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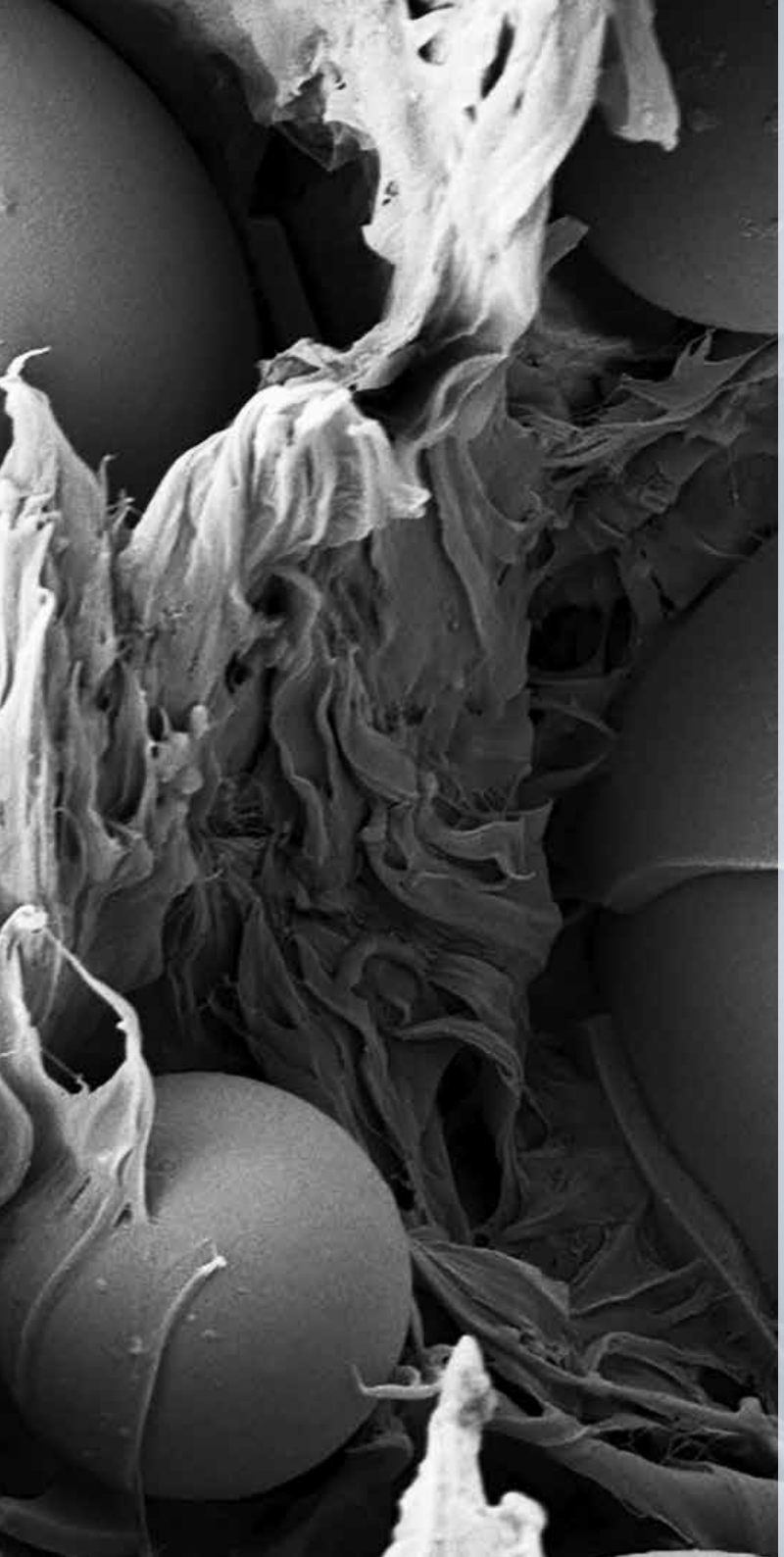
TECHNICAL UNIVERSITY OF LIBEREC
Faculty of Mechanical Engineering

STRATEGY RDI +2030
FACULTY OF MECHANICAL ENGINEERING

TECHNICAL UNIVERSITY OF LIBEREC



„ONE OF THE FUNDAMENTAL PRINCIPLES OF THE UNIVERSITY IS TO PRESERVE CULTURAL HERITAGE OF HUMANKIND. SCIENCE, TECHNOLOGY, DESIGN AND MATERIALS ARE INSEPARABLE PARTS OF HUMAN CULTURE.“

The Strategy of the Faculty of Mechanical Engineering of the Technical University of Liberec responds to actual societal challenges by formulating research programs based on cooperation between institutions, organizations and fields.

The Strategy of the Faculty of Mechanical Engineering of the Technical University of Liberec was approved by the Academic Senate of the Faculty of Mechanical Engineering and the Scientific Council of the Faculty of Mechanical Engineering in February 2020. The research programs of the Faculty of Mechanical Engineering of the Technical University in Liberec are open to cooperation with partners from universities, industry, state institutions, foreign universities, research organizations and companies.

FEBRUARY | 2020

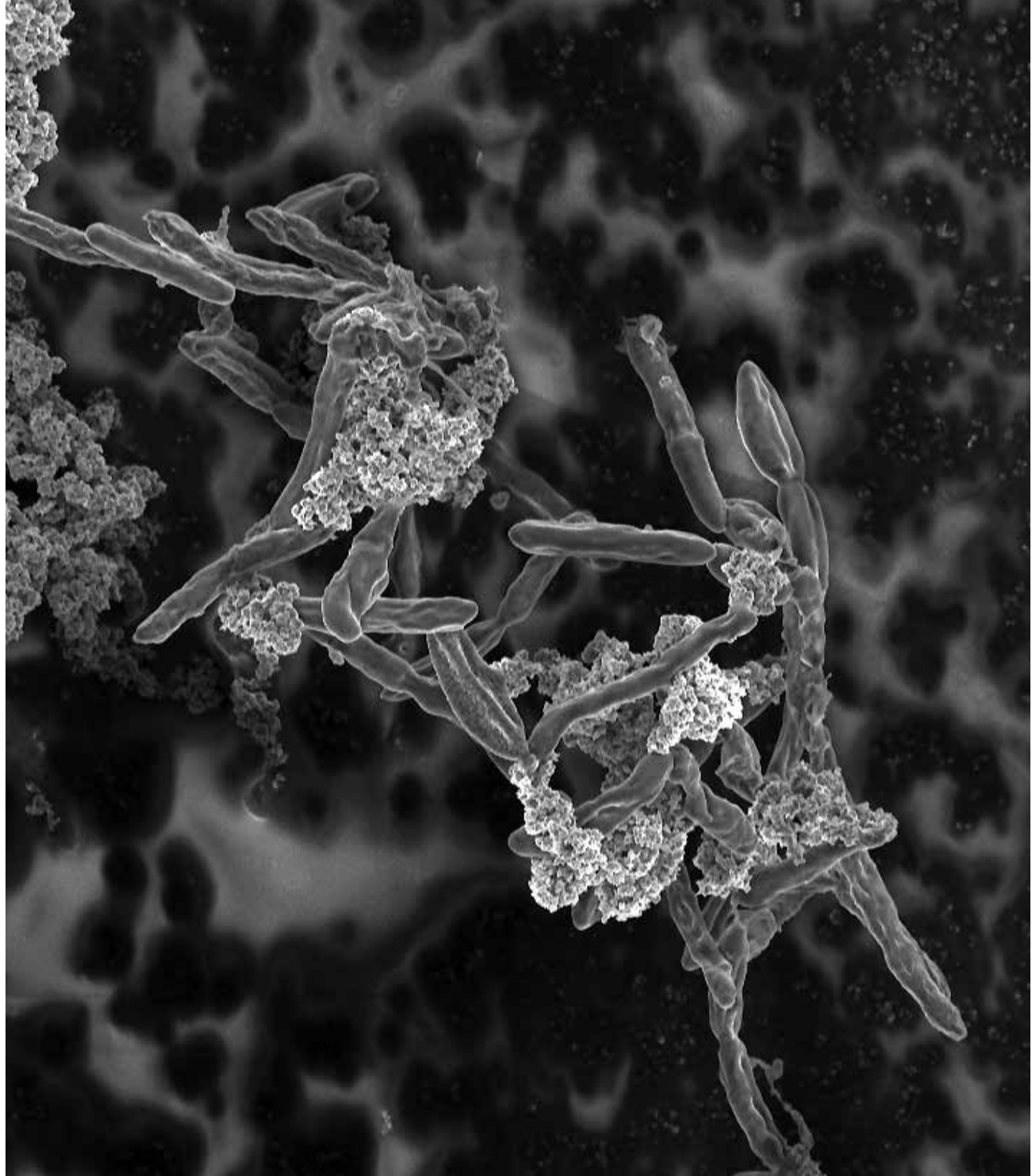
BACKGROUND FOR SCIENTIFIC, RESEARCH, DEVELOPMENT AND INNOVATION, ART AND OTHER CREATIVE ACTIVITIES

Faculty of Mechanical Engineering of Technical University in Liberec builds on freedom of scientific research, sharing the information and ideas and openness to different scientific opinions. It is based on the research tradition of European universities, where it systematically links educational activities with scientific, research, development, innovation and artistic activities, cooperates with renowned domestic and foreign partners and strives for a significant international dimension of its activities. A major advantage of the Faculty of Mechanical Engineering is its multidisciplinarity, the ability to solve innovative, complex issues across disciplines. It achieves top achievements and results that can be commercialized in many scientific areas.

TRADITIONS, NEW DIRECTIONS, NEW APPROACHES

Faculty of Mechanical Engineering is historically the oldest faculty of the Technical University in Liberec. It was founded in 1953 as the University of Mechanical Engineering and laid the foundations for the development of higher education in Liberec.

In the post-war period, besides the traditional textile and glass industry, Liberec industry began to focus on the automotive industry, production of machine tools and plastics processing. This fact determined, and to a certain extent predetermines, scientific and research orientation of the Faculty of Mechanical Engineering. The current focus of science and research is increasingly emphasizing areas such as ecology, safety, medicine, energy, nanomaterials and nanotechnology, with an emphasis on the topics and needs of the 21st century.
The Faculty of Mechanical Engineering is profiled as a Faculty of Science and Engineering.



MISSION

- Research at the Faculty of Mechanical Engineering is essential contribution to the development of education and to growth of the society.
- Scientific research and engineering activity is an integral part and dominant activity of academic and research workers and it is fundamentally involved in the profile of the Faculty of Mechanical Engineering.
- Faculty of Mechanical Engineering expands knowledge, also deepens and shifts knowledge of materials and processes with the aim of practical application of new knowledge for sustainable development of the society.
- Faculty of Mechanical Engineering is generally perceived and ranked among the most prestigious technically oriented universities in the Czech Republic with a significant international dimension.

VISIONS IN RESEARCH, DEVELOPMENT, INNOVATIONS +2030

- Faculty of Mechanical Engineering is an independent scientific research organization of European dimension consistently fulfilling the mission in areas of scientific research.
- Faculty of Mechanical Engineering is a respected partner in the framework of a national and international scientific research area.
- Faculty of Mechanical Engineering is a recognized and respected partner for collaboration with application and industry partners.
- Faculty of Mechanical Engineering is a clearly profiled research organization in the field of technical education and technical sciences, while achieving high quality results at national and international level.
- Faculty of Mechanical Engineering is a financially stable research organization relying on a strong research base to guarantee long-term perspective of the faculty's research, development and innovative activities.
- Faculty of Mechanical Engineering is a desirable workplace for doctoral students from Czech and foreign universities.
- Faculty of Mechanical Engineering is a part of research teams and projects within the university, Czech Republic and international research teams.
- Faculty of Mechanical Engineering is based on cooperation between faculty departments and university departments as well as research institutes.
- Faculty departments develop research programs, which are essential criterion for the functioning or establishment of research teams, a platform for mutual cooperation, as well as planning the personnel and financial resources.
- Faculty of Mechanical Engineering is a research center with developed infrastructure at a standard international level.

STRATEGIC FIELDS OF RESEARCH, DEVELOPMENT, INNOVATIONS

Based on traditional disciplines, new areas of research, development and innovation are being developed with an emphasis on topics and needs of the 21st century. Strategic areas will be strengthened and developed by research programs of the Faculty of Mechanical Engineering.

- Materials, nanomaterials, composites
- Progressive and environmental technologies and nanotechnologies
- Sustainable transportation and mobility
- Design of machines and devices
- Manufacturing systems, automation and robotization
- Energy and renewable resources

INVOLVEMENT OF FME DEPARTMENTS IN STRATEGIC FIELDS	DAM	DET	DMS	DPE	DME	DMA	DVE	DGR	DTM	DSA
materials, nanomaterials, composites	✓	✓	✓	✓	✓	✓				✓
progressive and environmental technologies and nanotechnologies		✓		✓	✓	✓		✓	✓	✓
sustainable transportation and mobility		✓			✓		✓			
design of machines and devices	✓				✓		✓	✓	✓	✓
manufacturing systems, automation and robotization		✓			✓			✓		✓
energy and renewable resources		✓		✓			✓			

OPPORTUNITIES, CHALLENGES TO STRENGTHEN RESEARCH, DEVELOPMENT, AND INNOVATION

Core of the research is based on Research and Development Strategy of FME TUL during 2007-2013 and research programs developed within the university. An important role is played by Basic Research as well as mostly applied research projects, supported by TA CR, MIT CR, MI CR. A significant share is made of non-public funds for contract research activities, where the Faculty of Mechanical Engineering has traditionally achieved very good results. The participation of the Faculty in international projects is not sufficient, though.

STRONG POINTS

Tradition and very good experimental base
Development of new areas and directions
Stabilized personnel base and qualification structure
Relatively smaller / more compact faculty compared to mechanical faculties in the Czech Republic
Partnership and cooperation with other faculties of mechanical engineering
Significant connection to application and industrial sphere, high share of contract research
Close contacts to research institutes in the Czech Republic.
Strong involvement of students in scientific and research activities
State-of-the-art laboratory equipment comparable to world standards

WEAK POINTS

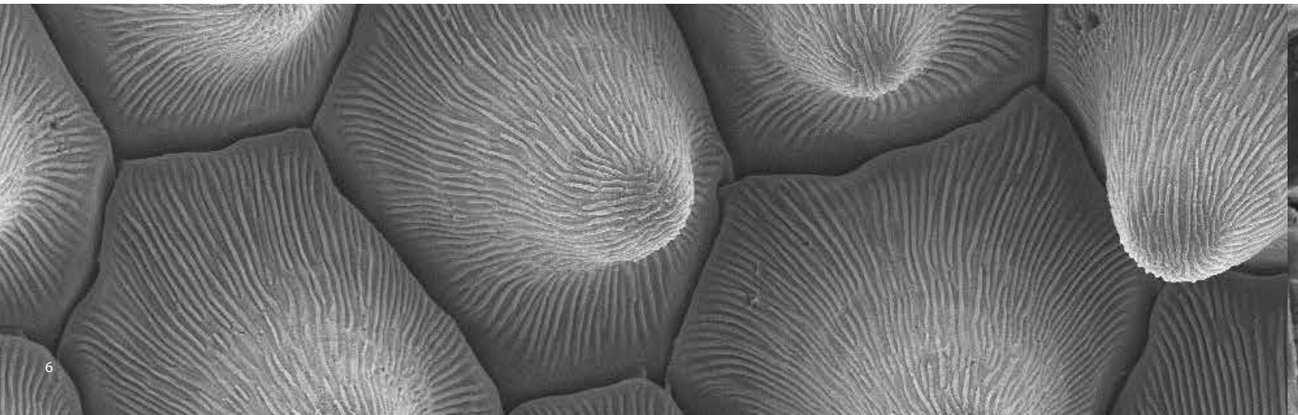
Low participation in international cooperation of science and research
Low share of funds for basic research
Low publication activity in prestigious magazines
Average mobility of teachers and students
Declining number of doctoral students
Low personnel diversity / Inbreeding
Insufficient support for the quality of RDI management and administration at TUL
High administrative burden related to research activities

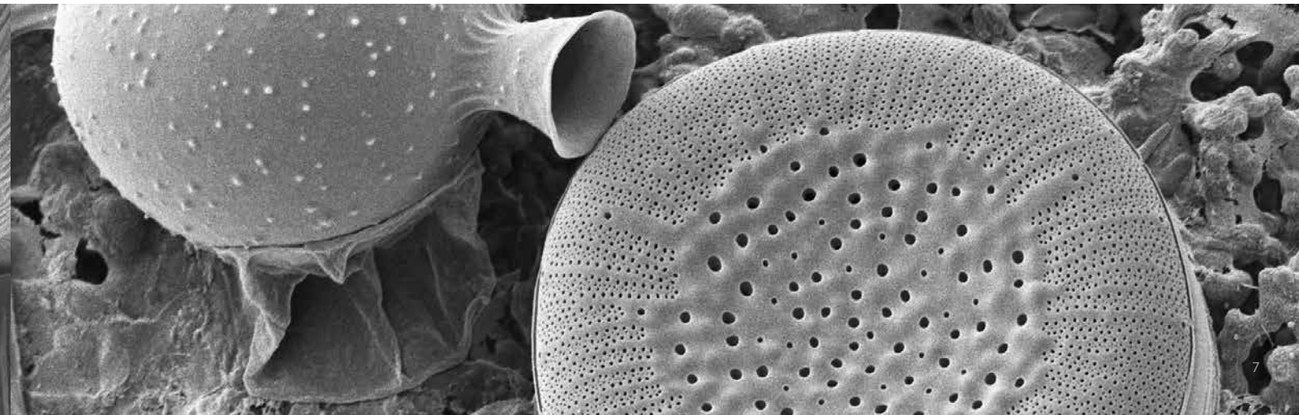
OPPORTUNITIES

Membership in the EU and strengthening the support of RDE, possibilities of cooperation with foreign institutions
Research background with strong potential for applied research and applicable results
Motivation and support of young scientists
Increased support from the industrial sector not only in applied research
Good conditions for interdisciplinary cooperation given by the structure of faculties and faculties of TUL
Investments into Hi-Tech technologies, laboratories
Rational orientation of the methodology concerning higher education evaluation
Increase in state support for technical education
Expected increase in graduates from secondary schools in the horizon of 8-10 years

THREATS

Leaving of key academics to the non-university sphere and abroad
Decrease in the level of student knowledge at all levels of the educational system
Lack of technical students
Low share of funds for free research in engineering fields
Increasing administrative burden on all processes related to the functioning of the university
Expected stagnation and economic downturn
Insufficient state support for faculties of mechanical engineering





KEY FACTORS OF RESEARCH, DEVELOPMENT, INNOVATIONS

PEOPLE

The most important and significant factor of any institution is staff. The key persons in the research teams are associate professors and professors. From the perspective of the faculty's sustainability and development, young academic staff and doctoral students in the positions of lecturers play the crucial role as well.

IDEAS AND RESEARCH QUALITY

Scientific potential is a prerequisite for research, development and innovation. It stimulates research and development with an emphasis on the quality of results and outputs, i.e. the scientific and application potential. Interdisciplinarity and multidisciplinarity in topics and research teams is a natural, inevitable and necessary requirement to meet all challenges of the 21st century. Scientific potential of the faculty is based on traditional technical disciplines on which new scientific areas are developed.

CONNECTION OF RESEARCH, DEVELOPMENT AND EDUCATION

Interconnection of various activities is the very essence of the university idea. Creative and educational activities are an integral part of work of each academic employee and a precondition for providing high-quality lecturing and teaching in accredited degree programs. Therefore, scientific research constitutes a prerequisite for effective development of study programs at the Faculty of Mechanical Engineering (FME) as well as the right of academics to educate students. The strong fact is that the faculty has accredited new study programs in all types of studies, including English accreditation. Naturally, the FME carries out some parts of study programs in the English language.

COOPERATION

The interdisciplinary approach and collaboration of scientific teams represents a logical precondition for successful scientific and research activities. Cooperation with the application sphere comprises a prerequisite and an impulse for the development of the engineering activities and social responsibility of the faculty. The challenge for the coming period is to strengthen international cooperation among research teams.

SCIENTIFIC-RESEARCH INFRASTRUCTURE

Scientific research infrastructure means the premises of laboratories and workplaces of academic staff, instrumentation and equipment of laboratories, pilot plants and information sources. The infrastructure also includes information and personnel environment supporting RDI.

FINANCIAL MEANS

Funds allocated and earned for research activities are another indicator of the nature, scope and quality of research activities. The funding of science, research and innovation represent a multi-source. The importance of available funds for research and development continues to prevail over funding for the education. Strengthening institutional support in relation to the volume of funding for research activities is a key condition for quality research activities.

LONG-TERM OBJECTIVES IN THE FIELD RDI ➟ PROPOSITION OF STRATEGIC MEASURES

HUMAN RESOURCES AREA

From the personnel point of view, the Faculty of Mechanical Engineering is stabilized. Age structure is at a very good level. In 2019, the situation looks as follows: approx. 150 workers, approx. 120 recalculated. There are about 13 FTE professors, 21 FTE associate professors, 41 FTE lecturers (Ph.D.), 12 FTE researchers, 33 other FTE. As for the development of the faculty, it is necessary to proportionally strengthen some research workplaces by young academics, ideally from the outside or from other parts of the university. It is desirable to increase internationalization and international mobility of the staff and also strengthen its diversity.

OBJECTIVES

- Increase of academic staff by around 20 %
- Increase of doctoral students by around 30 %
- Increase of personnel diversity of the faculty, i.e. incoming of new academic staff

MEASURES

- Support and motivation of young researchers
- Support of scientific growth and engagement of postdocs into R&D activity
- Strengthening students´ mentorship standards in doctoral degree programs
- Strengthening international standards in all areas of activities
- Open human resources politics towards heads of departments and feedback to the faculty management
- Strengthening the responsibility for fulfilling the plan about workplace development

RESEARCH AREA

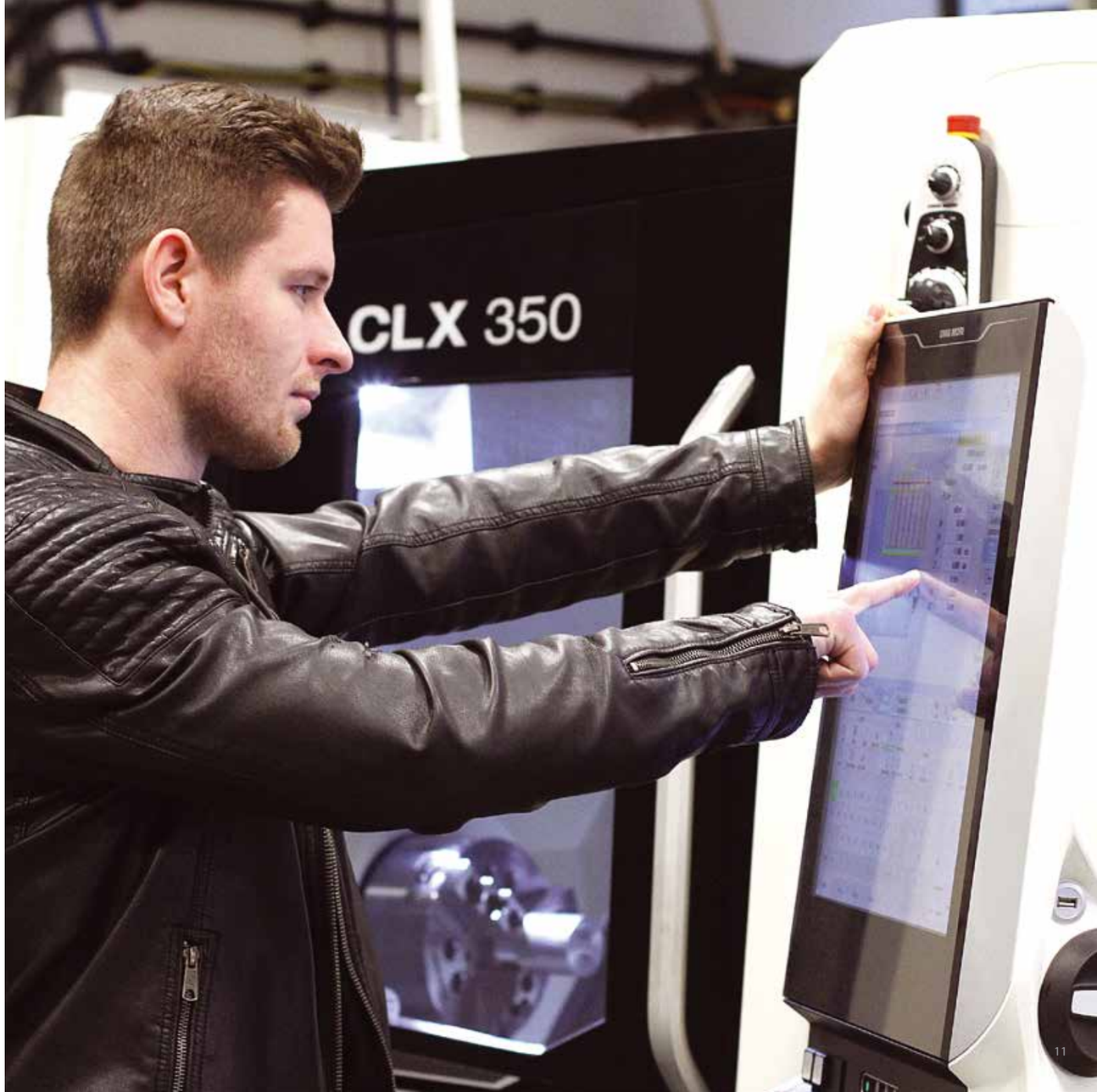
Applied research, development and innovation will also continue to be the focus of scientific research activities. Strengthening basic research, developing international scientific and research cooperation with different universities, research institutes and the application sector are essential domains for Research and Development potential. The quality indicator is constituted by the structure and numbers of results. Recent results show a trend towards increasing the number of high-quality outputs and the number of patents granted abroad.

OBJECTIVES

- Development and fulfilling research programs
- Involvement of research teams in international networks and platforms
- Participation in teams of international projects
- Strengthening the quality of results and outputs
- Increasing transfer indicators of applied results

MEASURES

- Support and motivation of workplace and employees to responsibility for publication, mobility and project activities
- Project, methodological, and publication support of academic staff and students
- Support of personal development and motivation towards qualification growth
- Supporting mobility of academics and Ph.D students
- Internationalization of activities as a space for co-authorship with foreign researchers
- Popularization of scientific research activities and results of scientific work
- Financial motivation supporting qualification growth



LONG-TERM OBJECTIVES IN THE FIELD RDI ➟ PROPOSITION OF STRATEGIC MEASURES

COOPERATION WITH APPLIED SPHERE

Cooperation with the application sphere has traditionally been one of the strengths of the Faculty of Mechanical Engineering. Quality indicators are both volume of cooperation and results of cooperation. In the area of RDI, cooperation includes collaborative research, contract research, ancillary and service activities.

OBJECTIVES

- Development and offer of new directions concerning contract research
- Maintaining contract research volume
- Strengthening quality indicators and transfer of applied results

MEASURES

- Maintaining contacts and strengthening active cooperation with graduates
- Promotion of the faculty in the area of offering scientific research topics for cooperation with the application sphere
- Popularization of scientific research activities and results of scientific work

SCIENTIFIC AND RESEARCH INFRASTRUCTURE

Recently, there has been a significant development and strengthening of R&D infrastructure as a result of Structural Funding. New laboratories have been completed and the existing ones have been gradually reconstructed. The laboratory equipment represents a high standard and corresponds with the world standard. The challenge is to maintain the pace of optimal recovery and investments in Hi-Tech technologies. Quality research requires support of administrative and managerial background, which is provided by the Department of Development and Projects Department.

OBJECTIVES

- Maintaining quality laboratory infrastructure
- Continuous upgrade of laboratories for the development of research programs
- Reduction of administrative burden related to R&D

MEASURES

- Preparation and use of European Structural Funds projects / resources
- Use of FRIM projects and funds
- Support of management of R&D management and strengthening of research and administration
- Cooperation of the faculty with the university management on development of the TUL information system and on the interconnection of individual activity management modules

FINANCING

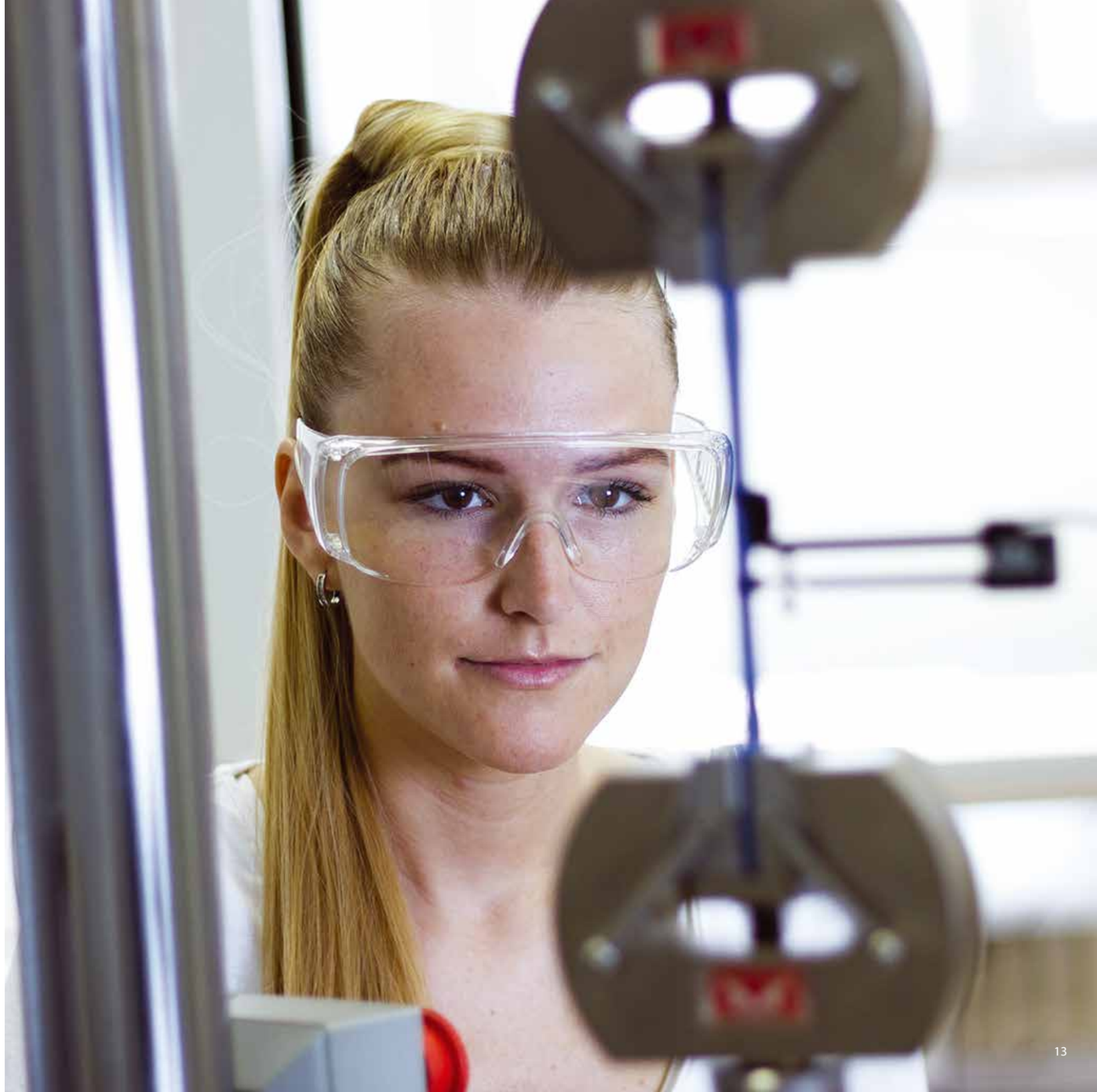
Since 2014, the percentage of funds has been increasing from projects supported by the Czech Republic budget and EU funds. Institutional support volumes have been more or less comparable in recent years. The transition to the evaluation of scientific research activities according to the M2017+ methodology will put pressure on excellent results and outputs with an impact on the funding of the Faculty's R&D.

OBJECTIVES

- Maintaining and increasing the volume of project resources
- Increase in the volume of institutional support up to 50:50 with project volume
- Improving the quality of publishing as a parameter for institutional funding

MEASURES

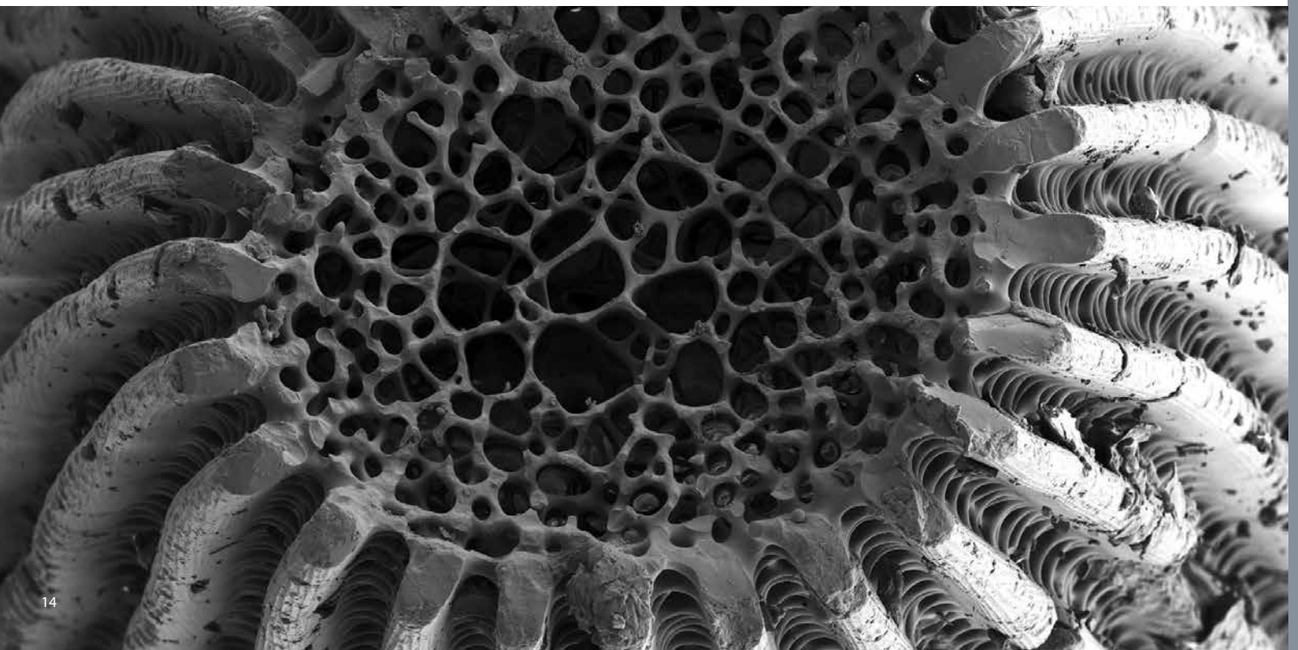
- Synthesis of these measures at the faculty level
- Cooperation between the faculty and university management on conceptual and financial instruments for R&D support
- Involvement of the Faculty in national and transnational strategic activities aimed at systemic steps to support R&D funding



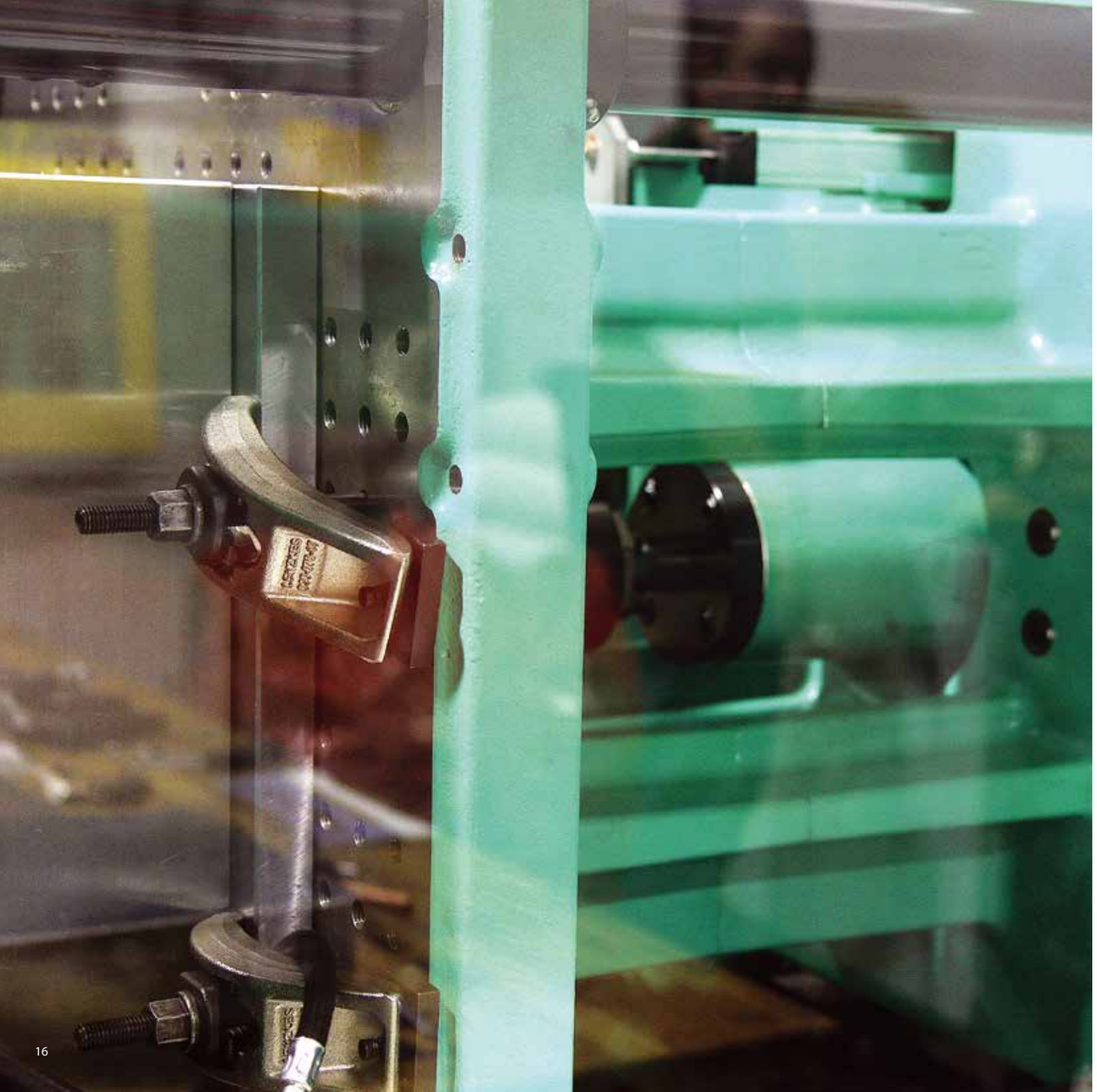
STRATEGIC PROGRAM FRAMEWORK
➡ PROGRAMS FOR RESEARCH, DEVELOPMENT, INNOVATION

Strategy RDI is based on research programs of individual workplaces and research teams. Research programs, their implementation and evaluation are both a basic tool for introducing the strategy and a platform as well as the offer for scientific and research cooperation among universities and non-university institutions.

- Synthetic and biodegradable polymer systems
- Metal materials and functional surfaces
- Expanded parts of metamaterials
- Machining of classic metal and composite materials
- Progressive materials and nanomaterials
- 3D technologies
- Artificial intelligence (machine learning)
- Automation / design
- Innovation of technical systems
- Safe and ecological means of transport
- Machines for production of fibrous and nanofibrous structures
- Single-purpose machines and equipment
- Robotization and automation in industry and service robotics
- Glass machines for 21st century
- Mechanics of intelligent materials and their thermomechanical response
- Vibroisolation
- Energy processes



LINKING RESEARCH PROGRAMS TO STRATEGIC RESEARCH FIELDS	synthetic and biodegradable polymer systems	metal materials and functional surfaces	expanded parts of metamaterials	machining of classic metal and composite materials	progressive materials and nanomaterials	3D technologies	artificial intelligence (machine learning)	automation / design	innovation of technical systems	safe and ecological means of transport	machines for production of fibrous and nanofibrous structures	single-purpose machines and equipment	robotization and automation in industry and service robotics	glass machines for 21st century	mechanics of intelligent materials and their thermomechanical response	vibroisolation	energy processes
materials, nanomaterials, composites	✓	✓	✓	✓	✓	✓			✓						✓		✓
progressive and environmental technologies and nanotechnologies	✓	✓	✓	✓		✓		✓	✓					✓			✓
sustainable transportation and mobility		✓	✓						✓	✓							
design of machines and devices						✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	
manufacturing systems, automation and robotization	✓						✓	✓	✓		✓	✓	✓	✓			
energy and renewable resources		✓								✓							✓



Research program:

SYNTHETIC AND BIODEGRADABLE POLYMER SYSTEMS

Abstract: RESEARCH AND DEVELOPMENT OF METHODS REGARDING PREPARATION AND PROCESSING OF HOMOGENEOUS AND HETEROGENEOUS POLYMER (SYNTHETIC, BIOPOLYMER) AND COMPOSITE (NANO, MICRO, LONG FIBER AND STRUCTURAL) MATERIALS. RESEARCH AND DEVELOPMENT OF MATERIAL COMPOSITIONS AND CHARACTERIZATION OF THEIR STRUCTURE AND PROPERTIES. RESEARCH ON THE PROCESSING OF MATERIALS PREPARED IN THIS WAY, INCLUDING RECYCLING AND DEGRADATION, WITH POSSIBLE APPLICATIONS TO THE DESIGN OF PARTS FOR A WIDE RANGE OF INDUSTRIES (CONSUMER, AUTOMOTIVE, SAFETY, MEDICAL, ETC.).

Research activities:

MULTIFUNCTIONAL POLYMER AND BIOPOLYMER MATERIALS

- Research on new, advanced, hybrid, hierarchical and multifunctional homogeneous and heterogeneous polymers and composites using available fillers and structures, obtained through non-traditional preparation processes from industrial and renewable sources to prepare specific materials with the desired properties.
- Characterization of material parameters, morphology and material properties for different types of fillers from nanometers through micro to macro dimensions for different application capabilities, from ultra-thin structures, light structures to standard parts.

PROGRESSIVE TECHNOLOGIES AND PROCESSES

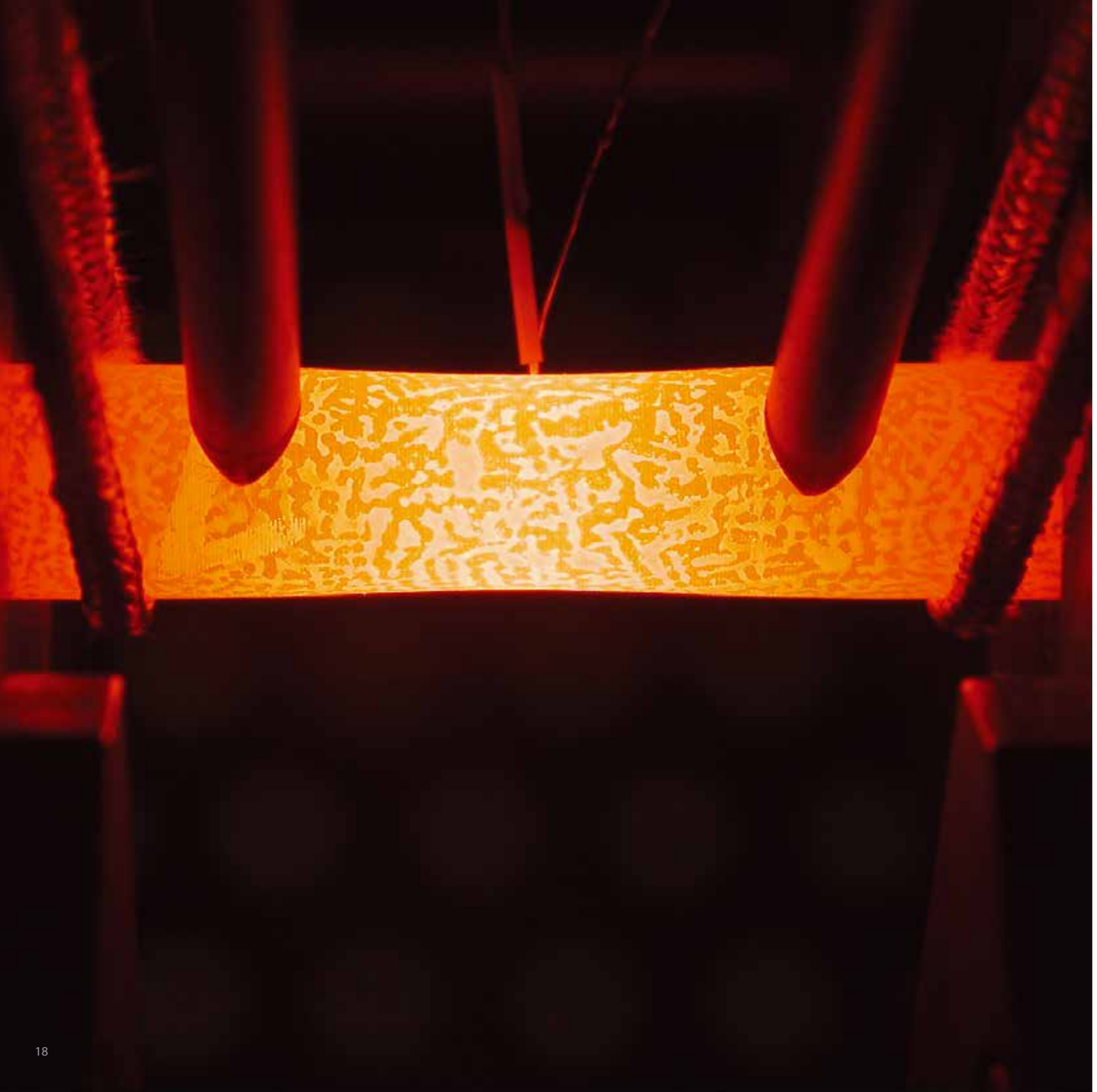
- Research in the field of standard and advanced technologies in preparation and processing of polymers and composites including monitoring and parameterization of processes in the area of pre-production stage (kneading, granulation, 3D printing) as well as in the field of processing technologies (injection molding, microcell injection molding, composite processing, machining).
- Application research of technologies and processes in processing of polymeric and bio-polymeric materials and composites for foil (2D) and solid (3D) parts.
- Research and characterization of impacts of processing technologies on final and utility properties, filler dispersion, rheology, morphology, degradation ability.

SIMULATION OF PROCESSES S RELATED TO PARTS DESIGN AND MOLDS

- Application of simulation procedures and processes in the design and construction of plastic and bioplastics parts, composites and in the design and construction of molds for processing of synthetic and biopolymer materials with prediction of defects and defects in the application of modern technological methods of processing.
- Verification of systems and results using image analysis and testing methods and tests.

DEGRADTION AND RECYCLING OF POLYMERS AND COMPOSITES

- Research on mechanisms, processes and kinetics of degradation and recycling of synthetic and biopolymer materials and composites through recycling processes, anaerobic, aerobic and climatic tests including UV radiation, bacterial and seawater environmental and health aspects.
- Research on the influence of processes and methods concerning degradation and recycling properties of synthetic and biodegradable polymers and composites with the impact evaluation on application possibilities, life of components and environmental aspects.



Research program:

METAL MATERIALS AND FUNCTIONAL SURFACES

Abstract: RESEARCH ON INFLUENCE OF TECHNOLOGICAL PROCESSES CONCERNING THE UTILITY PROPERTIES OF MATERIALS. RESEARCH OF MATERIALS INTENDED FOR HIGH-TEMPERATURE APPLICATIONS (POWER ENGINEERING, JET ENGINES, FOOD INDUSTRY), MATERIALS USED IN THE AUTOMOTIVE, RAILWAY AND AEROSPACE INDUSTRIES AND MATERIALS WITH FUNCTIONAL SURFACES (HEAT SPRAYING OF METALLIC, CERAMIC AND POLYMER MATERIALS, PLASMA NITRIDING). THE AIM IS TO ASSESS BOTH STRUCTURAL CHANGES AND CHANGES IN MECHANICAL PROPERTIES CAUSED BY THE USED TECHNOLOGY, OR TO FIND AND OPTIMIZE WORKABILITY BY SEARCHING SUITABLE PROCESS PARAMETERS OR BY USING SPECIAL TECHNOLOGIES.

Research activities:

MATERIALS FOR HIGH TEMPERATURE APPLICATIONS

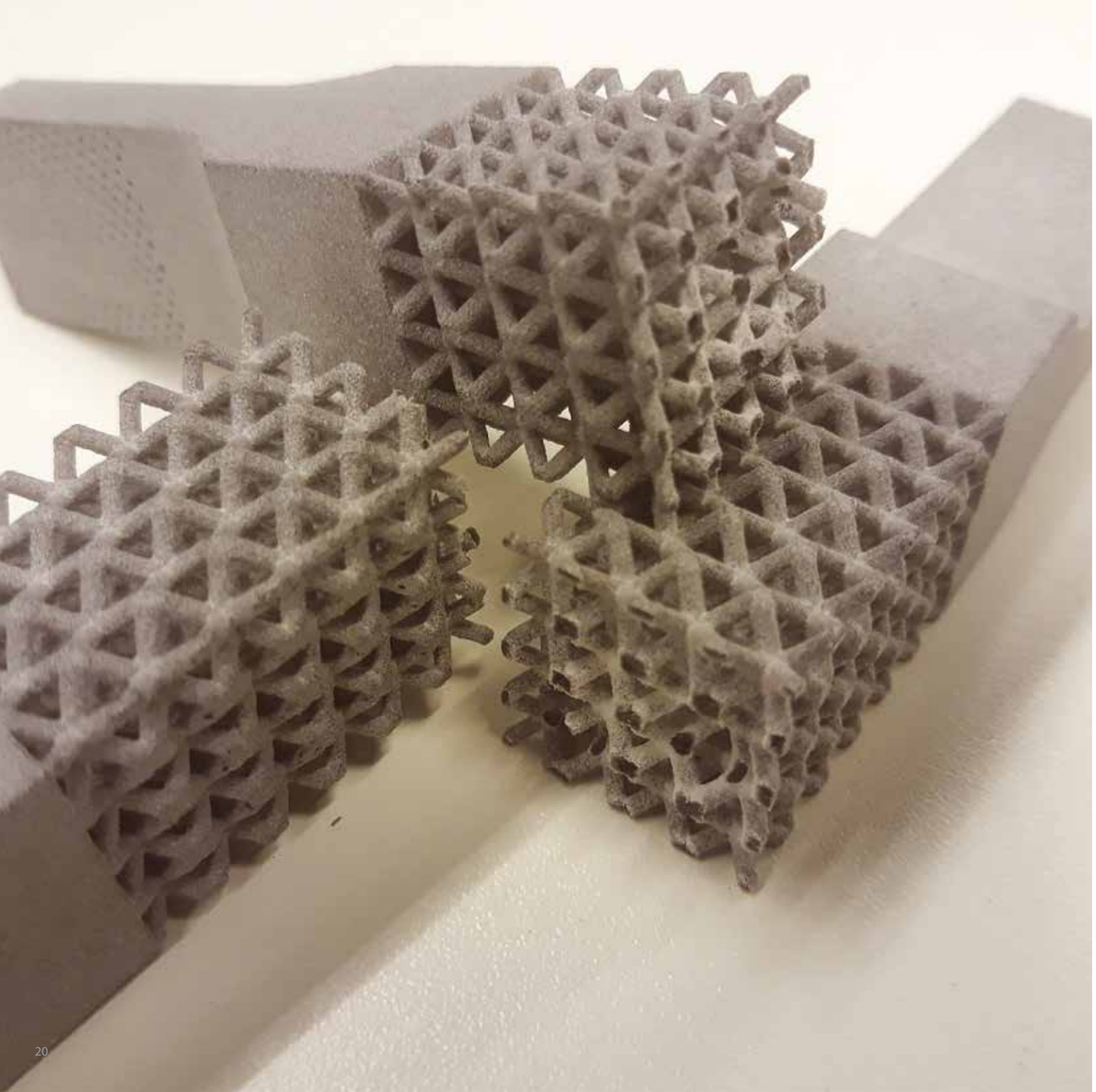
- Development of new materials in the form of intermetallic compounds for applications with increased abrasion resistance at elevated temperatures. Research aimed at improving the properties of Ni alloys and martensitic and bainitic Cr-Mo and Cr-Mo-V steels or other materials working in environments with temperatures above 450 °C.
- Optimization of welding and heat treatment processes. Study of susceptibility to hot cracks and possibilities of their prediction, thermal fatigue and applicability of special welding methods (diffusion welding). Interconnection with applicability assessment and the possibility of joining additively prepared parts with parts produced by conventional technologies and also possibility of using functional surfaces on mentioned materials.

MATERIALS FOR AUTOMOTIVE AND TRANSPORTATION

- Research on the influence of technological processing regarding utility properties of fine-grained steels, IF, TWIP and TRIP steels, Al, Ti and Mg alloys. Description of processes occurring in the materials and search for procedures in order to preserve and possibly improve the properties that the material had before the technological processing.
- Assessment of influence on different types of welding cycles, on mechanical properties changes. Studies of grain growth kinetics, impact of grain size on impact value and transformation temperatures, tensothermal effects of applied technology. Study of fatigue life of weld joints from common fine-grained and HSLA steels including possibility of prediction by Dang-Van criterion.
- Study of limit deformation states regarding new types of materials at different stress states characterizing given forming technology. Using photogrammetric methods, the kinetics of fracture formation will be studied with the emphasis on high-strength steels and Al alloys intended for processing of deep-drawing technologies. Research and definition of advanced FEM models considering anisotropic transition of material to plastic state and kinematic strengthening model.
- Research of metallurgy and crystallization of selected technical alloys. Research of heat treatment of curable Al alloys in order to determine its optimal technological parameters with respect to required properties.

MATERIALS WITH FUNCTIONAL SURFACES

- Assessment of various types of functional surfaces in terms of adhesion, functionality (hardness, abrasion resistance, corrosion resistance…) for molded, cast and additively formed parts including their combinations and assessment of surface properties at the joint boundary. Adhesion study of individual surface types and study of diffusion processes in materials, including determination of diffusion.
- Research of tribological processes and possibilities of influencing the stability during pressing by new functional and protective sheet coatings. Research in the field of increasing tool life of forming tools by targeted creation of various types of coatings in locally exposed places of tools.
- Development of new intermetallic surfaces by plasma powder welding or thermal spraying.



Research program:

LIGHTWEIGHTPARTS AND METAMATERIALS

Abstract: RESEARCH AND DEVELOPMENT OF LIGHTWEIGHT MATERIALS AND STRUCTURES CREATED BY CONVENTIONAL TECHNOLOGIES AND DEVELOPMENT OF METAMATERIALS CREATED MAINLY BY 3D PRINTING. RESEARCH OF PRODUCTION AND TECHNOLOGICAL PARAMETERS OF WORKABILITY, RESEARCH ABOUT APPLICATION OF METAL AND POLYMER FOAM STRUCTURES. RESEARCH OF METAL FOAMS, ESPECIALLY ALUMINIUM AND ITS ALLOYS. RESEARCH OF POLYMERIC FOAM STRUCTURES FROM CONVENTIONAL POLYMERS (PP, PA) OR BIOPOLYMERS (PLA, PHBV) BY MUCELL TECHNOLOGY. DEVELOPMENT OF LIGHTWEIGHT PARTS MADE BY METALLIC MATERIALS WITH SPECIFIC PROPERTIES (Ti AND Ni ALLOYS), AS WELL AS SPECIAL COMPOSITE AND BIOCOMPOSITE MATERIALS FOR TARGETED APPLICATIONS. RESEARCH OF METAMATERIALS FOCUSING ON THE USE OF NEGATIVE POISSON NUMBERS OR MATERIALS WITH MULTISTABLE BEHAVIOR. APPLIED RESEARCH OF ANALYSIS REGARDING SUITABLE MATERIALS AND THEIR PROPERTIES, DESIGN OF OPTIMIZATION STRUCTURES INCLUDING SIMULATION PROCESS AND PHYSICAL TESTING. RESEARCH AND DEVELOPMENT OF METAMATERIALS WITH UNIQUE MATERIAL PARAMETERS, SUCH AS HIGH STRENGTH / WEIGHT RATIO, THE POSSIBILITY OF APPLYING HIGH LOAD SPEEDS AND MAINTAINING ELASTIC BEHAVIOR OVER A WIDE RANGE OF DEFORMATIONS.

Research activities:

METAL AND FOAMED POLYMER STRUCTURES

- Research of lightweight metal structures and porous materials. Research on influence of parameters during direct foaming of Al and selected Al alloys (process and technological parameters, influence of mold construction). Evaluation of physical and mechanical properties regarding obtained structures including conditions of its application.
- Research of foamed polymer structures, microcell injection and chemical foaming of multifunctional polymer systems with inactive gases in terms of shape and dimensional stability of lightweight parts, their stress, physical properties, but also stability of the production process.

META MATERIALS

- Research and development of parts with variable physical and mechanical properties in the field of metallic materials and plastics. Transient effects of metamaterials in a very specific area of deformation of a given structure. Research on increasing the absorption capacity of a given material / structure. The main technology will be 3D printing, also with the effort to develop sandwich structures made up of different sub-components and connected, e.g. by diffusion.

Research program:

MACHINING OF METAL AND COMPOSITE MATERIALS

Abstract: RESEARCH ON TECHNOLOGY REGARDING MACHINING CLASSICAL METAL AND COMPOSITE MATERIALS IN TERMS OF CUTTING CONDITIONS AND THEIR OPTIMIZATION. CUTTING TOOLS AND MACHINED MATERIAL, EVALUATION OF TECHNOLOGICAL CHARACTERISTICS CONCERNING PROCESS LIQUIDS WITHOUT ENVIRONMENTAL IMPACT, EVALUATION AND OPTIMIZATION OF TOOLS WITH DEFINED AND UNDEFINED CUTTING GEOMETRIC STABILITY AFTER MACHINING PROCESS.

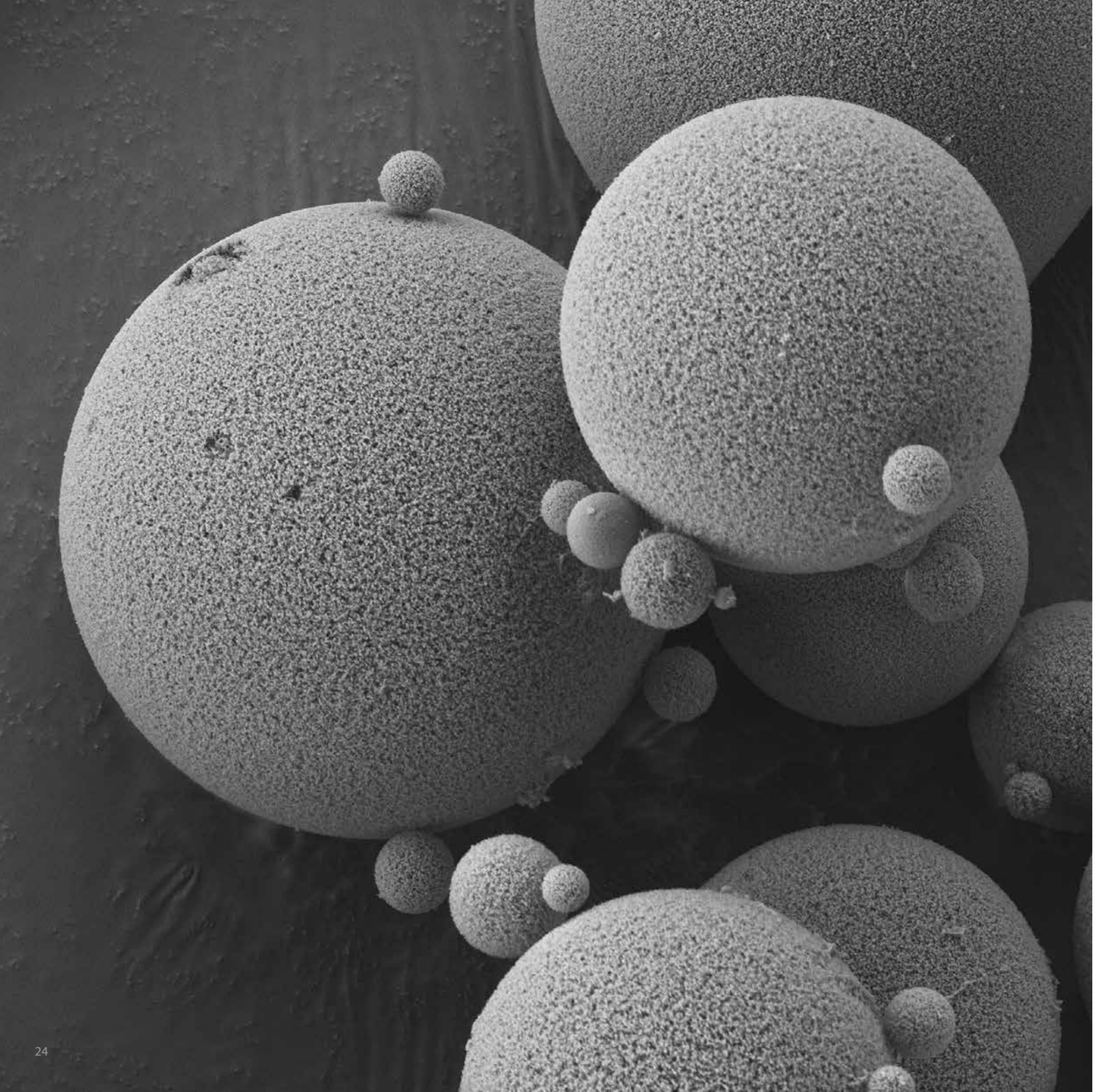
Research activities:

MACHINING OF CLASSICAL METAL MATERIALS

- Research and evaluation of technological characteristics and reliability of cutting tools.
- Evaluation of technological characteristics of process liquids.
- Determination of cutting conditions and their optimization in terms of cutting tool and machined material.
- Evaluation of chip forming during machining with tools with defined and undefined cutting geometry.

MACHINING OF COMPOSITE MATERIALS

- Research on machining of composite materials with different matrix and types of fillers.
- Determination of cutting conditions and their optimization in terms of cutting tool and machined composite material.
- Evaluation of technological characteristics concerning process liquids for composite material machining.
- Evaluation and optimization of tools with defined and undefined cutting geometry for composite material machining.
- Evaluation of surface quality and dimensional stability after machining of composite materials.



Research program:

PROGRESSIVE MATERIALS AND NANOMATERIALS

Abstract: RESEARCH OF METALLIC AND NON-METALLIC MATERIALS, THEIR PROPERTIES AND STRUCTURES IN TERMS OF APPLICATION REQUIREMENTS AND NEEDS OF THE INDUSTRIAL SPHERE. FUNCTIONALIZATION OF SURFACES USING PHYSICAL, CHEMICAL, THERMAL AND COMBINED PROCESSES TO ACHIEVE NEW UTILITY PROPERTIES IN INDUSTRIAL PRACTICE. RESEARCH OF NANOMATERIALS AND NANOTECHNOLOGIES TO INCREASE THE EFFICIENCY OF TECHNICAL APPLICATIONS.

Research activities:

HIERARCHICAL STRUCTURES

- Research and development of materials in the atomic ordering - nanomaterials. Thin layers increasing utility properties. Study of biological materials - bionics, bio-mimetics.
- Creation of nanostructures (nanoparticles, nanofibers, nanostructures and nanocomposites) and evaluation of their interaction with biological systems. Searching for the application potential of nanostructures with regard to the risks of their deployment.
- Characterization of material parameters, morphology and properties via analytical methods - SEM, AFM, TA, LM (optical, digital and confocal), image analysis of structures, evaluation of physical, chemical, biological and mechanical properties.

MATERIALS WITH SPECIFIC PROPERTIES

- Research on preparation of composite systems mainly based on geopolymers. Study of behavior regarding metallic and non-metallic systems with high thermal, chemical and mechanical resistance. Application of secondary raw materials as fillers of composite systems. Application potential of geopolymer composites in construction, transport systems, glass industry and ecology.
- Research of intermetallic compounds - iron aluminides, i.e. materials with high thermal and chemical stability. Research on mechanisms, processes and kinetics of degradation regarding extremely stressed parts and evaluation of impacts on application possibilities and service life.
- Proposals for recycling of new material systems, including the possible use of waste in composites. Research concerning environmental impacts.

Research program:

3D TECHNOLOGY

Abstract: RESEARCH IN THE FIELD OF NON-CONTACT 3D DIGITIZATION, RESEARCH INTO THE ACCURACY OF 3D PRINTER PRODUCTION FOR TODAY'S ADVANCED TECHNOLOGIES SUCH AS SLS, SLA, FDM, POLYJET MATRIX, SLM ETC. RESEARCH AND COMPLEX ANALYSIS OF BOTH DIMENSIONAL AND SHAPE ACCURACY OF PARTS PRODUCED ON SELECTED 3D PRINTERS. APPLIED RESEARCH AND DEVELOPMENT IN THE FIELD OF MEASUREMENT CONCERNING MANUFACTURED MODELS. USING MODERN OPTICAL METHODS OF DIGITIZATION BY MEANS OF CONTACTLESS 3D SCANNERS INCLUDING SUBSEQUENT DATA EVALUATION AND REAL PART VERIFICATION AGAINST THE NOMINAL CAD MODEL FOR DIFFERENT INDUSTRIES.

Research activities:

RESEARCH AND USE OF 3D OPTICAL DIGITIZATION IN THE QUALITY CONTROL AND INNOVATION

- Research on digitization and data processing techniques.
- Research on the influence of factors concerning accuracy of optical 3D digitization.
- Research on automation regarding inspection processes while using 3D optical scanning.

RESEARCH IN THE ARE OF ADDITIVE TECHNOLOGIES / 3D PRINTING

- Research in the field of 3D printing of photo-polymer materials (3D printing of ceramics, glass, graphene, biogel, etc.)
- Research in the field of topological optimizations (maximum utilization of 3D printing potential in the design of parts.)
- Research in the area of FFF technology (individualization of 3D printer design for given thermoplastic materials with admixture or filler).
- Research in the field of metallic 3D printing.
- Research in the field of auxetic structures for the purposes of damping.
- Research in the field of bio-printing.
- 3D printing research in building construction.

Research program:

ARTIFICIAL INTELLIGENCE (MACHINE LEARNING)

Abstract: RESEARCH AND DEVELOPMENT ON MODELING BASIC ELEMENTS OF PRODUCTION SYSTEMS - EQUIPMENT, HUMAN AND PROCESS. RESEARCH IN THE AREA OF DESIGN REGARDING AUTONOMOUS PRODUCTION SYSTEMS, THEIR CONTROL BY MEANS OF ARTIFICIAL INTELLIGENCE ELEMENTS AND OPTIMIZATION BY HEURISTIC ALGORITHMS. DEVELOPMENT AND APPLIED RESEARCH OF MODERN ELEMENTS CONCERNING MANUFACTURING SYSTEMS - DIGITAL TWIN, IOT, VIRTUAL / AUGMENTED REALITY, SIMULATION, OPTIMIZATION AND DECISION ALGORITHMS TO SUPPORT PRODUCTION PLANNING, SCHEDULING AND PRODUCTION MANAGEMENT. RESEARCH AND APPLICATION OF RESULTS IN A WIDE AREA OF AUTOMATION OF PRODUCTION SYSTEMS, ESPECIALLY IN THE DEVELOPMENT OF ENTERPRISE INFORMATION SYSTEMS, IN THE DEVELOPMENT OF DIGITAL FACTORY TOOLS AND AUTONOMOUS PRODUCTION AND LOGISTICS SYSTEMS.

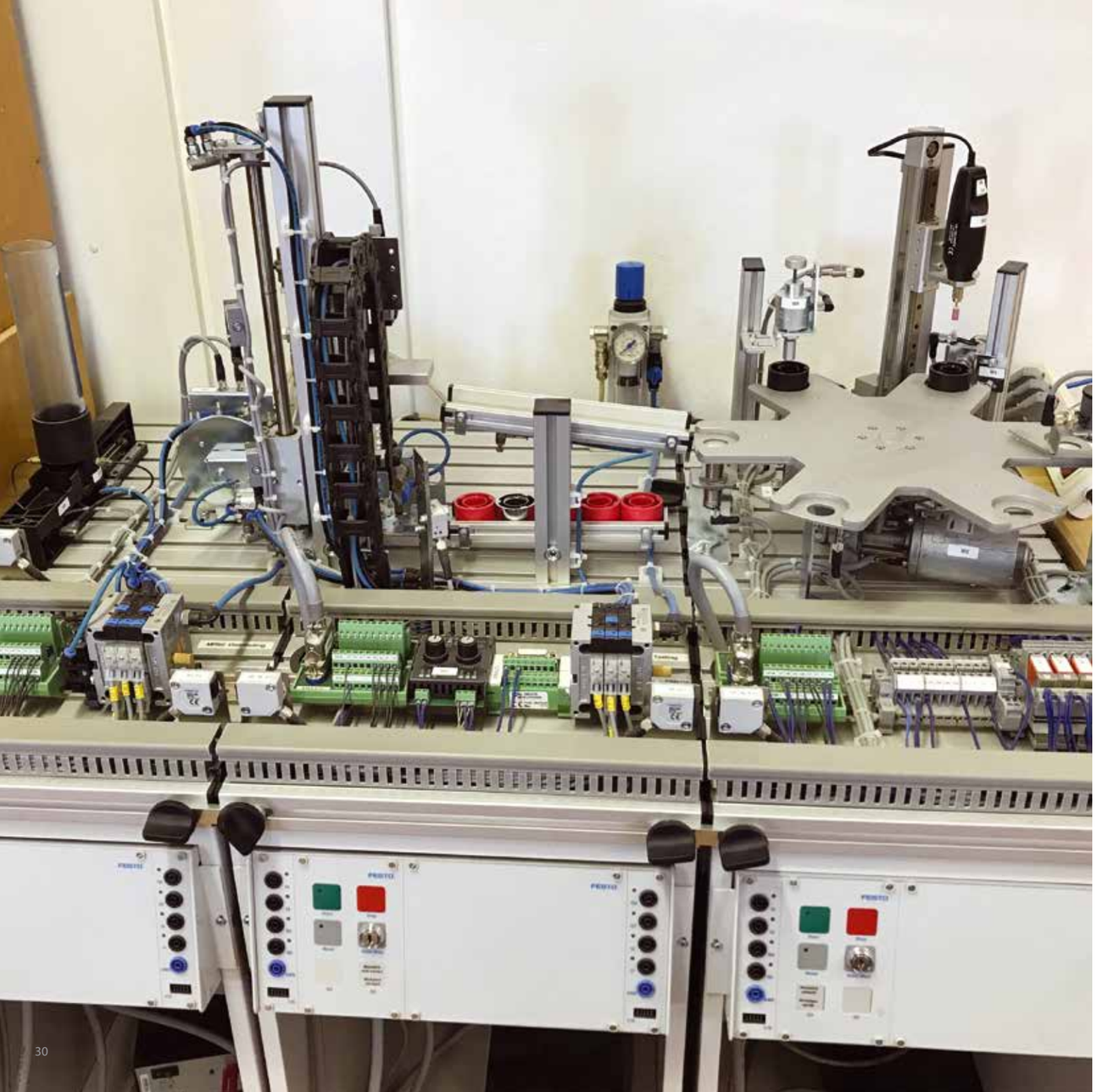
Research activities:

ANALYSIS, MODELING AND SIMULATION OF PRODUCTION PROCESSES (Digital Twins)

- Research on relationships and interactions between man, machine, computer model and real system.
- Motion analysis - MOCAP, modeling and reproduction of movement of machinery, people and systems.
- Research in the field of virtual commissioning of machines and equipment, remote or assisted operation and service of equipment, using digital twin, virtual (VR) or augmented reality (AR / XR).
- Creation of computational model - digital twin of any CNC machine in order to find dynamic parameters of „unknown" machine and then recalculate real machining time for given NC program.
- Application of 3D models for assessment and optimization in the field of movement economics and work ergonomics.
- Creation of simulation models regarding production systems with real constraints.

DESIGN AND MANAGEMENT OF AUTOMATIC PRODUCTION SYSTEMS (IoT, VR, AR/XR, EA)

- Development of autonomous manufacturing and logistics systems within Industry 4.0 mainly by IoT and mobile devices. Creating system modules and IoT connecting modules to each other.
- Optimization of control algorithms regarding individual parts, minimization of the amount of transmitted data and communication between all members of the system.
- Development of optimization (EA) and control algorithms. Application to real problems in production systems.
- Development of systems for autonomous control of optimization parameters concerning advanced (EA) optimization algorithms (generally for combinatorial and process problems).
- Research in the area of control and design about production systems using the application of Robot Process Automation (RPA), Artificial Intelligence, Virtual (VR) or Augmented Reality (AR / XR).
- Creation of new tools not only for information transfer in process management, logistics, production and education of employees using mobile platforms, VR, video mapping etc.



Research program:

AUTOMATION / CONSTRUCTION

Abstract: RESEARCH IN THE FIELD OF CONTROL AND APPLICATIONS IN CONTROL OF SPECIAL EXPERIMENTAL, MECHATRONIC APPLICATIONS IN COOPERATION WITH OTHER TUL DEPARTMENTS. CONSTRUCTION OF BIOREACTOR FOR DYNAMIC CELL CULTURE. CONSTRUCTION OF EQUIPMENT FOR PRODUCTION OF NANOFIBRES BY ELECTROSPINNING METHOD ON ROTATING COLLECTOR. DEVELOPMENT OF EQUIPMENT FOR PRODUCTION OF NANOFIBROUS YARNS AND THEIR OPTIMIZATION FOR OPHTHALMIC IMPLANTS. DEVELOPMENT OF POLYMER DOSING EQUIPMENT FOR PRODUCTION SYSTEM OF NANOFIBROUS YARNS. AUTOMATION OF PRODUCTION LINE OF MULTILAYER NANOFIBROUS TUBULAR STRUCTURES. IDENTIFICATION AND AUTOMATIC CONTROL OF MECHANICAL DYNAMIC SYSTEMS, SHOCK ABSORBERS, SPRINGS, PNEUMATIC AND HYDRAULIC SYSTEMS.

Research activities:

RESEARCH AND CONSTRUCTION OF SPECIAL EXPERIMENTAL EQUIPMENT, MECHATRONIC SYSTEMS, ROBOTIC APPLICATIONS

- Development of construction of complex devices for production of nanofibres by electrospinning method on rotating collector.
- Innovation of previously designed and implemented nano (micro) fiber production equipment.
- Development of bio cultivator for tissue culture.
- Development of equipment for synthetic biology (microfluidics).

RESEARCH IN LIQUID MECHANISMS

- Development and construction of autonomous device based on artificial pneumatic muscles, robotic device with elements of artificial intelligence.
- Research of pneumatic muscle control in interaction with adaptive controllers including implementation of artificial intelligence elements.

RESEARCH IN ACTIVE VIBRATION SOFTENING

- Development of ambulance beds. Development of a new version of active ambulance.
- Research on impact of shock-absorber description regarding the methodology of shock-absorber testing and design of new testing solutions.
- Development of the seat control system with variable stiffness. Development of improved control algorithms based on frequency analysis of the road signal.

RESEARCH AND DEVELOPMENT IN THE FIELD OF DRONES

- Development of drone construction, optimization of algorithms (topology), 3D printing.
- Research to increase drone safety in civilian environment.
- Research on the use of drones in military, police and firefighters.
- Research on the use of artificial intelligence (Bayesian networks) for drone control.
- Drone development on a simple microprocessor and its use for testing and research (various control options, application of algorithms).

Research program:

INNOVATION OF TECHNICAL SYSTEMS

Abstract: RESEARCH ACTIVITIES IN THE FIELD OF PRODUCT INNOVATION AS WELL AS MACHINES, EQUIPMENT AND GENERAL TECHNICAL SYSTEMS TO INCREASE THEIR VALUE OR EFFICIENCY WITH AN EMPHASIS ON ECOLOGY. DEVELOPMENT ACTIVITIES USING SPECIFIC METHODS OF INNOVATIVE ENGINEERING, E.G. TRIZ TYPE, PATENT ANALYSIS, ETC., WHICH WILL LEAD TO EFFECTIVE ACHIEVEMENT OF TECHNICAL INNOVATIONS IN VARIOUS FIELDS OF TECHNOLOGY. RESEARCH AND DEVELOPMENT OF MACHINE AND EQUIPMENT STRUCTURES MADE OF NEW MATERIALS, COMPOSITES, ESPECIALLY WITH FOCUS ON LIGHT STRENGTH STRUCTURES.

Research activities:

EVELOPMENT OF COMPONENTS, SYSTEMS, TECHNOLOGIES FOR AUTOMATIC SYSTEMS AND MECHANISMS

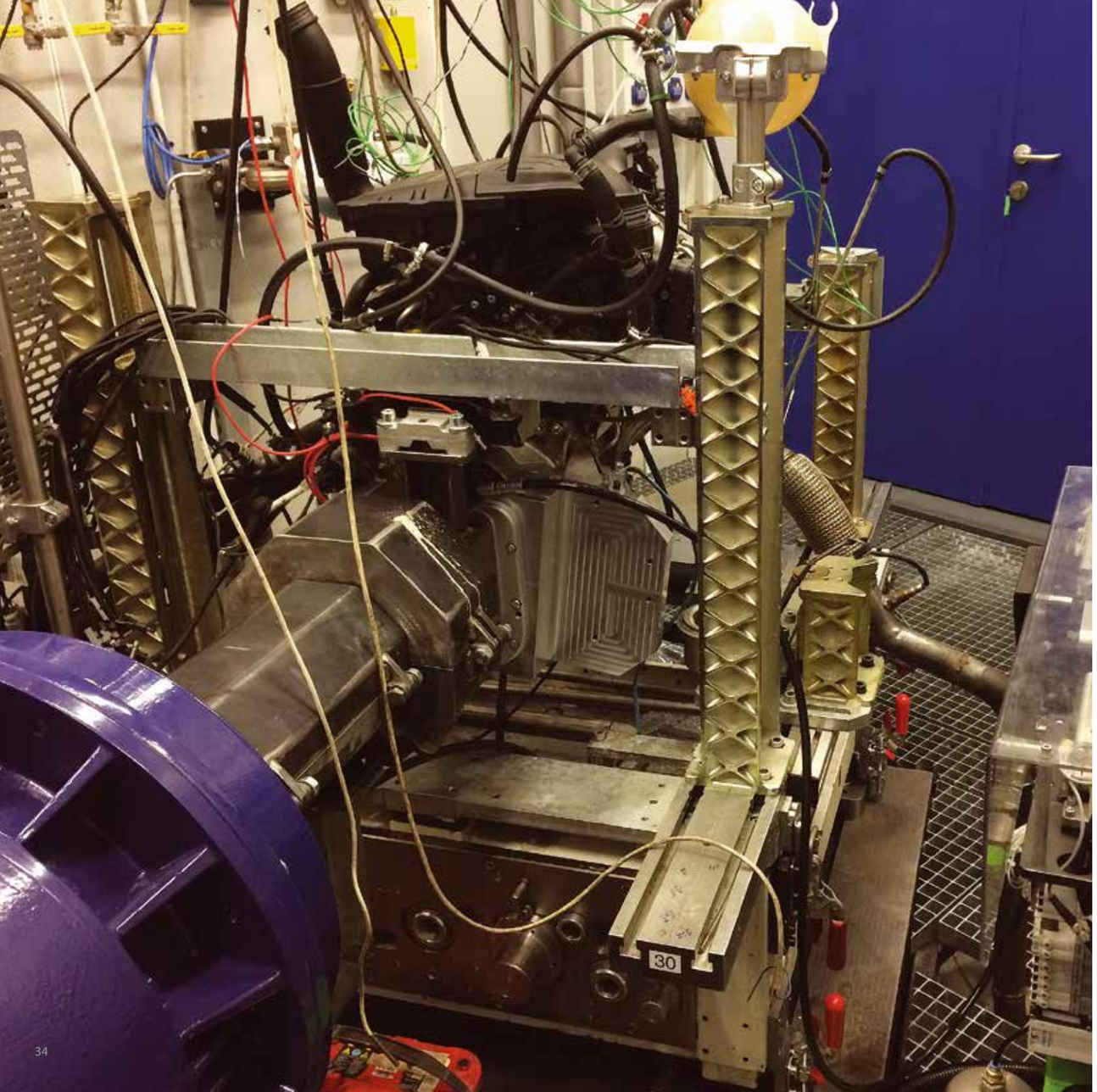
- Development and optimization of advanced construction systems, mechanisms and technologies with mechatronic elements.
- Research, testing, design and optimization of components and mechanisms for the industrial sector (conveyor and frame constructions, flexible supports, vibro-diagnostics and others).
- Research and testing of parts, components and complete car seats (comfort and safety).
- Design of advanced mechatronic systems, autonomous control.
- Electromobility, renewable energy - construction.
- Development of autonomous transport and storage systems.

DEVELOPMENT OF COMPONENTS, SYSTEMS, TECHNOLOGIES FOR LIGHT STRUCTURES WITH REDUCED ENVIRONMENTAL IMPACT

- Research, development and innovation of products and new technologies for industrial use that will significantly reduce the energy intensity of production (focused on usage of light material structures, composite structures, waste, recycled and recyclable material structures). Their application in the transport and manufacturing industry.
- Replacement of classic parts with new materials - change in design and technology.
- Designed to reduce carbon footprint, water, energy and CO_2 consumption.
- Construction of machine parts new, e.g. light or high-strength materials.
- Construction of parts from materials based on recycled or renewable sources.

RESEARCH AND DEVELOPMENT OF AUTOMATED SYSTEMS FOR INDUSTRY 4.0

- Research and development and optimization of advanced construction systems, mechanisms and technologies with mechatronic elements for transformation of energy forms, its accumulation and distribution.
- Solving of complex problems for which it is necessary to create comprehensive and well-founded syntheses (theoretically, simulated and experimentally based syntheses).
- Development of tools for systematic innovation and creativity.
- Elaborate Life-Cycle approaches and integrate them into transport systems.
- Application of new DFX methods in the development of systems for Industry 4.0



Research program:

SAFETY AND ENVIRONMENTAL TRANSPORT EQUIPMENT

Abstract: RESEARCH AND DEVELOPMENT OF SYSTEMS TO PROMOTE EFFECTIVE MOBILITY WITH A VIEW TO OPTIMIZING ENERGY CONVERSION AND TRANSMISSION IN POWER UNITS AND OTHER VEHICLES, MOBILE MACHINERY OR ENERGY EQUIPMENT TO INCREASE COMPETITIVENESS AND REDUCE ENVIRONMENTAL BURDENS. RESEARCH AND DEVELOPMENT OF SYSTEMS ENSURING A HIGHER DEGREE OF SAFETY AND COMFORT OF MOBILITY.

Research activities:

DRIVING SYSTEMS FOR TRANSPORT AND INDUSTRY

- Research on new methods for optimizing the working cycle of reciprocating internal combustion engines with the aim of increasing efficiency and reducing "pollutant emissions". Use of new types of energy carriers produced from renewable sources.
- Research of the hybrid arrangement of the powertrain of a car using an internal combustion engine, electric motor and energy storage.
- Research of innovative powertrain accessory components to reduce weight, mechanical loss and force interaction. E.g. electronic control of valves with high control variability, use of sliding and insulating coatings of nanomaterials.
- Research and development of advanced gearboxes, inter-axle clutches and differentials for powertrain and mobile power applications with high power transmission efficiency, comfort control and low noise.

VEHICLES AND THEIR SYSTEMS

- Research into new vehicle chassis concepts with advanced systems and integrated steering for driving dynamics and stability, vehicle safety and driving comfort.
- Research of autonomous driving methods and systems providing a higher level of driving safety in interaction with the surrounding environment.
- New and advanced means to increase the acoustic comfort of the crew.

EXPERIMENTS AND DIAGNOSTICS

- New methods and experiments aimed at analyzing events that have a negative impact on the environment. Computer experiments - modeling and simulation of vehicles and its subsystems.
- New diagnostic methods for identifying the characteristics and parameters of powertrains and other devices affecting vehicle performance and interaction with the environment.
- Research and solution of vibration and noise problems with emphasis on optimization of construction parameters, relation to valid legislation and compliance with Industry 4.0 and automotive industry requirements.
- Research and development of materials with emphasis on sound absorption. Measurement of sound absorption in impedance tube and alpha-cabin.
- Application research and implementation of predictive maintenance principles of machines with a focus on vibration disassembly diagnostics.

Research program:

MACHINES FOR MANUFACTURING FIBER AND NANOFIBER STRUCTURES

Abstract: RESEARCH AND DEVELOPMENT OF NEW ADVANCED STRUCTURES OF TEXTILE MACHINES. APPLIED RESEARCH OF CONTROLLED DRIVES AND MECHATRONIC ELEMENTS IN MACHINE DESIGN. THEORETICAL AND EXPERIMENTAL RESEARCH OF DYNAMIC PROPERTIES OF HIGH-SPEED MECHANISMS OF MACHINES AND EQUIPMENT WITH MATERIAL, SHAPE AND STRUCTURAL OPTIMIZATION OF SELECTED MACHINE SUBSYSTEMS IN TERMS OF THEIR IMPACT ON PRODUCTION PROCESSES. RESEARCH IN THE FIELD OF SPINNING MACHINES, MACHINES FOR PRODUCTION OF FELT HEADGEAR, SEWING MACHINES, WINDING AND UNWINDING SYSTEMS OF MACHINES. RESEARCH AND DEVELOPMENT OF NEW MACHINERY AND PRODUCTION LINES FOR PRODUCTION OF LINEAR, FLAT AND SPATIAL NANOFIBROUS FORMATIONS. FOCUS OF RESEARCH ACTIVITIES ON SPINNING TECHNOLOGIES UNDER THE INFLUENCE OF ELECTRIC CURRENT (AC AND DC ELECTROSPINNING) AND THE EFFECT OF CENTRIFUGAL FORCES (FORCE SPINNING).

Research activities:

MACHINES AND EQUIPMENT FOR MANUFACTURING OF FIBER STRUCTURES

- Machinery and equipment for the preparation of semi-finished products for the manufacture of felt products with a focus on machines and equipment for the technology of felting, fulling and other finishing operations, technologies and equipment for the preparation of a rabbit hair sliver.
- High speed yarn winding and unwinding system for spinning machines. Research process of ballooning yarn.
- Research and development of sewing machine mechanisms using controlled drives and mechatronic elements, development of nodes of sewing machines and single-purpose sewing machines.
- Research and development of winding and unwinding systems of fiber structures including the process of construction of winding.
- Development of new machine structures enabling a higher level of process automation.
- Modeling and simulation of mechanical nodes and mechatronic systems of machines, investigation of technological processes through modeling and simulation of physical fields and with the support of experimental development.

MACHINERY AND EQUIPMENT FOR MANUFACTURING OF NANOFIBER STRUCTURES

- Research and development of technologies, new machinery and operating lines for production of linear, surface and spatial nanofibrous structures under the influence of electric current (mostly AC electrospinning).
- Research and development of technologies and equipment for production of linear, areal and spatial nanofibrous structures by centrifugal forces.
- Research, development and optimization of subsystems of machines and equipment for preparation of nanofibrous materials for biomedical, hygienic, filtration, etc. applications.
- Theoretical and experimental analysis of spinning process, electrostatic field intensity simulation and other phenomena in spinning process.

Research program:

SINGLE-PURPOSE MACHINERY AND EQUIPMENT

Abstract: RESEARCH AND DEVELOPMENT OF NEW STRUCTURES OF SINGLE-PURPOSE MACHINES AND EQUIPMENT WITH EMPHASIS ON THE USABILITY OF RESEARCH RESULTS IN PRACTICE. THEORETICAL RESEARCH USING MODELING AND SIMULATIONS AND EXPERIMENTAL DEVELOPMENT WITH THE AIM TO FIND NEW STRUCTURES OF MACHINES AND EQUIPMENT FOR SELECTED INDUSTRIES (E.G. AUTOMOTIVE, TEXTILE, ELECTRICAL, MINING, ETC.) USING CONTROLLED DRIVES AND MECHATRONIC ELEMENTS. RESEARCH AND DEVELOPMENT OF SINGLE-PURPOSE DEVICES FOR AUTOMATIC HANDLING OF TEXTILE INTERMEDIATES USING ROBOTS AND MANIPULATORS.

Research activities:

RESEARCH AND DEVELOPMENT OF NEW STRUCTURES CONCERNING SINGLE-PURPOSE MACHINES WITH THE APPLICATION OF CONTROLLED DRIVES AND MECHATRONIC ELEMENTS

- Research and development of automatic machine for winding self-supporting bottom bobbins for industrial sewing machines.
- Development of automatic devices for sampling of biomass and solid fuels from the running belt surface.
- Development of new structures of machines enabling a higher degree of process automation (e.g. development of input equipment for the line for production of hybrid tapes, development of creasing machine etc.
- Development of dedicated measuring devices (eg measuring device for determining the thickness of the honeycomb, etc.).
- Simulation of machine behavior using assembled mathematical models (strength, deformation and stress analyzes, analyzes and optimization in the field of mechanisms, analysis of physical fields, etc.).
- Experimental support of machine design (verification of mathematical models using experiments, measurement of selected force and kinematic quantities by contact and non-contact methods, analysis of high-speed processes using a speed camera etc.)

RESEARCH, DEVELOPMENT AND CONSTRUCTION OF SINGLE-PURPOSE DEVICES FOR AUTOMATIC HANDLING OF TEXTILE PRODUCTS

- Research and development of machines for automatic manipulation with lower bobbins in sewing machines.
- Research and development of automatic robotic textile handling equipment.
- Research and development of robotic skin handling equipment for rabbit skins.

Research program:

ROBOTIZATION AND AUTOMATION IN INDUSTRY AND SERVICE ROBOTICS

Abstract: DEVELOPMENT OF INDUSTRIAL AND SERVICE ROBOTS FOR SPECIAL APPLICATIONS. DEVELOPMENT AND SYSTEM INTEGRATION OF HANDLING EQUIPMENT AND INDUSTRIAL ROBOTS INTO ROBOTIZED TECHNOLOGICAL WORKPLACES. RESEARCH AND DEVELOPMENT OF NEW TYPES OF EFFECTORS (GRIPPING AND TECHNOLOGICAL HEADS) OF ROBOTS. RESEARCH AND DEVELOPMENT OF SPECIAL GRIPPING HEADS FOR HEAVY DUTY AND SPECIAL OPERATING CONDITIONS (WITH INCREASED TEMPERATURE, INCREASED DUST, VACUUM ETC.) SUPPORTED BY NUMERICAL SIMULATIONS. DESIGN OF GENTLE HANDLING OF FRAGILE, HOT AND UNSTABLE OBJECTS, HANDLING OF COMPLEXLY SHAPED OBJECTS. RESEARCH OF METHODOLOGY AND DEVELOPMENT OF ALGORITHMS, SOFTWARE AND HARDWARE FOR EVALUATION OF PRODUCTION QUALITY, ACQUISITION AND INTERPRETATION OF 2D AND 3D IMAGES OF DIFFICULT TO DETECT OBJECTS. DEVELOPMENT AND APPLICATION OF MECHATRONIC SYSTEMS FOR SPECIFIC APPLICATIONS.

Research activities:

ROBOTIC MANIPULATION AND EFFECTORS

- Research and development in the field of robotic handling of less common objects due to their weight, temperature, brittleness, shape instability or shape complexity or to special environments such as elevated temperature, dust or vacuum.
- Development and system integration of handling equipment and industrial robots into robotized technological workplaces.
- Research and development of new types of robot effectors (gripping and technological heads).
- Support of research and development using numerical simulations.

OBTAINING 2D AND 3D IMAGES OF DIFFERENT DETECTABLE OBJECTS

- Research and development of methodologies for obtaining and interpreting 3D images of difficult to detect objects (glossy surfaces, surfaces with parasitic reflections, objects made of transparent materials or materials with subsurface light scattering and others).
- Research of methodologies for obtaining image data using electromagnetic radiation outside the visible spectrum (infrared and ultraviolet electromagnetic radiation), mechanical waves (ultrasound) and other physical fields for the subsequent interpretation of 2D and 3D images and quality evaluation. Development of applications for industrial use.

SERVICE ROBOTICS AND MECHATRONIC SYSTEMS FOR SPECIFIC APPLICATIONS

- Application of service robots for difficult and specific surfaces, in difficult conditions, in dangerous areas.
- Research and development of mechatronic systems for medical and rehabilitation purposes.
- Development of single-purposed machines and mechatronic devices for specific professional applications (de-icing, robotic lighting…).
- Support of research and development using numerical simulations.

Research program:

GLASS MACHINES FOR 21ST CENTURY

Abstract: VRESEARCH AND DEVELOPMENT OF GLASS MACHINES, PARTS OF AUTOMATIC LINES, CONSTRUCTION NODES AND QUALITY CONTROL EQUIPMENT. RESEARCH IN THE FIELD OF DETECTION OF TRANSPARENT MATERIALS AND DEVELOPMENT OF EQUIPMENT FOR INDUSTRIAL USE. BASIC RESEARCH IN THE AREA OF ADDITIVE TECHNOLOGIES FOR THE PRODUCTION OF GLASS PRODUCTS FOLLOWED BY APPLIED RESEARCH FOR APPLICATION OF KNOWLEDGE IN INDUSTRIAL PRACTICE.

Research activities:

ADVANCED TECHNOLOGIES AND MACHINES FOR PRODUCTION, PROCESSING, REFINEMENT AND NEW PRODUCTS

- Research and optimization of technology and production of brand new glass products.
- Research of advanced technologies regarding glass production, new technologies of processing and refining of glass products with emphasis on reducing energy intensity and ecological impacts of production, increasing utility value.
- Research and development of machines and equipment for advanced technologies of glass production, processing and processing under conditions of Industry 4.0. Utilization of numerical simulations for their design, development and optimization.

CONTACTLESS DETECTION AND CONTROL OF OBJECT SHAPE FROM TRANSPARENT MATERIALS AND DESCRIPTION OF THE SURFACE

- Research methods on object detection from transparent materials for obtaining their 2D and 3D images, detection of defects and defects in glass products.
- Research and development of equipment with application of methods of object detection from transparent material, defects and failures inside these objects.
- Basic research of application of fractal geometry for description of surface layers and application of algorithms to data from industrial practice including introduction of new data evaluation methodologies (based on fractal geometry tools, statistics, Fourier transformation, etc.) into industrial practice.

ADDITIVE TECHNOLOGY IN GLASS PRODUCTION

- Basic research in the field of additive technologies of glass production.
- Basic research of micro-melting glass batches and principles of heating of micro-nan batches to softening temperatures to melting temperatures. Study of dependence of boundary conditions change on final properties of doses.
- Development of experimental facilities supporting basic research in this area.
- Applied research in the field of 3D glass printing equipment.

Research program:

MECHANICS OF INTELLIGENT MATERIALS AND COMPOSITE MATERIALS

Abstract: RESEARCH AND DEVELOPMENT OF EXPERIMENTAL AND NUMERICAL METHODS FOR DETERMINATION OF COMPLEX THERMOMECHANICAL PROPERTIES OF INTELLIGENT POLYMERIC MATERIALS SUCH AS MAGNETORHEOLOGICAL ELASTOMERS AND PLASTOMERS (MRES AND MRPS), SHAPE MEMORY POLYMERS (SMPS) AND POLYMERIC FOAMS (PFS). THE BEHAVIOR OF THESE MATERIALS IS CONTROLLED BY EXTERNAL MAGNETIC, ELECTRICAL, LIGHT OR HEAT FIELDS. DEVELOPMENT OF MATERIAL MODELS BASED ON DESCRIPTION OF INTERNAL STRUCTURE AND EXPERIMENTALLY DETERMINED PARAMETERS. MATHEMATICAL MODELING OF COMPLEX THERMOMECHANICAL PROPERTIES OF THESE MATERIALS. NUMERICAL SIMULATION OF THE RESPONSE OF THESE MATERIALS USING THE FINITE ELEMENT METHOD.

Research activities:

EXPERIMENTAL RESEARCH ABOUT MECHANICS OF INTELLIGENT MATERIALS AND ITS THERMOMECHANICAL RESPONSE

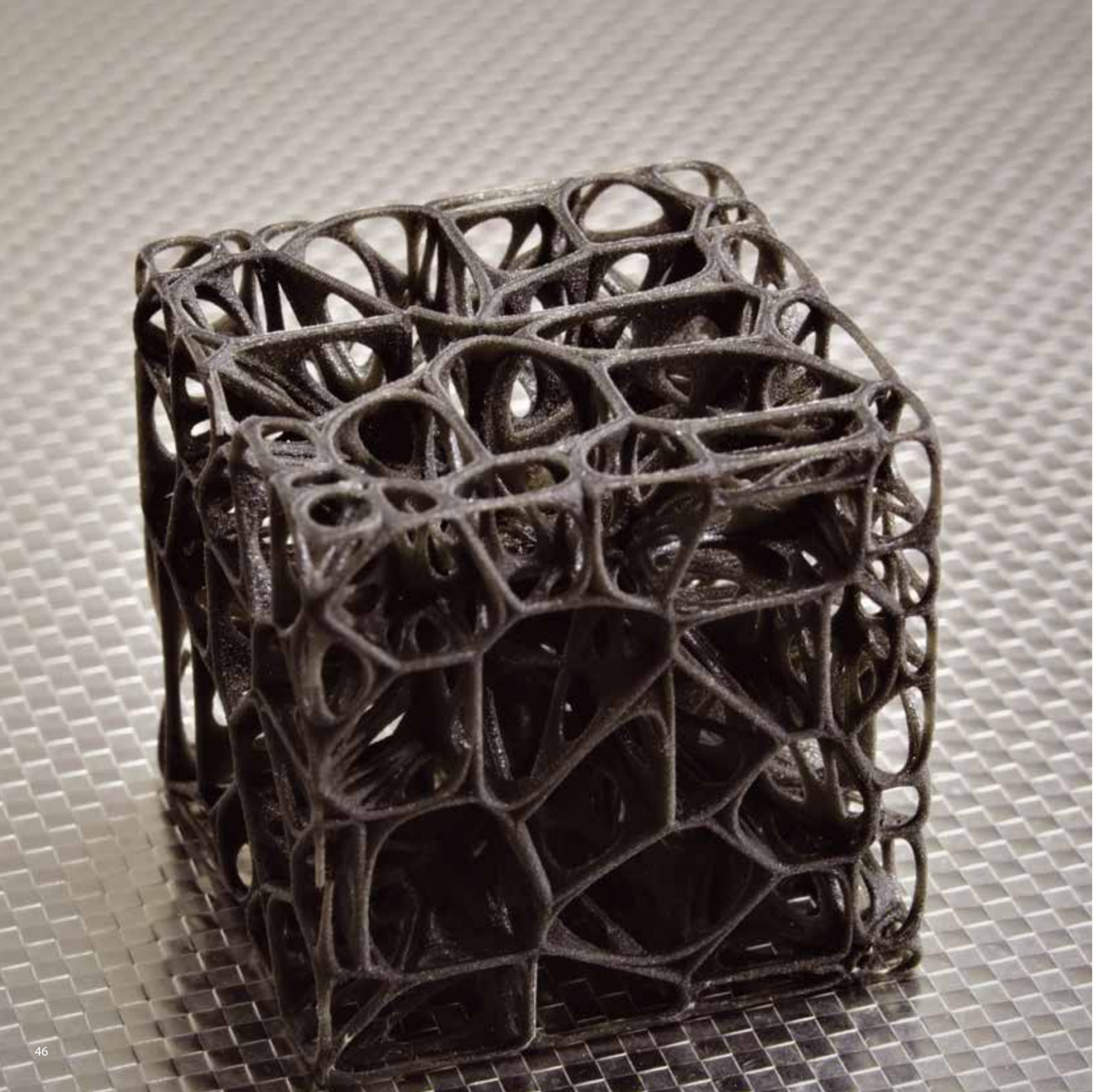
- Preparation of experimental samples using both traditional composite manufacturing methods and modern materials synthesis methods such as 3D printing. Production of anisotropic MREs under external magnetic field.
- Research on geometry of internal macro and microstructure by using imaging methods.
- Development of innovative experimental methods and experimental devices for response determination of composite intelligent materials to static and dynamic loading under the influence of magnetic field. Application of modern non-contact optical methods for deformation measurement.
- Determination of time-dependent rheological behavior of studied materials, relaxation response and behavior under dynamic loading.
- Experimental determination of the response of intelligent materials to the load with simultaneous action of another external stimulus in the form of magnetic, electric or thermal field.
- Research of dissipated energy mechanism in structural materials due to material damping and shear friction of structural elements.

DETERMINATION OF MATERIAL PARAMETERS AND CONSTITUTIVE RELATIONS

- Determination of material parameters and models based on experimentally obtained data.
- Creation of constitutive relations needed for numerical modeling of material response.
- Modeling of mechanical behavior of materials and their dependence on external forces and physical fields.

NUMERIC RESPONSE SIMULATIONS VIA FINAL ELEMENT METHOD

- Implementation and application of constitutive relationships in FEM software and simulation of the behavior of simple structures made of intelligent materials taking into account the coupling and interaction between the acting physical fields (force, magnetoelectric, thermal, etc.) and depending on boundary conditions.
- Verification of FEM simulation results and experimentally determined behavior using test methods and tests.



Research program:

VIBROISOLATION

Abstract: DEVELOPMENT OF METHODOLOGY OF NEURAL NETWORK CREATION AND LEARNING FOR CONTROL OF VIBROISOLATING ELEMENTS SUCH AS PNEUMATIC SPRINGS OR DAMPERS. APPLICATION OF ACQUIRED KNOWLEDGE TO COMPLEX STABILIZATION SYSTEMS. DEVELOPMENT OF MODELING OF FEEDBACK CONTROL SYSTEMS. RESEARCH OF STABILITY OF BIAXIAL GYRO STABILIZER, ANALYSIS OF INFLUENCE OF PASSIVE RESISTORS IN STABILIZER ON ITS FUNCTIONAL PROPERTIES. DEFINITION OF WORKING AREA AND APPLICABILITY OF GYRO STABILIZATION IN TECHNICAL PRACTICE. DEVELOPMENT OF THEORETICAL AND EXPERIMENTAL PROCEDURES LEADING TO A MATHEMATICAL DESCRIPTION OF THE BEHAVIOR OF SPRINGS AND DAMPERS WITH AN INCREASED REGARD TO EXTREME OPERATING CONDITIONS (LARGE DEFORMATIONS, HIGH VELOCITIES) AND ENERGY DISSIPATION MATERIALS. RESEARCH OF CAVITATION IN LIQUID DAMPER AND INFLUENCE OF CAVITATION BUBBLES ON DAMPER OPERATIONAL PROPERTIES.

Research activities:

ACTIVELY MANAGED VIBRO-INSULATION MEMBERS

- Design of electric and pneumatic circuits for control of vibroinsulating elements.
- Design of neural network learning system and application for control of pneumatic spring or MR damper.
- Design and development of control algorithms with regard to achieving specified system parameters.
- Verification of achieved results on specified system parameters.
- Design of the driver's seat with implemented air spring in the seat including assessment of the effect of the air spring on the distribution of contact pressures between the seated person and the seat.
- Application of acquired knowledge to other vibroinsulation systems.

GYROSKOPIC STABILIZATION

- Research of biaxial stabilizer properties.
- Analysis of stability and influence of passive resistances on system stability.
- Experimental verification of biaxial stabilizer properties.
- Design of gyroscope.

PASSIVE VIBROINSULATION

- Investigation of bubble formation in hydraulic damper oil.
- Identification of the principle of delay in the damper and its influence on operating characteristics.
- Experimental identification of properties of pneumatic springs and their mathematical description.
- Description of energy dissipation in structural materials.
- Development of constitutive and finite element models of vibroinsulating materials and their characterization.

Research program:

ENERGETIC PROCESSES

Abstract: RESEARCH IN THE FIELD OF ENERGY AND RENEWABLE ENERGY SOURCES, ENERGY PROCESSES, ENERGY CONVERSION EFFICIENCY, ENVIRONMENTAL RESEARCH. RESEARCH ON ENERGY STORAGE, HEAT TRANSFER, CAVITATION, MULTIPHASE FLOW AND PHASE CHANGES IN THE „SMART MATERIALS“ AND „SMART TECHNOLOGIES“ AREAS FOR USE IN BUILDINGS AND POWER EQUIPMENT. RESEARCH OF CAVITATION PROCESSES IN MEDICINE.

Research activities:

ENERGY AND RENEWABLE RESOURCES

- Solar and wind energy
- Research of combustion processes
- Energy storage technology
- Reliability of power equipment
- Research on increasing the efficiency of heat exchangers
- Energy savings

TECHNOLOGICAL EQUIPMENT OF BUILDINGS

- Research in the field of heating and cooling units
- Environmental comfort research (internal environmental quality)
- Research on reducing the energy performance of buildings

MULTIPHASE FLOW

- Research in the field of new materials and surface modifications regarding current materials to increase their cavitation resistance.
- Development of measuring method for identification cavitation impact using piezoelectric PVDF sensors. Evaluation of cavitated surfaces by pitting tests and their comparison with measurements by PVDF sensors.
- Research of interaction concerning cavitation with biological materials. Applied research of the use of ultrasonic cavitation for functionalization of biomaterials and their various forms in medical applications.
- Research on boiling and condensation.

INTENSIFICATION OF HEAT TRANSFER

- Research in the field of heat transfer during phase changes.
- Research on influence of physicochemical superficial properties on temperature and momentum boundary layers, research of boundary layer influence.
- Research on the influence of nanofluids regarding temperature and momentum boundary layers, research on the use of nanofluids for increasing the thermal conductivity of liquids and increasing the heat transfer.
- Research of thermo-physical properties of substances.

MODERN EXPERIMENTAL METHODS

- Development of Particle Image Velocimetry method for use in the study of multiphase flow.
- Development of Laser Induced Fluorescence method for measurement of 3D temperature fields.
- Development of Digital Holography Interferometry to measure temperature fields in liquids, to measure cavitation processes, to measure phase changes in.

STRATEGIC AND PROGRAM BACKGROUND

This strategic document is based on the „Strategic Development Plan of the Faculty of Mechanical Engineering at Technical University in Liberec till 2020" and on the „Strategic Development Plan of the Technical University in Liberec till 2020 with a view to 2030", while specifying it for the field of science and research during 2020-2030 with expected evaluation and update in 2025. Furthermore, the strategic document serves as the basic document for the management and decision-making and formulation of next steps for the development of the Faculty of Mechanical Engineering at the Technical University in Liberec.

CONCEPTUAL BACKGROUND

Strategic plan of educational, scientific, research, development and other creative activities of FME TUL for the period 2016-2020
Strategic Development Plan of the Technical University of Liberec until 2020 with a view to 2030
Strategy of Science, Development and Research FME TUL 2007-2013
Innovation Strategy of the Czech Republic 2019-2020
Horizon 2020 - 8th Framework Program
Horizon Europe - 9th Framework Program 2021-2027
National Research and Innovation Strategy for the Smart Specialization of the Czech Republic 2014-2020
National Research, Development and Innovation Policy of the Czech Republic 2021+
National Research, Development and Innovation Policy for 2016-2020
National RIS3 Strategy 2021+
National RIS3 Strategy 2014-2020
Regional Innovation Strategy RIS3 2021+
Evaluation Methodology M2017+

PROCESS STEPS

Strategy of FME TUL RDI +2030 reflects the process of discussing the direction of FME TUL in RDI area. Meetings and discussions took place from April to November 2019. The outcome represents an outline of a scientific research orientation as well as all necessary measures to fulfill the Faculty Strategy.

APRIL, MAY, SEPTEMBER, OCTOBER, NOVEMBER, 2019:
Meeting, discussion, presentation of research programs, facilitated meeting.

DECEMBER, 2019:
Presentation of the concept of strategy at the meeting of the Scientific Council of FME TUL.

FEBRUARY, 2020:
Approved by the Academic Senate of FME TUL on February 4, 2020.
Approved by the FME TUL Scientific Council on 5 February 2020.

PROCESSING TEAM

Professor Petr Lenfeld	*Dean of FME TUL*
Associate Professor Dora Kroisová	*Vice-Dean for Education and Student's Affairs*
Professor Pavel Němeček	*Vice-dean for Research, Development and Cooperation with Industry*
Professor Karel Fraňa	*Vice-dean for International and Public Relations*
Associate Professor Petr Lepšík	*Vice-dean for Postgraduate Studies and Research*
Associate Professor Iva Petríková	*Department of Applied Mechanics (DAM)*
Associate Professor Jaromír Moravec	*Department of Engineering Technology (DET)*
Professor Petr Louda	*Department of Material Science (DMS)*
Associate Professor Petra Dančová	*Department of Power Engineering Equipment (DPE)*
Professor Ladislav Ševčík	*Department of Machine Elements Design and Mechanisms (DME)*
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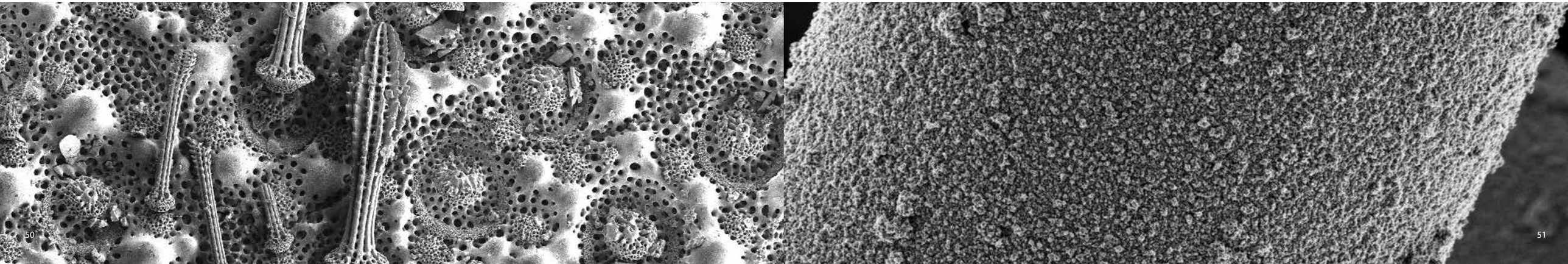
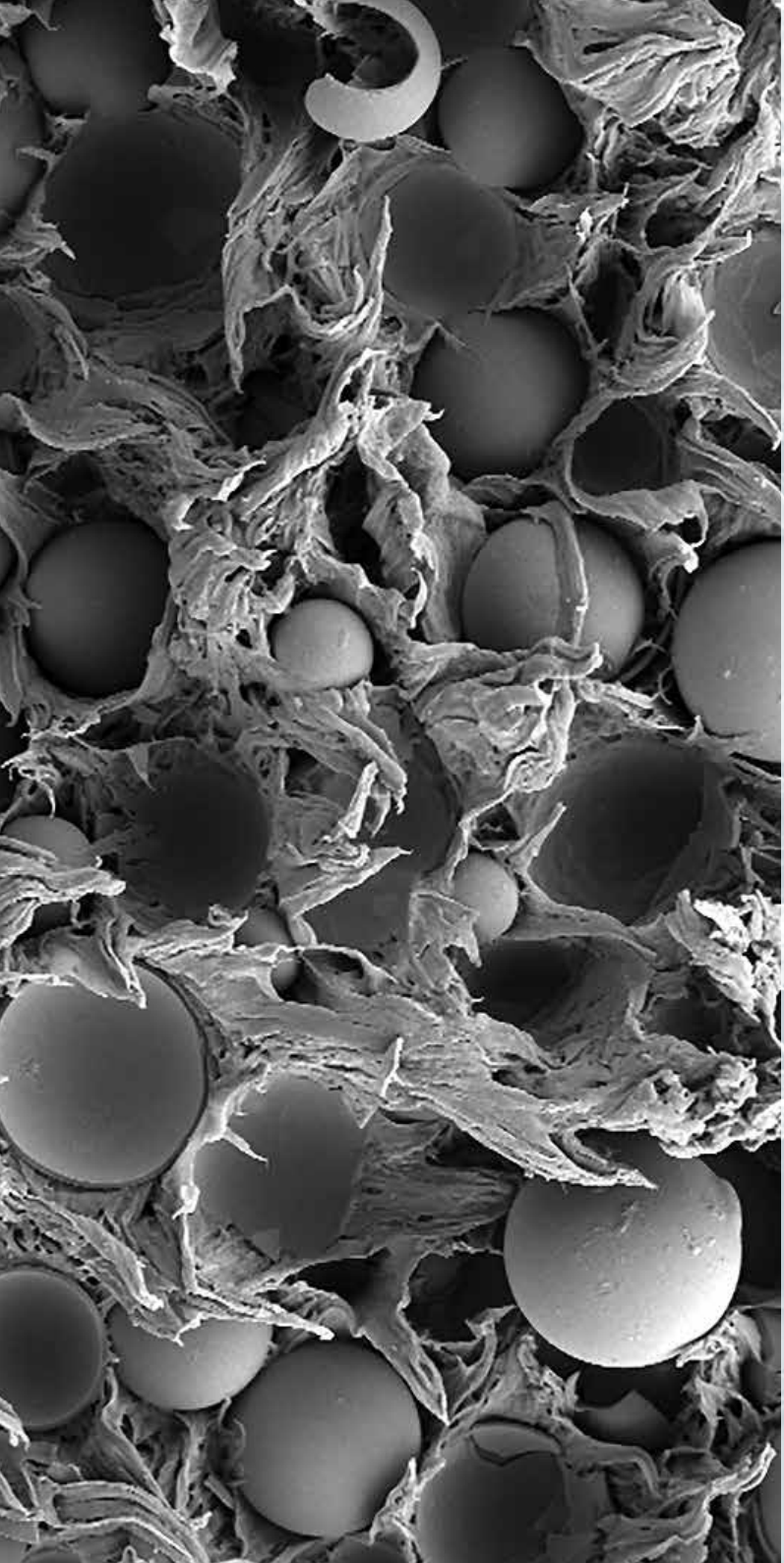
Associate Professor Martin Bílek	*Department of Textile and Single-Purpose Machines Design (DTM)*
Petr Zelený, Ph.D.	*Department of Manufacturing Systems and Automation (DSA)*
Tomáš Langer, Ph.D.	*Methodological Cooperation and Facilitation of processes*
RNDr. Iveta Lukášová	*Expert and Methodological Guarantee*





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