FACULTY OF MECHANICAL ENGINEERING CTU IN PRAGUE

DEPARTMENT OF MECHANICS, BIOMECHANICS AND MECHATRONICS

CTU in Prague, Faculty of Mechanical Engineering,
Department of Mechanics, Biomechanics
and Mechatronics
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„Let us activate the mind, body and machine together"

Prof. Ing. Milan Růžička, CSc.
Head of Department

EDUCATION FOR APPLICATIONS IN RESEARCH AND PRACTICE

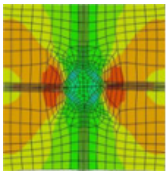
We guarantee the next specializations in the accredited study programme APPLIED SCIENCES IN MECHANICAL ENGINEERING:

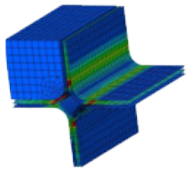
- Applied Mechanics,
- Mechatronics,
- Biomechanics.

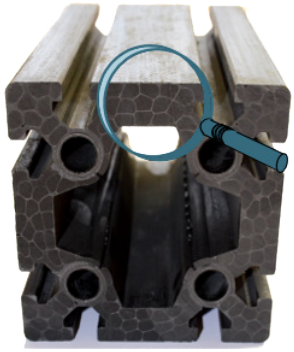
Further courses of the master study program (mechanics of mechanisms, vibration of mechanical systems, finite element method, continuum mechanics, vehicle dynamics, controlled mechanical systems, fundamentals of engineering experiments, statistical mechanics, fundamentals of anatomy and physiology, nanobiomechanics, etc.) as well as courses on specific design and computational and experimental methods used in technical practice in various fields (simulation of mechatronic systems, synthesis and optimization of mechanical systems, mechanics of composite materials, dynamic strength and life, etc.).

PARTICIPATE WITH US IN RESEARCH AND DEVELOPMENT

We investigate a large number of projects of applied research in cooperation with students. The activities of the department's divisions can be found on the next pages.







WE DEVELOP AND APPLY DISCIPLINES OF MECHANICS

in the design of machinery, equipment and in biomedical fields. The Department of Mechanics, Biomechanics and Mechatronics develops the principles of mechanical design and operation of machines and mechanisms in close association with electronics and intelligent computer and mechatronic control.

- Develops and verifies computational and experimental methods for the design and proper function of mechanical parts as well as of the use of available materials for their production.
- Creates and verifies material models and studies the limit states of their damage and failure.
- Studies the mechanical properties of biosystems and devises their mechanical description.
- Deals with the biomechanics of the musculoskeletal system and soft tissues.

WE COLLABORATE

with departments of mechanics of other technical universities in the Czech Republic (UWB in Pilsen, TU Brno, TU in Liberec and Ostrava) and foreign universities (Slovak TU in Bratislava, TU Košice and Žilina, University in Stuttgart, TU Munich in Germany, TU Wien in Austria etc.) and with domestic and foreign companies and partners in the implementation and commercialization of the outputs of research and development projects and activities as well as in consultancy and technical cooperation.

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STRENGTH OF MATERIALS

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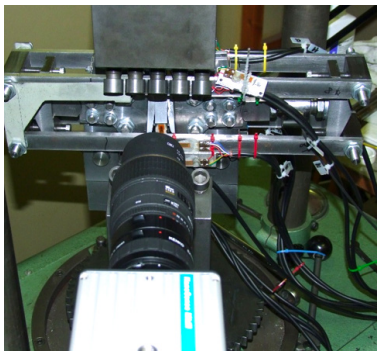
DIMENSIONING AND CHECKING MACHINES AND THEIR COMOPONENTS

The aim of strength of materials in mechanical engineering is to provide support in the dimensioning of machine components and in the assessment of their performance and operation in real conditions.

MODELS OF LIMIT STATES OF MATERIALS

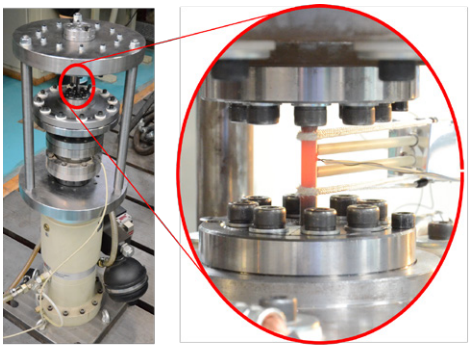
Damage which material is subject to in operation is so comprehensive that it can hardly be described absolutely accurately. The engineering approach is based on phenomenological models which focus more on demonstrating than on the physical nature of phenomena. The parameters of such models for particular materials are usually calibrated by specific experiments



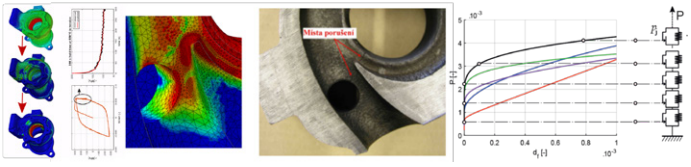
Measurement of contact slips in the research of the effect of fretting on life.

Fatigue is a degradation process under long-term variable loading. Research of fatigue criteria is performed taking into account, for example, multiaxial loading, elevated temperatures or contact with friction (**fretting**).

Ductile fracture modelling is particularly useful for simulating structures in cases of failure, such as over-loading, impact /crashes, falls, etc.



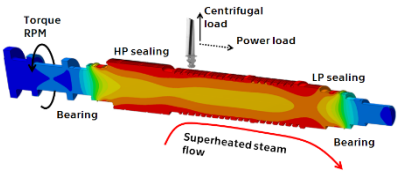
Development and calibration of low-cycle thermomechanical fatigue models and their application to the check of the strength of a turbocharger (Josef Božek Centre of Competence, CAAT).



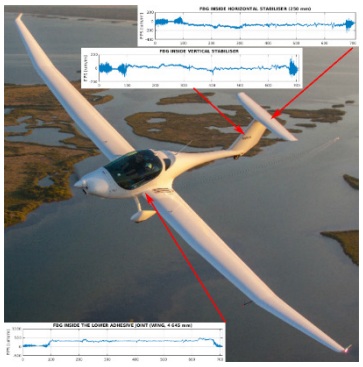
CURRENT PROJECTS

H2020 FLEXTURBINE & H2020 TURBOREFLEX

Two interrelated projects funded by the European Commission's Horizon 2020 Research and Innovation Program. The current EU energy trend is generating increasing demands for the flexibility of fossil power plant operations due to the need to cover the unstable supply of energy from renewable sources. The main objective of the projects is to revise the existing design methods of steam and gas turbines with respect to the changing demands on the operating conditions of these facilities. The projects are participated by an international consortium of companies, including the world's leading turbine manufacturers. CTU directly cooperates with Doosan Škoda Power, Ltd. and COMTES FHT, Inc.



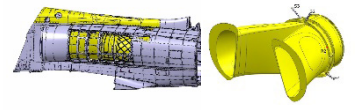
ENHANCEMENT OF OPERATING SAFETY



We are developing a monitoring system of operating parameters and loads of ultra-light aircraft using optical fibre sensors integrated into the composite structure of wings and the tail assembly (Cooperation with TAČR, Phoenix Air Ltd., SAFIBRA Ltd. and LA Composite Ltd.).

USE OF ADVANCED MATERIALS FOR ACHIEVING HIGHER--QUALITY PROPERTIES OF STRUCTURES

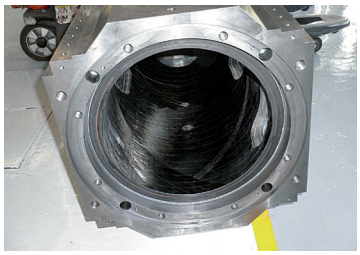
New materials often significantly improve the properties of structures. Their safe application requires new knowledge in dimensioning and assessment of the strength of components.



Composite air-intake for L-39 NG airplane

We apply analytical methods in the design of fibre reinforced composites or hybrid structures.

In cooperation with CK TAČR, AERO Vodochody AEROSPACE a.s. a VZLÚ, a. s. we work on experimental and numerical analysis of composite air-intake for L-39 NG airplane.



Hybrid slide (in cooperation with Tajmac ZPS, J.S.C.)

Our division participates in the Centre of Competence "Manufacturing Technology" and cooperates with industrial firms, e.g. TOS Kuřim, Škoda Machine Tools, Kovosvit MAS, TOS Varnsdorf.

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DIVISION OF MECHANICS AND MECHATRONICS

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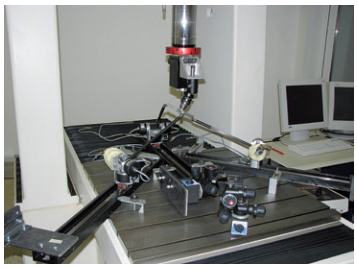
FUNDAMENTAL PRINCIPLES OF MACHINE PERFORMANCE

We develop mechanical principles of the purpose and performance of machines in close association with electronics and intelligent computer control and their practicability from available materials wth relation to biomechanics.

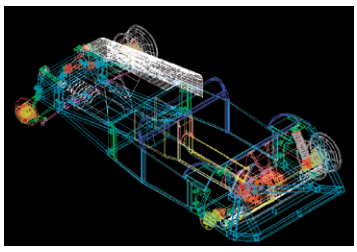
EDUCATION FOR WORK EXPERIENCE

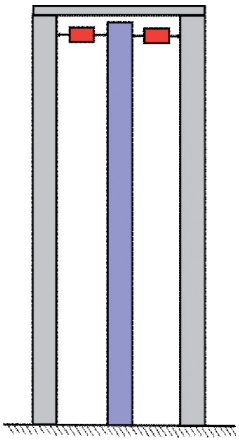
We give lectures on the theory of creation of mechanical models, statics, kinematics and dynamics of rigid bodies and systems of such bodies considering ideal and real bonds, mechanisms of machines, oscillation and vibration technology and optimization of mechanical systems, structural mechanics, statistical mechanics, etc.



KNOWLEDGE IN SUPPORT OF DESIGNING

Designing supported by knowledge has reached a level which makes it possible to create automatically e.g. the concept of an automobile.





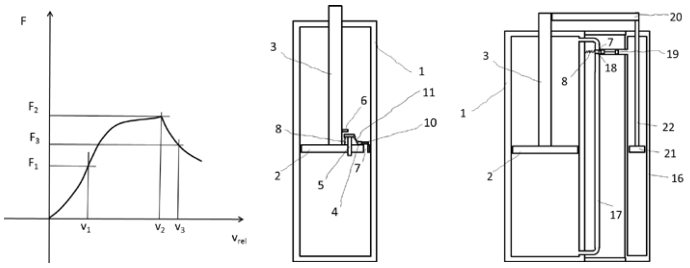
Mechatronic stiffness in a tube-in-tube form

MECHATRONIC COMPONENTS OF MACHINES

Mechatronics makes it possible to create new components of machines with enhanced mechanical properties. Mechatronic stiffness can serve as an example. Archimedes allegedly said: *"Give me a place to stand (fixed point) and I will move the earth"*. We are not able to do this but we can create a flexible point in space and from this point enhance dynamic stiffness and damping of mechanical structures.

VEHICLE DYNAMICS – NEW DEGRESSIVE DAMPERS

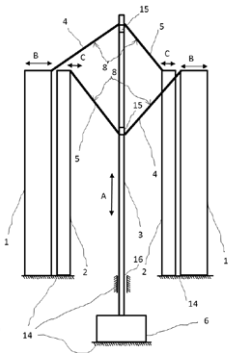
Dampers with degressive characteristics are necessary for protection against great impacts which originate when driving over big road irregularities. Traditional dampers in this case are useless – they require springs with negative stiffness. Alternative passive physical implementations were proposed. One principle is the hysteresis of the opening of the channel and the second a parallel damper which directly measures the relative speed of the damper.



Pasivní tlumiče s opravdovou degresivní charakteristikou

DISTANT ACTUATOR FOR MECHATRONIC STIFFNESS

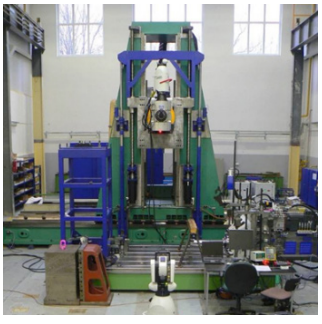
Mechatronic stiffness for compact implementation in the tube-in-tube form requires an actuator acting from the frame (not occupying space between the tubes) and is co-located. An actuator was patented consisting of a central bar and flexible plotters located on the frame which meets these requirements.

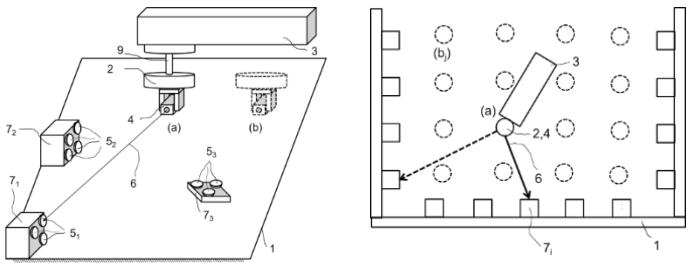


Mechatronic stiffness in a compact form

REDUNDANT MEASUREMENT OF THE POSITION IN LARGE WORKING SPACES OF MACHINE TOOLS

Inaccuracy of the measurement of the otherwise accurate measurement by a laser tracker increases with the area of the working space. Consequently a redundant optical measurement was proposed by a laser tracker reflecting from numerous optical reflectors in the working space of the machine tool. Experiments showed a sevenfold increase of accuracy.





Redundant optical measurement by one laser tracker reflecting from many optical reflectors

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INTRODUCTION OF BIOMECHANICS

The Division of Biomechanics ranks among traditional biomechanical workplaces on a global scale. Since the 70s of the last century mechanical methods were applied at the Faculty of Mechanical Engineering to biological tissues and their systems to improve the comprehension of the function of the human body. This research activity is associated with the first replacements of hip joints in Czech Republic.

Members of the biomechanical team, including students, always actively cooperated both with top Czech surgeons and manufacturers of joint replacements. The result of this collaboration is more than a hundred of different orthopaedic and trauma replacements which were introduced into clinical practice. In addition to replacements of the musculoskeletal system the Division of Biomechanics also deals with replacements of the cardiovascular system, such as blood vessels and valves or stents.

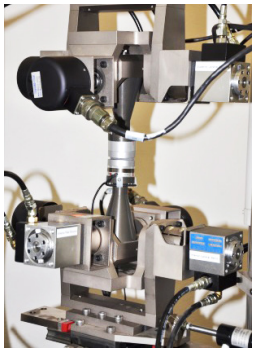
Research at the Division of Biomechanics attempts to comprehend the mechanical function of cell structures, tissues, organs or organ systems in perfectly equipped laboratories. The aim of the studies is not only to test mechanical properties but particularly to explain them by means of mathematical models and to use them in the design of new diagnostic methods and means of medical treatment.

Our graduates work not only in companies engaged in the production of medical devices and sporting equipment, but also in automotive industry where they deal with the issue of passenger safety and security.

LABORATORIES OF THE DIVISION OF BIOMECHANICS

MECHANICAL TESTING LABORATORY,

Testing Laboratory No. 1379 accredited by CAI according to ČSN EN ISO/IEC 17025 – seven test procedures for testing ceramics, dental implants and elbow crutches according to Czech and foreign technical standards; the laboratory has an MTS 858.2 Mini Bionix testing device which can simulate physiological load and kinematics in up to 8 degrees of freedom.



Spine simulator

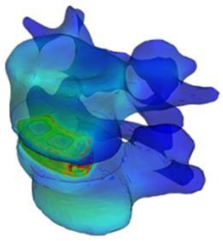
LABORATORY OF CARDIO-VASCULAR BIOMECHANICS

The laboratory studies the biomechanics of blood vessels and their substitutes. The laboratory is specialized in the comprehensive description of the behaviour of blood vessels as nonlinear anisotropic structures.

Test of a coronary stent expansion into the coronary artery in the study of deformation zones at the stent-artery interface

LABORATORY OF APPLIED COMPUTING

The laboratory performs comprehensive calculations determining the forces and stresses in various structures of the human body and their replacements. The knowledge of the staff of this laboratory allows them to create for the patient a specific model based on the comprehensive analysis of his motion.



FEM model of an intervertebral cage

RAPID PROTOTYPING LABORATORY

The laboratory is one of the first centres in the Czech Republic using the 3D printing technology of polymers. The results are anatomical 3D models which serve for the design of replacements. The laboratory also deals with the issue of 3D printing of biocompatible titanium alloys.

Copy of a skull made by 3D printing for a forensic facial reconstruction

LABORATORY OF FORENSIC BIOMECHANICS

The laboratory uses biomechanical methods to solve crimes. The laboratory performs analyses, motion studies and simulations of human locomotion, which can help to explain some unknown factors caused mainly by criminal activity.

Hysitron TriboIndenter TM TI 950

HYSITRON NANOMECHANICAL APPLICATIONS LABORATORY

The laboratory is a joint laboratory of the American company Hysitron and the Czech Technical University in Prague. Nanoindentation makes possible measurement by using small forces in the range of micro to piconewtons and small deformations in the range of tens of nanometers.

LABORATORY OF EXPERIMENTAL BIOTRIBOLOGY

The laboratory specializes in the experimental testing of wear of replacements such as hip or knee joints. Research also includes the analysis of explanted joint components.

Testing of the mechanical strength of the new design of a femoral stem