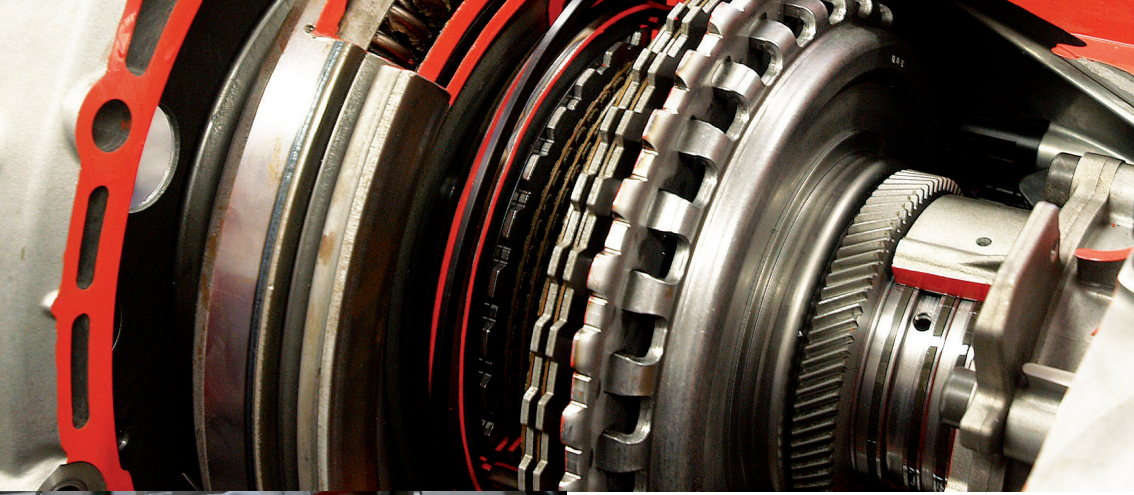
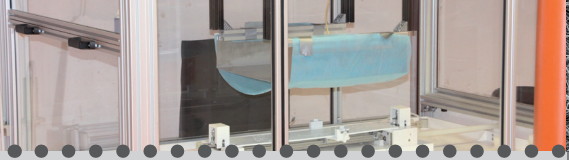


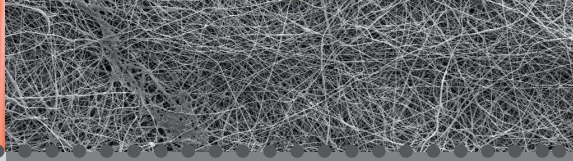
Research Program

Competitive Engineering

In the program COMPETITIVE ENGINEERING, research and development activities are focused on the use of advanced engineering constructions and technologies, in particular mechatronic systems, propulsion units and other components of machines and vehicles, and advanced technical processes of new technical materials.

The Head of the Research Program of Competitive Engineering is prof. Ing. Jaroslav Beran, CSc. (e-mail: jaroslav.beran@tul.cz)





Laboratory of Textile Machinery Innovation

Cooperation offered

- Advisory and consulting activities in the field of construction of textile and single-purpose machinery
- Research and development of textile machinery nodes
- Development and construction of special machines and equipment
- Research and development of machines and equipment for the production of nanofibres
- Development of automatic samplers for biomass and solid fuel
- Research and development of new medical instruments
- Solving issues of building mechanisms (synthesis, kinematic and dynamic analysis, simulation, optimization, measurement, experimentation)
- Computational and experimental modelling of dynamic properties and behaviour of machines and mechanisms with respect to elastic bodies, reducing machine frame vibrations
- Strength, stress and deformation analysis and optimization using FEM
- CAD applications including elaboration of technical documentation
- Analysis of high speed events with high-speed cameras

The main objectives and activities of the laboratory

- Implementation of advanced technologies in the development and production and special purpose machines and medical instruments
- Complex problem solving in the field of construction engineering techniques aimed at optimizing the properties of machines and instruments to interact with new work processes
- Research and development of new machinery and operating lines for the production of linear and three-dimensional nanofibrous units
- Use of new knowledge of material research in the design of engineering structures

Expert Guarantor:
doc. Ing. Michal Petru, Ph.D.
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Laboratory of Nanofibre and Nanosurface Preparation

The main objectives and activities of the laboratory

- Development of new nanofibre and nonwovens materials, including their production technology
- Patterning of nanofibre products using the cutting-edge commercial equipment NS 1WS500U
- Comprehensive solutions to specific issues relating to the production of these materials focused on the optimization of parameters and properties of the resulting materials
- Theoretical research on the formation and properties of nanofibre materials
- Use of the findings of new theoretical research to develop new machinery and operating lines for the production of linear, spatial and three-dimensional nanofibrous systems

Cooperation offered

- Work with external institutions on the development of particular products, based nanofibrous layers are made on the NS 1WS500U laboratory equipment
- Cooperation with Czech and foreign universities and research institutions in the area of electrospinning theory
- Preparation of nanolayers.

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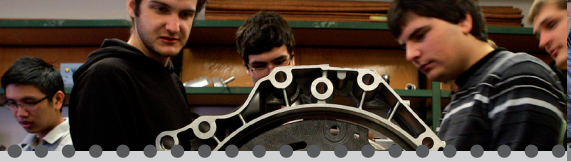

Laboratory of Propulsion Units

The main objectives and activities of the laboratory

- Research and development of ecological propulsion units with optimized transmission and energy transfer for transport, mobile machinery and energy equipment

Cooperation offered

- Research and development of spark ignition engines (gasoline, gas, alternative fuel) and diesel engines for cars and heavy vehicles
- Long-term engine testing in our own laboratory (water, eddy and electric dynamometers), cooperation in the supervision of tests in the customer's test room
- Visualization and calculation of mixture formation and combustion processes, measurement of exhaust emissions
- Experimental research of common rail injector systems for gaseous and liquid fuels
- Measurement of particle size in the most problematic size categories from single units to hundreds of nanometres
- Measurement of passive resistance of engines and transmissions
- Measurement of inertia of solids
- Strength and deformation analysis of parts of engines and vehicles

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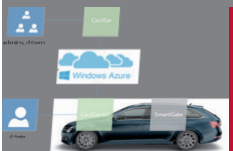
Laboratory of system integration

Cooperation offered

- app servers, operation and ensuring the application servers run specific software for research activities of laboratories and computing clusters
- database, ensuring database capacity for processing and evaluation of research results or solving individual jobs
- cloud, the ability to effectively utilize resources by moving some activities to the cloud environment
- data-lakes, data storage to store large volumes of unstructured data
- license management, effective control, audit and license management
- reporting, a common reporting solution including support of research teams in this field
- collaboration, system support for cooperation between the teams, including ensuring hardware and software resources for effective information sharing
- mixed reality, modern presentation techniques via augmented and mixed reality, including support of research teams in preparation the 3D scenes
- IoT, support in the use of IoT, communication, data collection, including elements that enable the smart car, smart factory or smart city approaches
- application development, development of individual applications
- analysis, analytic support for research activities in the field of IT or consolidation of specific research requirements to specific solutions
- development, of responsive web based application or desktop solutions in any area in Java, .NET or other platforms

The main objectives and activities of the laboratory

- Data management and computing, which is expected to ensure support in the field of storage, processing, evaluation and advanced analyzing and presenting large volumes of data
- Advanced methods of presentation of research results, support in the field of design, modeling and simulation, with emphasis on increasing the attractiveness of presentation of research results and tendering by the using the virtual, mixed and augmented reality or devices of large-screen projection, the use of GIS systems
- Promoting the collaboration and individual solutions, thus ensuring the promotion of cooperation and sharing of research results within the research teams internally but also to research partners externally, document management, efficient task and time management on projects and thus increase the efficiency and quality of work of management, research and support staff individuals and the research projects themselves.



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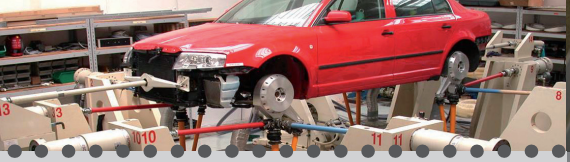
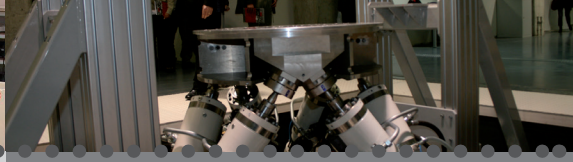
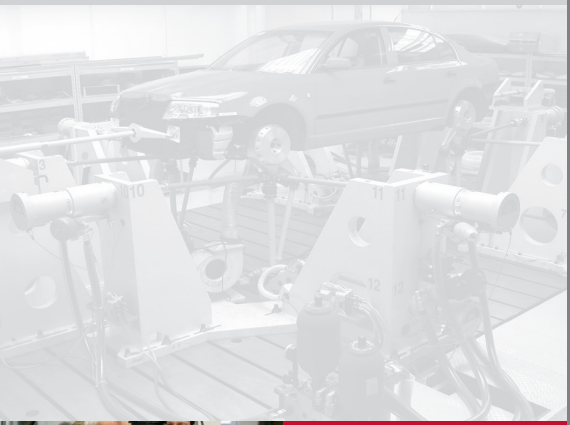
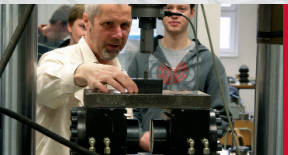




Laboratory of Hydrodynamics





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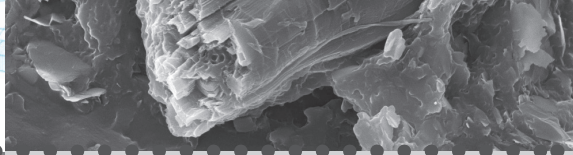
The main objectives and activities of the laboratory

- Active and passive vibration isolation systems, measurement of noise and vibration
- Stress tests of mechanical parts and machine nodes
- Development and testing of seats
- Design, measurement and verification of arrangements of exterior and interior vehicle components and assemblies in terms of protection of pedestrians and passengers during collisions and accidents

Cooperation offered

- Research and development of new principles and materials for active and passive vibration isolation systems
- Testing the strain on machine parts at temperatures from -40 to +120 °C
- Testing of machine parts at high speeds over 12m/s
- New materials and constructions of car seats
- New mechanisms and nodes and elements of machines for the production of nanofibres, fatigue tests



Laboratory of Mechanics

The main objectives and activities of the laboratory

- Use of conventional experimental methods in continuum mechanics (measurement of kinematic variables, deformation, strain, force effects, etc. using the appropriate sensors and measuring chains)
- Implementation and testing of new experimental methods based on market requirements
- Close interaction and collaboration with experimental workplaces at TUL
- Cooperation with industry and knowledge companies
- Support of the experimental needs of other departments of TUL

Cooperation offered

- Experimental research activities focused on safety and human comfort in vehicles
- Testing and construction of interior and exterior parts of vehicles increasing the safety of pedestrians and passengers during collisions and accidents
- New construction solutions, designs and prototypes of mechatronic devices with a special ejection mechanism and an impactor for measuring human biomechanical parameters

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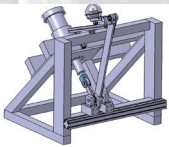
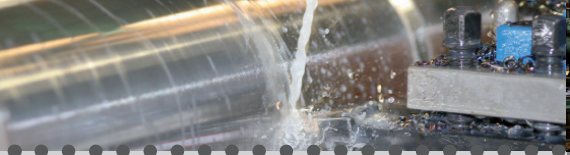
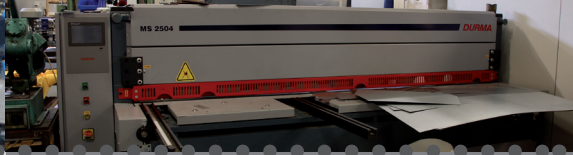






Laboratory of Particle Technology and Processes

Cooperation offered

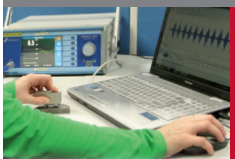
- analysis of the impact of tools, process liquids and machined material in the machining process during turning, milling, drilling and grinding (monitoring the machining process)
- optimization of technological parameters and working processes based on the monitoring of machining processes
- assessment of the impact of environmental working conditions on changes to the properties of surfaces and surface layers relating to the properties of base material of mechanical components (assessment of surface integrity)
- surface integrity parameter measurements under laboratory conditions using mobile instruments and under operating conditions of manufacturing enterprises
- 3D measurement of machine parts up to 500 x 500 x 500 mm with an accuracy greater than 5.5 microns, including an analysis of measurement uncertainty

The main objectives and activities of the laboratory

- Monitoring of machining parameters:
  - evaluation of cutting forces, material removal, temperature, deformation
  - testing the effects of the cutting environment
  - evaluation of the working capacity and reliability of cutting tools
  - design and optimization of process conditions
  - active monitoring of the machining process
- Analysis of surface integrity parameters:
  - evaluation of surface appearance, surface defects and surface microgeometry of machine parts
  - determination of effect, size and gradient of residual stress in the surface layer
  - assessment of crystallographic phase and texture of surface layers

In cooperation with workplace partners, we can also provide the assessment of structural and phase changes and hardness in the surface layer of machined parts

The laboratory is equipped with more than 25 machine tools, especially for the performance of turning, milling, drilling and grinding experiments



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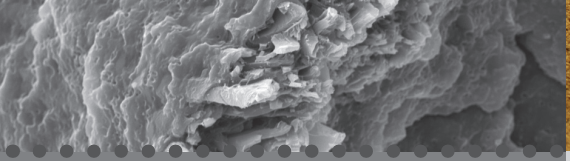

Laboratory of Advanced Engineering Technologies

The main objectives and activities of the laboratory

- Development, research, innovation and application of advanced non-splinter technologies for processing plastics, composites, metals and nonferrous metals in development and research projects and in practice
- Research, innovation and application of advanced technologies for industrial processing of modern and innovative materials
- Comprehensive solutions to technology and manufacturing processes as required by the manufacturing sector and comprehensive solution to technological issues in industry
- Monitoring, parameterization and optimization of the impact of technologies and processes in relation to the structure, final and utility properties of parts, and in relation to ecology and the environment

Cooperation offered

- Development, innovation and monitoring of technology for the processing of polymers and composites, production of test specimens, samples and parts
- Evaluation of the properties of polymers and composites (micro, nano, long fibres, etc.), polymers with natural fillers, biopolymers, recycled materials
- Tribological tests and testing of lubricants, surfaces and substrates; adhesive bonding and evaluation of adhesives
- High-strength materials, non-ferrous metal materials, shape memory materials and sandwich-based materials
- Development of metallurgical processes in the manufacture of gray and ductile cast iron and aluminium alloys, foundry casting, temperature regimes of moulds and cooling castings
- Iron and alloys based on nonferrous metals; sands with clay binders with cores based on biological binders
- Development and analysis of the process of resistance spot welding and sheet brazing, optimizing MAG welding, welding of aluminides
- Simulation of technological processes for plastic processing, simulation of sheet metal forming, welding and casting processes
- Consulting and advisory services, seminars and training

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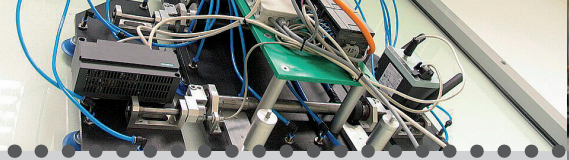


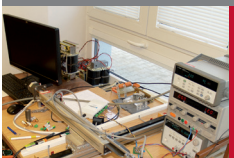
Laboratory of Controlled Electrical Drives and Servomechanisms

The main objectives and activities of the laboratory

- Research, development and implementation of advanced technologies in the field of automation technology, electrical engineering, electronics and robotics focused mainly on the working machine nodes of light industry
- Comprehensive solutions to specific problems, development of control blocks and units, electronic circuits and development of the application of embedded microcomputers, particularly in measuring instruments of non-electrical quantities, including PCB design and the related development of software
- Application of new knowledge of electrical engineering, electronics, mechatronics and cybernetics in advanced industrial technologies and transport. Support for research and development of new non-standard applications of electromagnetic fields in low-voltage systems up to 1 kV, frequency of 3 GHz and total power of up to 100 kW

Cooperation offered

- Design of customized solutions in the field of electrical engineering and automation (dynamically demanding actuators, robotics, manufacturing systems, power control, current limiters, development and testing of protective devices, transient effects, etc.)
- Special measurements of electrical and non-electrical parameters (resistances, relay contact resistances, verifying the characteristics of protective devices, measurement of transient effects, measurement of magnetic fields, temperature dependencies, verifying reliability and measuring a wide range of other variables)
- Design of FPGA based electronics, design of electronic nodes (analogue and digital circuits)
- Training of industrial sector workers in the above-mentioned fields.



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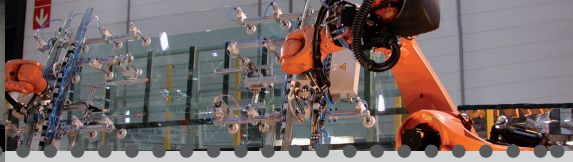

Laboratory of Robotic Systems

The main objectives and activities of the laboratory

- Solutions for specific design nodes of industrial robots and their effectors, mechatronic components of automation and peripherals of robotic workplaces
- Innovative research of autonomous service robots
- Development of equipment for robotized technological workplaces and integration into production lines
- Implementation of elements with a high degree of intelligence and new materials in robotic systems, mechatronic systems with a greater degree of freedom and with standard actuator topology

Cooperation offered

- Industrial and service robots for special applications
- Research and development of new types of robot effectors (snap-on and technological heads), robots
- Development and system integration of manipulation equipment and industrial robots in robot technology centres, optimization of manipulation functions and layouts
- Research and development of equipment for specific production conditions, development of machines, tools and equipment for the glass industry
- Computer simulation of shaping processes and contact issues
- Design and optimization of pneumatic actuators and synthesis of pneumatic circuits
- Research methodology and development of algorithms, software and hardware for evaluating the quality of production
- Machine vision systems and robot vision applications

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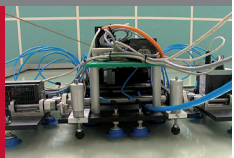

Laboratory of Prototype Technologies and Processes

The main objectives and activities of the laboratory

- Implementation of advanced technologies into the development of products and equipment
- Comprehensive solutions to specific issues of manufacturing techniques and technologies focusing on new work procedures and their application in product development
- Utilization of new knowledge gained from material research in the development of products and equipment with the application of new procedures and methods for implementation

Cooperation offered

- Development and consultation of new products, implementation of new manufacturing processes, prototyping, and testing prototypes

The following instruments and methods can be used:

- OBJET Connex 500 3D printer, with two-component printing for rapid production of models and highly accurate prototype functional parts and components
- Dimension machine from the company Stratasys using the FDM method from ABS materials for rapid production of small models and prototypes
- Vacuum processing of silicone moulds and manufacture of plastic or wax models for casting according to the required properties
- Reverse engineering and 3D measurement of digitizing shapes with subsequent processing of results – inspection by comparison with CAD model or a total transfer to CAD model
- Production of complex machining shapes in 5 axes on a Mazak Integrex 100-IV CNC turning-milling centre
- Flat laser cutting of various shapes from a selection of different materials
- Quick production of complex shaped parts using SLM 280HL, Selective Laser Melting from all machinable powdered metals (stainless iron, aluminum, titan, etc.)

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