FACULTY OF MECHANICAL ENGINEERING
UNIVERSITY OF WEST BOHEMIA

REGIONAL TECHNOLOGICAL INSTITUTE

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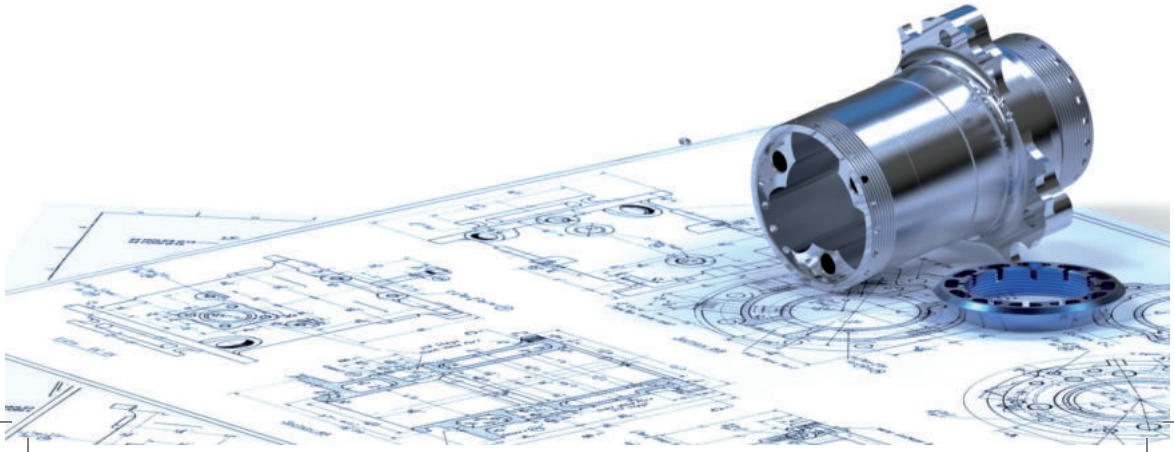
University of West Bohemia
Faculty of Mechanical Engineering

Offer for cooperation



FACULTY OF MECHANICAL ENGINEERING UNIVERSITY OF WEST BOHEMIA
REGIONAL TECHNOLOGICAL INSTITUTE

Dear Partners,

Regional Technological Institute (RTI) is a new research centre affiliated with the Faculty of Mechanical Engineering at the University of West Bohemia in Pilsen. It was built between 2011 and 2015; and since then has grown to comprise nearly one hundred young and gifted researchers, engineers, and members of administrative staff. Our scientists develop numerous research projects, many of them in collaboration with partners from industry. On behalf of manufacturing companies, RTI conducts contract research, which includes complex testing, measurements, and calculations. We also develop prototypes and verify new manufacturing processes.

RTI cooperates with a number of research institutions in the Czech Republic and seeks and continues to establish new relationships with foreign research organisations and universities.

The following pages give an overview of our themes for international collaboration. An overview of our laboratories is part of this offer.

The collaboration may take the form of joint research projects, as well as exchanges and study visits, lectures and workshops. In addition, there are doctoral programmes offered in English at our university. These study programmes are free of charge for students from Bavaria.

We will be happy to discuss your own ideas and suggestions; and look forward to working with you.

Miloslav Kepka

director of RTI

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FORMING PROCESSES

The core of our research into forming processes takes place at three laboratories of the Regional Technological Institute (RTI): the Laboratory of Forming Technology, Laboratory of Metallography and Laboratory for Mechanical Testing. It involves development of advanced high strength steels and optimization of their processing.

Our researchers possess many years of experience with TRIP (TRransformation Induced Plasticity) steels of various chemical compositions with varying contents of Si, Al, Mn and Nb. Recently, the focus has shifted towards TRIP-aided bainitic high strength steels with medium manganese levels, in which a part of Si content was substituted with Al.

Furthermore, we have been investigating martensitic steels for Q&P processing (Quenching and Partitioning). These steels, too, had various levels of Si, Mn, Cr. Another group of experimental materials of interest are Q&P steels with depressed M_s and M_f temperatures.

Our team has been working on incorporating deformation processes, such as incremental forming, directly into heat treatment routes and on optimizing processing conditions for achieving desired mechanical properties.

Our thermomechanical simulator is used for replicating deformation and temperature profiles similar to real-world forming processes, such as rotary spin extrusion, hot stamping process and open die and closed die forging.

We co-investigated several national and bilateral projects of basic and applied research concerned with development of high strength and tool steels (bilateral project GAČR P107/11/J083 and DFG WA 2602/2-1), as well as international projects focused on similar themes (RFSR-CT-2015-00019). Recently, we established cooperation with company ŠKODA AUTO a.s. involving development of a tool for hot stamping of AHSS.

The equipment and instrumentation used for these research efforts include thermomechanical rolling machine HDQT-R 30-12 (High Deformation Quenching and Tempering), a thermo-mechanical simulator, an SEM-FIB with an in-situ testing stage for micropillars or cantilevers and a heated deformation stage for in-situ experiments with larger samples, as well as miscellaneous equipment and devices for mechanical testing.

Examples of high-impact publications and patents generated from our research:

KUČEROVÁ, L.: The Effect of Two-Step Heat Treatment Parameters on Microstructure and Mechanical Properties of 42SiMn Steel. Metals, 2017, Volume 7, No. 12, pp. 1-14. ISSN: 2075-4701.
JIRKOVÁ, H., MAŠEK, B., WAGNER, M. F., LANGMAJEROVÁ, D., KUČEROVÁ, L., TREML, R., KIENER, D.: Influence of Metastable Retained Austenite on Macro and Micromechanical Properties of Steel Processed by the Q-P Process. Journal of Alloys and Compounds, 2014, Volume 615, No. 1, pp. 163-168. ISSN: 0925-8388.
MAŠEK, B., JIRKOVÁ, H., VANČURA, F., ŠTÁDLER, C., BUBLÍKOVÁ, D.: Method of Hot Forming Hybrid Parts. Alexandria, Virginia, USA, 2018.

ADDITIVE MANUFACTURING

Regional Technological Institute (RTI) has been active in the field of additive manufacturing (AM) for the last three and a half years. Over this period, a highly-relevant body of knowledge regarding research and development of metal additive manufacturing and special cutting tools has been acquired. The key AM machine at the Institute, the EOS M290 system, is used for sintering MS1 maraging steel, Inconel 718, and 316L stainless steel. We are currently involved in several national projects focusing on AM with the support from the Technology Agency of the Czech Republic under research programmes Epsilon, Zeta and Gama, where the last one ended in 2018, and projects supported by the Ministry of Industry and Trade under research programme TRIO.

The project under the Epsilon programme is focused on the properties of 3D-printed Inconel 718 at normal and high temperatures under static and cyclic loading involving creep and corrosion, and on its machinability. The findings and outputs from this project are applied by our industrial partners.

The Zeta programme project extends the knowledge base of materials and mechanical properties of maraging steel MS1 (1.2709) and is relevant to industry as well. Its main goal is to characterize mechanical properties (under static, dynamic and cyclic loading) of this steel at its service temperatures.

The Gama programme project aims at testing and verifying a unique patented milling head in various applications. This patented solution was awarded a Gold Medal for Innovation of a Component in Engineering at the International Engineering Fair 2018 in Brno, Czech Republic.

The project under the TRIO programme is an application-driven endeavour to reduce the total weight of 3D-printed parts through topology optimization.

Our continuously expanding knowledge base and expertise make us an attractive research partner for Czech companies as well other partners in Germany, France, Switzerland and the USA. An example of our successful international cooperation is the key role we play in a project entitled 'New Materials for Additive Technology' along with other consortium members, such as Fraunhofer Institut UMSICHT and Ostbayerische Technische Hochschule Amberg-Weiden.

With funding from an Integrated Territorial Investment project entitled 'Research of additive technologies for future applications in machinery industry – RTIplus', we plan to invest further in AM technology this year, and acquire a new machine with a system for monitoring the sintering process. This project aims to minimize the difficulties and limitations of AM, such as residual stresses, unmelted particles and pores in builds. The project focuses on closely monitoring the builds during and after the sintering process, optimizing the material and process parameters, and the post-processing operations to improve the final mechanical and other material properties of the builds.

Selected output/publications:

ZETEK, M., SCHORNÍK, V.: Milling cutter with braces, Patent, WO/2017/177990, PCT/CZ2017/000026.
MONKOVÁ, K., ZETKOVÁ, I., KUČEROVÁ, L. et al: Study of 3D printing direction and effects of heat treatment on mechanical properties of MS1 maraging steel. Archive of Applied Mechanics. Springer, 2018, ISSN 0939-1533, DOI 10.1007/s00419-018-1389-3.
HANZL, P. ZETEK, M., BAKŠA, T., KROUPA, T.: The Influence of Processing Parameters on the Mechanical Properties of SLM Parts, Procedia Engineering, 2015, Volume 100, pp. 1405-1413, ISSN 1877-7058.
KUČEROVÁ, L., ZETKOVÁ, I.: Metallography of 3D printed 1.2709 tool steel. Manufacturing Technology, 2016, Volume 16, No. 1, pp. 140-144. ISSN: 1213-2489.

HUMAN FACTORS IN SMART MANUFACTURING

Human factors and ergonomics have been of interest to the Regional Technological Institute (RTI) since its establishment. Experts at RTI who have been active in this field for many years focus primarily on the themes listed below.

Digital human models (DHM) are mainly used at RTI for application-driven studies in partnership with industrial companies. The models aid in evaluating existing workplaces and identifying the sources and manifestations of work stress. They are also used for assessing proposed changes to production that aim at increasing the worker comfort.

Ageing population – Most countries are facing demographic changes, which makes population ageing an important issue to address. At RTI, this theme is the focus of predominantly basic research. Our long-term projects concern degenerative changes in the human body and aim to gain full understanding of these changes, and to design appropriate industrial workplaces reflecting the presence of older workers and smart technologies.

Workload and stress in production – Smart manufacturing is generally understood as implementation of a variety of new technologies in production. Very often this involves automation of routine operations or reduction of physical load on human workers. However humans are not to be completely excluded from the process. The transformation of workplaces and processes is usually accompanied by a transition from physical stress to mental or sensory stress arising from operation of automated machines, monitoring of display screens, working on computerized workstations etc. These transformations are the core of this research theme.

Virtual work instructions – Virtual or augmented reality is a technology which has a strong potential for a variety of applications. Interactions between humans and the virtual environment are studied with a focus on cyber sickness and sensory stress. Virtual-reality work instructions are being developed for industrial practice.

Collaborative robotics – This theme is addressed mainly as part of hands-on industrial projects. Collaborative robotics develop quickly within the framework of smart manufacturing, which makes companies ever more interested in deploying various robots. We can identify suitable robots and accessories for specific applications, and perform dynamic simulations to validate the concept.

Tecnomatix Process Simulate and Tecnomatix Jack are the tools we use for our human factors studies and for collaborative robotics applications. For virtual reality studies the Unity 3D software is utilised. Our key industrial partners come from among SMEs (Amtech s.r.o., Baumruk & Baumruk, s.r.o.) as well as large international companies, such as ŠKODA AUTO a.s., Mubea s.r.o., and Grammer CZ s.r.o.

Selected publications:

BURES, M.: Experience with efficient utilisation of Digital Human Models in practise. In: Homo Sapiens Digitalis - Virtuelle Ergonomie und digitale Menschmodelle, pp. 321-328, Springer Vieweg 2016. ISBN 978-3-662-50458-1. DOI 10.1007/978-3-662-50459-8.

BURES, M., SIMON, M.: Adaptation of production systems according to the conditions of ageing population. In: MM Science Journal, vol. 2015, issue June, pp. 604 – 609, 2015. ISSN 1803-1269.

BURES, M., GÖRNER, T., SEDIVA, B.: Hand anthropometry of Czech population. In: International Conference on Industrial Engineering and Engineering Management (IEEM2015). Singapore, 2016, pp. 1077-1082. ISBN 978-1-4673-8066-9.

COMPETENCES IN THE AUTOMOTIVE SECTOR

The research activities that involve car body design at the Regional Technological Institute (RTI) are focused on the topology of the design concept and the body structure. Simulation analyses of materials for car body structures are performed, including light weight materials and modern material concepts, such as special steels, aluminium, hybrid sheet metal, foams, plastics, composites and other materials. This includes analysis of joining methods. Loads on and deflections of the car body are studied under conditions involving static vertical bending, torsion, lateral loading and overall dynamic loads from the chassis and traction forces. Analyses of passive safety provided by the car body and crash analyses are based on advanced and innovative algorithms. Car body vibration problems involve body-in-white and subsystems vibration modes. Mathematical simulation tools and simulation codes provide links to the analysis of stiffness and fatigue life assessment for car body parts and joints.

Studies of human-vehicle interaction deal with ergonomics and optimal working conditions.

Advanced driver assistance systems (ADAS) and active feed-back systems, including sensing, together with electric drive and autonomous driving are dominant trends in the future visions of transport. They are also the focus of the research at RTI. Research into electric-drive vehicles benefits from the knowledge and expertise acquired with rail vehicles.

Activities and expertise in the automotive field are based on long-standing cooperation with manufacturers of vehicles and extensive contacts in the sector.

Our vehicle engineering research is based on both mathematical simulations (CAE) and experiments. Using additive manufacturing technology (3D metal and plastic printing), specimens and special parts can be produced for testing, service stress analysis and measurement of stresses, strains and heat effects, and for monitoring with a high-speed camera and optical sensors.

In our international project Safe2Wheeler carried out as part of a COST call, we focus on general aspects of motorcycle safety. ‘Safe Tram Front End’ is a project co-funded by the Czech Ministry of Industry and Trade which involves knowledge transfer from the automotive field of pedestrian safety to tram design.

The Institute is a member of the Action Group ‘Autonomous Mobility’ under the auspices of the Czech Ministry of Transport.

Results and findings achieved in these fields are published in articles, proceedings and professional books for students and engineers.

Examples of high-impact publications:

HOZMAN, J., BRADÁČ, J., KOVANDA, J.: DG solver for the simulation of simplified elastic waves in two-dimensional piecewise homogeneous media. In: Neural Network World 4/2017 pp. 373-389 ISSN 1210-0552

VRÁNA, T., BRADÁČ, J., KOVANDA, J., PURŠ, H., RULC, V.: The Effect of Arm Stiffness on the Elasto-Kinematic Properties of Single-Axle Suspension by Using the MBS Simulation Model. In: The International Journal of Engineering and Science (IJES), Volume 6, Issue 2, pp. 52-61, 2017 ISSN (e): 2319-1813 ISSN (p): 2319-1805, DOI: 10.9790/1813-0602015261

RULC, V., PURŠ, H., KOVANDA, J.: Analysis of controlled mechanism with significant nonlinearities. In: Neural Network World, 4/2017, pp. 333-349 ISSN 1210-0552

FATIGUE LIFE CALCULATIONS AND TESTING

Fatigue considerations play a major role in the development of mechanical parts for structures and systems operating under dynamic loads. The Regional Technological Institute (RTI) performs fatigue life calculations and testing of materials and components of road and rail vehicles, agricultural machinery and other products. Our multi-channel electrohydraulic loading system is the main machine for fatigue tests. Fatigue life calculations are performed using nCode software. The problems addressed include both classic calculations of fatigue damage as well as cases involving vibration fatigue.

Our research efforts focus on probabilistic fatigue life assessment, considering the scatter of fatigue properties of materials as well as random loads on components. The loads can be measured using strain gauge systems in real-world operation of machines, vehicles, and other systems.

Our Strength and Fatigue Life Testing Laboratory collaborates with the large Dynamic Testing Lab at our private partner Research and Testing Institute Plzeň. Sharing our capacities allows us to study not only small components but also large structures and frames, such as bus bodyworks and bogies of rail vehicles.

In this field, our activities also involve, to a limited extent, research into additive-manufactured components, evaluation of weld joints and investigation and assessment of components which suffered fatigue failure in service.

Selected publications:

KEPKA, M., KEPKA Jr., M.: Deterministic and probabilistic fatigue life calculations of a damaged welded joint in the construction of the trolleybus rear axle. Engineering Failure Analysis Volume: 93 pp: 257-267 Published: NOV 2018, ISSN: 1350-6307

KEPKA M., KEPKA Jr., M.: Design, service and testing grounds stress spectra and their using to fatigue life assessment of bus bodyworks. IRF2018, Lisbon/Portugal, 22-26 July 2018, ISBN: 978-989-20-8313-1

KEPKA, M., KEPKA, Jr. M. Calculations of fatigue life of a welded joint in the construction of the trolleybus rear axle. In Procedia Structural Integrity. Amsterdam: Elsevier Science BV, 2017. pp. 1409-1416.

KEPKA, M., KEPKA, Jr. M., CHVOJAN, J., VÁCLAVÍK, J.: Structure service life assessment under combined loading using probability approach. Frattura ed Integrita Strutturale, 2016, Vol. 10, No. 38, pp. 82-91. ISSN: 1971-8993

KEPKA, M., KEPKA, M., BARTOŇ, L. Teaching and Research of service Strenght and Durability of Vehicles. In Book of Proceedings of 56th International conference of machine design departments. Nitra: Slovak university of agriculture in Nitra, 2015. pp. 179-184. ISBN: 978-80-552-1377-4

KEPKA, M., KEPKA, M. Parametric calculations of allowable operating stresses in vehicle components under fatigue loading. In Proceedings of the 5th International Conference Integrity - Reliability - Failure. Porto: INEGI/FEUP, 2016. pp. 241-254. ISBN: 978-989-98832-5-3

RTI Research Programmes

Research and Development of Advanced Vehicle Designs and Drive Systems

Virtual prototyping of advanced vehicle designs, testing of vehicles and their components, research into the properties and behaviour of mechanical components of drive systems.

Research and Development and Modernisation of Manufacturing Machines

Virtual prototyping of manufacturing machinery and research into the use of unconventional materials and technologies in the construction of manufacturing machinery.

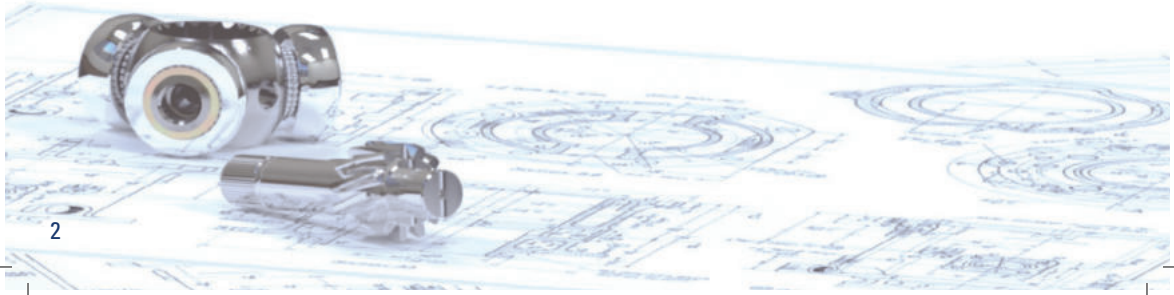
Research and Development of Forming Technologies

Analysis of material behaviour during forming, development of new technology chains and optimisation of manufacturing process parameters.

Research and Development of Machining Technologies

Machining of sculptured surfaces, virtual process planning, adaptation of cutting tool geometry, design of machining strategies, contact and non-contact 3D scanning.

RTI Laboratories



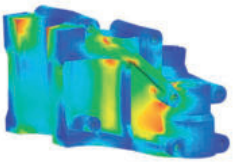
Regional Technological Institute

The Regional Technological Institute (RTI) is an engineering and technology research centre at the Faculty of Mechanical Engineering of the University of West Bohemia. It was established thanks to financial support from the European Regional Development Fund, the Operational Programme Research and Development for Innovation, Priority Axis 2: 'Regional R&D Centres'. Construction began in the first half of 2011 and the Regional Technological Institute (RTI) opened its doors on 1 July 2015. Almost one hundred researchers work in its laboratories, test rooms and facilities equipped with the latest research technology, software and computers.

MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY
EVROPSKÁ UNIE
EVROPSKÝ FOND PRO REGIONÁLNÍ ROZVOJ
INVESTICE DO VAŠÍ BUDOUCNOSTI
OP Výzkum a vývoj pro inovace

VIRTUAL PROTOTYPING LABORATORY

The Virtual Prototyping Laboratory focuses on virtual product development. It relies on the latest CAx tools for designing structures and for advanced computational analysis. Using optimisation software, the laboratory can develop effective structures and improve the utility value of existing solutions.



Structural analysis

The core of our simulations comprises structural calculations in the field of linear statics. Typical examples include strength and deformation calculations of structures involving 2D elements or more sophisticated spatial models with 3D elements.

Modal analysis

Modal analysis is the second most frequent choice for verifying the design of components and it is an essential starting point for developing components for operation under dynamic loads. The calculation identifies the first normal mode of structural units. It is then followed by dynamic calculations.

Topology optimisation

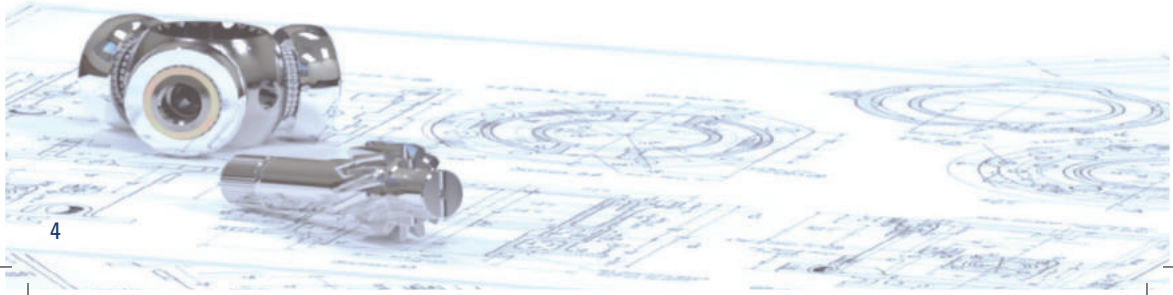
Topology optimisation is used to identify the optimal material layout within a specified space for the optimum stress distribution across a structure.

Composite materials

We perform design, optimisation and verification of structures made from composite materials. Our analysis can account for the overlap between fabric layers, including the calculation of fabric distortion and the direction of fibres in relation to the surface shape and the coordinate system. It can involve unidirectional-fibre components (e.g. wound products), as well as multi-layer laminates from various fabrics or prepregs, including those with isotropic or orthotropic cores.

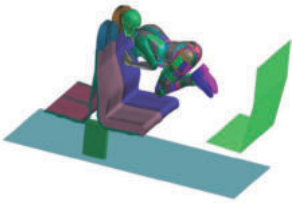
3D printing of composite materials

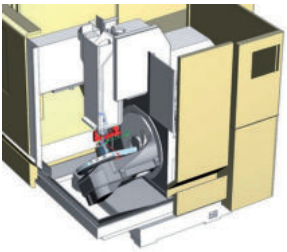
Creation and customisation of product models for additive manufacturing. 3D printing of functional and highly-durable components. The Markforged Mark Two printer works with nylon or nylon with short carbon fibres and can reinforce parts with continuous carbon, Kevlar or glass fibres.



Rapid dynamic phenomena

Rapid dynamic phenomena are investigated using Virtual Performance Solution. This involves using the explicit FEM solver Pam-Crash which can simulate processes involving large deformations and complex contacts. Collaboration between the University and software developers has led to VIRTHUMAN, a human body model for studying the probability of injury in passive safety problems in vehicle interior.

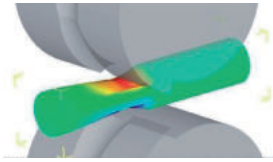




Advanced machining simulations

Using virtual CNC machines, the movements of the entire workstation or its particular mechatronic part can be simulated. The machining simulation is controlled by a real NC code.

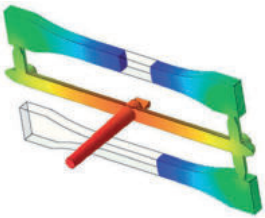
Simulations of forming technologies

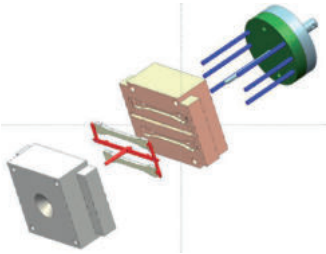


The effects of large deformations during hot and cold forming processes can be modelled, as can machining and other manufacturing processes. Simulations can predict the distribution of temperature, strain and stress, and flow of the workpiece material at every single moment of the manufacturing process.

Simulation of injection processes

Simulating injection processes can determine weak points in the design of a component or mould. The gate position can be optimised with respect to undesired melt solidification, inserts and 2K injection moulding can be simulated, the positions of cold joints can be optimised and the effect of the fibre orientation on the product properties can be analysed. Granules can be evaluated using mechanical testing, including the effects cold joints on mechanical properties.



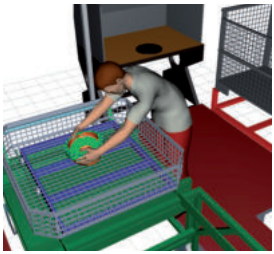


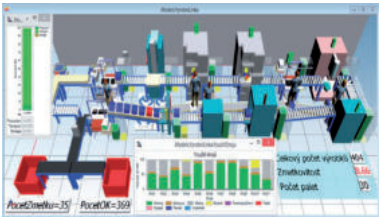
PRODUCTION PLANNING LABORATORY

The Production Planning Laboratory focuses on the virtual design and verification of production processes. It aims to provide a comprehensive portfolio of design services ranging from optimisation of individual workstations through groups of workstations, cells, lines and centres, to the layout of the entire production process. The final step involves dynamic simulation of the throughput of the planned or optimised production process.

Ergonomic studies using 3D digital human models

Ergonomic studies are carried out using digital human models (DHMs) which faithfully represent a real worker in production. DHMs can be used to evaluate the suitability of an existing layout or for designing a variety of scenarios, e.g. for large or small workers. The latest version of Tecnomatix Jack software is employed for this purpose.



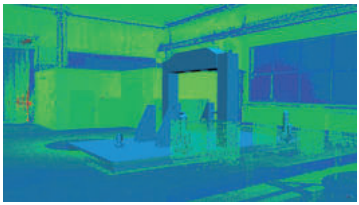


Dynamic simulations of manufacturing systems and processes

Once the workstations have been optimised, higher-level units are evaluated, such as production cells, lines or segments. Dynamic discrete-event simulations are employed to verify typical indicators of capacity, quality and time. These simulations are developed using the latest version of the Tecnomatix Plant Simulation software.

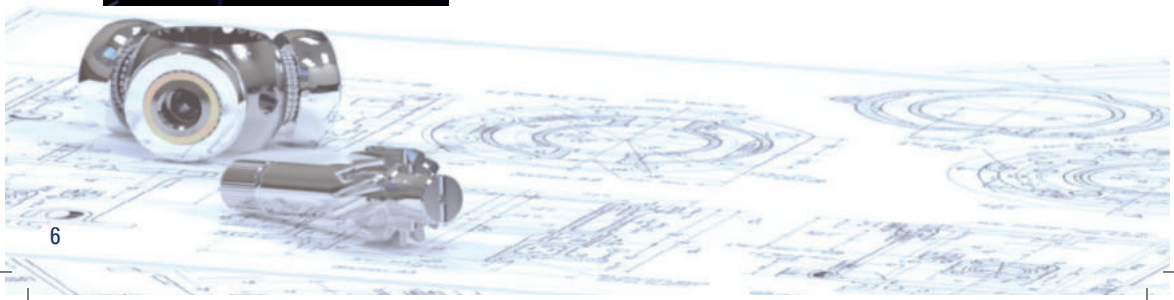
3D scanning of large-scale objects and outdoor and indoor environments

Advanced technologies for the digitisation of real-world environments are employed to reliably represent manufacturing processes and workstations. Using the Leica ScanStation C5 three-dimensional scanner, digital models of production machines, workstations or even entire halls can be acquired very rapidly.



Virtual tours of 3D models (production halls, warehouses)

Multiple layout variants and solutions are presented using virtual reality tools. Details can be visualised and designs viewed very realistically. Two techniques are available for visualisation: 3D stereoscopic projection onto a screen or head-mounted displays.



Tecnomatix Jack and Tecnomatix Plant Simulation Software

These are world-leading tools for digital design and production planning. They are primarily used for ergonomic studies and dynamic simulation problems.

Leica 3D scanner

A pulsed laser scanner for scanning large objects, ground surfaces, buildings and halls. The output is a point cloud suitable as a source for measurement, construction of 3D models or development of CAD data. The scanner is provided with a Leica CS10 GPS sensor.

Stereoscopic projection systems (CAVE, Oculus Rift)

CAVE (Computer Aided Virtual Environment) is a device which can project almost any design or technical data in 3D. It uses stereo glasses to provide the user with convincing 3D images. An even more immersive effect is obtained using the Oculus Rift headset, which can also display environments or objects in virtual reality. In this case, the need for motion control peripherals is partially eliminated, as the headset responds to the user's head movements.

METROLOGY LABORATORY

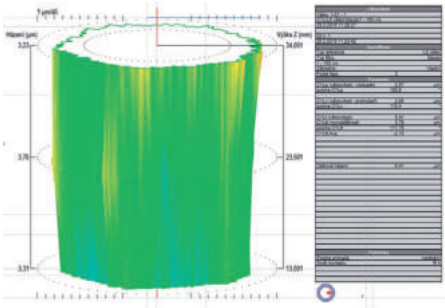
ACCREDITED TESTING LABORATORY IN ACCORDANCE WITH ČSN EN ISO/IEC 17025:2005

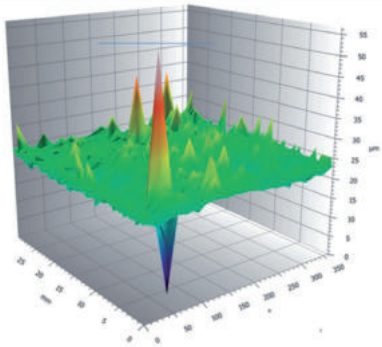
L 1718

The Metrology Laboratory focuses on highly advanced metrological analyses of complex-shaped and high-precision components, the development of inspection strategies, the evaluation of measuring systems, contact and non-contact 3D scanning, digitisation for constructing models by reverse engineering, and many other areas.

Development of measurement strategies

One of the core activities involves developing measurement strategies with the aid of advanced technologies and software tools. The strategies are tested in a laboratory environment and computational simulations are carried out using advanced Calypso software.



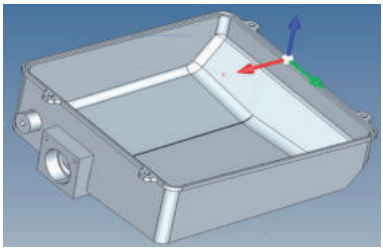


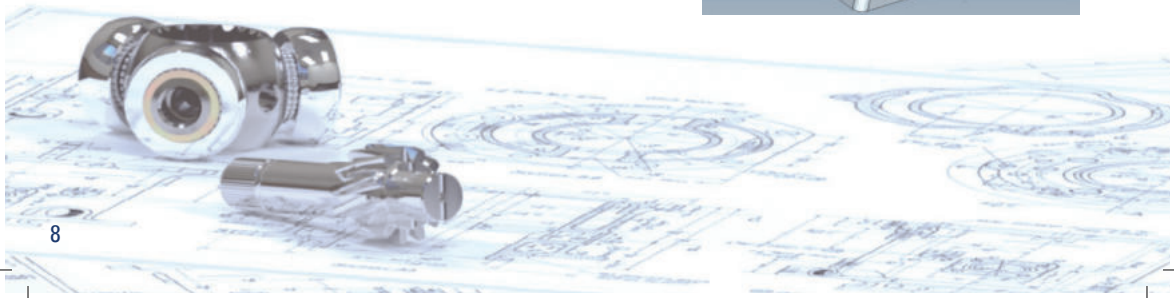
Contact and non-contact 3D scanning

Newly-proposed strategies are tested in the laboratory using universal machines and standard and special measuring instruments. Several variants are tested in order to select the solution which best meets the specification.

Digitisation for reverse engineering of components

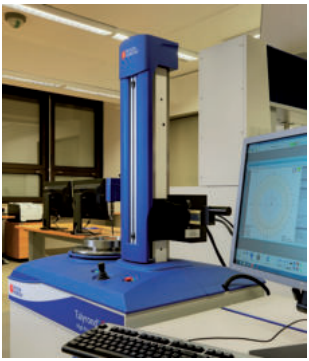
Complex prototype components or parts for which 3D models cannot be obtained can be scanned to develop models compatible with CATIA/SOLID which can then be reverse-engineered.





CMM Carl Zeiss Prismo 7 Navigator

Prismo Navigator from ZEISS is synonymous around the world for high-speed scanning and maximum accuracy in production environment. With a length measurement error of just 0.9+L/350 micrometres, the Zeiss Prismo 7 Navigator is ideal when strict demands on precision have to be met.



High-precision roundness instrument Taylor Hobson Talyrond 585 Lt

The machine is intended for measuring shape and position deviations, as well as linear and circumferential roughness. In addition, it enables cylindrical parts to be measured in 3D and analysed by means of the Talymap system. It is a top-quality machine which offers a deviation from LSCI of 0.015 + 0.00025 µm/mm.

High-precision contour/surface roughness measuring machine Hommel Etamic T8000

The Hommel-Etamic T8000 RC is a flexible solution for measuring geometric shapes, roughness and waviness of various component surfaces. The T8000 system has a modular configuration which enables various traverse units, probe types, columns and granite plates to be combined.

Other equipment

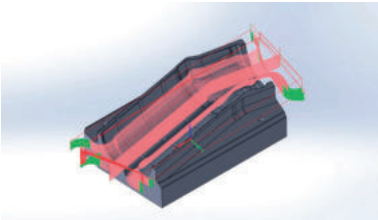
Length reference standards for the calibration of gauges for absolute and comparative measurement. Absolute and comparative manual gauges with an accuracy of 1 µm. Clamping kits for clamping and positioning complex-shaped components.

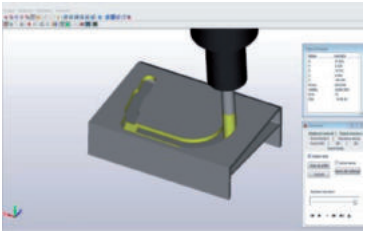
MACHINING TECHNOLOGY LABORATORY

The Machining Technology Laboratory focuses on comprehensive solutions to manufacturing process problems, selecting cutting tools and fixtures for advanced machining strategies, programming of NC machines, introducing new procedures and approaches to machining, and other areas.

Development of machining strategies

One of the core activities of the laboratory is the development of machining strategies involving advanced machining processes and the design of tools. The strategies are tested on universal machines. Computational simulations are carried out using advanced CAM systems SolidCAM and Catia V6.



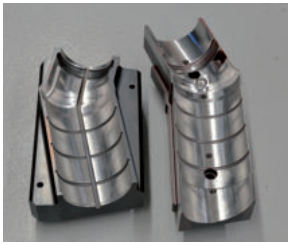


Verification of technologies

Designing machining strategies is naturally and closely related to process verification. The proposed strategies are tested in the laboratory using universal machines and standard as well as special tools. Several variants are tested in order to select the solution which best meets the specification.

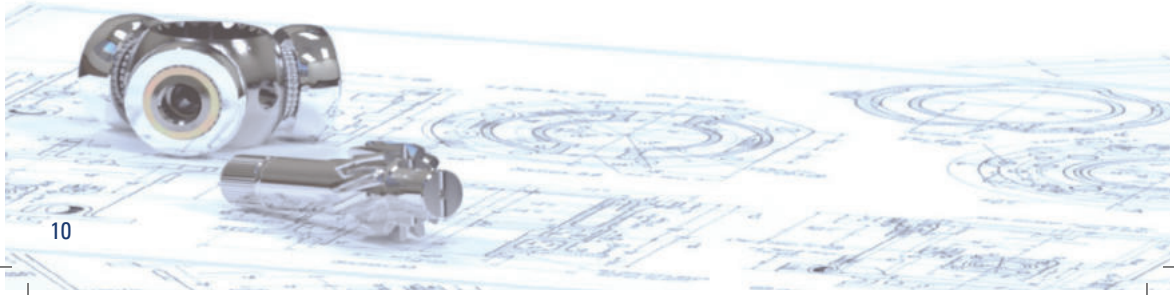
Development of functional samples

New functional samples are developed alongside advanced machining strategies to verify a component's functions and examine its design characteristics, material properties and life.



Cutting tool trials

Where advanced processes are to be used, not only conventional but also special cutting tools are required. Trials are carried out of these new cutting tools to improve the effectiveness of the cutting process.



CTX BETA 1250 multi-function turning centre

The unique concept of this 12-axis machine translates into a range of available turning and milling options. One of its strengths is the synchronised operation of the milling spindle and the bottom turret. Automatic transfer between the main and auxiliary spindles offers the advantage of seamless machining with improved accuracy. Up to 100 bar of pressure is available for effective cooling.

DMU 65 monoBLOCK multi-axis milling centre

This 5-axis milling centre has a working space of 650×650 mm size which can accommodate large workpieces. Positioning is provided by its cradle configuration and a ±360° rotary table (unlimited) for continuous 5-axis machining of sculptured surfaces. High-precision finishing is achieved with high spindle speeds (up to 18,000 rev/min).

DMU 40 eVo linear milling centre

This machine performs well in continuous 5-axis machining and accurate positioning along all axes. It enables complex-shaped parts to be produced in single clamping. Linear drives provide accelerations up to 1 g and feed rates up to 80 m/s drive during machining. Spindle speeds can reach 24,000 rev/min which facilitates high-precision finishing.

MAZAK QUICK TURN NEXUS 250-II MY multifunctional turning centre

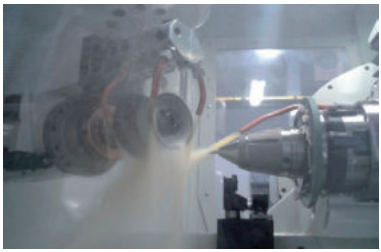
Thanks to its rugged construction and high stiffness, this multi-tasking turning centre can be used for verifying advanced technologies. Its automation capability is a major advantage. The machine's Y axis enables off-axis drilling and milling and other operations. To the existing family of control systems from HEIDENHAIN and Siemens, this machine adds the integrated Mazatrol system.

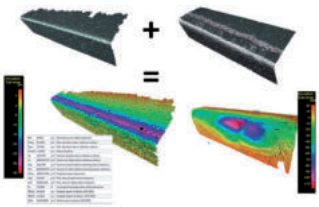
EXPERIMENTAL MACHINING LABORATORY

The Experimental Machining Laboratory focuses on the advanced engineering design and manufacturing of cutting tools, including preparation of their microgeometry, detailed measurements and grinding of sculptured surfaces, polishing, flute shape analysis, design of the grinding wheel shape, 3D printing of metallic parts, design of supports for 3D printing and optimisation of 3D printing parameters.

Design and manufacture of cutting tools

The core activities of this laboratory include designing solid cutting tools, cutting tools with exchangeable cutting inserts and special (custom-made) tools. State-of-the-art software is used for this purpose: e.g. for the computation of flute shapes and shapes of grinding wheels, for stress analysis, and for simulations of cutting processes and fluid flows.



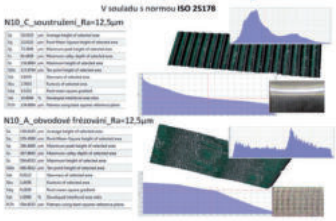


Microgeometry preparation and surface polishing

Today, no high-productivity cutting tool can be made without preparation of its cutting edge. The laboratory devotes great attention to this subject and conducts analyses of relevant processes and their effects on cutting tool durability and the machined surface quality. Polishing the flute surface has proven to be a necessary step in improving the utility properties of a tool. Polishing can also be used on general shapes where roughness (Ra) of less than 0.02 µm can be achieved.

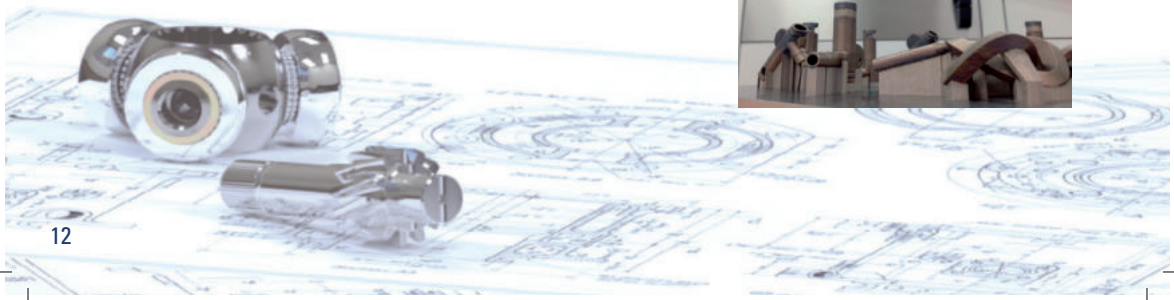
Measurement of areal roughness and cutting edge microgeometry

We design and manufacture metal parts using the DMLS additive manufacturing technology. To attain the desired quality, the appropriate build orientation and support structures are essential. In many cases, both internal and external supports must be provided and shaped to protect the build from distortion, excessive internal stresses and undesired surface roughness.



Fabrication of prototype components and support structures

We build complex-shaped parts specific to additive manufacturing. We also use advanced tools for preparing and processing the builds. Our services include consultancy and tailoring models for additive manufacturing. The build space is 250 × 250 × 320 mm.



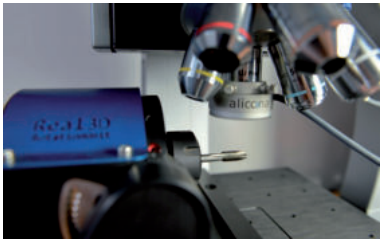
ANCA MX7 tool grinding machine

The machine can grind solid tools with diameters starting at 0.5 mm. It has high-precision spindles and other accessories for meeting specified tolerances. Exchangeable cutting inserts and sections made from various materials, including aluminium and titanium alloys, can also be ground. The laboratory has all the relevant software and inspection equipment for such applications.

EOS M290 3D printer

This printer uses the principle of Direct Metal Laser Sintering (DMLS). The printed object is built by depositing and sintering thin layers by a laser. The builds can have any external an internal shapes which are otherwise unachievable by conventional methods. The MS1 tool steel, Inconel 718 and 316L stainless steel are currently used for building metal components in the laboratory.

IFM G4 scanning optical microscope



The IFM G4 captures the surface topography, including true colour information. The main strength of this instrument is the integrated measurement of the shape and roughness in both 2D and 3D, which combines the functions of multiple measuring devices. Its output has the form of clearly arranged reports.

OTEC DF 3 surface finishing equipment

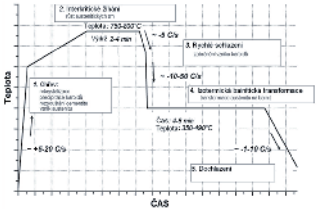
This equipment for finishing surfaces and cutting edges of tools, including the polishing of helical flutes, uses the drag finishing process. The tool or workpiece is clamped in a rotary head which is gradually lowered into a medium which exerts pressure on the workpiece, producing the desired surface finish. This head can be tilted at an angle, enabling the flute surfaces to be polished.

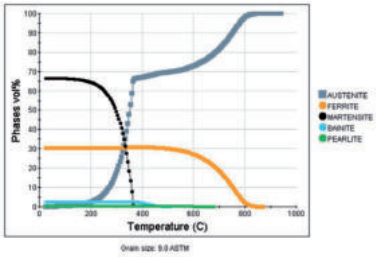
EXPERIMENTAL FORMING LABORATORY

The Experimental Forming Laboratory focuses on testing the viability of new ideas in the field of materials and processing and on the gradual optimisation and combination of processes which lead to extraordinary properties of materials or to efficient unconventional thermomechanical treatment processes.

Unconventional thermomechanical treatment of steels and alloys

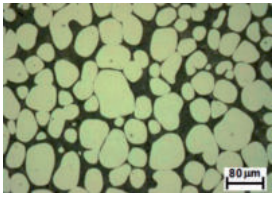
One of the core activities of the laboratory is the development of new thermomechanical treatment sequences and processes for low-alloy steels and alloys to achieve unique high-end mechanical properties. Unconventional metallurgical treatment leads to sophisticated microstructures which guarantee excellent strength and deformation characteristics.





Comprehensive modelling of thermomechanical processes with extreme changes in gradients

Modelling and simulation techniques are closely related to unconventional thermomechanical treatments of steels and alloys. Modelling facilitates effective designing and optimisation of forming processes. It supports evaluation of proposed parameter changes in existing processes and products and offers insight into the properties and microstructure of a product under development.

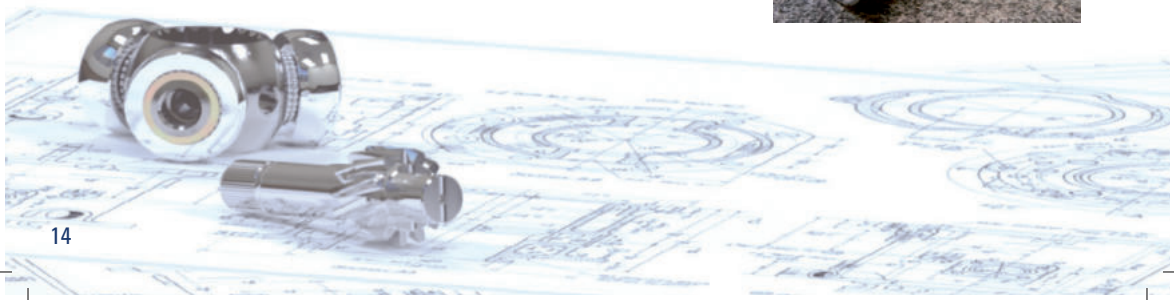


Design of unconventional and unusual microstructures

New processing techniques are developed for obtaining unusual microstructures in ordinary materials to improve their properties, such as resistance to wear, corrosion and creep and fatigue.

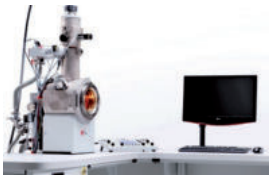
Examples of novel ideas

One of such examples is a sequence which combines internal high pressure forming, hot stamping and the Q&P process. These three techniques have been used for making thin-walled hollow products. They reached ultimate strengths of more than 1950 MPa and elongation levels higher than 15%.



Equipment for developing incremental forming processes

This special machine uses cross rolling to reduce the diameter of round bar feedstock. Optional reheating and rapid cooling of just-rolled products enables various thermomechanical treatments to be carried out. The equipment can produce products with cylindrical, conical and other pre-defined rotation-symmetric shapes with a straight longitudinal axis. The feed-stock materials which can be processed include a wide range of steels from carbon steels to stainless structural steels. As the equipment is primarily used for research and development of forming and thermomechanical processing, it was purposefully designed to offer a wide and flexible range of capabilities.



MEBW-60/2 electron beam welder

The equipment is used for electron beam welding in vacuum. Its power can be varied continuously from 0 to 2 kW. The achievable penetration is 10 mm (in stainless steel) at a welding speed of 10 mm/s.

Equipment for bending and brake bending of precision sheet metal parts

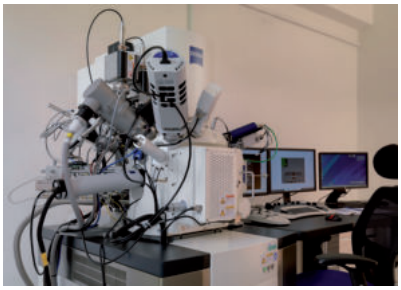
The machine employs a unique three-point bending technique. The punch presses the workpiece all the way down to the bottom of the die. The bottom of the die thus becomes the third point of contact in addition to both edges. As the die depth can be adjusted to any value, various workpiece angles can be achieved with high precision and with no need for tooling exchange. Three-point bending combines the precision of press forming and the flexibility of two-point bending. The forces required are slightly higher than for two-point bending.

FASTCAM SA-X2 high-speed camera

The camera is used to record rapid dynamic processes which occur during forming and other operations. High frame rates, a wide range of imaging modes and rugged construction make this camera one of the leading high-speed imaging instruments. Specifications: 1024 × 1024 pixel sensor, 12-bit imaging, full-resolution frequency of 12,500 fps, maximum frequency of 1,000,000 fps.

METALLOGRAPHIC LABORATORY

The Metallographic Laboratory focuses on research into transformation processes, microstructural evolution during heat treatment and thermomechanical processing, and on the high-temperature behaviour of materials. Our equipment includes state-of-the-art microscopes, devices for in-situ deformation and thermal experiments and instruments for measuring local mechanical properties.

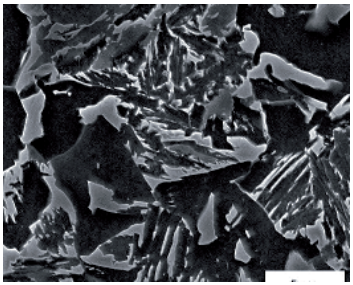


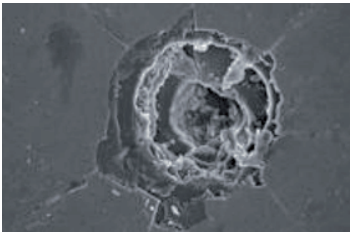
Microstructure analysis

Some of the key activities carried out on a routine basis include microstructure characterisation, measurement of the inclusion content, grain size and surface layer thickness, examination of microstructure and macro-structure of cast parts, forgings and welded joints and examination of microstructures after heat treatment and thermomechanical processing.

Identification of types and causes of failure

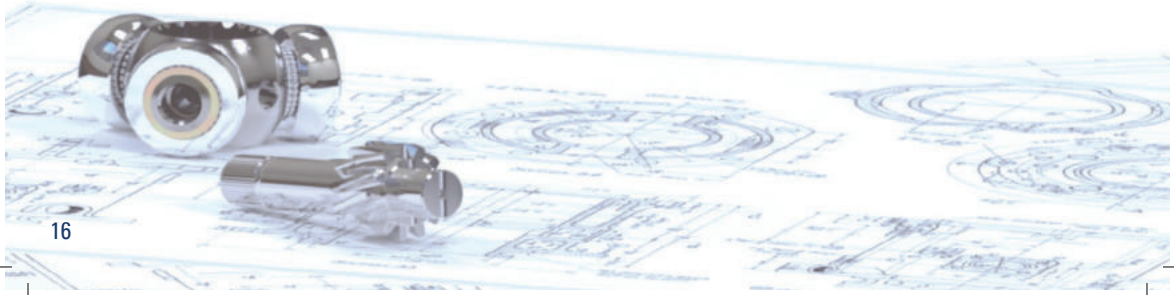
Detailed analyses of fracture surfaces and macrostructure and microstructure characterisation are carried out as part of more comprehensive examinations of failures in materials. These examinations are typically aimed at finding the causes of discontinuities, defects and premature fractures, providing assistance in the event of manufacturing problems and other issues.





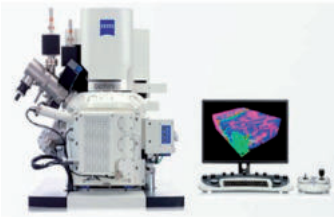
Evaluation of surface layers of cutting tools

High-temperature nanoindentation (up to 750 °C) under near-industrial conditions can shed light on various factors which affect the life of a tool. These include oxidation resistance, thermal stability, hardness at elevated temperatures, fatigue resistance and other characteristics. Scratch testing and wear testing can also be carried out.



Nanoindenter for measurements up to 750 °C

This modular nano and microindentation system provides fully automatic instrumented indentation analysis of mechanical properties of bulk materials, thin films and organic-inorganic materials under loads between 10 µN and 2 N. It also offers monitoring of mechanical properties, cyclic loading and indentation creep testing.

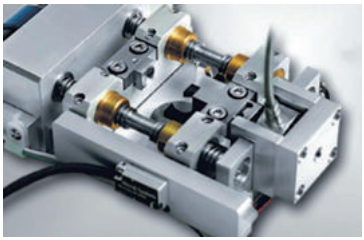


Auriga Cross Beam SEM-FIB Workstation

This scanning electron microscope offers ultra-high resolution and an integrated ion beam capability. It is equipped with BSE, EBSD, EDX and STEM detectors and enables 2D and 3D chemical composition mapping. Using the ion beam, nano-sized specimens can be prepared from selected locations in the microstructure. Such specimens can be used for in-situ testing in tension, compression and bending.

Deformation stage with heating capability up to 1200 °C for SEM

Deformation and thermal experiments can be conducted directly in the chamber of the scanning electron microscope. Microstructural changes, recrystallisation and phase transformations can be observed in situ. With the aid of the EBSD detector, changes in the crystal structure, texture and others can be quantified.



Non-destructive testing of materials

The available instruments include ultrasonic inspection equipment for the detection of internal defects in materials and an eddy current inspection instrument for finding surface and sub-surface defects in various materials, including electrically conductive non-magnetic materials. The equipment also offers the phased array technique for both methods, a coded-position scanner and a portable device for field microstructure examinations.

MECHANICAL TESTING LABORATORY

The Mechanical Testing Laboratory carries out tension tests, compression and impact test, hardness and cyclic testing, and other tests. The materials of interest include predominantly metals and plastics. Our research and development activities focus on the manufacturing and testing of miniature specimens made of small amounts of material.

Hardness testing

Conventional and instrumented hardness testing using fixed hardness testers (HV, HB, HRC). Field hardness testing using a portable hardness tester.

Testing of resistance to brittle fracture

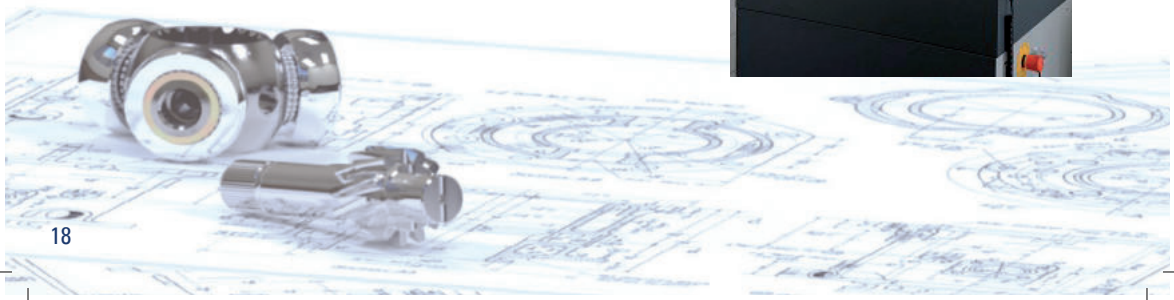
The resistance of materials to brittle fracture under static and dynamic loads is tested.

Mechanical testing

Basic mechanical testing of metals, plastics, ceramics, wires, ropes, textile specimens etc. at temperatures between -150 °C and 1200 °C according to applicable standards. Tests can be performed on round bars with cylindrical threaded heads and on flat rods, up to the maximum force of 250 kN. Measurement of mechanical properties of structural parts and evaluation of residual life on non-standard miniature specimens.

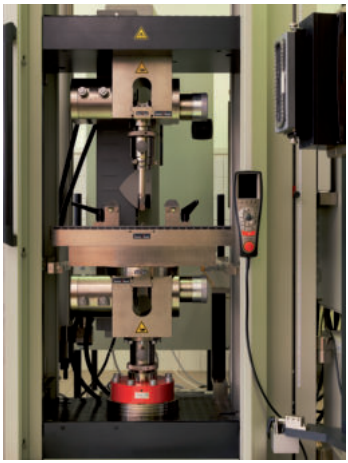
Fatigue testing

High-cycle fatigue testing from room temperature up to +900 °C. Construction of S-N curves, determining the fatigue strength. Low-cycle fatigue testing at room temperature. Measurement of fatigue crack propagation rate (using the Paris-Erdogan law).



ZWICK Z250 electromechanical testing machine

This 250 kN electromechanical machine provides tension testing from -150 °C to 1200 °C, compression and bending testing and, if required, basic testing under cyclic loads at room temperature.

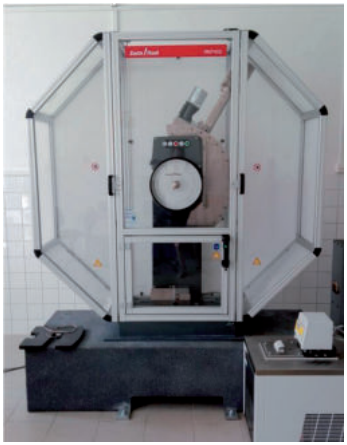


Zwick Roell HFP50 vibrophore

The vibrophore with a maximum test load of 50 kN is used for acquiring source data for S-N curves by high-cycle fatigue testing.

Instrumented Charpy pendulum 150 J / 300 J / 450 J

This instrumented pendulum impact tester with the maximum energy of 450 J provides testing at temperatures between -196 °C and 1200 °C.



Universal hardness tester

The universal hardness tester is employed for Brinell, Vickers and Rockwell hardness testing. The Mechanical Testing Laboratory has its own workshop for making test pieces.

Other equipment:

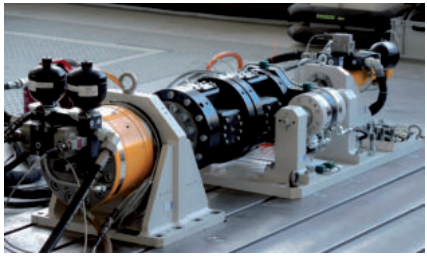
- Temperature chamber (-70 °C to 250 °C)
- Furnace with a temperature range up to 1200 °C

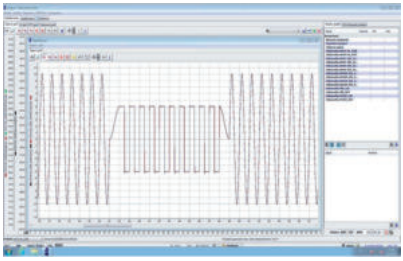
VEHICLE COMPONENTS TESTING LABORATORY

The Vehicle Components Testing Laboratory focuses predominantly on verifying various rail vehicle components under combined torsion-tension loads and on vibration diagnoses of rail vehicle components, such as gearboxes, traction motors and other equipment.

Verification of rail vehicle components

One of the main activities is the verification of rail vehicle components under combined torsion-tension loads. This verification can be performed on a special biaxial testing machine. Various components, e.g. clutches between the traction motor and the gearbox, can be mounted between two flanges and subjected to combined service loads. The measured in-service load plots can be fed into the computer system and used for physical simulations with the component mounted in the testing machine.



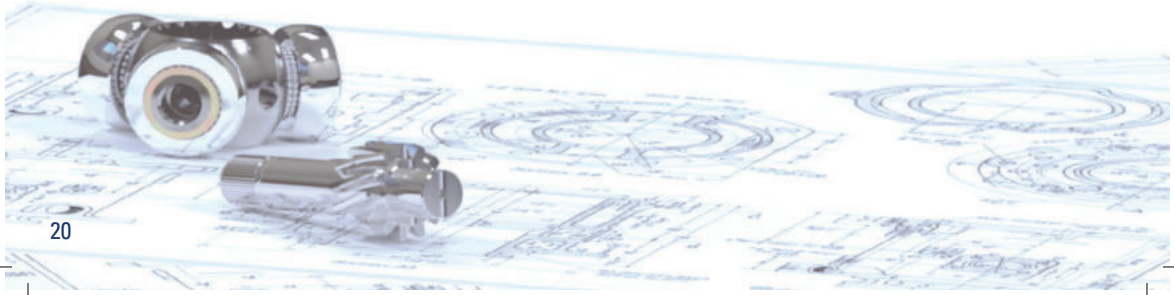


TEST CONTROL computer program

This computer program can be used to develop various static and dynamic-loading schedules for the equipment tested. Its iteration module means this program can accept field measurement data acquired from the component under investigation. The tested component can thus be subjected to real-world service loads. The input data can be fed to the program in many different formats.

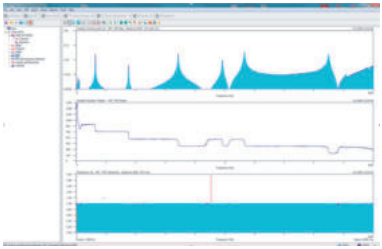
Vibration diagnosis and diagnosis of rail vehicle components

The testing laboratory also performs vibration diagnoses of rail vehicle components using the MICROLOG CMXA 80 instrument from the company SKF. With its many built-in modules, this instrument offers a vast number of functions. These range from balancing of rotating parts through modal analysis to data acquisition from numerous devices for comparative analysis. This four-channel instrument is portable and allows vibration diagnosis and initial rough evaluations to be carried out in the field.



SKF Analysis and Reporting Manager

Detailed FFT analysis is carried out using the SKF Analysis and Reporting Manager computer program. The program contains all the tools required for evaluating vibrations generated by damaged mechanical components of railway vehicles, e.g. axle bearings, traction motor bearings and teeth of gearbox gears. The cause of vibration is identified on the basis of specific vibration features.



CMAS100-SL SKF MACHINE CONDITION ADVISOR

This tool is used for rapid and flexible monitoring of vibration. This lightweight felt-tip-marker-sized device offers measurement functions for checking the condition of machines, temperature measurement and sends an automatic alarm in the event that the machine vibrations exceed the values prescribed by the relevant guidelines. The vibration measurement data include the overall vibration velocity and enveloped acceleration wherein all machine vibration signals are filtered apart from those generated by the bearings and gearboxes.

SKF TKED 1

Electrical discharges in bearings of electrical rotating machines are detected by the SKF TKED 1 device. This instrument measures the number of discharges between bearing raceways and rollers and thereby identifies trends in bearing damage. Bearings of electrical machines are often damaged by high-frequency bearing currents which occur when motors are fed from converters. This instrument is therefore very useful for comparative measurement of motor bearings. The laboratory is also equipped with an SKF TKE 10A endoscope for visual monitoring of inaccesible areas within machines.

STRENGTH AND FATIGUE LIFE TESTING LABORATORY

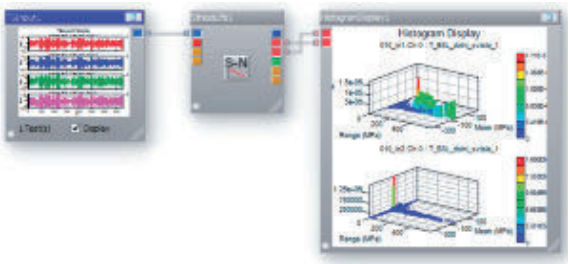
The laboratory houses a universal electrohydraulic loading system for the dynamic testing of structural parts and specimens. It focuses on evaluating the life of components and probabilistic sizing methods.

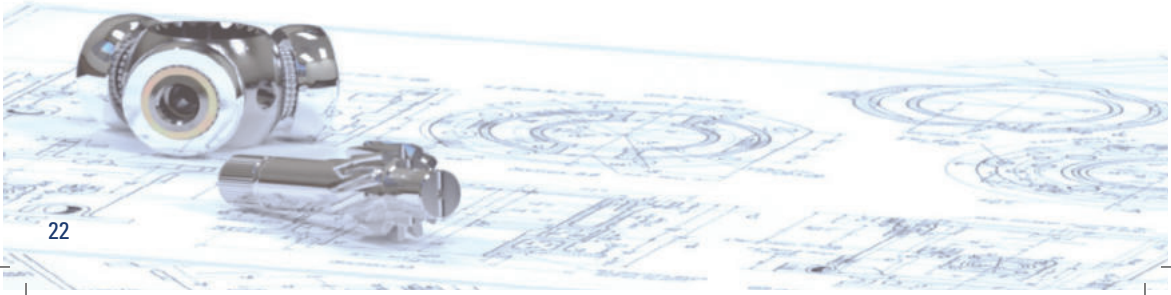
Tests of strength and fatigue life of structural components and structures

We test the mechanical properties of materials, structures and structural components with a focus on operational strength and fatigue life. We perform simulation of operating loads and accelerated testing. Furthermore, we measure the stiffness, deformation, stress and acceleration of parts under loading. We determine the low-cycle fatigue properties of materials (Manson-Coffin curve, cyclic stress-strain curve), and investigate high-cycle fatigue (S-N curve, Smith chart) and perform materials testing under multi-axial loading.

Fatigue analysis and service life calculations

The testing laboratory is equipped with software for analysing operational and laboratory data from strain gauges and accelerometers, and for post-processing outputs from FE models. In collaboration with the Virtual Prototyping Laboratory, we are currently specializing in computer simulation of vibration fatigue tests for the automotive industry.





Set of independent loading cylinders and support structures

- T-slotted clamping bed of 8 × 4 m
- ten independent loading cylinders, as indicated in the table
- two-column frame with an adjustable crosshead for mounting up to two cylinders
- four horizontal adjustable brackets for cylinders

Cylinder - static force	Cylinder - dynamic force	Stroke - amplitude
10 kN	8 kN	± 50 mm
25 kN	20 kN	± 50 mm
40 kN	32 kN	± 125 mm
100 kN	80 kN	± 125 mm
160 kN	128 kN	± 125 mm

FU-O-250 biaxial testing machine

- The machine is provided with a linear cylinder and a pivoting hydraulic cylinder for simultaneous loading by axial force and torque.
- Other features include jaws for flat and round specimens up to 32 mm, as well as a load cell, torque sensor, accelerometer and a uniaxial and biaxial extensometer. The machine can be adapted to different types of static and dynamic tests.
- Static and dynamic, single-axis and multiaxial tension-torsion-pressure tests.
- The basic parameters of the linear hydraulic motor: force ±250 kN and a stroke of 100 mm, the pivoting hydraulic motor: 2 kNm and a stroke of 100 °.

Our main software packages include the commercial licences for nCode GlyphWorks, a measurement data analysis tool, and nCode DesignLife, a finite element method post-processor. This is graphic-oriented software aimed at fatigue analysis.

MECHANICAL ENGINEERING LABORATORY

The laboratory focuses on facilitating research and development in the fields of manufacturing processes, materials, designing unique solutions and new types of equipment, and production and testing of prototypes and functional samples. It is equipped with advanced experimental instruments for measuring operating loads and responses, dynamic characteristics, noise, residual stresses in materials and heat effects on various objects.

Measurement of common physical parameters

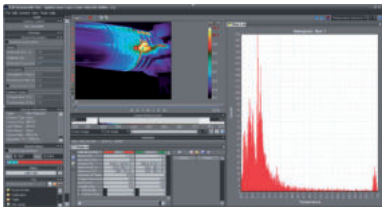
Extensive measurement of common physical parameters using a wide range of force, torque and pressure transducers, temperature and rpm sensors and other devices. The measuring module provides a large number of input ports and a backup power source.

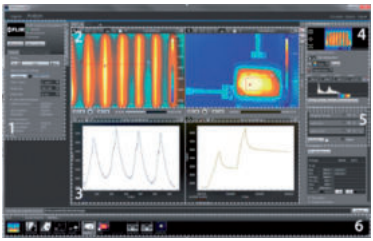
Measurement of in-service static and dynamic loading and deformation within structures

Extensive strain-gauge measurement of stress in structures under load can be performed. The measuring module offers a large number of input ports. Defined loads can be applied to determine the fatigue life of parts. Fibre optic strain gauge sensors immune to electromagnetic interference are available.

Extensive temperature measurement

Large numbers of measuring locations can be monitored using contact-type thermocouples or resistance sensors. Part of the measurement can be carried out at elevated temperatures of up to 650 °C.

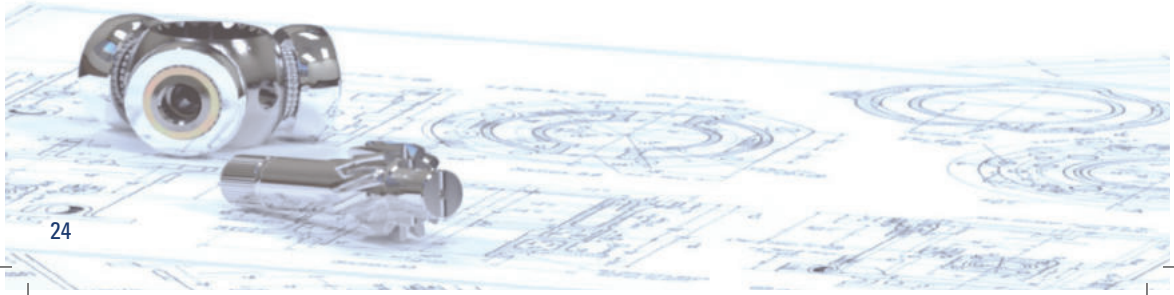




High-speed thermal imaging and other activities

Measurement and monitoring of temperature fields at full resolution and a rate of 380 fps or at reduced resolution and rates up to 25,000 fps.

Other activities including vibration and noise measurement, experimental modal analysis and verification of computational models and analyses.



The PULSE system for measuring dynamic phenomena, vibrations and acoustics

The system consists of modules that can work independently or in a group. Very rugged construction. Accessories also include an impedance tube for measuring the acoustic properties of materials.

- Programmable generator: 2 channels
- Up to 32 input channels
- FFT, Order, Envelope and Orbit Analysis, Two-plane Balancing, ODS Run-up/down, Modal Analysis Pro
- Order Analysis
- Modal hammers, accelerometers, microphones
- Electrical exciters for dynamic forces of 100 N, 440 N and 1000 N
- Impedance tube

FLIR SC 7550

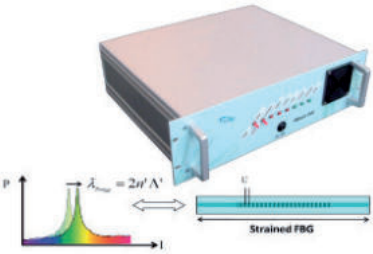
A camera with high flexibility, superior sensitivity, accuracy, spatial resolution and speed. It was specially designed for research and development in academic and industrial environments.

- InSb detector: 1.5 to 5.1 µm, cooled by Stirling cooler
- Resolution: 320 × 256 pixels
- Measuring range: -20 °C to 3000 °C (calibrated for 5 °C to 1500 °C)
- Frame rate: max. 380 Hz full window, up to 28,800 Hz subwindow
- Temperature resolution: better than 0.025 °C
- Lenses: 25 mm: F/2 and 100 mm – F/2

FBGUARD 1550 FAST

This unit can process and evaluate readings from FBG sensors. It is fully autonomous and equipped with a hard drive. The communication is provided via a web interface (remote access available).

- Wavelength range: 1500-1588 nm
- Four independent optical channels with a switching option
- Up to 80 optical fibre sensors
- Scan frequency: two channels at 1500 Hz, four channels at 750 Hz
- Total dynamic range: up to 25 dB
- Optical connectors: FC/APC
- Temperature measurement range: -270 °C to 300 °C
- Length of connected sensors: on the order of kilometres



University of West Bohemia

The University of West Bohemia (UWB) is the only higher education institution based in the Pilsen Region. It has nine faculties with almost 60 departments and twelve thousand Czech and foreign students.

Besides providing education, the University is involved in scientific research, including basic and applied research, and pursues innovation and knowledge transfer activities.

Faculties

- Faculty of Applied Sciences (FAV)
- Ladislav Sutnar Faculty of Design and Art (FDU)
- Faculty of Economics (FEK)
- Faculty of Electrical Engineering (FEL)
- Faculty of Philosophy and Arts (FF)
- Faculty of Education (FPE)
- Faculty of Law (FPR)
- Faculty of Mechanical Engineering (FST)
- Faculty of Health Care Studies (FZS)

Research centres

- New Technologies for the Information Society (NTIS)
- Regional Innovation Centre for Electrical Engineering Contact (RICE)
- Regional Technological Institute (RTI)
- New Technology and Materials Centre (CENTEM)

Institutes

- Institute of Applied Language Studies (UJP)
- New Technologies - Research Centre (NTC)

Faculty of Mechanical Engineering

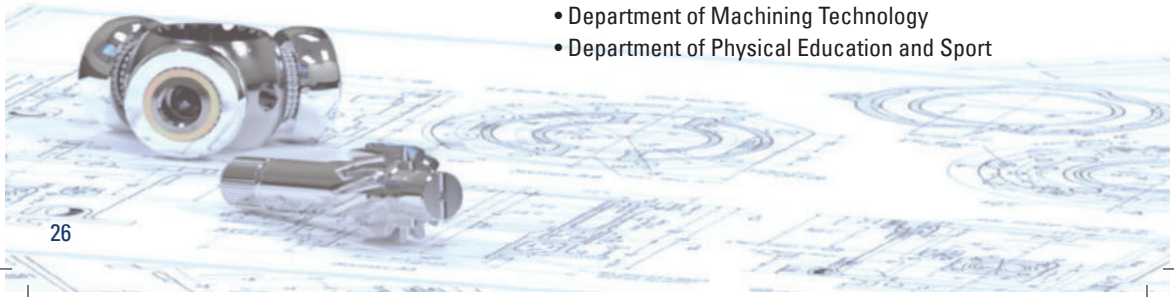
Faculty of Mechanical Engineering is one of the oldest faculties of the University of West Bohemia. It is located on the main university campus on the south-west outskirts of Pilsen. It offers lecture halls, laboratories, departments and other facilities housed in closely-spaced buildings convenient for students. Thanks to its close collaboration with foreign technical universities and industrial companies based in the Pilsen Region and elsewhere, the Faculty provides high-quality education with advanced engineering research and development experience.

Research centres at the Faculty of Mechanical Engineering

- Regional Technological Institute (RTI)
- Energy Research Centre

Departments at the Faculty of Mechanical Engineering

- Department of Power System Engineering
- Department of Machine Design
- Department of Material Science and Technology
- Department of Industrial Engineering and Management
- Department of Machining Technology
- Department of Physical Education and Sport



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