: EXHIBITION MECHTECH in the halls of INTER EXPO & CONGRESS CENTER OF SOFIA and Innovations exchange and consulting services for the Industry.*

*We invite you to take part (personally or by correspondence) in the VII INTERNATIONAL CONGRESS **MTM'10** with publishing of your papers or messages on innovative technical solutions for the industry. You are welcome to participate either in the common stand "SCIENTIFIC INNOVATIONS FOR THE INDUSTRY" which is organized by us.*

TOPICS:

01. MACHINES
02. TECHNOLOGIES
03. MATERIALS

SCIENTIFIC PROGRAM:

- *PLENARY SESSION with ordered papers*
- *SECTIONAL SESSIONS in the congress halls of Inter Expo & Congress center*
- *POSTER PRESENTATIONS OF PAPERS at the congress stand in the exposition of the Forum*
- *Participation with models, prospects, samples and/or multimedia presentations at the "SCIENTIFIC INNOVATIONS FOR THE INDUSTRY stand in the Forum's exposition.*

OFFICIAL LANGUAGES AT MTM'10: BULGARIAN, RUSSIAN, ENGLISH

PUBLICATIONS:

- *In separate volume ISSN 1310-3946 of the proceedings for each topic session, which will be lodged in St.St. Cyril and Methodius National Library and Central Scientific-technical Library in Bulgaria*
- *In CD, containing all papers.*
- *Detached issue of the International virtual scientific-technical journal "MACHINERY, TECHNOLOGY MATERIALS" (ISSN 1313-0226). This publishing is at will and requires additional payment.*
- *Author's scroll, containing the title page, the content of the volume and printed copy of the author's paper with the page numbers from the Proceedings.*

IMPORTANT DATES:

- *Sending the full text of the paper and Application Form "A":15.02.2010*
- *Confirmation of the paper receiving: 01.03.2010*
- *Payments and Application Form "B": 15.03.2010*
- *Announcement of the plenary and sectional sessions program on our web page: 15.04.2010*
- *The Organizing Committee will receive posters up to: 15.04.2010*
- *Receiving of the application for transfer: 14.05.2010*
- *Registration of the participants: 25 and 26.05.2010*
- *Opening of the congress: 26.05.201*

TIME AND SPACE:

26 - 28. 05. 2010,
Inter Expo Centre,
bul. „Tzarigradsko shose" №147,
SOFIA – BULGARIA

SECRETARIAT:

SCIENTIFIC-TECHNICAL UNION OF MECHANICAL ENGINEERING
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