Applicant: Slovak University of Technology in Bratislava

Project: Knowledge-based Faculty for Economic Practice

ITMS code of project: 26110230113

Activity: 3.2

Responsible for activity: PhDr. Kvetoslava Rešetová, PhD.

INSTITUTE of PRODUCTON TECHNOLOGIES - PROFILE PRESENTATION

Name of activity	**Activity 3.2** Building the tools for knowledge transfer into education
Specific objective	**3. Building the tools for knowledge transfer into education**
Aim of activity	The activity of building the tools for knowledge transfer into education concludes the information flow attained from the analysis of environment impact, and sets up specific tools for the knowledge transfer into education. It is aimed at building a set of tools for transferring the knowledge collected in the previous activities into education at the Faculty, thus enhancing the knowledge base of the target group, while focusing on the functionality of the knowledge transfer to the target group.
Date of activity implementation	10/2013 – 09/2015

Project part: activity 3.2 : <u>1. Tool for knowledge transfer – profile research presentations</u>

The Faculty research is oriented particularly on the following fields:

- research in materials with focus on the research, development and technological processing of the main types of engineering materials,
- research and development of new technologies in industrial production oriented mainly on technological processing of modern technical materials and environment-friendly production,
- research in identification, automation and control of processes as well as information security of the technology, production and organizational systems,
- research and verification of principles of managerial control and its organizational structures,
- research in quality and certification of processes and products,
- research in safety and reliability of technological devices and systems with emphasis on the methods of systems analysis and synthesis.

The defined research characteristics reflect the Faculty research fields, and are subject to the Faculty evaluation processes. **The current profile presentations comprise the research profile, its identification and recording in a new way**. The Faculty experts in the research fields make the audience familiar with the research characteristics, research and development orientation, so that to provide a comprehensive research profile of the Faculty institutes (there are six institutes at the Faculty) in both Slovak and English languages. The elaboration of text in an adequate number of quires, text translation and copyright rules – all this is subject to the method of the profile presentation implementation. The elaborated profile presentations might be an important material source for:

- training at the Faculty in its key subjects
- domestic and international presentation of the Institute
- enhancement of the advertising space for promotion purposes of the project
- innovative elaboration of the Faculty research contents.

Defined project outcomes:

The project outcomes will be determined by successful implementation of the project activities, particularly activity 1.1 - stakeholding, activity 2.1 - portal of companies, activity 3.1 -implementation from acquired e-sources. Such interaction along with the information flow can influence the success of knowledge transfer into education. The outcomes of previous activities will be utilized in this final activity which should provide space particularly for knowledge transfer and improvement of knowledge base, and simultaneously provide a space for meeting the main project aim. Specific outcomes of the activity will be as follows:

- **six profile presentations mapping the research character of six Faculty institutes, applicable in training and with strong potential for the Faculty promotion**

- production of minimum 30 virtual records of technological procedures outsourced from economic practice and applicable in education, i.e. enhancement of information on applicability for the Faculty doctoral students
- production of minimum 30 virtual records of the Faculty technological procedures and processes, for application in the Faculty education, and for the purposes of comparison of the technological processes and theoretical knowledge acquired in the Faculty training to the knowledge acquired in practice
- four expert lectures for doctoral students (and also for interested Faculty researchers), forming the knowledge base of the target group in four principle science fields.

Implementation of activity:

1. In compliance with the project aims, the activity was introduced to the Heads of the STU MTF Institutes: **Appendix 1**: Information for institutes of 12 Dec 2013 , **Appendix 2** : Letter to the Heads of the STU MTF Institutes of 21 Jan 2014
2. Heads of the STU MTF Institutes delegated in writing an Institute representative who will be in charge of the profile presentation elaboration – letters to Heads of the Institutes are in the project archive of the principle investigator
3. Individual meetings of the principle investigator with related employees with focus on structure and contents of profile presentations
4. Collection of data, text modifications, graphical design of presentations
5. Text translation
6. Final arrangement of presentations into e-proceedings of scientific papers
7. Publicizing the profile presentations

Guarantors of profile presentations:

Institute of Materials – Mgr. Marián Palcut, PhD.

Institute of Production Technologies – Assoc. Prof. Ing. Erika Hodúlová, PhD.

Institute of Industrial Engineering and Management – Assoc. Prof. Ing. Helena Makýšová, PhD.

Institute of Safety, Environment and Quality – Prof. Ing. Maroš Soldán, PhD.

Institute of Applied Informatics, Automation and Mechatronics – Prof. Ing. Pavol Tanuška, PhD.

Advanced Technologies Research Institute – Assoc. Prof. Ing. Maximilián Strémy, PhD.

Introduction

The orientation of the STU MTF research activities fastens on the Faculty education profile and is in compliance with the long-term development of the Slovak University of Technology in Bratislava, covering the whole spectrum of the education at STU MTF. The activities of STU MTF researchers are implemented within the following projects:

- projects of base research supported by VEGA grant agency,
- projects of applied research supported by KEGA grant agency,
- projects investigated within international programmes,
- projects of international scientific and technical cooperation,
- projects of base and applied research supported by APVV grant agency,
- contractual research and development (business contracts).

1. Science and Research in STU MTF

Vision of STU MTF

The STU Faculty of Materials Science and Technology in Trnava, in compliance with the STU vision, intends to be a research oriented and internationally renowned faculty within the similar faculties framework, i.e. the faculties developing modern trends in research and industrial production with focus on progressive materials, sophisticated production technologies and industrial management, automation and IT implementation of production and technological processes such as quality, safety, as well as environmental and managerial aspects of industrial production.

Mission of STU MTF

In compliance with the defined mission of the Slovak University of Technology, the STU Faculty of Materials Science and Technology intends to actively contribute to meeting the requirements of the mission – with the priority laid on materials science and production technologies – in accredited fields of education, research and development within the stipulated competences:

- provide the university system of education in all stages in accredited study programmes
- disseminate, improve and develop knowledge by the research and development tools,
- ensure transfer of research results into educational process,
- ensure transfer of research results into entrepreneurial practice,
- protect its research results,
- integrate into the system of university life -long learning,
- participate in sustainable development of society with all its activities, mainly by the development of the student personality in the context of humanism and democracy ideals.

General and strategic goals of research

1. Publish the research and creativity results internationally, particularly in the renowned international scientific journals.
2. Increase the STU MTF status in the projects of international cooperation.
3. Build the research infrastructure (equipment) including the qualified service.
4. Intensify the cooperation with practice, ranging from private industrial companies to public institutions and authorities.
5. Focus the research results and free investigation also on the outcomes, e.g. patents.
6. Improve the orientation on other than grant sources from the state budget, particularly on the sources from abroad, project grant agencies and entrepreneurial activity.

The scientific and research activity of STU MTF is carried out in the forms of:

- projects of the base and applied research and development,
- projects solved within the international programmes,
- projects of the international scientific collaboration,
- projects of contractual research.

The research content is focused on the following areas:

- materials research with a focus on the research, development and technological processing of the basic and advanced types of technical materials,
- research, development and optimisation of the new technologies of industrial production, oriented particularly on the technological processing of advanced technical materials and ecologically clean processes and products, and the numerical simulation of technological processes,
- process identification, automation and control, as well as information support for technological, production and organisation systems,
- research and verification of the managerial control principles and their organisation structures,
- quality control and certification of processes and products,
- safety and reliability of technological equipment and systems, while emphasising the methods of system analysis and synthesis.

2. Institute of Production Technologies - Profile Presentation

2.1 Characteristics of the Institute

Institute of Production Technologies (UVTE) is a science, research and pedagogy workplace professionally oriented on the field of technology of joining and cutting, machining, forming and casting predominantly the metal, non-metallic and composite materials, while covering also the fields of metrology, assembly, design and operation of production systems.

Principal research fields of UVTE include:

1. Technologies of machining the metal and non-metallic materials – 5-axis machining and progressive methods of machining
2. Technologies of processing plastics
3. Technologies of sheet metal forming – incremental forming, metal spinning
4. Technologies of laser joining of materials
5. Technologies of casting

2.1.1 Technologies of machining the metal and non-metallic materials – 5-axis machining and progressive methods of machining

Development of information technology has opened new dimensions in the development of mechanical engineering technologies. Conventional technologies have changed fundamentally. The CNC turning, milling, laser machining and development of support software have upgraded the important technology of machining to a highly sophisticated level. Such change has naturally found reflection in the university education of experts. It was therefore necessary to build the Centre of Excellence of 5-axis Machining on the premises of STU MTF. The Centre oriented on the research of hard-to-machine and free-form shaped surfaces is equipped with the unique advanced high-speed, multi-axial and multi-power technologies, which is a good prerequisite for becoming a solid link in the European research area and for the training the experts for the modern economic practice. The built equipment and laboratory software base has provided new options for the research into CNC milling of free-form shaped surfaces, high-speed CNC milling and turning, CNC ultrasonic and 5-axis milling, CNC laser machining, application of computer-aided design and manufacturing technologies (CAx), tool wear during machining and parameters of cutting process along with the parameters and properties of cutting fluids.

Centre of Excellence of 5-axis Machining (CE5AM) comprises three workplaces:

- Workplace of CNC technologies
- Workplace of 3D scanning and measurement
- Workplace of computer-aided design and manufacturing (CAD/CAM)

Workplace of CNC technology (author of text: Ivan Buranský) is equipped with 5-axis machine tools. CTX 500 Alpha CNC machine is a multi-axis turning-milling centre. In addition to the main spindle, the lathe also has a counter spindle. It includes a revolver h6 turret, where, besides turning blades, also the driven tools such as drills and cutters can be clamped. It enables to produce free-form shaped parts in one clamping. The lathe enables milling outside of the main rotary axis, in the directions either perpendicular to or parallel with the axis. For the purposes of the piece change automation, the lathe is equipped with an automatic bar feeder.

Lasertec 80 Shape CNC machine is designed for production of free-form shaped parts made of the conventional, progressive and hard-to-machine materials, generally at the micro level. The laser beam of appropriate parameters and appropriate incident direction on the workpiece is used for the 3D micro-machining processes such as laser engraving, laser milling and laser surface structuring.

Laser machining finds application where emphasis is on the minimum heat affect on the material being machined and the surface treatment with the aim to modify tribological properties. Production of chips shapers on the cutting inserts of cemented carbide, manufacture of a welding pin for the technology of friction stir welding (FSW) or production of the surface textures with modified tribological properties of tools for incremental forming operations can be mentioned to illustrate some practical applications.

Ultrasonic HSC 20 linear is a CNC machine for rotary ultrasonic machining. The high-speed spindle enables using the tools of a very small diameter. Five controlled axes enable production of complex parts in one clamping. Laser measurement of tools provides high-precision machining. The machine allows for displaying the load in the individual axes and operating temperatures of engines.

Ultrasonic energy enables machining hard and brittle materials, while applying significantly lower cutting force, providing longer tool life and lower roughness of the machined surface. During machining, the workpiece is not thermally or chemically affected. The attained accuracy and roughness are comparable to the grinding by diamond wheel.

High-speed spindle provides the required cutting speed even of the small-diameter tools. Instruments of common diameters can thus work in the high-speed machining mode. In this method, conventional machining tools can effectively machine hardened steels, while achieving higher accuracy, lower roughness, longer life and lower cutting forces when compared to conventional milling. Five-axis kinematics can be used for positioning or continuous 5-axis machining. A touch sensor may be used to define the zero point of the program, or to measure the distance, straightness, flatness, inside diameter, outside diameter etc. Measurement and tool change are automatic. The machine can be operated either manually and by manual programming, or by using CAM software.

DMU 85 Monoblock CNC machine is a high performance 5-axis milling centre. Design of the machine is of the cradle type; its spindle performs three translational motions X, Y, Z and two rotational motions A, C, accomplished by the table of the machine tool. The CNC machine is mainly used for roughing, i.e. removal of excess material in the form of chips in the shortest time.

HSC 105 linear CNC machine is a 5-axis milling centre intended mainly for high-speed machining. The spindle reaches rotational speed of 42000 min^{-1}. CNC machine provides high cutting speeds used in the manufacture of moulds, tools and dies. Design of the machine is of the tilted spindle type. Spindle performs two translation motions in the Y and Z directions and a rotational motion around Y axis, denoted as B. The table performs a translational movement in the X-direction and a rotational motion about Z-axis denoted as C.

WZS60 CNC tool grinding machine is a 5-axis production centre for the production of rotary tools. The grinder is used to produce the tools for other CNC machines located in CE5AM. The tools are made of the cutting material which is called sintered carbide. New instruments are designed by Numroto Plus software. Besides manufacturing tools, the grinder is used for sharpening worn tools.

The grinder is connected to a Zoller Genius 3 measuring device. Zoller equipment measures geometry of the manufactured/re-sharpened tool. Result is comparison of the nominal geometry data with the real data in Numroto Plus software. In case of identified differences, the tool geometry can be corrected by grinding. Grinder with Numroto software can be used in the field of design and manufacture of a new geometry for machining the ferrous and nonferrous metals as well as composites.

The workplace of CNC technology comprises the devices for the preparation of rotary tools for CNC milling centres and a tool grinding machine. The devices also include a balancing machine tool, equipment for heat tool holding and devices for the measurement and inspection of instruments. Rotary tools must be balanced in order to increase the service life of the CNC machine spindle. After balancing the tool, we get the rotation frequency of the tool. The main area of application is high-speed machining. Heat tool holder clamping method enables the fixed tool-tool holder connection. After the tool holder is induction-heated to a desired temperature, the tool is inserted into it. The set is cooled by air or water emulsion. Holders for heat tool holding are generally used for high performance and high-speed milling. Zoller Genius 3 measuring device is designed to measure the set of tool and tool holder. The measurement provides the information on tool diameter and length of the set, relevant for the CNC machines. The device is used to measure the tools of various kinds, such as mills, drills, cutting inserts, thread cutting tool, taps etc. The devices in CE5AM are mainly used to check the geometry of the tool produced on a WZS 60 tool grinding machine.

CAD/CAM workplace is equipped with the latest software from the field of design and manufacture of moulds, tools, dies and complex components. The design is elaborated in the PowerSHAPE CAD program. In modelling, functions of the solid and surface modelling are used. The software is also used in reverse engineering. The 3D data scanned in e.g. STL format can be used to convert the format to a surface model that is more suitable for designers. Another function is modification of the damaged models, mainly the 3D models that were created in other CAD software. It is necessary if the 3D model is to be used in CAM program, where a defective 3D model used for generating machining paths may cause a machine-workpiece collision. Modern CNC machining centres are programmed using CAM software. The workplace possesses PowerMill CAM software designed to generate machining paths for 5-axis milling machines. The software is used to design CNC programs. Modern CAM programs include simulation of machining, which is important to avoid collisions.

Workplace of 3D scanning and measurement is equipped with ATOS II TripleScan optical 3D scanner and TRITOP contactless coordinate measuring system. The ATOS system utilizes the principle of structured light. Result of 3D scanning is a 3D model in a computerized form. The resulting 3D model can be subsequently used for 2D and 3D measurement of linear and angular dimensions, shape and position tolerances and GD & T geometric tolerances. The acquired 3D model can be also used in reverse engineering. The ATOS system along with the TRITOP system are used when checking the manufactured moulds, dies, tools and complex components. Adjustment of the measuring volume enables to measure very small parts such as the geometry and the tool wear, or big parts such as the forming tool for the automotive industry.

CE5AM STU MTF in Trnava can be useful in the following areas:

Research into
- 5-axis CNC milling of free-form shaped surfaces,
- HSC CNC milling and turning,
- CNC ultrasonic and 5-axis machining,
- CNC laser machining (ablation),
- CNC tool grinding,
- machining of hard-to-machine materials,
- tool wear in machining,
- optimisation of the cutting process parameters,
- parameters and properties of cutting liquids.

Education in the fields of
- NC programming,
- CAD/CAM systems,
- Reverse Engineering,
- organizing workshops,
- organizing seminars.

Consultancy in the fields of
- CAD/CAM systems,
- environment-friendly approach to machining,
- process media,
- optimization of production process.

Production of
- pilot-batch,
- prototypes, forms, pieces of art,
- 3D scanning (contactless measurement method – 1-D and 3-D active triangulation),
- photogrammetry measurement (contactless method of measurement – passive triangulation),
- inspection of dimensions and shape by contactless method of measurement,
- Reverse Engineering,
- design, production and optimization of 3D models.

2.1.2 Plastics processing technology

The field of plastics production and processing is currently the most dynamically developing sector of engineering production. Over 150 million tons of plastic products are manufactured yearly worldwide; 50 million tons of that number (more than 25% of the world-wide production) in Europe. Major producers in Europe are:
- Germany – 7.5%
- Benelux – 4.5%
- France – 3%
- Italy – 2%
- Spain – 1.5%

The total annual production of plastics in Slovakia achieves approximately 280 kg/capita, which represents about 1.3 million tons. Plastics industry in Europe employs 1.6 million workers or so.
The key areas of plastics application comprise:

- Automotive industry – production of big and small components for car bodies, a big part of the interior equipment etc. A modern car comprises more than 100 kg of plastic parts (or even 150 kg in some cases). Proportion of plastics in modern cars is thus quite big.
- Packaging technology – plastics are primary materials for making various foils, bottles, crucibles, lids, crates etc.
- Building industry and architecture – construction and decoration elements, distribution and sewerage systems, insulation materials, floor covering, plastic windows, doors etc.
- Machine industry – construction materials, measuring devices, low-noise gears, wire insulation, various tools, gaskets, hoses etc.
- Food industry – agrofoils, hoses, containers, tanks, magazines, irrigation systems
- Electrotechnical industry – sockets, switches, terminals, distribution assemblies and drums, installation boxes and cable glands, lights, cables, switchboards, wiring tubes, plastic parts of electrical devices and appliances etc.
- Textile industry – upholstery, protective overalls, various kinds of fibres, letherine etc.
- Chemical industry –plastics resistant to acids and corrosion,
- Medicine – packages of medical goods, laboratory and orthopaedic aids, tooth prostheses, dental bridges, collar-crowns, various tools
- sport – sport accessories for nearly all kinds of sport
- plastics in households and toys

Advantages of plastics are:

- low specific weight,
- relatively high strength – suitable strength/density ratio (Rm/ρ),
- corrosion-resistance,
- insulation properties – electric, heat,
- formability,
- wide choice of colour,
- ready-made parts,
- low price.

Disadvantages of plastics are:

- made of crude oil prevailingly (non-renewable natural sources),
- relatively low weight and big volume,
- limited recyclability,
- majority of them is nearly imperishable in nature.

The advantages, however, significantly outnumber the disadvantages.

Plastics-processing technologies cover:

- injection, the most frequently used production technology
- blowing
- pressing
- extrusion
- rolling

- hot and cold forming

Other technologies applied in plastics production comprise:

- joining plastics by welding and gluing
- machining and cutting
- treatment – wetting, spraying, coating, printing, metal coating etc.

Technical preparation of plastics manufacturing is a demanding process that covers mainly:

- design of plastic products, while respecting the principles of technology of structure, which requires the application of appropriate design programs to create frequently very complex free-form shaped models of plastic mouldings,
- proposal of a suitable type of plastics for the given application and processing technology,
- simulation of processing in order to optimize the shape, dimensions and technology parameters of the process,
- design of the tools (mould) for the manufacture of the product using the simulation results,
- production of the tools (mould) and its testing on the production device (injection press).

A special workplace has been built to achieve the above-mentioned goals via supporting the challenging tasks in the fields of technical preparation of production of plastic mouldings, enhancing the cooperation in research and development, and improving the quality of vocational training in the plastics and rubber processing.

The workplace is currently equipped with four powerful computers used for the research and education in the field of the design of models of plastic mouldings, simulation of injection processes of plastics and rubber, as well as the design of models and drawings of moulds for injection of plastics and rubber. To solve these tasks, CATIA V5 and CATIA V5 R19 2013 software installed in the powerful computers comprise, besides standard modules, also a CAD module for plastics, mould design, as well as a CAM module for machining moulds. The software is widely used e.g. in the field of automotive industry. MOLDEX 3D software installed in these computers enables simulating the process of plastics manufacturing and analysing the results of simulation of plastics injection during moulding processes. The software allows following a method of filling the forms at the designed inlet system, monitoring the temperature effect of plastic injection, mould temperature, injection pressure, pressure time holding and cooling on the quality of moulded plastics even before the design and manufacture of the mould itself. The software allows tracking the arrangement and orientation of the filler (glass fibres, carbon fibres and the like.), deformation of the blank, formation of any defects, moulding shrinkage, and thus also precision of mouldings. The results can be then used to optimise the technological parameters and structure of injection mould, in order to achieve the required properties of moulded plastics.

For the purposes of simulation and achievement of its best results, it is necessary to know precise rheological (flow) characteristics of the plastics being processed. For this, the workplace is equipped with a high-pressure capillary LCR rheometer designed to analyse rheological properties, i.e. formation of flow curves and determination of the flow index of thermoplastics and thermoplastic elastomers at a test force between 5 to 10 kN and at a temperature up to 430 ° C. The obtained precise data regarding the given plastics are then imported into the simulation program to provide the most accurate outputs from the simulation.

The workplace is equipped with BABYPLAST, a small injection press used to verify the production design of plastic mouldings, process parameters of injection and the actual production of small plastic mouldings. It is a horizontal injection moulding machine with clamping force of 6.5 tons (65 kN), the maximum injection volume 4 cm^3, and the mould dimensions 75x75 mm. The injection moulding machine has a piston plasticization (injection) unit and is equipped with a touch screen to enter the injection parameters as well as to observe the injection process, which makes it suitable preferably for the use in training and research of the injection processes. Moreover, the pressure permits the use of ejectors to remove the mouldings from the mould. The press can also be fitted with an independent cooling system for cooling either the injection mould or the machine itself.

The workplace is further equipped with MDR 2000 torque rheometer. The device is fitted with a heated, sealed and rotor-free system of moving forms. A sample is sealed in a chamber closed by heated moulds. The lower mould oscillates at a frequency of 1.66 Hz. The related torque is measured at the upper form and is proportional to the degree of cross-linking as a function of vulcanization time. The maximum torque is 20 Nm. Rheometer is designed to determine the vulcanization curves on the basis of which technological parameters of the production process of rubber products such as various types of flexible rubber-metal parts and silentblocks can be established (determination of parameters such as temperature and the cure time necessary to achieve the desired properties of the mixture being processed). The torsional rheometer enables testing up to the temperature of 200° C. Temperature of the sample during the measurement is controlled by a microprocessor. Evaluation of the tests is carried out using special software connected to the rheometer via a PC. Evaluation of the resulting measured values may be either in a printed form or in the form of a graphic output showing the vulcanisation curves of the ratio of torque and time of vulcanisation.
To determine the final hardness of rubber, or even the hardness of the soft plastic mouldings, the workplace is equipped with HT-6510 durometer. Hardness tester is designed to measure hardness in ShA units. The device consists of a hardness tester and a stand. It may be adjusted to the thickness of the sample measured. To assure the objective measurement, the minimum thickness of measured sample is 6 mm.

Activity of the presented Workplace of plastics processing is oriented mainly on the following fields:

- education of students, i.e. teaching, supervising the bachelor, master and dissertation theses etc.)
- staff trainings,
- practical simulation and construction analyses within the research projects,
- participation in the base, applied and experimental research and the development oriented on the fields of plastics processing, while involving the undergraduate and doctoral students and researchers,
- elaboration of scientific and research projects.

2.1.3 Technology of sheet metal forming – incremental forming, metal spinning

Research of sheet metal processes in the Institute of Production Technologies focuses mainly on the processes based on an incremental deformation of material. Attention is paid mainly to the metal spinning process. It is a method of processing metal sheets, tubes or complex axially symmetric blanks to axially symmetric products of complex shapes.
Experimental research in this area is carried out in cooperation with Sandrik 1895, spol. s r. o., Hodruša-Hámre, EIBEN, spol. s r. o., Vlkanová, Silesian University of Technology, Katowice in Poland,

and Impromat, a research and development company in Bilbao, Spain. It focuses primarily on monitoring stress-strain states of spun parts, assessing their macrogeometric precision and integrity of surface layers.

Research in the field of analysis of strain states of spun parts is carried out preferably by the grid analysis method, based on the principle of the circle or rectangular grid application on the blank, and the evaluation of the deformation at any point of time or at the end of the forming process. The methods of measuring strain hardening, residual stresses measurement by X-ray diffraction and evaluation methods of the microgeometry and surface topography are used to analyse the integrity of surface layers.

Comprehensive research into quality of spun parts produced by CNC conventional metal spinning was enhanced by the evaluation of macrogeometric features of formed parts, including variability of the formed part wall thickness, degree of springback and tendency to flange instability, depending on the main technological process parameters and anisotropy of the properties of the formed material.

Evaluation of the geometric precision of formed parts by contact method was enhanced by contactless measurement methods such as scanning by ATOS II MV 320 optical 3D scanner.
Research in the field of thin-walled axially symmetrical sheet metal parts is also focused on the evaluation of exploitation properties of formed parts, particularly corrosion resistance in relation to the degree of plastic deformation on the samples of carbon steel, Cr-Ni austenitic steels and aluminium alloys.

Within the current framework of international cooperation under the 7th RP ERA-NET MANUNET, the workplace focuses on the research into the changes of tribological conditions at the tool – material interface by application of laser texturing of the forming tool surface.

2.1.4 Technology of the laser joinng of materials

Laser applications present a major challenge nowadays. Although the physical nature of laser has been described in the 50s of previous century, the boom of large-scale technological applications started in the last few years.

UVTE possesses a universal robotic workstation equipped with a disk laser generator with the maximum output power of 4 kW, the welding and cutting heads and the milling spindle. The workplace can also use programming software for programming a robot offline.

Laser is a very versatile tool using a beam of thermal energy for various applications such as welding, cutting and machining. It is a concentrated energy source which can be used for melting, evaporation of the material or heat treatment of the material surface.

The workplace is primarily used for the research and development of the materials currently used in practice. One of the major sectors is the automotive industry which constitutes a large percentage of GDP. The automotive industry is forced to reduce emissions and fuel consumption, and carmakers therefore started using high-strength and lightweight materials.

The research of the laser beam welding is therefore focused on the thin high-strength, corrosion-proof and surface-treated materials. The materials with enhanced mechanical properties can be used to make car parts of lower thickness, thus reducing the total weight of the vehicle.

In the past, the UVTE led the projects of joining nitrooxidation-treated metal sheets that exhibit very good formability and corrosion resistance of the material surface. While surface finishing by standard welding technologies causes problems such as excessive porosity in the weld metal, the sheets have been successfully welded together by using a laser beam, and exhibited good mechanical properties of the weld joints.

Currently, UVTE deals with the project of welding and forming duplex steels, while examining the impact of the change of material structure on the resulting corrosion-resistance and mechanical properties of the weld joints. Owing to their specific structure, duplex steels require new welding procedures by concentrated energy sources in order to preserve the original characteristics even after welding. For the purposes of the material analysis, the Faculty is equipped with a modern laboratory where it is possible to track the changes in the material structure on the level of nanometers.

In the field of welding light alloys, UVTE it carries out the research into weldability of the aluminium and magnesium alloys which are widely used in the automotive, aerospace and other industry sectors. In the area of laser beam welding, the Institute cooperates with businesses in the research of joining the aluminium alloys of the 6000, 5000 and 3000 classes. Such alloys are deployed mainly in the automotive industry thanks to their technology properties such as machinability and formability. Aluminium alloys of the 7000 class represent a novelty in the field of welding research; they are used e.g. for the frames of bicycles. Though these aluminium alloys exhibit the elevated strength, they pose problems in terms of weldability, such as a decrease of mechanical properties and a high content of zinc which causes porosity of the weld joints.
Information about weldability of Mg alloys is still insufficient. Presence of the surface oxide layer, high thermal conductivity, low viscosity, hot cracking, liquation cracking in HAZ, porosity, high affinity of Mg to oxygen, evaporation of Mg which is due to low boiling point, and the propensity to forming the low-melting eutectics are the major problems encountered in welding the Mg alloys.
In terms of the research, the AZ 31, AZ 61 and AZ 91 Mg alloys have been successfully welded. Thickness of the welded sheets ranging from 0.8 to 3.0 mm met the requirements for their application in the automotive industry.

At the same time, we achieved unique results in welding the Mg alloys with the addition of rare earth elements such as ZE 10 and ZE 41. Currently, the research deals with the analysis of properties of the weld joints of the aluminium and titanium alloys.

Another interesting field of the laser beam application was the treatment of heat substrates surfaces made of high-speed tool steel with the aim of increasing the adhesion of thin AlTiN PVD coatings. After the deposition process, the coatings were then processed similarly. In some cases, there was an increase of critical load required to disrupt the coating-substrate system. We can therefore state that the above-mentioned heat treatment had a positive effect on the adhesive characteristics, which may be associated with the enhanced hardness and wear resistance of the coatings.

The future research in the Faculty will focus on welding the combinations of various materials of different thicknesses, so called tailored blanks. The problems may appear mostly due to the presence of different structures and difference in heat transfer into individual materials. The device can also be used for surfacing by means of wire or powder.

The UVTE actively cooperates in the field of the welding process expertise and the weld joints analysis. The Faculty has signed about 50 cooperation agreements with the businesses and companies such as Visteon Halla Climate Control, Automation PGS, The First Welding Co., ZVS Holding, Trumpf Slovakia, Precision Tubes Europe, Profiweld etc.

In the field of laser cutting, the Institute investigates the impact of the laser cutting parameters on the final surface roughness of the material at the place of the cut, size of the impact on material and cutability of specific materials. The cutting of surface-treated or non-metallic materials is a very specific application. Surface finishing usually ensures special properties of materials. It is therefore necessary to achieve the minimum impact on the surface layer. Equally important in the research is the determination of cutability of the materials such as carbon fibre composites in which the adhesives in adhesive joints degrade to the greater distances from the place of cut, which is due to the lower melting temperature, and thus also reduced protection of the carbon fibres.

Deployment of laser technology keeps growing. Given the high adaptability of these technologies in the industrial sector, new problems may appear in the processing of new materials. It is therefore important to collaborate with the production sector and to educate students so that they address the current needs of industry.

Robotic machining applications are unconventional systems deployed in the industry. However, they are used for machining both small and large-size components. As the robotic arms do not achieve the precision attainable on gantry, it is necessary to determine the admissibility of technology for the given application. In terms of the manufacturing accuracy, it is important to focus on the surface roughness and accuracy in order to define the machining strategy. Various machining operations provide different precision in production, and it is therefore necessary to optimize the parameters of technological processes and production.

2.1.5 Casting

The main trends in the technology of foundry in UVTE are as follows:

Technology of art castings

The Institute of Production Technology disposes the technology for the production of art castings by the lost wax technique. It is a technology of precision casting with an emphasis on the precise reproduction of relief. The entire process of art castings consists of a wax model fabrication using lukopren, production of moulds of the 2nd generation moulding compounds mainly of gypsum, and casting the mould. The process of a gypsum mould manufacturing consists of a wax model casting, sticking a gating system (also made of wax), subsequent forming the wax mould into the sand mixture, burning-off wax and heat treatment of the mould. The technology is designed for casting metal at the casting temperatures of 1200 ° C, mostly for making art castings of copper alloys (brass and bronze).

Technology of plasma discharge in electrolyte

Technology of plasma discharge in electrolyte is used for surface treatment of metal materials. It can be used for polishing the surface, reducing the surface roughness, pre-treatment of metal surfaces prior to the application of the metal and non-metallic coatings or other surface finishing options. Another technologically important application area is the deburring and chamfering of workpieces particularly of free-form shaped products. The resulting gloss, roughness decrease and the value of the material removal from the polished surface do not depend on the distance and orientation of the surface from the cathodes. Another advantage is that the process characteristics are only minimally affected by chemical changes of electrolyte, thus guaranteeing a long-term constant and time-bound value of the removal, which allows polishing the surface of the machined parts with tight tolerances in the dimensions of workpieces, particularly of free-form shaped products. Workplace of the Institute of Production Technologies specializes in the application of this technology mainly for finishing machine parts made of stainless steel.

Technology of plasma discharge in the electrolyte is an environment-friendly and technologically advantageous alternative to conventional electrochemical polishing. Concentrated mixtures of acids are replaced by low-concentrated aqueous solutions of chemically neutral salts. The advantage over the electrochemical polishing is that the shielding effect does not occur and it is possible to uniformly polish the outside surfaces as well as cavities and holes of the given product, without the need of placing the auxiliary electrodes to the parts.

In addition to the research in the above-mentioned field, the Institute of Production Technologies carries out entrepreneurial activities oriented on commercial utilisation of prototypes of technological equipment. The existing technological equipment developed in the workplace allows modifying the surface of metal products (generally workpieces and castings for the food industry, pharmaceutical and healthcare industry) up to 0.05 square meters. According to the information available, the workplace is the only institution so far equipped with such modern and environment-friendly technology not only in Slovakia, but also in the neighbouring countries.

Technology of centrifugal casting

Workplace of the Institute of Production Technologies carries out research of centrifugal casting, using a method of pseudo-centrifugal casting of low melting temperature alloys into the vulcanized silicone moulds. It is a technology that uses the effect of centrifugal force to fill the mould cavities with liquid metal. This leads to the increased density of the castings by removing gases, eliminating micro-shrinkages and increasing the quality of castings structure by removing non-metallic inclusions from the cast material.

The research priority is the impact of the casting process parameters on the properties of zinc alloys, as zinc is the second most significant constituent of the foundry alloys. Zinc alloys are used for gear wheels production of different counters and for casting the moulds for pressing the aluminium and brass mouldings. Zn-Al alloys are widely used for the die casting of carburettors, handles, frames of the radio, photographic equipment etc. The double zinc-aluminium and zinc-copper, the ternary zinc-aluminium-copper alloys, as well as the zinc-aluminium-copper-magnesium alloys are the most widely used in the foundry industry.

As the workplace of Institute of Manufacturing Technologies does not directly dispose the technological equipment enabling the production of silicone moulds and casting, there is an active cooperation with the private sector owning this technology. This cooperation allows the implementation of the results obtained by the Institute directly in practice.

Technology of inoculation and modification of high-speed steels in the production of cast cutting tools

Manufacture of cutting tools by casting allows more economical use of expensive high-speed steel thanks to the multiple re-use of tool scrap and direct utilization of steel waste during the molten steel preparation. Besides, the foundry scrap and the residues of wrought steel rod blanks, briquettes of compacted chips of high-speed steel can be used as a batch component. Despite the better quality of rolled high-speed steel, there has always been an effort in practice to replace conventional cutting tools made of wrought high-speed steel by the cast ones. For this, it is necessary to provide the steels for cast cutting tools with suitable impact toughness to guarantee reliable operation of cast tools throughout their exploitation. Tool life of the cast cutting tools may be then substantially longer when compared to that of conventional ones. To succeed in the market, the impact toughness of the tools cast of high-speed steel must be primarily improved.

When considering particularly the effectiveness and additional production costs necessary for the application of various methods of improving the quality of cast high-speed steel, vaccination and modification seem to be the most available and effective technological methods. It is therefore important to widen the assortment of inoculators and modifiers of the cast high-speed steels, while regarding diversity of their structure and properties. Workplace of the Institute of Production

Technologies has been involved in the research into theoretical and experimental verification of the effect of mechanisms of various inoculators and modifiers in cast high-speed steels, and the study of interaction between the vaccination and modification parameters, structural changes and characteristics of modern high-speed steels subjected to vaccination and modification.

Objective of UVTE is to become an internationally recognized research institute of the STU Faculty of Materials Science and Technology, developing modern trends in research and manufacturing, with an emphasis on advanced materials and sophisticated manufacturing technologies. In accordance with the defined mission of the MTF STU, UVTE intends to actively contribute to meeting the priorities in the field of materials science and manufacturing technology in education, science and research via:

- providing and implementing a university system of education in all degrees of accredited study programmes,
- disseminate, deepen and develop the knowledge by using the tools of science and research,
- supporting transfer of the science and research results into the process of education,
- supporting transfer of the science and research results into entrepreneurial practice,
- publishing the results research and creative activity in the international forums, particularly in the renowned international scientific journals,
- supporting research activity of researchers via the projects of the base and applied research within the domestic and international agencies,
- strengthening the position of STU MTF in the projects of international collaboration,
- building the research infrastructure (devices) including qualified staff,
- supporting cooperation with practice, from the private industrial companies up to the public institutions and authorities,
- focusing the research on the output in the form of patents,
- focusing the Institute research activity primarily on the research and development of new technologies of industrial production in the sectors such as technology of processing advanced technical materials and environmentally clean production.