

Trajceviski, N., Kuzinovski, M., Cichosz, P.

INVESTIGATION OF TEMPERATURE DURING MACHINING PROCESS BY HIGH SPEED TURNING

Abstract: This paper presents the results and obtained mathematical models of temperature during machining process by high speed turning as a function of processing parameters v , f , a and r_e . The machining process by turning is performed on lathe type "Prvomajska TVP 250" with power $P=11,2$ kW and step change of number of revolutions between $n=16$ and 2240 rev/min, by using ceramic cutting tool inserts type SNGN 120712- 120716- 120720 made from mixed ceramics type MC 2 ($Al_2O_3 + TiC$) and manufactured by HERTEL and tool holder type IK.KSZNR -064 25x25 manufactured by KENNAMETAL. Workpiece material is C 1630 (DIN C 55). Cutting tool holder is reconstructed to provide transmission of the voltage signal from the cutting tool insert. Processing parameters are varied in range interval between $v = 300$ and 500 m/min, $f = 0,16-0,30$ mm/rev, $a=0,5-1,0$ mm and $r_e=1,2-2,0$ mm. Average temperature is determined by using of natural thermocouple method and computer aided research equipment. Experiments and the mathematical processing of the results are performed at the Faculty of Mechanical Engineering in Skopje using the program CADEX combined with MATLAB. Four factorial first order experimental plan was used.

Key words: Machining by turning, average cutting temperature, natural thermocouple, factorial experiments

1. INTRODUCTION

It is known that during the transformation of workpiece machined layer into chips, because of energy transformations in the cutting zone it is released significant quantities of heat. Created heat in the cutting process is directly dependent on the applied processing parameters (v, f, a, \dots), workpiece material condition and cutting tool stereometry ($\chi, \lambda, \gamma, r_e, \dots$). The heat reflected through the maximum temperature is an important factor which has a dominant influence: the mechanism of transformation of the workpiece machined layer into chip; on the phenomenon that occur in the process of cutting tool wear (abrasive, adhesive, diffusive, heat, oxidative); the magnitude of the cutting force components, which is in close correlation with thermal model of creation residual stresses; and thus to the creation of the resultant

characteristics of the new constituted technological surface layer /TSL/ [1]. Therefore, in the machining process it is important accurately to know the magnitude of the temperature that occurs in the cutting zone as function of machining parameters. The temperature in the cutting process can be determined in an analytical and experimental way, which are developed many methods [2]. From the experimental methods, the most widespread is the method of natural thermocouple, where the natural thermocouple consists of the cutting tool and the workpiece. Methods of natural thermocouple are simple to implement, but require knowledge of the thermoelectric characteristics of the natural thermocouple, and its determination is only by experimental way [3]. The emergence of modern cutting materials, especially cutting ceramics, creates conditions for the application of significantly higher cutting speeds.

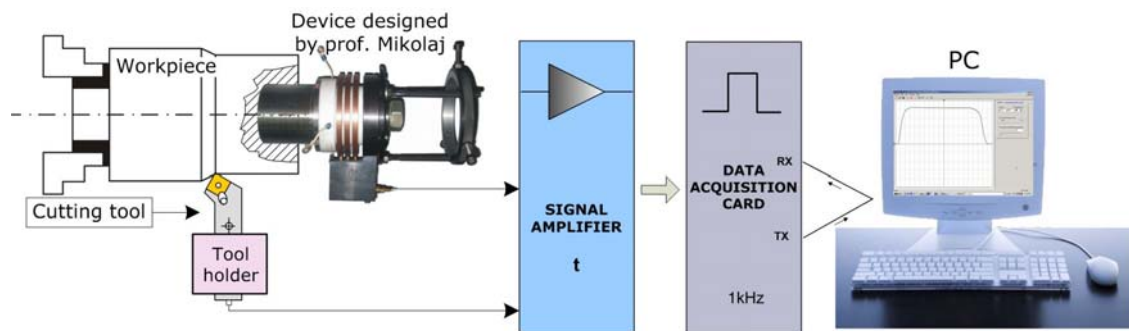


Fig. 1. Schematic view of the research experimental setup

The high temperatures and material removal dynamics in such conditions more intense influence on the

mechanisms of chip creation and on the cutting tool wear, as well to technological effects in /TSL/. Increased stiffness is required from the system Machine - Device - Workpiece - cutting Tool (MDWT). The system for measuring the temperature is required: to reduce errors that occur in the transmission of the signal from the workpiece-cutting tool thermocouple; be able to record increased quantity of information in relatively short interval; application of computer technology for reliable determining of the temperature in the cutting process. The goal is to reduce the interval of measuring uncertainty of the results obtained from measurements performed. The creation of computer aided research equipment for measuring temperature in the cutting process is the result of joint research realized on the Faculty of Mechanical Engineering and the Faculty of Electrical Engineering in Skopje, in cooperation with the Institute of Production Engineering and Automation of the Wroclaw University of Technology, Poland. Using the research equipment, investigations of dependence of the temperature from the machining parameters v , f , a and r_ϵ are carried out.

2. EXPERIMENTAL CONDITIONS

2.1 Cutting tool

The processing is performed by use of ceramic cutting tool inserts type SNGN 120712- 120716- 120720 made from mixed ceramics MC 2 ($Al_2O_3 + TiC$) manufactured by HERTEL and cutting tool holder type IK.KSZNR -064 25x25 manufactured by KENNAMETAL. Cutting tool stereometry is:

$$\chi = 85^\circ, \chi_1 = 5^\circ, \gamma = -6^\circ, \alpha = 6^\circ, \lambda = -6^\circ,$$

$$\gamma_f = -20^\circ, b_f = 0,2 \text{ mm}, r_\epsilon = 1,2 - 1,6 - 2,0 \text{ mm}$$

Cutting tool holder was previously reconstructed to provide transmission of the voltage signal from the cutting tool insert, which is presented on Fig. 2.

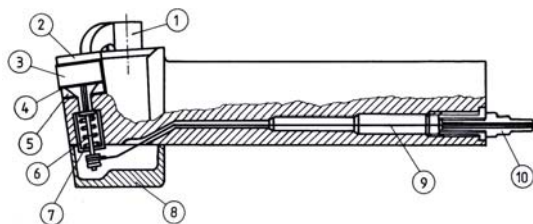


Fig. 2. Cutting tool holder cross-section, 1 - thumb, 2 - chip breaker made from Al_2O_3 , 3 - cutting tool insert made from mixed ceramics MC 2, 4 - mica, 5 - washer, 6 - mechanism, 7 - isolation bushing, 8 - protective cap, 9 - signal conductor, 10 - connector.

To reduce the impact of disruption factors during transmission of the generated signal and thus to increase the accuracy of measurements, cutting tool insert is completely isolated in the nest of cutting tool holder, by using of mica. To obtain the required chip

shape, a chip breaker made from zircon-oxide ceramics is used.

2.2 Workpiece

Material C 1630 (DIN C 55), normalized to the hardness of 200 HB.

2.3 Metal cutting machine

Lathe type "Prvomajska" TVP 250, with power $P = 11,2 \text{ kW}$ with step change in the numbers of revolutions between $n=16$ and 2240 rev/min.

2.4 Cutting parameters

Cutting speed $v = 300-500 \text{ m/min}$, feed $f=0,16-0,30 \text{ mm/rev}$, depth $a=0,5-1,0 \text{ mm}$, cutting tool insert tip radius $r_\epsilon=1,2-1,6-2,0 \text{ mm}$.

2.5 Device for transmission of the signal from workpiece

For measuring the average temperature in the cutting process by using method of "natural thermocouple", for transmission of generated signal from the workpiece a specially designed device is constructed, Fig. 3. This device after screwing into workpiece, allows transmission of generated signal through three rotating rings and fixed brushes. Particular attention is paid to the choice of material for rings and brushes, which in this case is black-lead bronze. The thermocouple ring - brush when heated to 373,16 K (100° C) generate thermovoltage of 0,3 mV.

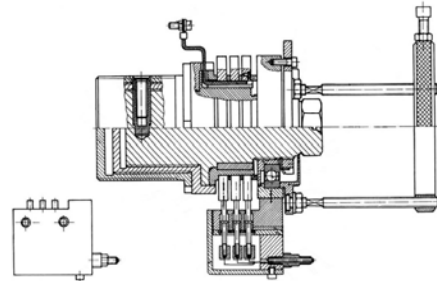


Fig. 3. Device for transmission of the signal from workpiece, cross-section [4]

2.6 Experimental plan

It is used first-order full four factorial plan of experiments ($2^4 + 4$), presented in Table 1. Power function is accepted for the mathematical model to describe the changes of the temperature. Mathematical processing is performed at the Faculty of Mechanical Engineering in Skopje with the application of program CADEX in connection with Model-Based Calibration (MBC) Toolbox Version 1.1, contained in the Matlab software package, which is intended for design of experiments and statistical modeling. Using the advanced features of Matlab and MBC provides significant advantages in the realization of experimental studies, with an option for graphic interpretation of results.

2.7 Research equipment

Monitoring of the thermovoltage (temperature) in the cutting process is done with computer aided research experimental setup, presented on Fig. 1 [5, 6]. Part of the research setup is specially designed PC interface that consist of signal amplifier and data acquisition card [7]. Measurements are done at the Faculty of Mechanical Engineering in Skopje. Graphical interpretation of monitored quantities by the software FORTMON is shown on Fig. 4.

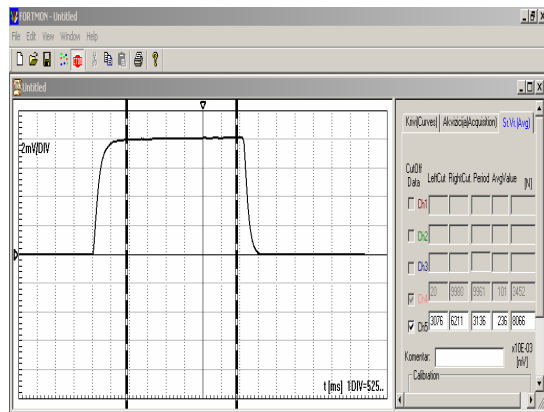


Fig. 4. Graphical interpretation of monitored quantities by the software FORTMON

Determining the average temperature by the method of natural thermocouple request to define of correlation between the thermovoltage measured by mV and the temperature expressed in °C. In this case, thermocouple is C 1630 - MC 2. For this purpose, a calibration installation is created. After regression analysis on the results obtained from the calibration measurements, the dependence between temperature T and thermovoltage u is obtained and represented as a polynomial of fourth degree [6]:

$$T = 104,426 - 42,646 \cdot u + 44,734 \cdot u^2 - 4,937 \cdot u^3 + 0,17 \cdot u^4 \dots \quad (1)$$

By using of the equation (1) in the software of the research experimental installation, showed on Fig.1, it is enabled direct transformation of the measured thermovoltage into temperature.

3. RESEARCH RESULTS ANALYSIS

Changes of average cutting temperature T_c as function of machining parameters are investigated during researches. Power function was adopted for describing of these changes:

$$T_c = C v^x f^y a^z r_\epsilon^q \dots \dots \dots \quad (2)$$

Experimental plan and results are presented in Table 1. Obtained results processing includes analysis of mathematical models with and without mutual effect, determination of 95% confidential interval for analyzed models, evaluation of significance of coded polynomial coefficients, determination of experimental

error and determination of multiple regression coefficient. Performed analysis, after complete computer processing, showed adequacy of obtained mathematical model (3).

$$T_c = 444,662 \cdot v^{0,164} \cdot f^{0,138} \cdot a^{0,054} \cdot r_\epsilon^{-0,088} \quad (3)$$

Obs No	Independent variables - Real matrix				Result T_{Cav} [°C]
	v [m/min]	f [mm/rev]	a [mm]	r_ϵ [mm]	
1	300,00	0,16	0,50	1,20	821,69
2	500,00	0,16	0,50	1,20	895,41
3	300,00	0,30	0,50	1,20	915,16
4	500,00	0,30	0,50	1,20	970,23
5	300,00	0,16	1,00	1,20	891,37
6	500,00	0,16	1,00	1,20	951,23
7	300,00	0,30	1,00	1,20	919,21
8	500,00	0,30	1,00	1,20	1043,63
9	300,00	0,16	0,50	2,00	819,56
10	500,00	0,16	0,50	2,00	845,19
11	300,00	0,30	0,50	2,00	879,32
12	500,00	0,30	0,50	2,00	961,36
13	300,00	0,16	1,00	2,00	819,57
14	500,00	0,16	1,00	2,00	887,23
15	300,00	0,30	1,00	2,00	873,42
16	500,00	0,30	1,00	2,00	998,38
17	387,30	0,22	0,71	1,55	909,53
18	387,30	0,22	0,71	1,55	917,18
19	387,30	0,22	0,71	1,55	903,37
20	387,30	0,22	0,71	1,55	901,28

Table 1. First order four factorial experimental plan

Some graphical interpretation of the influence of cutting speed - v , feed - f , cutting depth - a , and cutting tool insert tip radius - r_ϵ on the changes of average temperature T_c are shown on Fig. 5. It can be noticed that most significant effect on average temperature increase has cutting speed increase, then cutting feed, and, the least, cutting depth. Cutting tool insert tip radius increase results in temperature decrease. Average temperature increase as result of cutting speed increase is explained, mainly, by decreasing contact between chip and face surface of cutting tool insert, resulting with chip ramming decreases, chip sliding speed against face surface increases, heat discharge is worse and friction is increased. Heat created in cutting area is, mainly, a sum of heat of machined layer deformation, which decreases, due to cutting speed increase, till certain limit as well as of heat generated by chip friction against face surface of cutting tool, which increases by cutting speed increase, which is basic reason for average temperature increase. Average temperature increase due to feed increase is results of higher deformation, which alternatively causes higher heat quantity. However, feed increase also means increase of contact surface between chip and cutting tool, which results by conditions for improved heat discharge. Therefore, de facto, there is smaller effect of feed onto

average temperature. Similar is cutting depth effect. Namely, this means that deformation work increases by cutting depth increase, thereby generating higher heat quantity, however also increasing contact surface between chip and cutting tool and improving heat discharge. In addition, cutting blade active length directly increases. This provides much better conditions for heat discharge thereby smaller temperature gradients. The cutting tool insert tip radius r_e effect is much interesting. Average temperature decreases by r_e increase. This is due, mostly, to increased active length of cutting blade, which provides much better heat discharge. Besides this, reduction of angle χ , as result of increase of r_e , is, also, a reason for smaller cutting forces, smaller deformation work and thereby smaller heat quantity. It should also be stated that increase of measured average cutting temperature is result of temperature increase on rear side of cutting wedge due to increased friction of rear main surface and auxiliary rear surface with machined surface.

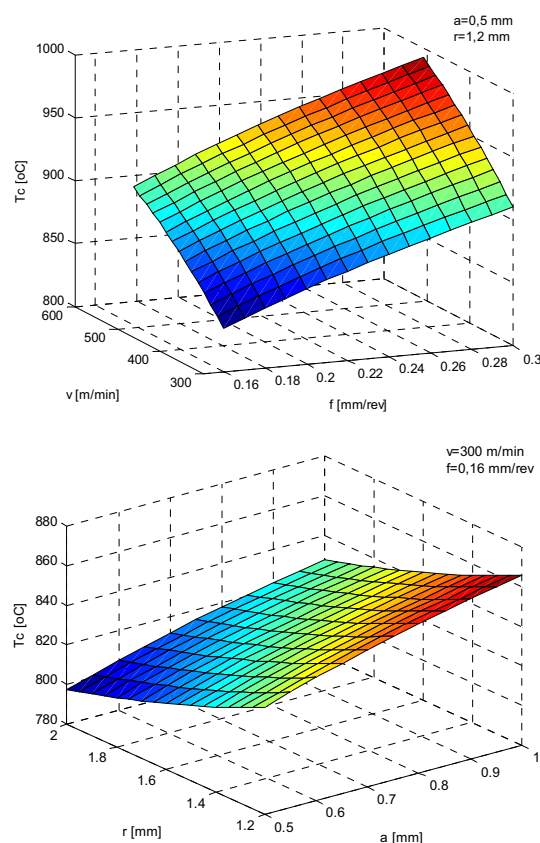


Fig. 5. Graphical interpretation of the influence of cutting speed - v , feed - f , cutting depth - a , and cutting tool insert tip radius - r_e on the changes of average temperature T_C

4. CONCLUSIONS

Following remarks and conclusions can be reached from performed experimental researches, obtained mathematical models, as well as results analysis:

- Statistical analysis indicated that describing changes of average cutting temperature T_C as function of machining parameters v, f, a and cutting tool insert tip radius r_e , by means of power function, is correct;
- All factors adopted in models are significant, and their effect is as follows:
- Average cutting temperature mostly depends upon cutting speed and feed, while from cutting depth, the least. The increase of these parameters causes average temperature increase, which reached highest value of 1043°C in the investigated domain.

5. REFERENCES

- [1] Pavlovski, V., Kuzinovski, M., Zebrovski, H., Cichosz, P.: *Experimental research of the physical phenomena in turning with ceramic cutting inserts*, Third International Conference on advanced manufacturing systems and technology, AMST '93, Udine, Italy, 1993.
- [2] Milikić D.: *Temperature pri obradi rezanjem i mogućnosti njihovog tačnog određivanja*, XIV Savetovanje proizvodnog mašinstva Jugoslavije, p.p. 292-305, Čačak, 1980.
- [3] Stanić, J.: *Metod inženjerskih merenja*, Mašinski fakultet, Beograd, 1990.
- [4] Kuzinovski M.: PATENT MKP B23Q 11/14, G01K 13/08, 900600, 30.09.2000.
- [5] Trajčevski, N., Kuzinovski, M., Filiposki, V., Cichosz, P.: *Computer aided measurement of the temperature in the cutting process by machining with turning*, Proceedings of the Scientific Conference with International Participation "Manufacturing and management in 21-st century", p.p.129-134, Ohrid, Republic of Macedonia, September 16-17, 2004.
- [6] Trajčevski, N.: *Monitoring system in experimental investigation in machining with turning*, Master thesis, Skopje, February 2008.
- [7] Trajčevski, N., Filiposki, V., Kuzinovski, M.: *Personal computer interface for temperature measuring in the cutting process with turning*, Proceedings, Faculty of Mechanical Engineering - Skopje, Vol.23, No.2, p.p. 65-74, 2004.

Authors: Trajčevski Neven, MSc, Military Academy - Skopje, Macedonia. Prof. Kuzinovski Mikolaj, PhD, University "Ss. Cyril and Methodius", Faculty of Mechanical Engineering, Skopje, Macedonia. Prof. Cichosz Piotr, DSc, Institute of Production Engineering and Automation of the Wrocław University of Technology, Wrocław, Poland.
E-mail: neven.trajchevski@gmail.com
mikolaj@mf.edu.mk
piotrc@itma.pwr.wroc.p

University of Novi Sad
FACULTY OF TECHNICAL SCIENCES
DEPARTMENT FOR PRODUCTION ENGINEERING
21000 NOVI SAD, Trg Dositeja Obradovica 6, SERBIA

10th INTERNATIONAL SCIENTIFIC CONFERENCE ON
FLEXIBLE TECHNOLOGIES



PROCEEDINGS

Novi Sad, October 2009

**PROCEEDINGS OF THE 10th INTERNATIONAL SCIENTIFIC CONFERENCE ON
FLEXIBLE TECHNOLOGIES - MMA 2009.
Novi Sad 2009.**

Publisher: FACULTY OF TECHNICAL SCIENCES
DEPARTMENT FOR PRODUCTION ENGINEERING
21000 NOVI SAD, Trg Dositeja Obradovica 6
SERBIA

Organization of this Conference was approved by Educational-scientific Council of Faculty of Technical Sciences in Novi Sad, at 26th meeting held on November, 26th 2008.

Editor: Dr Ilija Ćosić, *red.prof., Dean*

Reviewers: Dr Velimir TODIĆ, *Professor*
Dr Ljubomir BOROJEV, *Professor*
Dr Janko HODOLIČ, *Professor*
Dr Pavel KOVAČ, *Professor*
Dr Bogdan SOVILJ, *Professor*
Dr Milan ZELJKOVIĆ, *Professor*
Dr Marin GOSTIMIROVIĆ, *Assoc.Professor*
Dr Miodrag HADŽISTEVIĆ, *Assist.Professor*
Dr Milenko SEKULIĆ, *Assist.Professor*
Dr Slobodan TABAKOVIĆ, *Assist.Professor*

Technical treatment and design: Dr Ognjan Lužanin, *Assistant,*
Borislav Savković, *dipl.ing.-master*

Manuscript submitted for publication: October 05, 2009.

Printing: 1st

Circulation: 300 copies

CIP classification:

CIP- Каталогизacija u publikaciji
Библиотека Матице српске, Нови Сад

621.7/.9 (082)

**INTERNATIONAL Scientific Conference on Flexible
Technologies (10 ; 2009 ; Novi Sad)**

Proceedings / 10th International Scientific Conference on
Flexible Technologies – MMA 2009, Novi Sad, October 9-10,
2009 ; [editor Ilija Ćosić] . – Novi Sad : Faculty of
Technical Sciences, Department for Production Engineering,
2009 (Novi Sad : Grafički centar Grid). – VI, 310 str. :
ilustr. ; 30 cm

Tiraž 300. – Bibliografija uz svaki rad. – Registar.

ISBN 978-86-7892-223-7

a) Производно машинство - Зборници

COBISS.SR-ID 242833159

Printing by: FTN, *Graphic Center*
GRID, Novi Sad

ISBN: 978-86-7892-223-7

*Finansiranje ovog Zbornika radova pomogao je pokrovitelj konferencije **Ministarstvo za nauku i tehnološki razvoj Republike Srbije i Pokrajinski sekretarijat za nauku i tehnološki razvoj AP Vojvodine.***

Financing of the Proceedings was sponsored by the Ministry of Science and Technological Development of the Republic of Serbia and aided by the Ministry of Sciences and Technological Development of AP Vojvodina.



10th INTERNATIONAL SCIENTIFIC CONFERENCE
Novi Sad, Serbia, October 9-10, 2009

CONFERENCE ORGANIZER

University of Novi Sad
FACULTY OF TECHNICAL SCIENCES
DEPARTMENT FOR PRODUCTION ENGINEERING
21000 NOVI SAD, Trg Dositeja Obradovica 6, SERBIA

INTERNATIONAL SCIENTIFIC COMMITTEE

Prof. dr Velimir Todić, FTN Novi Sad, chairman
Prof. Dr. Joze BALIC, SF Maribor
Prof. Dr. Helmut Bley, University of Saarlandes
Prof. Dr. Ljubomir BOROJEV, FTN Novi Sad
Prof. Dr. Konstantin BOUZAKIS, AU Thessaloniki
Prof. Dr. Miran BREZOCNIK, SF Maribor
Prof. Dr. Ilija COSIC, FTN Novi Sad
Prof. Dr. Pantelija DAKIC, MF Banja Luka
Prof. Dr. Cristian DOICIN, PU Bucharest
Prof. Dr. Dragan DOMAZET, MF Nis
Prof. Dr. Janko HODOLIC, FTN Novi Sad
Prof. Dr. Frantisek HOLSOVSKY, PU Ústí nad Labem
Prof. Dr. Amaia IGARTUA, TC Eibar
Prof. Dr. Juliana JAVOROVA, UCTM Sofia
Prof. Dr. Vid JOVISEVIC, MF Banja Luka
Prof. Dr. Mara KANDEVA, TU Sofia
Prof. Dr. Tatjana KANDIKJAN, MF Skopje
Prof. Dr. Pavel KOVAC, FTN Novi Sad
Prof. Dr. Malik KULENOVIC, MF Sarajevo
Prof. Dr. Ivan KURIC, FME Zilina
Prof. Dr. Mikolaj KUZINOVSKI, MF Skopje
Prof. Dr. Miodrag LAZIC, MF Kragujevac
Prof. Dr. Stanislaw LEGUTKO, PTF Poznan
Prof. Dr. Chusak LIMSAKUL, PSU Hatyai
Prof. Dr. Ljubomir LUKIC, MF Kraljevo
Prof. Dr. Vidosav MAJSTOROVIC, MF Beograd

Prof. Dr. Ostoja MILETIC, MF Banja Luka
Prof. Dr. Jozef NOVAK-MARCINCIN, FMT Presove
Prof. Dr. Miroslav PLANCAK, FTN Novi Sad
Prof. Dr. Snezana RADONJIC, TF Cacak
Prof. Dr. Zygmunt RYMUZA, UT Warsaw Area
Prof. Dr. Bogdan SOVILJ, FTN Novi Sad
Prof. Dr. Miroslav TRAJANOVIC, MF Nis
Prof. Dr. Dusan SEBO, SF Kosice
Prof. Dr. Branko SKORIC, FTN Novi Sad
Prof. Dr. Peter SUGAR, TU Zvolen
Prof. Dr. Branko TADIC, MF Kragujevac
Prof. Dr. Wiktor TARANENKO, SPI Sevastopol
Prof. Dr. Ljubodrag TANOVIĆ, MF Beograd
Prof. Dr. Andrei TUDOR, PU Bucharest
Prof. Dr. Dzemo TUFEKCIC, University of Tuzla
Prof. Dr. Gyula VARGA, University of Miskolc
Prof. Dr. Vojo VISEKRUNA, FSR Mostar
Prof. Dr. Radomir VUKASOJEVIC, MF Podgorica
Prof. Dr. Milan ZELJKOVIC, FTN Novi Sad
Assoc. Prof. Dr. Marin GOSTIMIROVIC, FTN Novi Sad
Assoc. Prof. Dr. Borut KOSEC, FS Ljubljana
Assoc. Prof. Dr. Mirko SOKOVIC, FS Ljubljana
Doc. Dr. Igor DRSTVENSEK, SF Maribor
Doc. Dr. Milenko SEKULIC, FTN Novi Sad
Doc. Dr. Miodrag HADZISTEVIC, FTN Novi Sad
Doc. Dr. Slobodan TABAKOVIC, FTN Novi Sad

HONORARY COMMITTEE

Prof. Dr. Dragutin ZELENOVIC, Academic
Prof. Dr. Illes DUDAS, University of Miskolc
Prof. Dr. Ratko GATALO, FTN Novi Sad
Prof. Dr. Branko IVKOVIC, MF Kragujevac
Prof. Dr. Jerzy JEDRZEJEWSKI, UT Wroclaw
Prof. Dr. Milenko JOVICIC, MF Beograd
Prof. Dr. Milisav KALAJDZIC, MF Beograd
Prof. Dr. Jan MADL, FME Praha
Prof. Dr. Vucko MECANIN, MF Kraljevo
Prof. Dr. Vladimir MILACIC, MF Beograd
Prof. Dr. Dragoje MILIKIC, FTN Novi Sad
Prof. Dr. Ratko MITROVIC, MF Kragujevac
Prof. Dr. Stanislaw PYTKO, PTS Cracow
Prof. Dr. Jozef REKECKI, FTN Novi Sad
Prof. Dr. Sava SEKULIC, FTN Novi Sad
Prof. Dr. Joko STANIC, MF Beograd
Prof. Dr. Jelena STANKOV, FTN Novi Sad
Prof. Dr. Momir SARENAC, MF E. Sarajevo
M.Sc. Dragan BANJAC, FTN Novi Sad

ORGANISATIONAL COMMITTEE

Prof. Dr. Pavel KOVAC, chairman
Doc. Dr. Milenko SEKULIC
Doc. Dr. Miodrag HADZISTEVIC
Doc. Dr. Slobodan TABAKOVIC,
Dr. Ognjan LUZANIN, Assistant
M.Sc. Aco ANTIC, Assistant
M.Sc. Igor BUDAK, Assistant
M.Sc. Miodrag MILOSEVIC, Assistant,
M.Sc. Dorde VUKELIC, Assistant
M.Sc. Dejan LUKIC, Assistant
M.Sc. Aleksandar ZIVKOVIC, Assistant
Ivan MATIN, dipl.ing., B.E.
Igor BESIC, dipl.ing., B.E.
Borislav SAVKOVIC, dipl. ing. master., secretary



10th INTERNATIONAL SCIENTIFIC CONFERENCE
Novi Sad, Serbia, October 9-10, 2009

ACKNOWLEDGEMENT

Organisation of the 10th International Scientific Conference MMA 2009 – Flexible Technologies, was greatly supported by the following sponsors:

- **TEHNOEXPORT** – Indija
- **RITAM INŽENJERING** –Beograd
- **BEOHEMIJA**–Beograd
- **METALS-BANKA A.D.** – Novi Sad
- **FKL A.D.** – Temerin

Being held on a regular basis, like some other conferences of long tradition, the MMA – FLEXIBLE TECHNOLOGIES contributes to continuous application of scientific results and professional know-how in the metalworking industry, regardless of the difficulties this industry has been facing during the last fifteen years.

By organizing the MMA 2009 Conference, the research potential of our country relies on its traditional enthusiasm and perseverance in order to contribute to advancement of production engineering in this region – not only through application of scientific results and professional know-how in practice, but also in education of engineers in the area of production technologies and techniques.

The MMA Conference - FLEXIBLE TECHNOLOGIES is being held for the seventh time with international participation, while this is the first time that it has the official status of international conference. Throughout the years, by the number of contributions, their quality and participation of international authors, the Conference has earned a respectable reputation among scientists and industry professionals.

Initially, MMA - FLEXIBLE TECHNOLOGIES focused exclusively on TECHNOLOGIES, TOOLS AND EQUIPMENT FOR MACHINING BY CHIP REMOVAL with the following topics:

- ◆ MACHINING AND PROCESS PLANNING
- ◆ MACHINE TOOLS
- ◆ TOOLS, FIXTURES, METROLOGY AND QUALITY
- ◆ FLEXIBLE MANUFACTURING SYSTEMS, CAD, CAPP, CAM, CAQ, ..., CIM systems

However, the X Conference comes with a slightly broadened choice of topics:

- ◆ ENVIRONMENTAL TECHNOLOGIES AND ECOLOGICAL SYSTEMS
- ◆ OTHER AREAS

The organizers of this Conference are convinced that by broadening the scope they did not collide with the similar conferences of long tradition.

With around 80 papers and more than 50% contributions by international authors, 10th International Scientific Conference MMA 2009 – FLEXIBLE TECHNOLOGIES successfully maintains the high level set by the previous conferences. Participation of a large number of domestic and international authors, as well as the diversity of topics, justifies our efforts to organize this conference and contribute to exchange of knowledge, research results and experience of industry experts, research institutions and faculties which all share a common interest in the area of production engineering.

Novi Sad, October 2009

*INTERNATIONAL SCIENTIFIC AND
ORGANISATIONAL COMMITTEE*

Contents

KEYNOTE PAPERS:

Pilipovic, M., Spasic, Z. VIRTUAL MANUFACTURING – MODELING FOR CIM ENTERPRISE.....	1
Cus, F., Zuperl, U. EMBEDDED LOAD CONTROL SYSTEM FOR MILLING PROCESSES.....	5
Brezocnik, M., Brezovnik, S., Balic, J., Sovilj, B. SWARM INTELLIGENCE BASED ROBOT SYSTEM.....	9
Kovac, P., Gostimirovic, M., Sekulic, M., Savkovic B. MAIN DEVELOPMENTS IN CUTTING TECHNOLOGY.....	13

Section A: METAL CUTTING

Invited Paper:

Kovac, P., Gostimirovic, M., Sekulic, M., Savkovic B. MODELING AND SIMULATION OF CUTTING PROCESS.....	22
---	----

Invited Paper:

Kuzinovski, M., Tomov, M., Cichosz, P. EFFECT OF SAMPLING SPACING UPON CHANGE OF HYBRID PARAMETERS VALUES OF THE ROUGHNESS PROFILE.....	28
--	----

Antic, A., Zeljkovic, M., Hodolic, J., Zivkovic, A. MODEL OF CLASSIFICATION SYSTEM OF TOOL WEAR CONDITION WHILE MACHINING BY TURNING.....	33
--	----

Gostimirovic, M., Kovac, P., Sekulic, M., Savkovic B. INVERSE TASK SOLUTION OF HEAT CONDUCTION IN GRINDING PROCESS.....	37
---	----

Kovac, P., Savkovic, B., Sekulic, M., Mijic A. MODELING OF CUTTING FORCES IN FACE MILLING.....	40
--	----

Kovac, P., Serdar B., Savkovic, B., Gostimirovic, M. COMPUTER ANALYSIS OF CUTTING FORCES ACTION ON CUTTING TOOL DURING TURNING.....	44
--	----

Krsljak, B. SURFACE GRINDING OF FLAT WOOD SURFACES AND WOODEN MATERIALS WITH GRINDING BELTS, STATE CHARACTERISTICS AND PROCESS OPTIMIZATION.....	48
--	----

Kuzinovski, M., Trajceviski, N., Cichosz, P. INVESTIGATION OF CUTTING FORCES DURING MACHINING PROCESS BY HIGH SPEED TURNING.....	52
---	----

Miletic O., Todic M. DEPENDENCE OF DEFORMATION FROM PARAMETERS OF PROFILING PROCESS.....	56
--	----

Pechacek, F., Hruskova, E. POWER ULTRASOUND IN MACHINING.....	60
Pejovic, B., Dakic, P., Mićic, V. SUPPLEMENT FOR IMPROVEMENT EXISTING MODEL FOR CALCULATING SPIRALLY FLUTED DRILL	64
Radonjić, S., Baralic, J., Sovilj-Nikić, I. CENTERLESS GRINDING AND POLISHING OF CIRCULAR STAINLESS STEEL TUBES	68
Sekulic, M., Kovac, P., Gostimirovic, M., Jurkovic, Z., Savkovic, B. THE THRUST FORCE STRUCTURE IN DRILLING	72
Sekulic, S. ONE METHODOLOGY FOR DETERMINATION WEIBULL'S DISTRIBUTION FUNCTIONS BY MEDIAL RANKS FOR WHICHEVER SIZE SAMPLE.....	76
Tomov, M., Kuzinovski, M., Cichosz, P. GENERAL EFFECT OF TOTAL DATA POINTS NUMBER ON MATERIAL RATIO CHANGE OF THE ROUGHNESS PROFILE.....	80
Trajcevski, N., Kuzinovski, M., Cichosz, P. INVESTIGATION OF TEMPERATURE DURING MACHINING PROCESS BY HIGH SPEED TURNING	86
 Section B: MACHINE TOOLS	
Deticek, E., Zuperl, U. POSITION CONTROL OF HYDRAULIC DRIVES IN MACHINE TOOLS BY FUZZY SELF-LEARNING CONTROLLER	90
Dimic, Z., Zivanovic, S., Vasic, M., Cvijanovic, V., Krosnjar, A. VIRTUAL SIMULATOR FOR FIVE AXIS VERTICAL TURNING CENTER IN PYTHON GRAPHICAL ENVIRONMENT INTEGRATED WITH OPEN ARCHITECTURE CONTROL SYSTEM	94
Pozhidaeva, V., Kandeva, M., Assenova, E. ESTIMATION OF WEAR AND SERVICEABILITY OF ROLLING BEARINGS IN OPEN PIT COAL MINING MACHINES.....	98
Todic, V., Lukic, D., Milosevic, M. FUNDAMENTALS FOR PLANNING AND CALCULATION OF MACHINING SYSTEMS' CAPACITY	101
Vukicevic V., Albijanac R., Benisek M., Komadinic V. THE CONSIDERATION OF THE DYNAMIC UNBALANCE PROBLEM OF ROTATING MACHINERY	105
 Section C: TOOLS, TRIBOLOGY, FIXTURES, METROLOGY AND QUALITY	
<i>Invited Paper:</i>	
Cep, R., Sadilek, M., Kouril, K., Budak, I., Hadzistevic, M. MEASURING OF MACHINE TOOL ACCURACY BY RENISHAW BALLBAR QC10.....	109
<i>Invited Paper:</i>	
Sovilj, B., Javorova, J. G. , Geric, K., Brezocnik, M., INFLUENCE OF TEMPERATURE ON THE PHASE TRANSITION IN CoPt ALLOY	113

Invited Paper:

Vukelic, Dj., Tadic, B., Hodolic, J., Matin, I., Krizan, P. DEVELOPMENT A DATABASE OF MODULAR FIXTURES	117
Cerjakovic, E., Tufekcic Dz., Topcic A., Selo R. SIVUR SOFTWARE APPLICATION FOR MODELING OF PENDING CONVEYER.....	121
Doric, J., Pilic, V., Besic, I., Hodolic, J. APPLICATION OF REVERSE ENGINEERING BASED ON FEATURE RECOGNITION	125
Hadzistevic, M., Hodolic, J., Besic, I., Pavlov, A. TESTING SOME SIGNIFICANT PARAMETERS ON MEASUREMENT ERROR OF COORDINATE MEASURING MASHINE	129
Javorova, J. G., Sovilj, B., Sovilj-Nikic, I. INFLUENCE OF FLUID INERTIA ON THE STABILITY OF EHD JOURNAL BEARINGS	133
Krizan, P., Soos, E., Vukelic, Dj. COUNTER PRESSURE EFFECTING ON COMPACTED BRIQUETTE IN PRESSING CHAMBER	136
Majstorovic, V., Ercevic, B., Ercevic, M., Zukan, I. ONE CAI MODEL IN THE DIGITAL FACTORY	140
Makedonski, A., Makedonski, B., Vilcek, I. ORGANIZATION OF THE TRYBOSYSTEM "TOOL – PART" AFTER MAGNETIC- ULTRASONIC TREATMENT.....	144
Sovilj, B., Radonjic, S.,Kovac, P., Sovilj-Nikic, I. ANALYSIS GEAR CHARACTERISTICS AND SERATION PROCESSING IN "KOLUBARA - METAL" FACTORY	147
Sovilj, B., Radonjic, S., Sovilj-Nikic, I. ANALYSIS OF APPLICATION OF PROFILED TOOLS FOR SERATION IN "KOLUBARA - METAL" FACTORY	151
Trakic, E., Avdic, S., Saric B. REVERSE ENGINEERING OF STATOR WINGS OF VARIABLE TURBO CHARGER	155
Zuperl, U., Cus, F. AUTOMATION OF MILLING FIXTURE VERIFICATION PROCESS	158

Section D: FLEXIBLE MANUFACTURING SYSTEMS, CAD, CAPP, CAM, CAQ, ..., CIM

Invited Paper:

Borojevic, S., Jovisevic, V., Jokanovic, S. MODELING, SIMULATION AND OPTIMIZATION OF PROCESS PLANNING	162
---	-----

Invited Paper:

Budak I., Sokovic M., Hodolic J., Kopac J. POINT DATA REDUCTION BASED ON FUZZY LOGIC IN REVERSE ENGINEERING.....	166
--	-----

Invited Paper:

Milosevic, M., Todic, V., Lukic, D. MODEL DEVELOPMENT OF COLLABORATIVE SYSTEM FOR PROCESS PLANNING	170
--	-----

Invited Paper:

Petrovic, B., P., Jakovljevic, Z., Pilipovic, M., Mikovic, Dj, V. IN PROCESS IDENTIFICATION OF WORKPIECE/SYSTEM GEOMETRICAL DEVIATIONS BASED ON GENERAL PURPOSE ROBOTS AND LASER TRIANGULATION SENSORS - Part 1: Conceptual Framework.....	174
--	-----

Invited Paper:

Petrovic, B., P., Jakovljevic, Z., Pilipovic, M., Mikovic, Dj, V. IN PROCESS IDENTIFICATION OF WORKPIECE/SYSTEM GEOMETRICAL DEVIATIONS BASED ON GENERAL PURPOSE ROBOTS AND LASER TRIANGULATION SENSORS -Part 2: Evaluation.....	178
Babic A., Pljakic M., Ilic N. MODELLING OF PROCESSES AND MACHINES FOR THE SUPPORT TO HYDROENGINE COMPONENTS PRODUCTION.....	183
Babic A., Pljakic M., Ilic N., Petrovic A. MODELLING OF INSTALLATION OPERATIONS IN CAM OF ROADHEADER DESIGN FOR THE PROCESSING OF INFRASTRUCTURAL OBJECTS	186
Brajlih, T., Drstvensek, I., Valentan, B., Tasic T., Balic, J. ADVANTAGES OF COMBINING RAPID PROTOTYPING AND RAPID TOOLING TECHNOLOGIES IN PROTOTYPE PRODUCTION.....	190
Charbulova, M., Matusova, M., Caganova, D. INTELLIGENT PRODUCTION SYSTEMS AND CLAMPING SYSTEMS FOR INTELLIGENT PRODUCTION SYSTEMS	194
Eric, M., Stefanovic, M., Tadic, B. ARCHITECTURE OF INFORMATION MODEL FOR REENGINEERING OF TECHNOLOGICAL PROCESSES FOR SMALL ENTERPRISES	198
Grujic, J., Zeljkovic, M., Tabakovic, S., Gatalo, R., Sekulic, J. IMPLEMENTATION CAD/CAE/CAM PROGRAM SYSTEM IN THE PROCESS DESIGNING AND PRODUCING REVISION HIP JOINT PROSTHESIS	202
Javorova, A., Hruskova, E., Matusova, M. AUTOMATED DESIGN OF ASSEMBLY SYSTEM WITH COMPUTER AIDED SYSTEM HELP	206
Javorova, A., Zvolensky, R., Pechacek, F. METHODOLOGY AND DESIGN OF AUTOMATED DISASSEMBLY DEVICE	210
Luzanin, O., Plancak, M., Barisic, B. GESTURE RECOGNITION USING DATA GLOVE AND ANN-BASED PROCESSOR	214
Luzanin, O., Vilotic, D., Plancak, M., Movrin, D. INTEGRATED CAD/CAM AND SIMULATION TOOLS FOR DESIGN AND MANUFACTURE OF FORGING TOOLS	218
Matin, I., Hadzistević, M., Hodolic, J., Vukelic, DJ., Tadic, B. DEVELOPMENT CAD/CAE SYSTEM FOR MOLD DESIGN	222
Movrin, D., Vilotic, D., Milutinovic, M., Plancak, M., Skakun, P. DESIGN OF FORGING TOOLS FOR YOKE-LIKE ELEMENTS BASED ON NUMERICAL SIMULATION.....	226
Reibenschuh, M., Cus, F. STRESS ANALYSIS OF A BRAKE DISC CONSIDERING CENTRIFUGAL LOAD	230
Slota, J., Spisak, E., Gajdos, I. THE APPLICATION OF COMPUTER-AIDED METHODS IN DEVELOPMENT PROCESSES OF PLASTIC PRODUCT	234
Sljivic, M., Radonjic, R., Stanojevic, M. MODELING OF FORWARD EXTRUSION PROCESS BY VIRTUAL MANUFACTURING	238

Section E: ENVIRONMENTAL TECHNOLOGIES AND ECOLOGICAL SYSTEMS

Invited Paper:

Crnobrnja B., Budak I., Ilic M., Hodolic J., Kosec B. ENVIRONMENTAL LABELLING OF TYPE I ACCORDING TO SRPS ISO 14024:2003	242
Flimel, M. NEED OF PREDICTIVE ENVIRONMENTAL FRIENDLY SYSTEM OF NOISE PROTECTION	246
Hricova, B., Nakatova, H., Badida, M., Lumnitzer, E. APPLICATION OF ECODSIGN AND LIFE CYCLE ASSESSMENT IN EVALUATION OF MACHINE PRODUCTS.....	250
Ilic, M., Budak, I., Crnobrnja, B., Hodolic, J., Kosec, B. ANALYSIS OF SELF-DECLARED ENVIRONMENTAL LABELS AND DECLARATIONS ACCORDING TO STANDARD ISO 14021	254
Liptai, P., Badida, M., Lumnitzer, E., Moravec, M. APPLICATION OF ACOUSTIC CAMERA IN INDUSTRIAL SITE.....	258
Lukacova, K., Badida, M., Lumnitzer, E., Liptai, P. CONCENTRATION OF SOLID AEROSOLS IN WORKING ENVIRONMENT	262
Nakatova, H., Hricova, B., Badida, M., Lumnitzer, E. COMPLEX EVALUATION OF THE QUALITY OF THE WORK ENVIRONMENT OF SELECTED FACTORS AND WORKPLACES IN ENGINEERING INDUSTRY	266
Sebo J. Fedorcakova M., Nakatova H. Sebo D. Halagovcova K. OPERATING EXPERIMENT OF WASTEWATER CLEANING AROUND THE BLAST FURNACE IN THE USS-KOSICE	270

Section F: OTHER AREAS

Invited Paper:

Balos S., Grabulov V., Sidjanin L. 50CrV4 STEEL AS A MATERIAL FOR PERFORATED PLATES IN BALLISTIC APPLICATION	274
<i>Invited Paper:</i> Rajnovic, D., Sidjanin, L., Eric, O. PROCESSING WINDOW AND AUSTEMPERABILITY OF ALLOYED AUSTEMPERED DUCTILE IRONS	278
Balos S., Grabulov V., Sidjanin L. PATENTED WIRE MESH AS ADD-ON ARMOUR	282
Bashir Raddad , Mohieldeen Abdel-Rahman, Said Al-hashani AN INVESTIGATION ON THE FLOW BEHAVIOR OF METALS WHEN FORGING SPECIMENS HAVING DIFFERENT CROSS SECTIONS.....	286
Celovic S., Tufekcic Dz., Cerjakovic E., Topcic A., Saric B. NEW PRODUCT DEVELOPMENT BASED ON MULTICRITERIAL DEMANDS	290
Geric, K., Sovilj, B. PROPERTIES OF SPRAY FORMED TOOL STEELS	294
Jovanovic, D., Nedic, B., Cupovic, M. INFLUENCE OF THE TECHNOLOGICAL HERITAGE ON LIFE CYCLE OF MACHINE ELEMENTS	298

Simonovic, S. DESIGNING PRODUCTS AND EQUIPMENT WITH RESPECT TO REDUCTION OF SETUP TIMES.....	301
Trbojevic, I., Vilotic, D., Jovicic, R., Luzanin, O., Movrin, D. COST ANALYSIS BASED ON MODERN FORGING TECHNOLOGY PLANNING	305
AUTHOR INDEX	309
INFORMATION ABOUT DONATORS	

10th INTERNATIONAL SCIENTIFIC CONFERENCE ON
FLEXIBLE TECHNOLOGIES

PROCEEDINGS



KEYNOTE PAPERS

Novi Sad, October 2009.