Bánki Donát Faculty of Mechanical Engineering

Institute for Material Science and Manufacturing Engineering

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Head of Institute: **Dr. Béla Palásti Kovács**

1 Introduction

The Institute is the continuer of the professional tradition of 'Technology' which became famous during the turning point of the 19th century and is also carrying the name of the previous institute which was founded in 1879.

The Institute of Material Science and Manufacturing Engineering became to exist during the founding of integrated Budapest Tech, by merging the famous Department of Mechanical Technology later known as ***Department of Material and Forming Technology*** with the ***Department of Manufacturing Engineering***. The ***two institutional departments*** work harmonically together in teaching and research by joining their vast connection systems.

The ***main fields of interest of the Institute*** are connected with forming technologies, heat treatment and welding, cutting technologies, CAD, CAM, Measuring Technologies, Quality Control and also metal sciences and assembly processes. The IMM has a valuable machine park, state of the art technological and testing equipments. The efficient use of the apparatuses in teaching and research require great coordination and precise organising.

The Institute staff consists of ***37 members***, of which 23 are working as teachers, ***8 of them have scientific degree,*** 2 of them are habilitated professor and one is the doctor of the Hungarian Academy of Sciences. There are also 3 members who take part in PhD program.

The Institute takes part in the basic education with Metallographic and Material Testing and also Length-measuring technology and Quality control laboratories and is also involved in the ***professional education*** with CAD/CAM-, FMS, Topographical, Intelligent Design Systems, Plastic Forming and Welding laboratories. The main aim is to introduce the students the processes of basic

research and the important cutting and chip-less technologies in real life, during practical education.

2 Education Profile

The Institute is the caretaker of ***CAD/CAM-profession,*** and is involved in all section of the basic teaching of the branch of ***Mechanical Engineering*** with the subjects of Material Sciences, basics of Cutting Technologies, Measuring Technologies and Quality Control.

The students who have profession major have an ability to confidently use the computer aided design systems in all phases of production such as design, drafting, development and manufacturing. The course provides experience in the computer aided design and selection of forming and cutting technologies and in the operation and control of different integrated level production instruments. With the deep knowledge of production processes our students are able to solve the problems: of company quality assurance, design and development of quality of machine industry and also to use the new techniques and methods of quality assurance.

The Institute is involved in the education of the following field (out of the scope of mechanical engineering subject):

- ***Mechatronics engineering basic major:*** quality assurance, manufacturing engineering, robotised materials handling
- ***Tactical and security engineering basic major:*** material and production knowledge,
- ***Technical manager basic major, organisation and informatics major:*** production processes, quality management,
- ***Information engineering basic major:*** Material sciences, informatics of technological processes, and technical design systems,
- ***Higher degree professional training:*** (engineering assistant): material sciences, manufacturing engineering, measuring technology, quality control, tool and appliance design.

In the frame ***of Cooperative training*** companies and factories welcomes our students in ever increasing numbers. This way they have an opportunity to obtain direct practical experience and to prepare their diploma work in the field of the current engineering industry.

Numerous students from the institute take part in the Scientific Students' Associations (TDK). In the last three national conferences they won 2 first places,

4 second places, 3 third places in the field of modern cutting, forming and welding technologies, and also in the subject of quality control and computer simulation of thermal processes.

Important areas of our education are the professional further education of company workers. The most important of these are:

Education that grants Professional engineering qualification:

- Product development, welding and quality control professional education,

Education that grants European and international qualification:

- EOQ Quality affaire system manager, TQM manager

The training started in December 1999 with the expert certification expert committee of EOQ MNB recognized the training as **EOQ Quality System manager** qualification course. The quality control system of the Institute that developed according to the standard ISO 9001:2000 that was recognised in 2005 fits harmonically into the training of the quality control systems of engineering-experts/expert. By the results of continuous development the previous expert committee recognised the training as **EOQ TQM Manager** authorised qualification course in January 2006.

- European Welding Technologist (EWT)

- International Welding Technologist (IWT)

and also courses the gives OKJ qualification, such as

- Plastic-injection mould design and

- Welder.

3 Research and Scientific Activity

The Institute has numerous researches concerning many fields of machine industry:

The Institute has good tradition in the field of ***material sciences and manufacturing researches***, in the development of ***experimental apparatus*** and gathered many experiences in these fields. In the last few years the Institute systematically takes part in national level ***research and development programs***

and realises competitions. The Institute staff regularly participate in national and international conferences as lecturers, speakers and as committee members. We participate in many material sciences COST actions and have close working relationship with national partner institutes and also with the staff of the universities of Lisbon, Košice and Helsinki. The three last working relations are supported by Hungarian Science and Technology Foundation (TéT) bilateral cooperation contracts.

The most important areas of research and experimental developments are the following:

The Development and Investigations of Evaluation Technologies of Surface Topologies, the Interactions of Micro Topography of Surface Pairs in Different Abrasion Processes

(Supervisor: Dr. Béla Palásti Kovács, professor, CSc)

The research-development is continuous since 1975: between 1998-2001 OTKA (Hungarian Scientific Research Fund) T026117, between 2003-2006 joint research with the TUB Machine Parts Institute T 043151 OTKA. The detailed knowledge of topography of interconnecting working parts of machines is an important subject of modern basic and applied research. The conclusions derived from the examinations of phenomena has an effect on the development of manufacturing tasks, the mathematical and computer processing of topography characteristics has an important result in tribological research, besides the behaviour of connections of surfaces (such as medical subjects, electric switches, stationary and sliding metal-metal and metal-composite materials, etc.). We developed the national 3D surface measurement facility base that has the quality of international standard for measurements, mathematical and computer science using the union of university and institute and moreover the experimental investigations of connecting surface pairs and the abrasion process computerised on-line tracking.

In recent times the old time 2D analogue instruments that can measure one-two parameters simultaneously (Ra, Rz) are succeeded by the full parameter computerised evaluators and then by 3D processing, by which numerous research directions were opened. The examinations are helped by the state of the art section-touching roughness measurer (Perthometer Concept), the self developed 3D evaluator program, and by the Jeol type scanning electron microscope. (Fig. 1).

The 3D measuring technology makes it possible to track and evaluate the wear processes, the detailed time investigation of the wear phenomena, such as the cut piece and the tool’s edge effects on each-other or the observation and revealing of scratch development (Fig. 2).

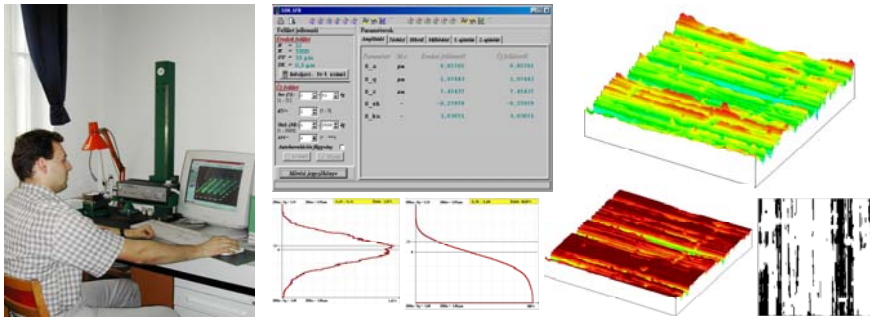


Figure 1

Test devices and possibilities of surface topography

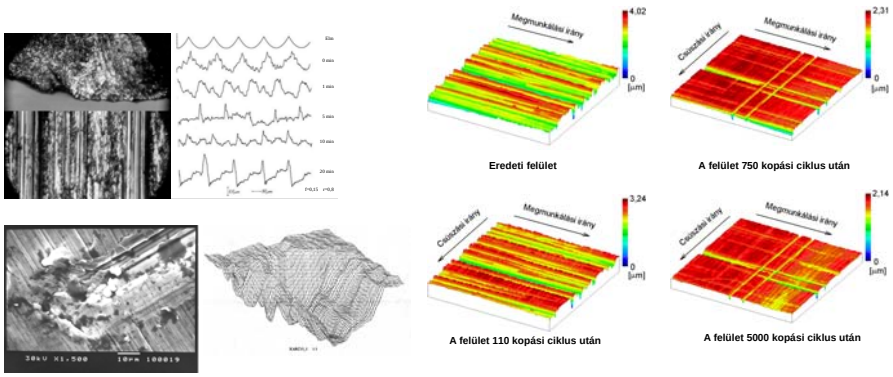


Figure 2

Illustration of the wear process

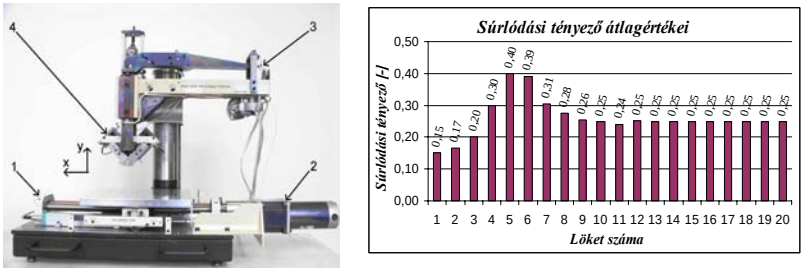


Figure 3

Friction wearing tester and change of friction coefficient in case of subsequent strokes

The multifunctional experimental instrument, developed in the Institute, allows the deeper exploration of the working characteristics, so we can follow the surface wear change processes, the changing effects and their connections can be evaluated, the finished surface characteristics can be examined. Plentiful

information can be gathered for designing the working surface topographies, for choosing the proper production technology, the deeper acquaintance of tribological processes during working and for their conscious control and influence (Fig. 3).

These researches and their related developments help the work of researchers of associate institutions (such as Faculty of Transportation Engineering, Budapest University of Technology and Economics (BME KSK), Faculty of Mechanical Engineering, University of Miskolc (ME GEK), etc.), the participations at international conferences, the postgraduate studies at the Universities (BME, ME, Széchenyi István University SZIE,), and also widen the possibilities of research and development places with industrial researchers.

Application of Computer-aided Engineering and Manufacturing in the Field of Machine Tools and Parts Manufacturing

(Supervisor: Dr. Balázs Mikó, associate professor, PhD)

The computer-aided design and manufacturing are everyday industrial practices, however there are numerous questions concerning design technique, design theory and methodology which answers can be a challenge for a researcher. The subject can be considered as a basic and also as an application research, because the industry demands the new results and their immediate introduction.

The aim of the research is to explore the application possibilities of CAD/CAM systems in the field of manufacturing parts design and manufacturing (appliances, tools, etc.), improvement and applications of manufacturing cost forecast technologies in different areas, the automation technological design processes, and the simulation of manufacturing with the help of a virtual factory. A CAD laboratory provides the background of the research with 13 machines (CATIA R5), and a connected FMS laboratory with 12 machines, where different CNC simulation software (NCT, SinuTrain, MTS) and a digital tool catalogue help the work of the designer.

The research can be divided into many sub areas, which operate in national and international cooperation and also as individual initiative.

- „OCTOPUS" – the development of a unified far distance education system for programming CNC machines and its connection in an informatics system (IOR-00010/2004).
- Advanced manufacturing technology in the automobile industry (CEEPUS CII-SK-0067-01-0506). The participants of the program: Technical University of Košice (Slovakia), Technical University of Vienna (Austria), Tomas Bata University (Czech Republic), University of Miskolc (Hungary), Technical University of Krakow (Poland).
- Manufacturing cost estimation of cut parts, which aim is to investigate the process and role of cost estimation, the methods used in the industry and also

the analysis of applicability of different artificial intelligent methods (case-based reasoning, rule-based reasoning, artificial neural networks).

- Automating technological design, in this subject the solution for the complex process of computer automation of technological design and merging different theories designs are investigated.
- Cost estimate of plastic injection moulding tools, where we work on the development of a cost estimate system that can estimate with adequate precision in industrial situations the cost of a tool for producing plastic parts.
- Reverse engineering, in this subject the problem of reconstructing an arbitrary part is investigated by using a coordinate measuring machine (Mitutoyo BX 303), CAD system (CATIA R5) and a CNC milling machine at the department.

Cutting Research

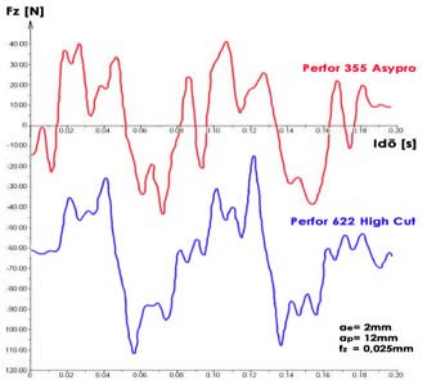
(Supervisor: Dr. Tibor Cselle, professor, CSc)

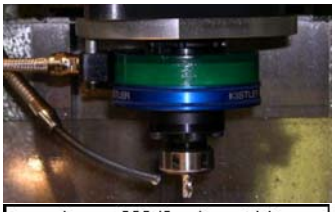
The cutting research program consists of three subfields:

- We qualify the structural materials, in which we develop and discuss the complex characteristics of cutability to the public that is applicable to describe and give numerical value for this complex concept.
- We classify the different geometry and material tools by instrumental measurements of their main characteristics and qualitative examination by request of national and foreign manufacturing companies.
- We classify the different cooling, lubrication and irrigation substances according to their effect on the tool. We examine the environmental friendly gas substances and also the additive emulsions according to their environmental load effects.

In the work frame of our research our students can examine modern cutting tools for their Scientific Students' Associations (TDK). Many decades of experience show that these subjects are of interests of the participants, they can gather lots of experience this way the preparation of their diploma work is made easier. In these subject the measuring and registration equipments takes great parts which were purchased from different research competitions (especially OTKA). For example in 2002 the OTKA M042000 project, ‘Cutting force and torque instruments with tool fixtures and multi-channel amplifier’ an instruments was purchased, which was used for examining turning tools (drills, mills) (Fig. 4).

The Perthometer S6P surface roughness measuring instrument registered on OTKA T023351 and a 3D evaluation software are successfully used for investigating cut surfaces. In the latter subject we cherish a mutual favourable research contact with the Faculty of Mechanical Engineering at the Technical University of Košice (SK 10/2004) (Fig. 5).





Asypro 355 (forgácsosztós)	
Axiális erő minimum, N	-40
Axiális erő maximum,N	+40
Átlagos erő, N	**– 0**
High Cut 622 (simító)	
Axiális erő minimum, N	-15
Axiális erő maximum, N	-110
Átlagos erő, N	**- 70**

Figure 4

Axial force component acting on end mills with High Cut coated, normal edge vs. non coated special edge (Asypro roughers)

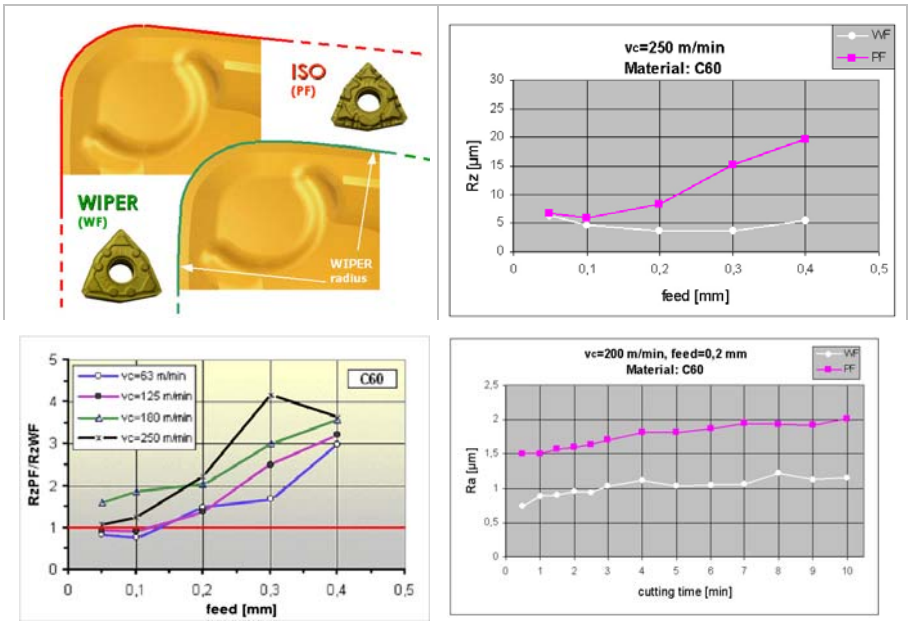


Figure 5

Roughness parameters vs. feed rate PF and WF coded WNMG inserts

Cutting conditions: depth of cut: a = 1 mm; without cooling

Remarks: ISO inserts have PF, wiper inserts have WF coded chip formers

Computer-aided Heat and Surface Treatment Process Design and Simulation

(Supervisor: Dr. Tamás Réti, full professor, DSc.)

The main aim of the research is the mathematical modelling of thermal processes that occurs during heat treatment and surface treatment (mainly concerning material structure change) primarily to forecast the microstructure and material quality. The research is aimed at the processes of quenching, tempering, carburisation, nitriding, laser surface hardening, and cladding.

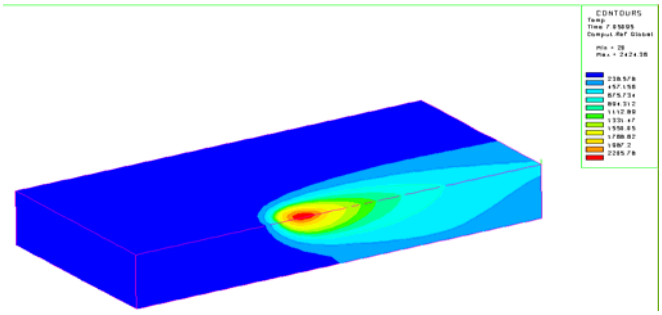


Figure 6
Temperature distribution in case of laser surface treatment

The research and development is aimed at the design and suitable precision estimation of the material properties of heat treated and surface treated parts (hardness distribution, carbon-distribution, strength, microstructure, surface layers structure, distortion, etc.). For this mathematical models and simulation algorithms were developed – based on physical and material science theories – with which the connection between the technological parameters and product property can be described. The developed models and simulation methods formed the base of computer programs and software systems for the technology design of heat treatment (quenching, tempering) and surface treatment (laser surface quenching, surface alloying) (Fig. 6). The later gained important place in the education, because most of the developed simulation procedures were incorporated in the practical studies of information engineering and partly into the studies of mechanical engineering.

In recent times we have taken part in numerous research projects based on national and international cooperation, mostly as supervisors. The OTKA mainly supports the theoretical founding of the material science and mathematical modelling. The particular experimental works the evaluation of measurement data and the verification of reliability of the models were helped by the support from Research Projects in Higher Education (FKFP) and the National Office for Research and Technology (NKTH, earlier OMFB). International relationship and mutual works with foreign institutions were also made possible (disregarding the

previously mentioned) by Hungarian Science and Technology Foundation (TéT) competitions. Main national partners: Bay Zoltan Institute For Materials Science and Technology (BAYATI), Dunaferr Co., Dunaferr Research Institute, Dunaferr Steel Works Kft., University of Miskolc, Szent István University, Széchenyi István University. International partners: Brisbane University (Australia), CETIM Institute (France), University of Birmingham (UK), Instituto Superior Tecnico (Portugal), Jiao Tong University (China).

Experimental Research and Mathematical Modelling of Solidification and Casting Processes with Special Interest of Continuous Casting of Steel

(Supervisor: Dr. Mihály Réger, professor, PhD)

The research consists of three major subjects. The task of the first great field is to reconstruct the current circumstance of solidification from the information content of the internal (primary) structure of continuously cast products. In this subject the results of digital image processing and image analysis are used. The other main subject is the clarification of the relation between non-steady state parameters of solidification and the characteristics of the evolved dendrite structure, which is primarily based on the crystallisation experiment made on a transparent model material. The third main field of subject is the mathematical modelling of the processes of continuous casting, which consists of numerous modelling of sub processes (such as: thermodynamics, fluid mechanics, deformation, micro- and macrosegrations) due to its technological complexity (Fig. 7).

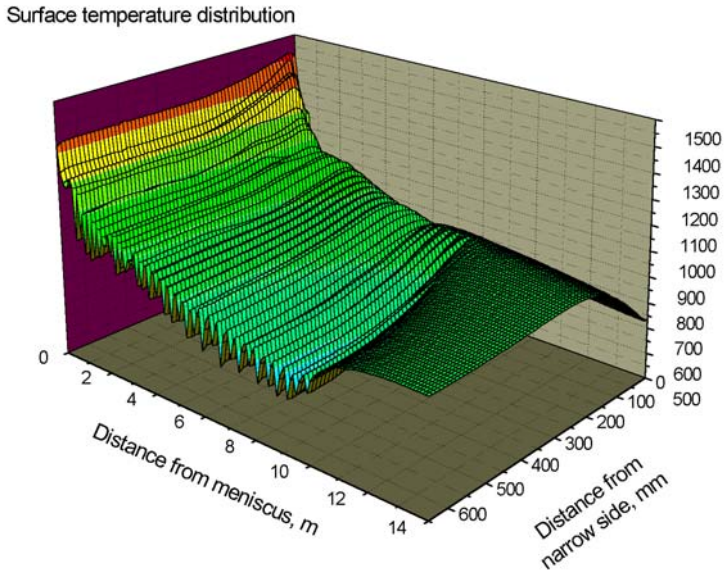


Figure 7
Calculated surface temperature distribution on the surface of the continuously cast slab

The main aim of the research is the clarification of the complex processes involved in continuous casting, their mathematical modelling, in the interest of technological optimisation and quality improvement.

Based on the results of the present researches an EU project were handed in with the title 'Integrated models for defect free casting' to the Research Fund for Coal and Steel with German, Italian and Belgian partners. In recent years we were involved in many national and international joint research projects in the field of modelling of solidification processes. From this point of view the research and cooperation with the Finnish research group and the international COST project is outstanding.

Mapping of transformations properties of multiphase steels

(Supervisor: Dr. Mihály Réger, professor, PhD)

The development of the multiphase - increased (high) strength and large deformability - steels is the central topic of international steel research. With the help of a National Research and Development Programmes (NKFP) competition, industrial experiments and extensive research was performed in Hungary for the aim of introducing the domestic production of such type of steel. A subfield of the great subject is the mapping of the transformation behaviour of multiphase steels is the key question of the development of manufacturing. The general aim of the researches is the development of a simple comprehensive procedure with great information content that allows the mapping of the transformation characteristic of multiphase steels in the wide interval of cooling rates from an intercritical austenization temperature (ferrite/austenite).

An approach to the above mentioned subject was developed that uses a new method the so-called intercritical Jominy test. The main point of the examination is that the traditional Jominy test is performed from an intercritical initial state, this way the material contains ferrite and also austenite in the ration according to the temperature. The heating, maintaining the specimen at the given temperature and cooling are accurately measured by two inbuilt thermoelements, then from the measurement data the time dependent thermal history of the specimen is determined using a mathematical model. After the detailed metallographic examination of the Jominy specimen the different cooling graphs and evolved microstructure can be ordered together with great safety (Fig. 8). Later we are planning to perform the interrupted Jominy test, also starting from intercritical temperature, during which the temperature change on the specimen approaches the circumstances that evolves in the hot-roll bands on the cooling lines and during the coiling.

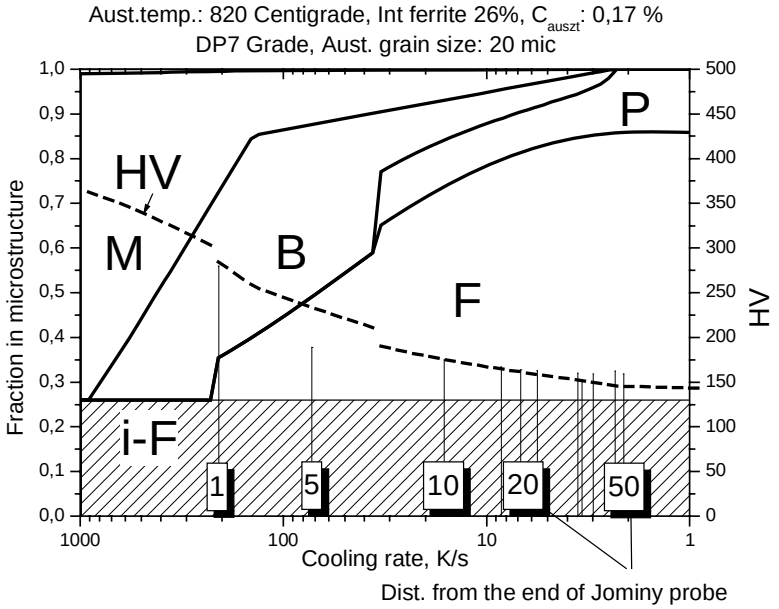


Figure 8
Transformation diagram and hardness curve of an intercritical heat treated steel

National partners: Dunaferr Ltd. Innovation Management, Bay Zoltan Institute for Materials Science and Technology (BAYATI), Budapest University of Technology and Economics, MTA Hungarian Academy of Sciences Material Science Research Group, Silco Ltd. Foreign cooperation: Helsinki University of Technology, Jiao Tong University Shanghai, Chinese-Hungarian Bilateral Cooperation (TéT), COST 526, 'Automatic Process Optimization in Materials Technology' (APOMAT) with participation of Management Committee and a Working Group 2 (Liquid-Solid Processing).

Development of Local Wear Experimental Methods

(Supervisor: Tünde Kovács, assistant professor, PhD student)

By studying experiments of various principles we have drawn the following deductions that the modelling of wear processes is favourable if we gain the results by experiments that take up the shortest possible time and are the simplest to evaluate. The reproducibility of traditional sphere/plane principle experiments are made difficult because of numerous uncertainty factor. It is practical to eliminate these factors; besides using the developed instruments advantages. The main aim of the researches is to develop an experimental method using the sphere/plane contact principle that can be reproduced in a short time and produces results that have small dispersion and are easily to evaluate with constants parameters.

The developed instrument allows the study of local (point like) wear (Fig. 9). The test specimen is planar and the part producing the wear is a sphere, this way the contact is a point at the beginning of the experiment. The equipment allows the examinations of the behaviour of specimens at given load (normal force), given revolution and the negligibly variating surface roughness. The surface of the wear sphere is not changing because the sphere is performing a planetary motion, this way the changing of the surface roughness is negligible. The revolution is transmitted with great safety by the conical drive and by the help of the bearing support. The normal force is constant due to the vertical load and to the properly designed instrument lever grasping. The load is not modified by the wear on the test piece and the changing of the friction coefficient. The procedure provides small scattering results in great numbers and in short examination time, which gives reliable results for performing wear resistant comparing examinations.

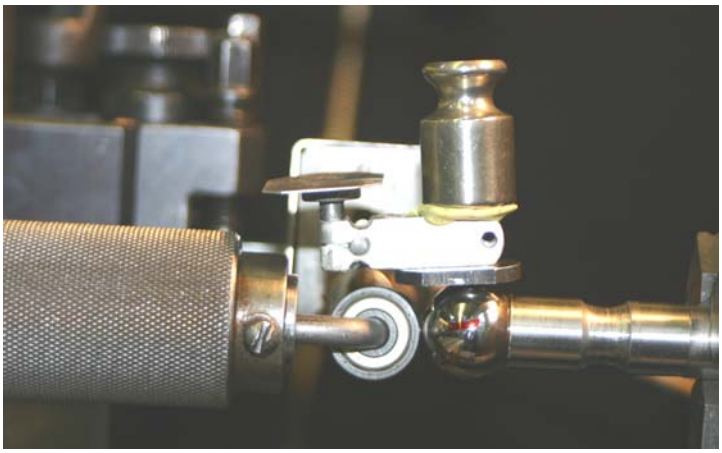


Figure 9
The construction of local wear equipment

National partners: Department of Material Science and Technology, Budapest University of Technology and Economics; Department of Polymer Engineering, University of Miskolc. International partner: Instituto Superior Tecnico (Portugal).

Increase of Damage Resistance of Cold Forming Steel Tools with Surface Treatment

(Supervisor: Dr. Gyula Bagyinszki, professor, CsC)

The tools and materials used in the field of plastic forming are exposed to very large loads. A great proportion of the loads are usually concentrated on the work surface that is why the working surfaces of the tools have to be improved against mechanical, thermal effects wear and damage. After the adjusting of the ratio of sufficient strength-toughness by heat treatment, the further improvement of surface hardness with the related wear resistance improvement and making the

adhesion and friction more favourable can be achieved by surface treatment. The important terms of consideration of achievement of the technical and economical effectiveness, the increasing of tool life, the decreasing of the demand for maintenance and the sufficient quality of the product manufactured by the tool are as follows:

- The knowledge of the characteristics of cold forming steels, and the proper material selection upon this knowledge, taking into considerations the properties of the material formed with the tool;
- The knowledge of the properties of heat and surface treatment processes applicable to tool-steels, including effects on the geometrical tolerances (of shape and dimension precisions);
- The preparation considering surface treatment, coating, surface layer, the accurateness of the post treatment, moreover the knowledge of the application characteristics of the developed surface crust/coat.

The gathering, systematization and processing of this knowledge can form the knowledge base of an expert system, with the help of which the reliability of construction and technological design can be improved. Our research aims the development of such an expert system.

National partner: Bay Zoltan Institute for Materials Science and Technology (BAYATI).

Besides the presented fields the continuously performed research and development activity covers the development and manufacturing of material testing equipments, (supervisor: Dr. György Sárossy), the modelling of plastic forming technologies (supervisor: Dr. László Horváth) and for the welding researches (supervisor: Dr. Mihály Kovács).