FACULTY OF MECHANICAL ENGINEERING
BIALYSTOK UNIVERSITY OF TECHNOLOGY

SCIENTIFIC BROCHURE 2018

69 years of

Faculty of Mechanical Engineering
Bialystok University of Technology

CONTENTS

FACULTY AUTHORITIES (term of office 2016-2020)

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THE FACULTY YESTERDAY AND TODAY

Faculty of Mechanical Engineering is one of the oldest faculties of Bialystok University of Technology, created upon The Private Evening Engineering College established on the 1st of December 1949. The first 54 students commenced their education in the field of Mechanics on the 1st of February 1950. The Faculty activities were focused on general education of engineers in the field of *machine construction technology* as a response to growing demand for engineer personnel in developing industry. This study proved to be predominant for a considerable number of years. On the 1st of September 1964, The Evening Engineering College was transformed into Engineering Academy and the rights to conduct full-time engineering studies in the field of Mechanics were obtained. In 1973 full-time Master's Programme was opened in the field of Mechanics and Machine Construction. Along with the development of new trends in industries connected with automation of technological processes, a new programme of studies was introduced - Automatic Control and Robotics - the 5-year uniform Master's Studies. Following the need of providing future engineers with interdisciplinary knowledge in the fields of technology and medicine, the educational offer of the Faculty was expanded, resulting in a new speciality of *orthopaedic and prosthetic engineering*, which was subsequently transformed into Biomedical Engineering (Bachelor of Engineering Studies since 2008 and Master's Studies since 2011). Following cooperation with Electrical Engineering Faculty, an inter-faculty programme of *energetics* was created in 2010 and subsequently was transformed into *eco-energetics* in 2013, with additional involvement of Civil and Environment Engineering Faculty. In 2014 the educational offer of Mechanical Faculty was further expanded with the introduction of *mechatronic* Systems and Materials studies taught both in Polish and English. Starting in October 2018, a new study major will be offered – material and manufacturing engineering. In 2017, the Polish Accreditation Committee granted an outstanding assessment to *mechanics and construction of machinery*. Other courses attained positive assessments.
Since its first days approximately 10 000 students have graduated from the Faculty.

The first Dean of the Faculty of Mechanical Engineering was Prof. Marian Poniatowski, PhD, Eng. who was elected in December 1951 and held the post until March 1958. The subsequent Deans of the Faculty of Mechanical Engineering (or Directors of Institute of Mechanics) who set formal and organizational foundations as well as established new trends in the development of the Faculty include the following: Jan Zubaczek, MSc Eng. (1958-1967), Prof. Henryk Popko PhD, Eng. (1968-1971), Prof. Tadeusz Jeszke DSc, PhD, Eng. (1971-1975), Prof. Henryk Bernacki DSc, PhD, Eng. (1975-1979), Prof. Józef Jezierski DSc, PhD, Eng. (1979-1981), Prof. Stefan Ignatiuk DSc, PhD, Eng. (1982-1990), Czesław Celmerowski DSc, PhD, Eng. (1990-1994), Roman Niesteruk PhD, Eng. (acting as the Dean in 1994 r.), Prof. Jan Łach DSc, PhD, Eng. (1994-1999), Prof. Jan Piwnik DSc, PhD, Eng. (1999-2002), Prof. Franciszek Siemieniako DSc, PhD, Eng. (1981-1982 and 2008-2012) and Prof. Andrzej Seweryn DSc, PhD, Eng. (2002-2008, and since 2012).

The 1970s was a period of time when the University underwent a noticeable and dynamic development. A modern campus was constructed at Wiejska 45. with Faculty of Mechanical Engineering also obtaining facilities suiting its increasing educational and scientific needs.

The laboratory base was expanded, serving both modernization of teaching and development of research activities.

Following the agreement with the Minister of National Education, on the 1st of October 1988 the Institute of Mechanics was formally transformed into the Faculty of Mechanical Engineering of Bialystok University of Technology.

Constant development of the Faculty of Mechanical Engineering resulted in obtaining the rights to confer the degree of Doctor of Technical Sciences (PhD) in the field of machine *construction and maintenance* in 1989 and in the field of *mechanics* in 2005. Further development of academic staff and scientific research brought the possibility of conferring a Postdoctoral Degree (DSc.) in the field of *machine construction and maintenance* in 2006 and in the field of *mechanics* in 2009. In 2006, the Faculty extended its offer even further with two additional PhD courses in the fields of *machine construction and maintenance* and *mechanics*. In 2014, the Faculty obtained the rights to confer the degree of Doctor of Philosophy (Ph.D.) in the fields of *biocybernetics and biomedical engineering*, and in 2016 - in the field of *automatic control and robotics*. Subsequently PhD courses were offered in these fields in 2015 and 2017 respectively.

Following comprehensive assessments of educational and research activities research units conducted by Committee for Evaluation of Scientific Units commissioned by Ministry of Science and Higher Education, the Faculty of Mechanical Engineering received category A twice.

Upon the Faculty of Mechanical Engineering motion, honorary degrees were conferred to Prof. Zenon Mroz, DSc, PhD, Eng. (Institute of Fundamental Technological Research, Polish Academy of Science in Warsaw) in 2012, Prof. Jarosław Mikielewicz, DSc, PhD, Eng. (Institute of Fluid-Flow Machinery, Polish Academy of Science in Gdańsk) in 2014, Prof. Krzysztof J. Kurzydłowski (Faculty of Material Science and Engineering, Warsaw University of Technology) in 2015 and Prof. Janusz Kowal, DSc, PhD, Eng. (Faculty of Mechanical Engineering and Robotics, University of Science and Technology in Kraków) in 2017. Furthermore, in 2014, an honorary professor degree was conferred to a long-time faculty employee and a former Dean, Prof. Franciszek Siemieniako, DSc, PhD, Eng.

Currently, there are five departments, covering general and specialized education within the scope of available studies as well as conducting advanced scientific research and developmental works in the following fields:

- Mechanics of modern materials with particular focus on the development of damage and fractures,
- Construction and maintenance processes of machines and vehicles,
- Modern materials, technology of shaping, processing and measurement of technical objects,
- Modelling, diagnostics and controlling systems and objects, including autonomous mobile robots and unmanned aircrafts,
- Modern constructions and technologies in biomedical engineering,
- New solutions and applications of medical information technology
- Modern heating/cooling systems and devices.

EDUCATIONAL OFFER

1st cycle undergraduate studies (fields of study and specialisations)	**mechanics and construction of machinery** • computer-aided design and manufacturing • construction and maintenance of machinery and vehicles • machines technology
	automatic control and robotics • mobile robots • process automation and informatization
	biomedical engineering • medical structures and materials • computer assistance in medicine
	mechatronics • photonic engineering • smart structures
	material and manufacturing engineering • modern manufacturing technologies • materials and composites

2nd cycle master's degree (fields of study and specialisations)	**mechanics and construction of machinery** • mechanics and applied computer science • automobiles • heat technology, refrigeration and air conditioning
	automatic control and robotics • industrial automation • information systems
	biomedical engineering • modern structures and technologies for medicine • computer science in medicine
	mechatronics

3rd cycle studies (scientific disciplines)	**construction and maintenance of machinery**
	mechanics
	biocybernetics and biomedical engineering
	automatic control and robotics

The Faculty of Mechanical Engineering provides an attractive educational offer covering a three-stage educational system - Bachelor of Engineering, Master's Degree and Doctoral studies. The students may broaden their theoretical knowledge and are introduced to utility and scientific activities. Students are presented with a remarkable possibility to study modern technologies and acquire knowledge from professional academic staff, using state-of-the-art laboratories and facilities. Multiple contacts across the world allow the students to participate in studies and subsequently work in numerous countries abroad. As a part of their studies, students may take part in major-oriented internships in leading industry companies. Furthermore, they actively participate in student associations, engage in research projects conducted at the Faculty and conduct their own academic projects - they construct vehicles, mobile robots, unmanned aerial objects, wheelchairs, and prostheses, among others, also taking part in conferences, exhibitions and fairs. Significant achievements of the students of the Faculty of Mechanical Engineering should be emphasized, both in domestic and international competitions. One example is a project of Martian rover analogues. Six such robots were constructed in the Faculty of Mechanical Engineering, repeatedly succeeding in University Rover Challenge taking place in Utah in USA. In 2010, Magma rover reached 3rd place. In subsequent year, Magma2 took 1st place, similar to Hyperion and Hyperion2 rovers in 2013 and 2014 respectively. In 2015 Next reached 4th place and in 2016 RED rover took 7th place. In European Rover Challenge, our students took 2nd place in 2015 and 5th place in 2016.

Representatives of the Faculty in SumoMasters team are undisputed champions of robotic sumo competition modelled on Japanese wrestling. In 2016, the team took 3rd place in BattleLab Robotica 2016 in Cluj-Napoca (Romania) and 5th place in All Japan Robot-sumo Tournament 2016 in Tokyo (Japan). In 2017 the team took 1st and 4th place in Robolid 2017 competition in Valladolid (Spain) and did not lose any fights during Robotchallenge 2017 in Beijing (China), taking 1st and 3rd place with their robots. In Robochallenge 2017 in Bucarest (Romania), the SumoMasters team won the 1st place, in Robotiada 2017 in Vilnius (Lithuania) – 2nd and 3rd and in Robotex 2017 in Tallin (Estonia) – 3rd place. However, the greatest success was the victory in All Japan Robot Sumo Tournament 2017 in Tokyo.

The Cerber Motorsport within the Faculty team constructed four vehicles for international car racing competition – Formula Student. In 2013, the students took part in races in Hockenheim (Germany) and Győr (Hungary), winning FSG Sportsmanship Award. The team took part in multiple Formula Student races: UK, Czech, Hungary and Italy in 2014 and UK on Silverstone Circuit and Czech in Hradec Kralove, Hungary in Győr and Italy in Varano de' Melegari. Cerber Motorsport is the first Polish team to ever reach the podium in general classification (2nd place in Formula Student Italy). In 2016 the team also took 4th place in Formula Student Czech Republic and was classified at 35th place (out of 547 teams) in global ranking. in 2017, the team took part in several Formula Student races: Czech, Hungary and Italy.

In years 2015-2017, the students of the faculty of Mechanical Engineering constructed three pneumobiles – vehicles propelled with compressed air and took part in international Aventics Pneumobil competition in Eger (Hungary).

The Aviation Students' Club took part in Air Cargo Challenge three times (Ota, Portugal in 2013, Stuttgart, Germany in 2015, Zagreb, Croatia in 2017) as well as participated in New Flying Competition in Hamburg, Germany (2016, 5th place). Mechatronix Students' club also participated in autonomous micro-aircraft competition: International Micro Air Vehicles Competition 2017 in Toulouse (France).

The students of the Faculty also conducted the HERMES project – economical attachment propelling wheelchairs. The project was awarded with a gold medals during International Invention and Innovation Show INTARG 2016, INOVA-BUDI UZOR 2016 in Croatia and Brussels Innova 2016.

On the Faculty of Mechanical Engineering, works are also conducted to create a Bobot – big, intelligent mobile robot which is to work in hospital children wards, serving as a electronic caretaker of the young patients. The robot was awarded with gold medal during International Invention and Innovation Show INTARG 2017. The inter-disciplinary students' club BiomCyberMedic operating in the Faculty created SENSO-Tunnel, deviced used in therapy of autistic children 3-12 years of age for exercising three of their senses: eyesight, hearing and touch. The device was also awarded a gold medal during International Invention and Innovation Show INTARG 2017.
Students of Faculties of Mechanical Engineering and Electrical Engineering won 2nd award during prestigious International Contest of Application in Nano-Micro Technology (iCAN) in Sendai (Japan) in 2014 with their wireless ICT system for observation of natural environment RECON.
The alumni of the Faculty of Mechanical Engineering find employment in renowned companies, leading brands in industry, such as Philips, Samsung, General Electric, ABB, Siemens, Volkswagen, Bosh, Voortman, Ford, Aesculap, Otto Bock, Johnson & Johnson, Fujitsu-Siemens, Chifa, Smith and Nephew, MAHLE, Delphi as well as in virtually every company in Podlaskie voivodeship. The Faculty also supports student innovative entrepreneurship. One example of such activities is Photon Entertainment, a company established by members of Robotics Students' Club and Mobile Technology Group within the Faculty of Mechanical Engineering as well as students from the Faculty of Computer Science. The students designed, created and constantly develop an interactive robot called *Photon*, which allows children to learn programming and develop logical thinking. Photon start-up obtained 10 million PLN investment from AHB2 Group for entering the educational robot into production and introducing the product to the international market.

DEPARTMENTS

Department of Mechanics and Applied Computer Science

Department of Automatic Control and Robotics

Department of Materials and Production Engineering

Department of Machinery Design and Thermal Engineering

Department of Biocybernetics and Biomedical Engineering

DEPARTMENT OF MECHANICS AND APPLIED COMPUTER SCIENCE

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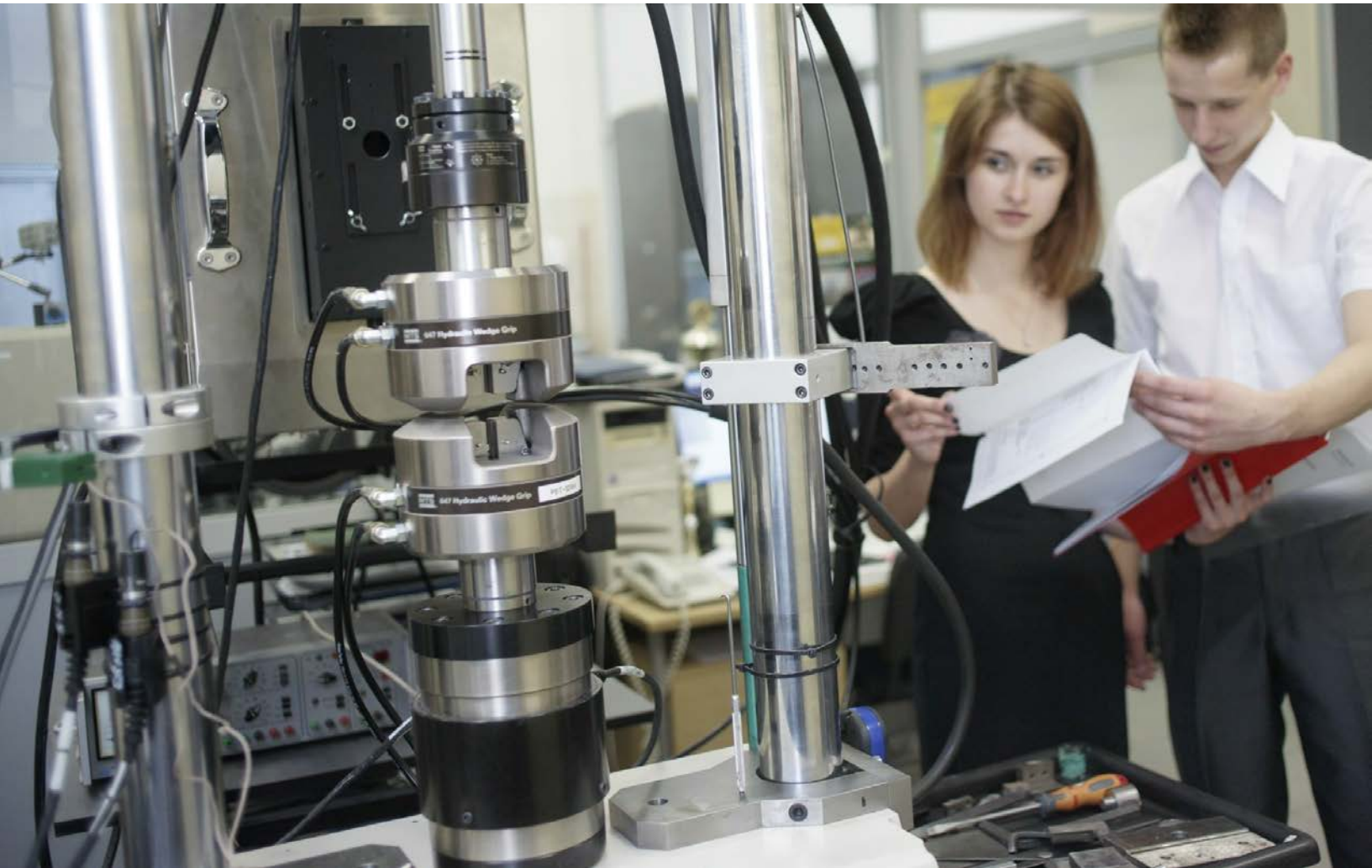


Research topics

1. Modelling of brittle and ductile fracture process in structural materials, also in heterogeneous and anisotropic media.
2. Mechanics of composite materials including polymer fiber composites, metal layer composites and sandwich structures.
3. Thermomechanics problems of laser heating of surfaces and frictional heating of brake components.
4. Analytical and experimental investigation of damage accumulation under complex stress states and high temperatures.
5. Prediction of strength and fatigue durability of structural elements with cracks and notches.
6. Thermoelastic contact problems of materials with complex thermomechanical properties, cracks and holes.
7. Non-destructive testing and measurement of thermal properties of materials by the method of active thermography.
8. Modelling of coupled thermo-electro-magneto-elastic field problems in anisotropic homogeneous and heterogenous media with cracks and thin inclusions.
9. Experimental investigations and numerical models of multiphase flow - in particular a dynamic of gas bubbles formation in liquid.
10. Elasticity and thermoelasticity problems of solids with gradient coatings.
11. Thermomechanical couplings in polycrystalline material under low-cycle fatigue.
12. Tribological and ecological study of friction materials.

Research and expertise offer

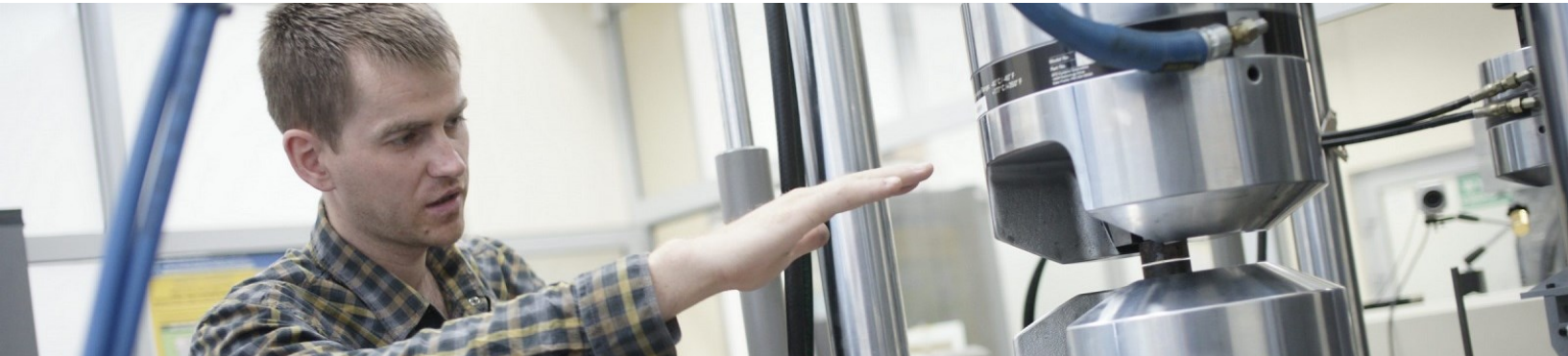
1. Mechanical testing solids and structures;
2. Fatigue testing of solids and structures;
3. Determination of strength and fatigue properties of solids and structures at elevated temperatures;
4. Rheology of materials at elevated temperatures;
5. Hardness and impact testing of materials;
6. Use active and passive infrared tomography;
7. Computer aided designinig of structural parts;
8. Finite element analysis of structural parts;
9. Computations of thermomechanical processes;
10. Providing measurments with strain gauges;
11. Determination of thermal properties of solids;
12. Providing expertises in a field of static and fatigue strengths of solids and structures and failure mechanisms.

Workshop offer

1. Consulting and training cources in using SolidWorks and Catia V5 software packages;
2. Finite element analysis of thermomechanical problems;
3. Computations of composite material structures;
4. Parametrical and multielement designing of structural parts;
5. Using techniques of reverse engineering and rapid prototyping in computer designing;
6. Non-destructive testing methods in mechanics.

Selected publications

1. Aleksander Yevtushenko, Michal Kuciej, Ewa Och (2017), LinkInfluence of thermal sensitivity of the materials on temperature and thermal stresses of the brake disc with thermal barrier coating, *LinkInternational Communications in Heat and Mass Transfer,* 87, 288-294.
2. Tomczyk A., Seweryn A., (2017), Fatigue life of EN AW-2024 alloy accounting for creep pre-deformation at elevated temperature, *Int. J. Fatigue*, 103, 488-507.
3. Doroszko M., Seweryn A., (2017), A new numerical modelling method for deformation behavior of metallic porous materials using X-ray computed microtomography, *Materials Science and Engineering: A*, Vol. 689, 142-156.
4. Pasternak Ia., Pasternak V., Pasternak R., Sulym H. (2017), Stroh Formalism in Evaluation of 3D Green's Function Inthermomagnetoelectroelastic Anisotropic Medium, *Mechanics Research Communications,* 84, 20-26.
5. Zubelewicz A., Oliferuk W. (2016), Mechanisms-based viscoplasticity: Theoretical approach and experimental validation for steel 304L, *SCIENTIFIC REPORTS*, 6, 23681.
6. Robert Uścinowicz (2016), Identification of yield surface segment of two-layer Pa38/M2R composite, *Mechanics of Composite Materials*, 52 (2), 163–170.
7. R. Kulchytsky-Zhyhailo, A. Bajkowski (2016), Axisymmetrical problem of thermoelasticity for half-space with gradient coating, *International Journal of Mechanical Sciences*, 106, 62-71.
8. Savruk, M. P., Kazberuk, A. (2016), Stress concentration near sharp and rounded V-notches in orthotropic and quasi-orthotropic bodies, *Theoretical and Applied Fracture Mechanics*, 84, 166-176.
9. Grzes P., Oliferuk W., Adamowicz A., Kochanowski K., Wasilewski P., Yevtushenko A.A. (2016), The numerical-experimental scheme for the analysis of temperature field in a pad-disc braking system of a railway vehicle at single braking, *Int. Commun. Heat Mass Transfer*, 75, 1 -6.
10. Yevtushenko A.A., Grzes P. (2016), Mutual influence of the sliding velocity and temperature in frictional heating of the thermally nonlinear disc brake, *International Journal of Thermal Sciences*, 102, 254-262.
11. Derpenski L., Seweryn A. (2016), Ductile fracture of EN-AW 2024 aluminum alloy specimens with notches under biaxial loading. Part 2 - Numerical research and ductile fracture criterion, *Theoretical and Applied Fracture Mechanics*, Vol. 84, 203-214.
12. Górski G., Mosdorf R. (2016), Identification of two-phase flow patterns in minichannel based on RQA and PCA analysis, *International Journal of Heat and Mass Transfer*, 96, 64-74.



Test equipment

MTS 322 series Servohydraulic Material Testing System

- MTS Silent Flo 505.20 Hydraulic Power Unit with 62.5 l/min nominal flow rating;
- control by using MTS Testar II 90.01;
- test space: width 600 mm and height up to 1000 mm;
- dynamic force range of the 1st actuator: ± 50 kN; working stroke of the actuator: ± 75 mm;
- dynamic force range of the 2nd actuator: ± 250 kN; working stroke of the actuator: ± 150 mm;
- control of experimental tests by using extensometer, displacement or force;
- flat and round specimens for testing;
- hydraulic grips.

MTS Bionix 858 Axial-torsional Servohydraulic Material Testing System

- MTS Silent Flo 505.11 Hydraulic Power Unit with 41.6 l/min nominal flow rating;
- control by using MTS FlexTest SE 2- Channel Plus;
- test space: width 300 mm and height up to 500 mm;
- dynamic force rating: ± 25 kN;
- total stroke of linear actuator: 100 mm;
- dynamic torque rating: ±200 Nm;
- total angular displacement: 270°;
- control of experimental tests by using a displacement (and/or angle of torsion) sensor;
- force (and/or torque) transducer;
- flat and round specimens for testing;
- hydraulic axial-torsional grips with regulated clamping force.

MTS 809.10 Axial-torsional Servohydraulic Material Testing System

- MTS Silent Flo 505.11 Hydraulic Power Unit with 42 l/min nominal flow rating;
- control by using MTS FlexTest 40;
- test space: width 533 mm and height up to 1085 mm;
- dynamic force rating: ±100 kN;
- total stroke of linear actuator: 150 mm;
- dynamic torque rating: ±1100 Nm;
- total angular displacement: 90° dynamic, and 100° static;
- control of experimental tests by using a displacement (and/or angle of torsion) sensor;
- force (and/or torque) transducer;
- flat and round specimens for testing;
- collet and wedge hydraulic axial-torsional grips sets with regulated clamping force.

MTS Insight Material Testing Systems

- axial loading range ± 1 kN;
- vertical test space (crosshead travel) up to 750 mm;
- position accuracy 0,01 mm;
- position resolution 0,001 mm;
- maximum test speed 1500 mm/min;
- minimum test speed 0,001 mm/min;
- stepless speed control (possibility of flexible speed changes during test);
- adapter for the hardness and microhardness testing;
- adapter for bending and shear tests;
- measurement of friction coefficient;
- flat and round specimens for testing.

Four-column electromechanical creep testing machine Zwick-Roell KAPPA 100 SS

- axial load range: ± 100 kN;
- working area 1350 mm × 720 mm;
- load speed range: 1 micron / h to 100 mm / min;
- cylinder stroke: 250 mm;
- independent control of the force or movement;
- define the sequence of individual load and temperature;
- short- and long-term (10,000 hours) creep tests and creep tests to destruction;
- tensile test;
- stress relaxation tests;
- possibility to implement all of the tests at room temperature or at elevated temperature (up to 1000° C);
- test sample: axially symmetrical or flat.

MTS 651.05E-02 Environmental Test Chambers

- strength tests at -75 ÷ 315°C;
- control software by MTS controller FlexTest SE;
- internal dimensions of the Test Chamber: width 286 mm, depth 305 mm, height 457 mm;
- chamber set on a specific mobile platform allowing for its quick installation on different;
- test machines;
- integrated PID control system;
- the ability to cool the samples during the test liquid nitrogen;
- inspection window to view the work area.

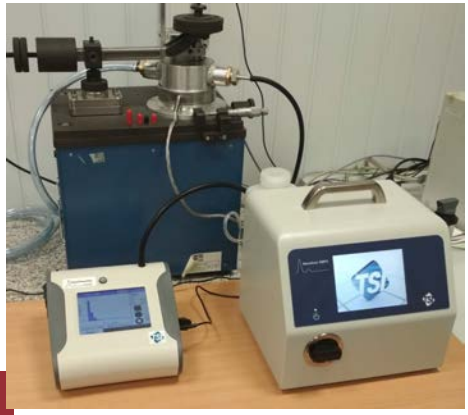
Scanning electron microscope Phenom XL

- image magnification range, light optical: 3 - 16x;
- image magnification range, electron optical: 80 - 100000x;
- test chamber size: 100mm x 100mm x 65mm;
- resolution: <20nm;
- sample loading time from optical to SEM less than 60 seconds;
- rimage resolution option from 456 x 456 to 2048 x 2048 pixels;
- installed detectors: BSD (BackScatter Detector), EDS (Energy-dispersive- spectroscopy), SED (Secondary Electron Detector) provides detailed information of the examined surface topography and allow analysis of the sample's chemical composition.

High resolution desk-top micro-ct Skyscan 1172

- X-ray source 10W;
- spot size <5 µm;
- up to 4000x2664 pixel (11 Mp) X-ray camera;
- field of view (FOV) 24 mm x 36.0 mm;
- nominal resolution 0.7-25 µm/px;
- variable position geometry of the camera-object-X-ray source, allowing faster scanning at higher resolution;
- X-ray source with the possibility of adjustment from 20 to 100 kV;
- electronically switched filters;
- software with complete solution for acquisition, reconstruction and data analysis.

Spectrometers NANOSCAN 3910 and OPS 3330



NANOSCAN 3910

- measurement of concentration of particles from 10 to 420 nm up to 1 000 000/cm^3;
- Inlet flow rate 0.75 LPM;

OPS 3330

- measurement of concentration of particles from 0.3 to 10 µm up to 3 000/cm^3;
- Inlet flow rate 1 LPM.

Digital high-speed monochrome camera Phantom v1610/96

- max speed at full resolution of 1280 x 800 is 16,000 fps;
- max speed at reduced resolution of 128 x 16 is 1,000,000 fps;
- CMOS sensor;
- 12-bit depth;
- 28 µm pixel size;
- 1 µs minimum exposure standard, 500 ns minimum exposure with FAST option;
- High-Speed Image Correlation System Q-450 by Dantec Dynamics.

High performance Infrared Camera Cedip TITANIUM 560M

- state-of-the-art InSb (indium antimonide) sensor with 3.6-5.1 µm spectral response;
- 640 x 512 resolution and full 14-bit dynamic range;
- high speed frame rate operation up to 5 KHz (380Hz in full frame mode);
- smart external triggering;
- Camera Link and USB2.0 interfaces, S-Video output;
- temperature calibration range from -20°C to 400°C w/o high temp. Filter;
- temperature measurement accuracy ±1°C or ±1%;
- Noise Equivalent Temperature Difference (NETD) < 25 mK;
- Non-Destructive Testing with Active Thermography.

Other laboratory equipment

- electromechanical testing machines EDZ 100 i EDZ 40;
- electromechanical universal testing machine ZD10/90;
- testing machine KM-50-1;
- extensometers to measure of deformations and control: biaxial (elongation-shortening + torsion angle) - MTS 632.85F-05/14/, MTS 632.80F-04, Epsilon 3550HT and axial (elongation-shortening)) - MTS 632.68F−08, MTS 632.18, Epsilon 3542, Epsilon 3541;
- torque sensor 20, 100 1000 Nm;
- universal DAQ Amplifier QUANTUM X;
- Brinell, Rockwell, Vickers hardness testing machine;
- stand for testing the fatigue life of toothed gears.

DEPARTMENT OF AUTOMATIC CONTROL AND ROBOTICS

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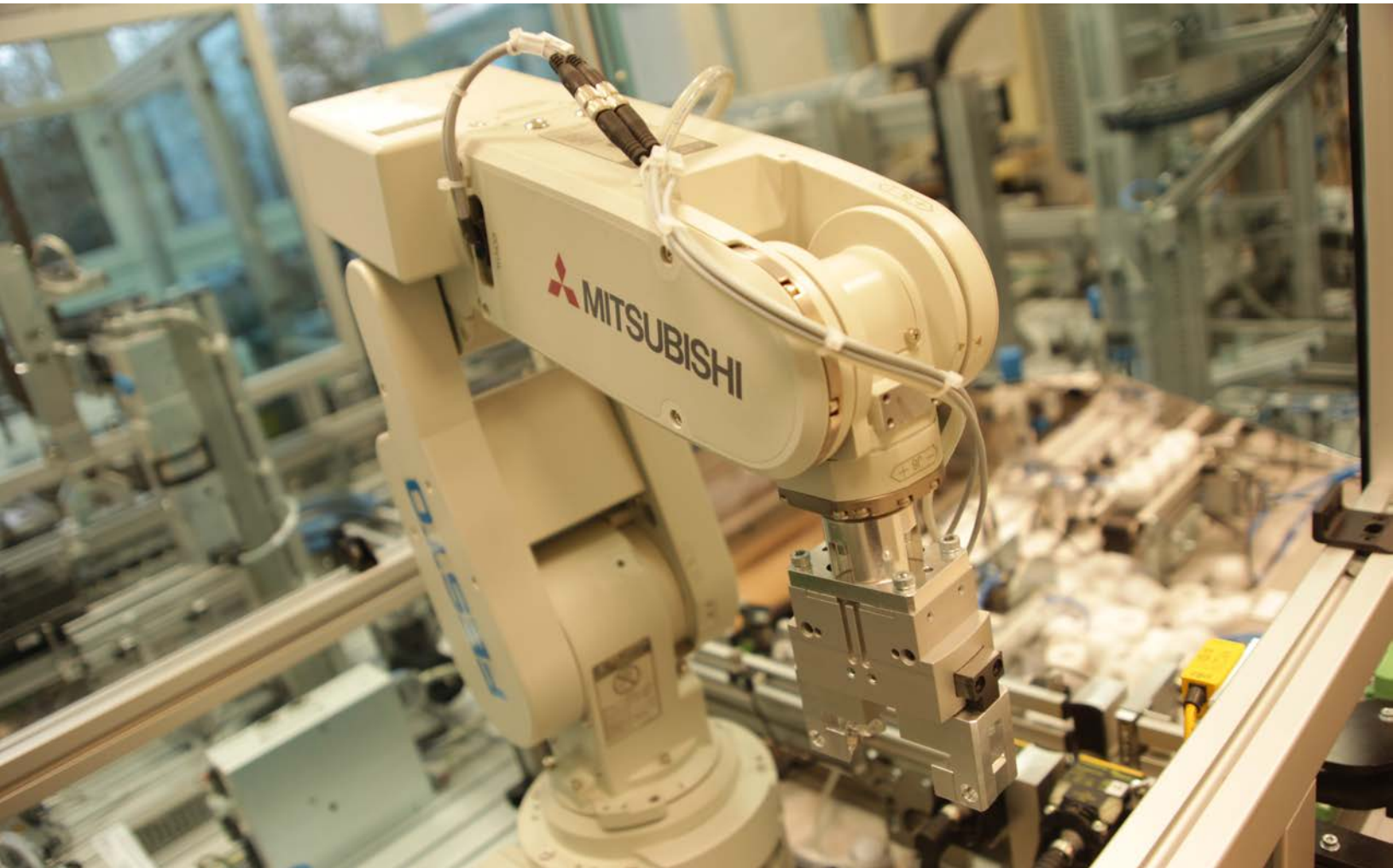


Research topics

1. Unmanned Aerial Vehicles (UAVs)
   - Formation flight of UAVs
   - Autonomous control systems of UAVs
   - Autonomous take-off and take-on of UAVs
   - Electromagnetic launchers for UAVs
2. Overground mobile robotics
   - Wheeled and walking robots
   - Gripper optimization
   - Industrial applications
3. Human gait biometrics, systems with biological feedback, pneumatic artificial muscles
4. Passive, active and hybrid magnetic bearings
5. Vibration control methods for mechanical structures
6. Flywheel energy storage systems
7. Application of piezo elements in dynamical systems
8. Diagnostics of rotor shafts and turbine blades failures
9. Leak detection in transmission pipelines and water networks
10. Control systems on time scales
11. Control systems on fractional orders

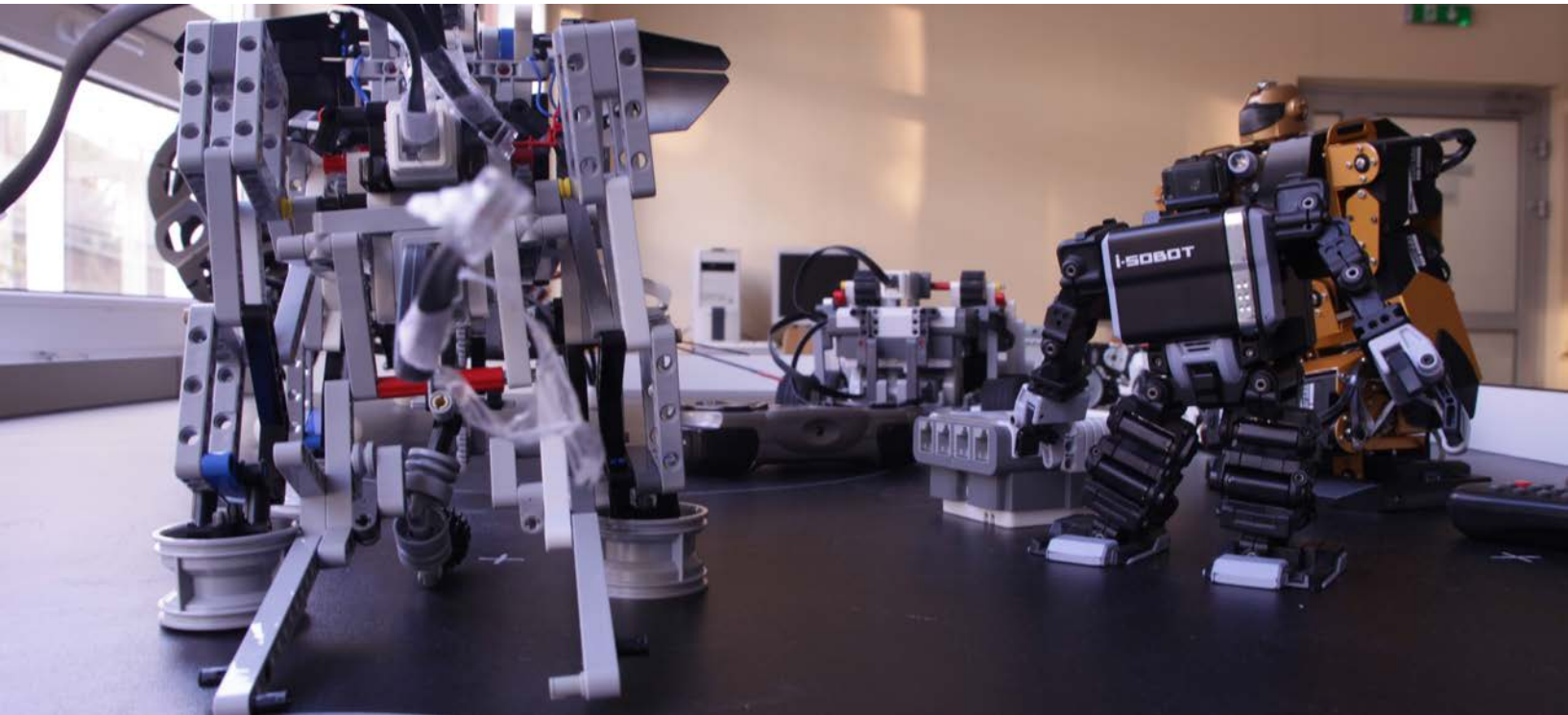
Advanced robust and nonlinear control systems

Research and expertise offer

1. Design and realization of passive, active and hybrid magnetic bearing systems.
2. Diagnostics and analysis of Ethernet, PROFIBUS/PROFINET RT/IRT 1/2/3 class data frames.
3. Dynamics study of pneumatic breaking systems for vehicle.
4. Design of industrial networks structure.
5. Programming of PLC and controllers working in the network.
6. Design of industrial process visualization systems.
7. Design of an active vibration isolation system for rotating machines.
8. Flexible rotors balancing with weight up to 3000 kg.
9. Application of manipulators/robots in technological lines.

Workshop offer

1. Industrial networks Profibus DP and Profinet IO.
2. Programming of industrial process control systems.
3. Application of real time controllers PLD I FPGA.
4. ARM microcontrollers programming.
5. Computer graphics.
6. Web design.



Selected publications

1. Kownacki C., Ambroziak L. (2017) Local and asymmetrical potential field approach to leader tracking problem in rigid formations of fixed-wing UAVs, *Aerospace Science and Technology*, 68, 465-474
2. Daunoravičienė K., Žižienė J., Pauk J., Idźkowski A., Raudonytė I., Juocevičius A., Linkel A., Griškevičius J. (2017), Stroke-affected upper extremity movement assessment via continuous relative phase analysis, *Measurement*, 11, 84-89.
3. Wolniakowski A.,Miatluk K., Gosiewski Z.**,** Kruger N. et al. (2017), Task and context sensitive gripper design learning using dynamic grasp simulation, *Journal of Intelligent and Robotic Systems*, Springer, 87(1), 15–42.
4. Mystkowski A., Kaparin V., Kotta U., Pawłuszewicz E., Tõnso M. (2017), Feedback linearization of an active magnetic bearing system operated with a zero-bias flux, *International Journal of Applied Mathematics and Computer*, 27(3),
5. Mystkowski A., Koszewnik A. (2016), Mu-Synthesis robust control of 3D bar structure vibration using piezo-stack actuators, *Mechanical Systems and Signal Processing*, 78, 18-27.
6. Kownacki C. (2016), A concept of laser scanner designed to realize 3D obstacle avoidance for a fixed-wing UAV, *Robotica,* 34(2), 243-257.
7. Kulesza Z., J. T. Sawicki (2016), Parametrically induced damping in a cracked rotor, ASME *Journal of Engineering for Gas Turbines and Power*, 139(1), DOI 10.1115/1.40 34197.
8. Mullari T., Kotta U., Bartosiewicz Z., Pawłuszewicz E., Moog C. H. (2016), Forward and backward shifts of vector fields: towards the dual algebraic framework, *IEEE Transactions on Automatic Control*, 62(6), 3029-3033.
9. Girejko E., Pawłuszewicz E. (2016), Remarks on fractional discrete cone control systems with n-orders and their stability, *Journal of Dynamical and Control Systems*, 23(2), 269-281.
10. Koszewnik A., Gosiewski Z. (2016), Quasi-optimal locations of piezo-elements on a rectangular plate, *European Physical Journal Plus*, 131:232, DOI.org/10.1140/epjp/i2016-16232-2.

Test equipment

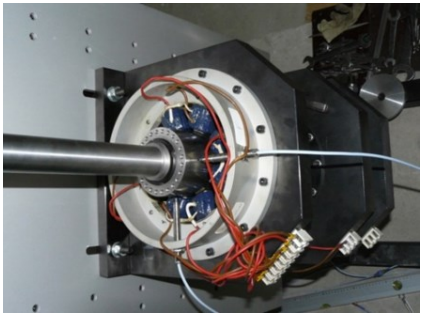
ADEPT COBRA i600 industrial robot workstation

- SCARA type robot with four degrees of freedom,
- replaceable vacuum or jaw gripper,
- work radius in XY plane: 600mm,
- Z axis movement in the range 0 ÷ 210mm,
- payload rated/max.: 2kg/5.5kg
- built-in high resolution, absolute encoders
- repeatability: XY ± 0.017 mm, Z ± 0.003 mm, Theta ± 0.019 °,
- 12 digital input and 8 digital output channels
- wide range of peripherals such as feeders, sensors, indexing table,
- MicroV + programming language,
- cooperation with the vision system

High-speed flywheel energy storage system

- nominal stored energy up to 7.2 MJ at rotor speed of 20,000 rpm;
- rotor diameter 0.47 m;
- shaft length 1.12 m;
- total rotor mass 195 kg;
- two 3-phase synchronous electric motors/generators, each of 50 kW;
- FPGA-hardware controller for PWM control of motors/generators.

Active magnetic bearings type LM90 test rig LM90/204/90



- measurement system of rotor displacement in sensor planes (x and y) using eddy-current sensors with accuracy up to 1 μm;
- max. rotational speed 24 000 rpm;
- PWM power amplifiers of active magnetic bearings (AMB);
- AMB current control range ±10 A or ±5 A. Rotor displacement measurement in several planes by eddy current sensor with measuring accurancy up to 0.001 mm.

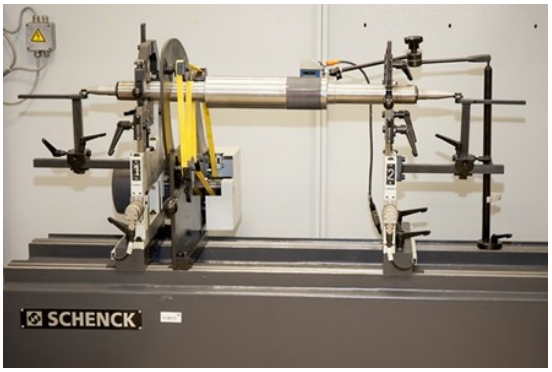
MPS 500-FMS – a flexible manufacturing line stand

- distribution station with gravitational feeder and rotary actuator;
- control station equipped with sensors, lifting mechanism, guides and measurement unit;
- grasping station with 2 DoF manipulator armed with pneumatic gripper and object identification system;
- sorting station;
- assembly station equipped with 5 DoF robotic arm and distribution unit;
- robotized recycling station;
- continuous system automation unit.

UR5 Universal Robots package, collision avoidance algorithms

- weight: 18,4 kg;
- payload: 5 kg;
- reach: 850 mm;
- movement: +/- 360°
- maximum speed: 180°/s;
- repeatability: +/- 0,1 mm;
- degrees of freedom: 6;
- Communication: TCP / IP and Modbus TCP;
- Software: Polyscope - Graphical User Interface on the 12" touch screen.

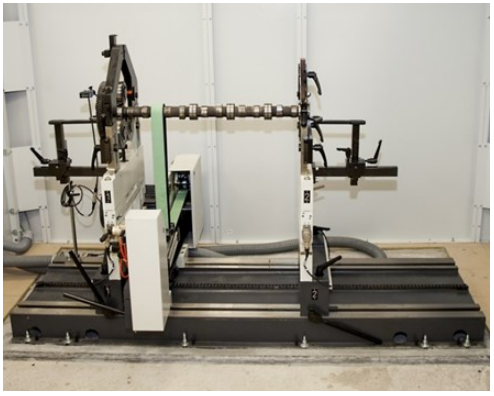
Schenck HE2BK horizontal balancing machine for rigid shafts



- universal balancing machine for rotors of mass up to 40 kg;
- maximum rotor diameter 800 mm;
- unbalance correction in two planes;
- separate correction of static and coupled unbalance;
- strong bearing pedestals for shafts of 8-50 mm diameter;
- min. distance between roller supports without drive: 50 mm;
- min. distance between roller supports with drive: 110 mm;
- accuracy up to 0.1 gmm/1 kg;
- measurement range 100-5000 rpm.

Dynamic balancer HS40 for flexible rotors

- maximum rotor mass: 3000 kg;
- maximum load per support: 1500 kg;
- bed length: 2000 mm;
- limit of calibration constant value: $630 \cdot 10^6$ kg/min^2;
- measuring range: from 120 to 65,000 rpm;
- minimum distance between rollers with drive: 110 mm;
- measuring accuracy: 0,1gmm /1kg of rotor mass (not less than 1gmm);
- measuring range: 100-5000 rpm.



Kawasaki FS003N industrial robot

- six joints, 3 kg payload, +/- 0.05 mm repeatability, 620 mm;
- FD70-hardware controller (32 I/O, Ethernet, RS-232C, 2 MB RAM, multi-tasking);
- portable teach pendant with 6.4″ screen and touch panel function;
- KCWin communication software;
- vacuum gripper.

Other laboratory equipment

- rotational laser vibrometer RLV-5500; 8-channel telemetry system KMT; dSPACE Processor Board DS1006; dSPACE R&D Controller Board DS1104; dSPACE Connector Panel CP1104; 8-Slot, National Instruments up to 8 GB/s PXI Chassis - PXIe-1082 (with mounted: NI PXIe-8135 – Embedded Controller, NI PXIe-6368 – X Series Multifunction DAQ, NI PXIe-4322 – 8ch Analog Output, NI PXIe-4499 – flexible gain dynamic signal analyzer, NI PXI–6232 – M series multifunction DAQ, NI PXI–7854R – R series multifunction RIO with Virtex-5 LX110 FPGA); high end laser shaft alignment system Easy Laser e710; electromagnetic vibration generator TIRA TV 1140;
- FFT Dynamic Signal Analyzer 35670A; Oscilloscope Agilent 54624A; Digital Phosphor Oscilloscope Tektronix DPO4054; Oscilloscope OS-9100D GoldStar; Audio Oscillator GoldStar AO-3001C; Logic Analyzer Tektronix TLA5202B; Programmable DC calibrator Z183 CTH Meratronik; Function / Arbitrary Waveform Generator Agilent 33220A;
- Kestrel autopilot with equipment; On-board equipment with reference station GPS for mobile robots; Development boards for rapid prototyping of control systems: Xilinx VC707 development board, Xilinx ZC706 development board;
- test stand for rotating machines diagnostics; test stand for diagnostics of leaks from long pipelines and water supply networks;
- machine toolset for composite laminates production:
  3D laser plotter Seron for precision cutting,
  CNC machine tool Kimla BFN 1006;
- system SMART with two Kistler dynamometric platforms and the measurement system of muscles electromiographic (EMG) activity (EMG); rehabilitation treadmill Zebris FDM-TDSL-3I;
- high-performance computing cluster of 5 Actina Solar G200 S6 computers with total 120 processor cores.

DEPARTMENT OF MATERIAL AND PRODUCTION ENGINEERING

Head of Department: Assoc. Prof. Piotr Mrozek, DSc, PhD, Eng

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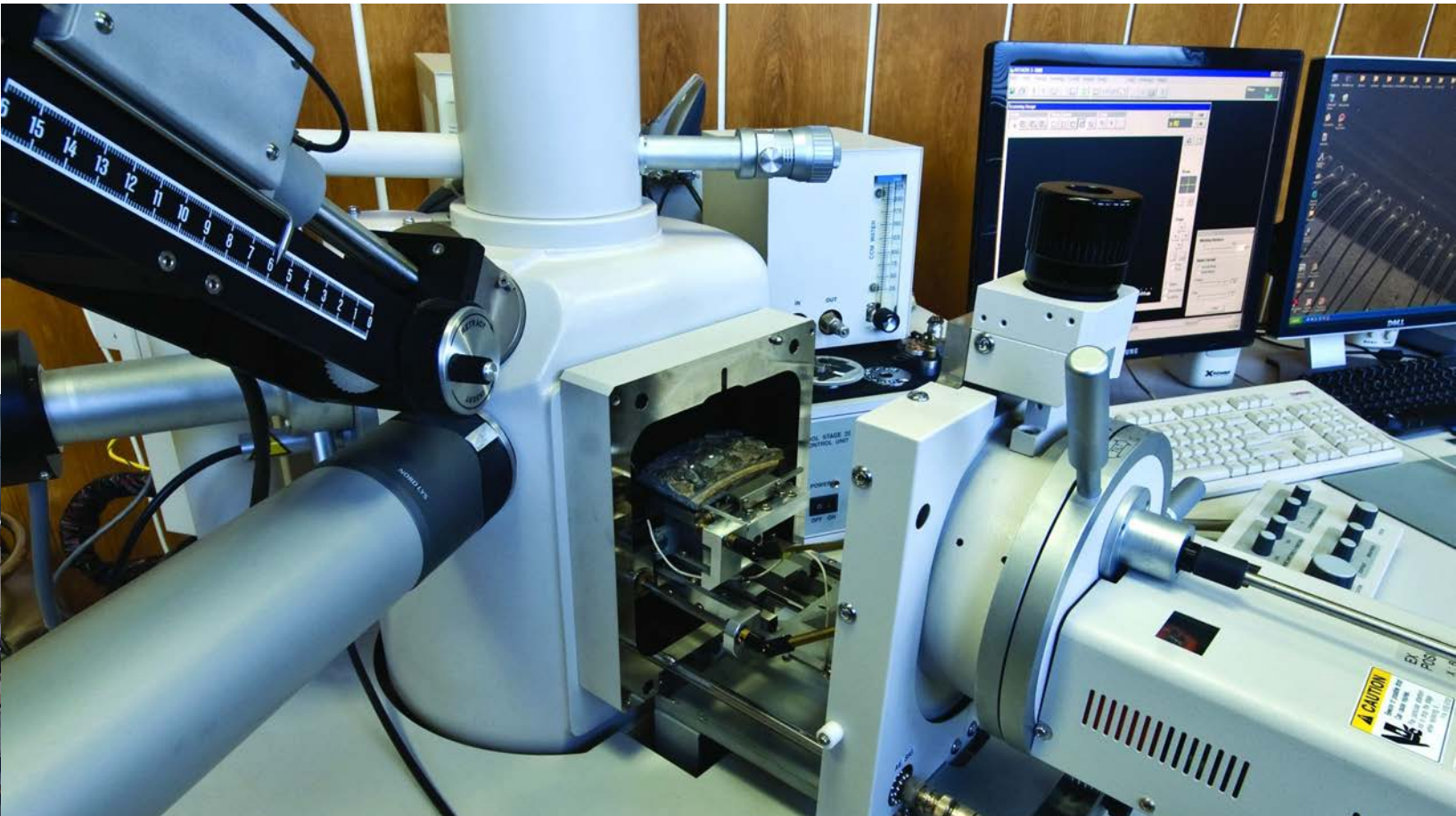
Research topics

1. Biomaterials for bone surgery and stomatology, focused on:
   - sintering materials based on implantable alloys
   - polymers and composites
   - modification of biomaterial's surfaces
2. Biotribology of human joints and stomatognatic system
3. Steels and other types of metallic alloys reinforced with yttria nanoparticles
4. Coordinate measurements and analysis of free surface displacements
5. Error correction of the complex shaped surfaces on CNC milling machines
6. The quality of surface layer and accuracy of manufacturing process in the mass production of machine parts and elements
7. Analysis of the microstructure development and the quality of the final product in the plastic deformation process
8. Modern welding technologies

Research and expertise offer

1. Manufacturing and investigations of sintered materials based on titanium, cobalt and iron alloys.
2. Optimization of heat treatments parameters of titanium and stainless steel alloys
3. Tribological characterization of friction materials and lubricants.
4. Rheological investigation of fluids, especially biological fluids and food products.
5. Optimization of technological process parameters of injection molding and extrusion of thermoplastic polymers.
6. Application of rapid prototyping method for manufacturing of various machine components.
7. Errors correction of machining objects manufactured by means of the CNC machines
8. Measurements and analysis of the geometric structure of the surface.
9. Coordinate measurements and assessment of the accuracy measurements of the parts with complex spatial shapes.
10. 3D digitization of surfaces be means of contacting and non-contacting methods.
11. Hardness, micro-hardness and nano-hardness measurements of materials in the load range from 0.01 mN to 30 N by means of Vickers and Berkovich methods.



Workshop offer

1. Programming treatments milling, turning and electro.
2. Operation of numerically controlled machines.
3. Support for coordinate measuring devices.
4. Reverse engineering of spatial objects.
5. The application of CVD and PVD techniques for applying the surface layers.

Selected publications

1. Mystkowska J., Ferreira J., Leszczyńska K, Chmielewska S., Dąbrowski J.R., Wieciński P., Kurzydłowski K.J. (2017), Biocorrosion of 316LV steel used in oral cavity due to *Desulfotomaculum nigrificans* bacteria, *Journal of Biomedical Materials Research Part B: Applied Biomaterials*, 105(1), 222-229.
2. Niemirowicz K., Car H., Sadowska A., Wątek M., Krętowski R., Cechowska-Pasko M., Wilczewska A.Z., Mystkowska J., Kasacka I., Torres A., Bucki R. (2017), Pharmacokinetics and Anticancer Activity of Folic Acid-Functionalized Magnetic Nanoparticles, *Journal of Biomedical Nanotechnology*, 13(6), 665-677.
3. Mystkowska J., Mazurek-Budzyńska M., Piktel E., Niemirowicz K., Karalus W., Deptuła P., Pogoda K., Łysik D., Dąbrowski J. R., Rokicki G., Bucki R. (2017), Assessment of aliphatic poly (ester-carbonate-urea-urethane)s potential as materials for biomedical application, *Journal of Polymer Research*, 24, 11.
4. Tokajuk G., Niemirowicz K., Deptuła P., Piktel E., Cieśluk M., Wilczewska A. Z., Dąbrowski J. R., Bucki R. (2017), Use of magnetic nanoparticles as a drug delivery system to improve chlorhexidine antimicrobial activity, *International Journal of Nanomedicine,* 12, 7833-7846.
5. Oksiuta Z., Perkowski K., Osuchowski M., Zalewska M., Andrzejczuk M. (2018), Microstructure and thermal properties of mechanically alloyed W-1%TiC powder consolidated via two-step HIPping, *Fusion Engineering and Design,* 126, 51-58.
6. Werner A. (2016), Method for enhanced accuracy in machining curvilinear profiles on wire-cut electrical discharge machines, *Precision Engineering,* 44, 51-58.
7. Łępicka M., Grądzka-Dahlke M., Pieniak D., Pasierbiewicz K., Niewczas A. (2017), Effect of mechanical properties of substrate and coating on wear performance of TiN- or DLC-coated 316LVM stainless steel, *Wear,* 382-383, 62-70.
8. Pogoda K., Piktel E., Deptuła P., Savage P.B., Lekka M., Bucki R, (2017), Stiffening of bacteria cells as a first manifestation of bactericidal attack, *Micron,* 101, 95-102.
9. Oksiuta Z., Hosemann P., Vogel S. C., Baluc N. (2014), Microstructure examination of Fe14Cr ODS ferritic steels produced through different processing routes, *Journal of Nuclear Materials*, 451(1-3), 320-327.
10. Poniatowska M. (2015), Free-form surface machining error compensation applying 3D CAD machining pattern model, Computer-Aided Design, 62, 227-235.

Test equipment

Scanning electron microscope Hitachi S-3000N

- high and low vacuum;
- ability to work in BSE and SE modes, high sensitivity solid -state BSE detector;
- equipment for biological structure analysis;
- EDS Thermo Ultra Dry and phase identification system EBSD NORDLYS equipment HKL technology;
- maximum magnification up to 100 000 x.

Confocal laser scanning microscope Olympus Lext OLS 4000

- nanometre level imaging, magnification ranges from 108 to 17000x;
- UV, polarized light analysis;
- 3D measurement and roughness measurement;
- Resolution: XY: 0.120 µm; Z: 0.01 µm;
- surface measurements: distance, height, curvature radius, diameter, surface area, volume, and surface topography;
- linear profiles estimation, layer thickness, surface objects analysis.

Optical emission spectrometer Thermo ARL Quantris

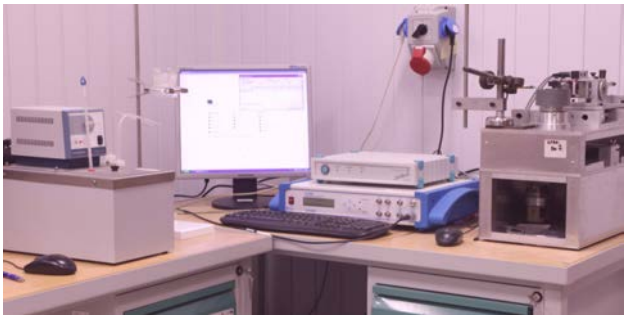
- vacuum operation;
- CCD technique;
- quantitative chemical analysis of alloys based on Fe, Ti, Al;
- full and continuous coverage of wavelengths: 130-780nm.

Biotribotester (friction simulator of hip joint)

- interchangeable pairs of friction: ring-disc or head - acetabulum;
- variable load in the range of 0 to 16 MPa;
- reverse-rotational motion of 1 Hz;
- maximum sliding velocity v max = 0.018 m/s;
- dry, wet work environment (depends on the research program);
- ability to regulate the friction slot.

Fretting and fretting-corrosion tester

- fixed and variable load;
- oscillating and rotary motion;
- smooth adjustment of the amplitude of the oscillation in the range from ± 0.01 to ± 0.06 rad;
- changeable radius of friction;
- maximum load up to 600N.



Testing machine ZWICK/ROELL Z010

- testing machine is equipped with X-force load cells;
- data acquisition rate, internal 320 kHz;
- test speed: 0.001 - 2000 mm/min;
- test load up to 10kN;
- testXpert® analysis program.

Coordinate measuring machine (CMM)

- control of manufacturing precision of parts in the machine industry;
- range of measurement: 710x660x460 mm;
- measurement deviation: 2,5+4L/1000 µm;
- max load of the table: 600 kg;
- the maximum number of measurement points/minute: 48/min;
- five axes fully controlled via a PC computer.

Coordinate measuring machine Global Performance 07 07 05

- continuous scanning of the measured work piece;
- range of the measurement: 700x700x500 mm;
- fully automatic system of temperature compensation;
- manual correction of the work piece expansion coefficients;
- driver with the auto-smoothing feature of the path of the machine movement;
- possibility to compensate for the weight of the heads by means of air pressure adjustment.

AFM microscope equipped with nanoindenter and scratch tester

- UNHT module, load 0 - 50 mN, penetration depth 0-50 µm, Berkovich indenter;
- UHT module and Scratch (Micro Combi Tester), load 0.010 - 30 N, penetration depth 0-50 µm; Rockwell and Vickers indenter C, R=100 µm, acoustic emission sensor;
- table movement 245x120 mm;
- AFM microscope with (XY) 110 x 110 µm, Z=22 µm; with scanning resolution of 400x300 µm, 800x600 µm, 1600x1200 µm;
- OLIMPUS optical microscope with magnification up to 4000x.

Measuring microscope Falcon

- magnifications: 10x, 20x, 30x, 40x, 80x, 100x;
- table size 150x150 mm;
- range of measurements in Z-axis - 115 mm;
- CCD camera 5:1;
- incremental scale X, Y, Z axis - 1 µm;
- software with the sensor QC5000VED edge.

Laser interferometer system XL-80

- homodyne laser;
- range up to 80 m;
- measurement accuracy ±0,5 µm/m;
- sampling from 10 Hz to 50 kHz;
- maximum speed of measurement 4 m/s;
- resolution 1 nm with 4 m/s;
- measurement of angular deviations;
- straightness measurement (Wollaston's optic), range 0,1-4 m.

3D Production System - The FORTUS 360mc

- size of the working chamber (XYZ): 355 x 254 x 254 mm;
- thickness singular layer from 0.127 to 0.330 mm;
- manufacturing accuracy 0.127 mm or 0.0381 mm/mm;
- Insight software;
- material: ABS-M30, PC-ABS, PC.

Wire EDM machine AU-300iA

- working distance 765 x 535 x 215 mm;
- XY movement: 350 x 250 mm;
- movement of UV axis: 80 x 80 mm;
- Z-axis displacement: 220 mm;
- optical Heidenhain gauges with resolution of 0,1 µm;
- speed of cutting 300 mm2/min;
- surface roughness Ra 0,15 µm.

Vertical machining milling center

- control in 4 axes, positioning accuracy of 5 µm;
- working range 1÷12 000 mm/min;
- speed of movement 20 000 mm/min;
- range of the spindle speed 60-8000obr/min;
- automatic tools exchange;
- tool magazine up to 24 pieces;
- range of displacement (XYZ) 1020x510x510 mm;
- the spindle taper of 40;
- control system of iTNC 530 Heidenhain;
- probe for tool and work piece measuring.

CNC lathe DMG CTX 310 eco

- SIEMENS 840D control system;
- 12-tool head possible position VDI;
- automatically traversable tailstock;
- passage clamping device ø51 mm;
- max passage 330 mm;
- passage over lathe carriage 260 mm;
- max turning diameter ø200 mm;
- movement in X-axis: 160 mm;
- movement in Z-axis: 450 mm;
- spindle drive of 4 000 rpm, 8,4 kW, 20Nm (40% ED).

5-axis vertical machining center DMU 50 eco

- SIEMENS 840D control system;
- swivel rotary table with digital NC drives;
- positioning accuracy of table up to 0,008 mm;
- tool magazine 16 pieces;
- electrospindle of milling with 8.000 rpm, 13 kW, 83 Nm (40% ED).

Water jet cutting machine KIMLA

- working range in XYZ axis: 2000 x 1000 x 200 mm;
- dimension of the cut sheet: 2000 x 1000 mm;
- 5-axis cutting head;
- max thickness: 200 mm;
- max pressure of the pomp: 4137 bar;
- abrasive feeder: 300 kg;
- pneumatic delivery system of abrasive;
- possible cutting under water;
- KIMLA control system of cutting head movement.

Other laboratory equipment

- optical microscope NIKON ECLIPSE E50I;
- stand for electrochemical analysis VoltaLab 21;
- rheometr RheoStress 6000 (Thermo HAAKE);
- helium picnometer Micromeritics AccuPyc 1330;
- plastometer REO-100;
- powder particles analyser FRITSCH ANALYSETTE 22;
- high-temperature tube furnace Czylok PRC65M/PR with vacuum system PT50;
- measuring arm Romer RA-7520-2;
- roughness measurement system Mitutoyo SJ 500;
- optical 3D scanner Scanbrigt i Scanbrigt Mini;
- CNC QC20-W Ballbar wireless machine for tool performance diagnosis.

DEPARTMENT OF MACHINERY DESIGNE AND THERMAL ENGINEERING

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Research topics

1. Experimental investigations and modelling of machinery elements:
   - fatigue strength and fracture of inhomogeneous materials and welded joints;
   - investigations of tribological and mechanical properties of composite materials;
2. Experimental investigations and modelling of automotive vehicles:
   - investiogations of air brake systems in agricultural vehicles;
   - alternative energy sources in vehicles;
   - comparative studies of engines with various fuel systems;
   - assessment of inequality dosing of the injectors;
3. Experimental investigations and modelling of thermal and flow phenomena:
   - investigations of one- and two-phase ejectors in application to refrigeration and heat pump systems;
   - experimental investigations of ejector reactors for gas clearing systems;
   - investigations of heat transfer and flow resistance in heat exchangers in application to thermal power engineering and refrigeration;
   - innovative cold storage systems of vegetables and fruits.

Research and expertise projects

1. Issues of machinery design:
   forming technology of machine elements and evaluation of quality of external surface;
   tribological examination of elements of machines;
   analysis of the durability and reliability of mechanical structures;
   machinery design along with technical and technological documentation.
2. Issues of automotive vehicles and engines:
   testing of vehicle engines with different fuel systems;
   analysis of irregularity injectors dosing in vehicle engines.
3. Issues of thermal engineering:
   refrigeration systems driven by low grade heat sources;
   application of low-emission working fluids in refrigeration and heat pump engineering;
   innovative cold storage of fruits and vegetables;
   thermal and flow measurements of fully-scale heat exchangers;
   monitoring of vacuum systems in steam turbounits;
   measurements of velocities distributions in flow ducts and thermal;
   measurements of properties of fuels (gas, liquid, solid).

Workshop offer

1. Certified training and examinations in refrigeration, air-conditioning and heat pump engineering, including F-Gases procedures - formal accreditation of Polish Office of Technical Inspection (UDT);
2. Diagnostics of automotive vehicles;
3. Machinery design with use of SolidWorks environment;
4. Polygeneration and local power centres.

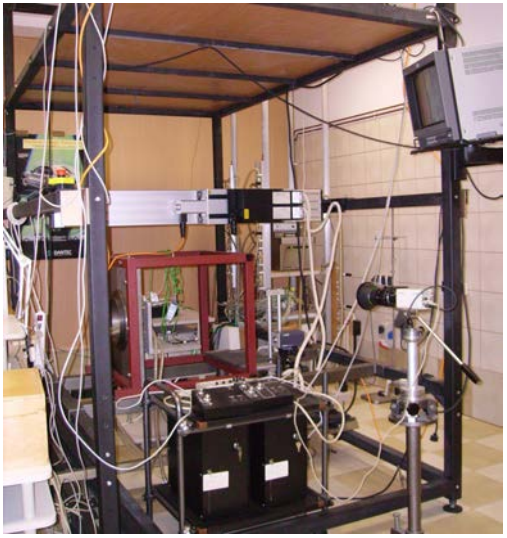
Selected publications

1. Rogowski G., Molski K. (2016), The T-stress effect on the plastic zone size in a thin ductile material layer sandwiched between two elastic adherents, *Engineering Fracture Mechanics*, 168, 260-270.
2. Szpica D. (2017), Comparative analysis of low pressure gas-phase injector's characteristics. *Flow Measurement and Instrumentation*, 58, 74-86;
3. Kamiński Z., Kulikowski K. (2017), Measurement and evaluation of the quality of static characteristics of brake valves for agricultural trailers, *Measurement*, 106, 173–178;
4. Szpica D. (2016), The influence of selected adjustment parameters on the operation of LPG vapor phase pulse injectors. *Journal of Natural Gas Science and Engineering*, 34, 1127-1136.
5. Gagan J., Śmierciew K., Łukaszuk M., Butrymowicz D. (2018), Investigations of thermal performance of ejection refrigeration system driven by low grade heat, *Applied Thermal Engineering*, 130, 1121–1138;
6. Śmierciew K., Butrymowicz D., Przybyliński T., Pawluczuk A. (2017), Investigations of heat and momentum transfer in two-phase injector operating with isobutane, *Applied Thermal Engineering*, 127, 1495–1505;
7. Śmierciew K., Gagan J., Butrymowicz D., Łukaszuk M., Kubiczek H. (2017), Experimental investigation of the first prototype ejector refrigeration system with HFO-1234ze(E), *Applied Thermal Engineering*, 110, 115-125;
8. Gagan J. Smierciew K., Butrymowicz D. (2014), Comparative study of turbulence models in application to gas ejectors, *International Journal of Thermal Sciences*, 78, 9-15;
9. Butrymowicz D., Śmierciew K., Karwacki J., Gagan J. (2014), Experimental investigations of low-temperature driven ejection refrigeration cycle operating with isobutqne, *International Journal of Refrigeration*, 39, 196-209;
10. Śmierciew K., Gagan J., Butrymowicz D., Karwacki J. (2014), Experimental investigations of solar driven ejector air-conditioning system, *Energy and Buildings*, 80, 260-267.

Test equipment

Floe-field diagnostic - PIV Measurements System

- measurement of the velocity field using the PIV technology;
- HI Sense PIV/PLIF camera and PIV SONY camera (resolution 1600x1200 pixels, 40 frames in full resolution, time between frames: 200 ns.);
- camera control module, laser optical measurement systems and sensor, positioning mechanism, image processor, Dynamic Studio Software;
- velocity field measurement;
- laser wavelength 532 nm;
- laser power 145 mW;
- frequency 15 Hz;
- precise positioning mechanism.



Aerodynamic tunnel

- investigation of conventional and mini-channels heat exchangers;
- steady and unsteady condition of investigation;
- dimensions: 1 x 1m;
- modern controlling system with data acquisition system;
- measurement of the temperature, pressure and relative humidity at ambient conditions;
- temperature sensor at the nozzle inlet;
- multiple spot temperature sensor at heat exchanger inlet and outlet;
- measurement of the static pressure drop at heat exchanger;
- measurement of the relative humidity of air at heat exchanger inlet and outlet;
- measurement of differential pressure at nozzle;
- measurement of the temperature and pressure of fluid at heat exchanger inlet and outlet;
- measurement of the fluid mass flow rate.

Vapour compression refrigeration system

- working fluid: propane;
- cooling capacity: 48 kW at -14°C/+45°C;
- investigation of vapour compression refrigeration systems;
- investigation of heat exchange and heat exchangers – evaporators and condensers;
- system suitable for external connections;
- modern controlling system with a data acquisition system.

Calorimeter KL-12Mn

- accuracy of temperature digital readout 0,001K;
- capacity of calorimetric bomb 0,35 dm^3;
- marking the heat of combustion compliant with Polish Standard PN-C-04375;
- calibration with reference fluid;
- automatic control via a PC computer, storage and backup of test results.

Other laboratory equipment

- micro-interferometer BIOLAR PL;
- spectrometer Nicolet (Nexus);
- testing bench for the investigation of hydraulic pressure loss;
- multi-functional portable diesel and Jet Fuel analyser TD PPA, PetroSpec;
- multi-functional portable gasoline analyser GS PPA, PetroSpec.

Load chassis dyno MAHA LPS 3000 4x4

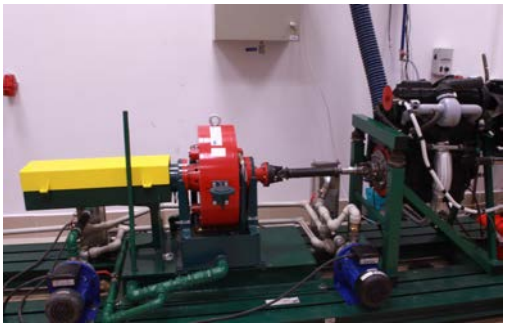
- determination of external characteristics of the engine and losses in the drive system of the vehicle;
- measurement of torque and power at a constant engine speed or vehicle speed;
- simulation as a function of load speed vehicle (programmable driving cycles);
- measuring the concentration of toxic exhaust with direct assignment of excess air coefficient;
- exhaust gas analyser MGT-5 MAHA;
- opacimeter MDO-2;
- meter particulate MPM-4;
- Fuel flow-MAHA AIP.

Strength test Machine INSTRON 8502 with a thermal chamber INSTRON 3119

- load range for tension-compression: ± 100 kN;
- torque range: ± 500 Nm;
- Control: FastTrack 2 with controller 8800;
- workspace 664x1200 mm;
- 6-channel data acquisition and control;
- accuracy class 0.5;
- temperature range from -150 to +600°C;
- external controller EUROTHERM 2408;
- workspace 560x400x400 mm chamber.

Engine dyno AUTOMEX

- maximum power of 100 kW;
- maximum torque: 240 Nm;
- maximum speed: 10,000 rev / min;
- eddy current brake EMX-100/10000 water-cooled;
- speed accuracy ≤ 1 rev / min;
- torque measurement accuracy: 1% of range;
- sensors: barometric pressure, temperature and humidity of the intake air, the composition of the mixture;
- air flow;
- gravimetric flow meter to measure fuel consumption.



Measuring kit vehicle wheel alignment in 3D Hofmann Geoliner 680 Lift

Measurement possibilities:

- taper angle of individual wheels including the cumulative angle;
- angle of camber and caster angle;
- movement of the rear axle and its inequalities;
- maximum steering angle;
- wheel track/axles track;
- camber for convergence equal to 0;
- position of four wheels.

The equipment contains a database with reference values.

Other laboratory equipment

- hydraulics HP202 stand for research and teaching;
- apparatus friction T11;
- programmable viscometer BROOKFIELD DV-II;
- LPG injectors stand;
- tractor engine with an open controller.

DEPARTMENT OF BIOCYBERNETICS AND BIOMEDICAL ENGINEERING

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Research topics

1. Medical construction projects, focused on :
   - orthopaedics (ostheosyntesis, joint arthroplasty, instrumentary)
   - stomatology (prosthesis, orthodontics, maxillofacial surgery
   - orthopaedic supply (insolts, corsets, ortheses, rehabilitation equipment)
2. Biomechanics of bones and bone-implant interaction
3. Computer aided medical treatment
4. Biomedical signal and image processing
5. Telemetry and telemedicine application in muscle contraction activity research
6. Knowledge discovery from medical databases
7. Security of medical databases

Research and expertise offer

1. Charakterystyki tribologiczne narządu zębowego człowieka.
2. Badania momentów sił mięśniowych wykorzystaniem systemów BIODEX i BIOMETRICS.
3. Zaawansowana analiza sygnałów biomedycznych EKG, EEG, EMG.
4. Biometryczne aspekty chodu człowieka.
5. Eksploracja reguł akcji z niepełnych systemów informacyjnych.

Selected publications

1. Ogrodnik J., Piszczatowski Sz. (2017), Influence of modified muscle morphology and activity pattern on the results of musculoskeletal system modelling in cerebral palsy patient, *Acta of Bioengineering and Biomechanics*, 19(3), 63-75.
2. Borowska M., Borys K., Szarmach J., Oczeretko E. (2017), Fractal dimension in textures analysis of xenotransplants, *Signal, Image and Video Processing*, 11, 1461-1467.
3. Pawińska M., Szczurko G., Kierklo A., Sidun J. (2017), A laboratory study evaluating the pH of various modern root canal filling materials. *Advances in Clinical and Experimental Medicine*, 26 (3), 387-392.
4. Dardzinska A. (2013), Action Rules Mining , SCI 468, Springer-Verlag Berlin Heidelberg.
5. Lemancewicz A., Borowska M., Kuć P., Jasińska E., Laudański P., Laudański T., Oczeretko E. (2016), Early diagnosis of threatened premature labor by electrohysterographic recordings – The use of digital signal processing, *Biocybernetics and Biomedical Engineering*, 36(1), 302-307.
6. Prochor P., Piszczatowski S., Sajewicz E. (2016), Biomechanical evaluation of a novel Limb Prosthesis Osseointegrated Fixation System designed to combine the advantages of interference-fit and threaded solutions, *Acta of Bioengineering and Biomechanics*, 18(4), 20
7. Borowska M., Brzozowska E., Kuć P., Oczeretko E., Mosdorf R., Laudański P. (2017), Identification of preterm birth based on RQA analysis of electrohysterograms, *Computer Methods and Programs in Biomedicine*, 153, 227-236.
8. Jałbrzykowski M., Derlatka M., Urban D. (2016), Occlusion trajectory and a concept of a device for testing operating life of dentures, *Advances in Medical Science*, 61(2), 180-186.
9. Mierzejewska Ż.A., Kuptel P., Sidun J. (2016), Analysis of the surface condition of removed bone implants, *Maintenance and Reliability*, 18(1), 65-72.

Bruker Biotribotester UMT-2

- ability to implement different measurement of kinematic pairs and nano-hardness;
- registration of strength, torque, temperature, acoustic emission, electrical resistance, humidity and pressure; frequency from sensors with 16-bit resolution and data rates up to 200kH;
- force sensors are available in multiple ranges from 1 to 100mN all the way up to 10 to 1,000N;
- two-axis sensors are frequently used to monitor friction and normal forces simultaneously, sensors can be combined to measure multiple forces;
- programmable range of movement of the sample in the Z axis: min. 150 mm and a resolution of 0.5 microns at the rate of 0.002 to 10 mm/s with the position changes recording in the software; programmable range of motion for positioning the sample in the X-axis and to examine the scratch resistance (scratch-test) min. 75 mm by resolution 0.25 microns at the rate of 0.001 to 10 mm/s with the registration of position changes.

BIODEX SYSTEM 4 PRO for muscles force moment analysis

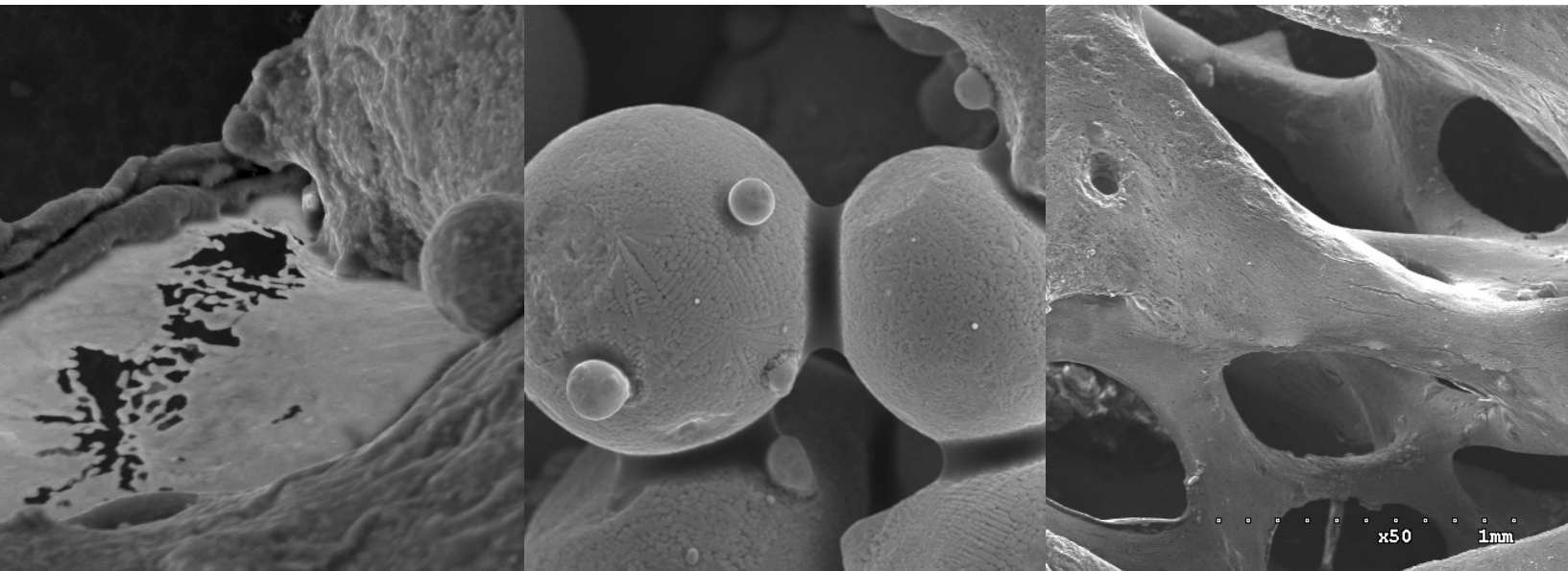
- moment of force control during isometric, isokinetic and isotonic work with shoulder, elbow, wrist, hip, knee and ancle joints;
- testing during passive motion, isometric, isotonic, isokinetic (concentric and eccentric) reactive eccentric work;
- archive and data export to statistic data analyses.

Zestaw do trójwymiarowej rejestracji lokomocji oparty na szybkich kamerach

- 10 camera Oqus 500+ used for moves recording process both in visible light and infrared (4 MP, 2048 × 2048, 180 fps; 1 MP, 1024×1024, 360 fps);
- 2 monochromatic fast camera Emergent 2000 HS (2048x1088, 338 fps, Interface 10GigE);
- video camera Overlay Oqus 210C (Full HD/ 2 MP/1920×1080, 337fps) ;
- video camera Legria HF R606 (Full HD/2 MP/1920×1080, optical zoom 32x) ;
- workstation with software.

Other laboratory equipment

- pedobarography platform FOOTSCAN RSscan INTERNATIONAL (two platforms – 1,8 m lub 2 m);
- BIOMETRICS LS900 Laboratory System for functional evaluation of muscle-skeletal system with surface electromyography EMG equipment;
- body composition analyzer JAWON MEDICAL X-CONTACT 357S.



SELECTED RESEARCH AND DEVELOPMENT PROJECTS

- Mechanics problems of heterogeneous and anisotropic materials – leader: Michał Kuciej, DSc, PhD, Eng
- Modelling of elasto-plastic damage accumulation and cracking problems of structural elements in the complex fatigue condition – project coordinator: prof. Andrzej Seweryn, DSc, PhD, Eng
- Analytical and numerical modeling of the transient heat generation process in the frictional elements of the brake systems – project coordinator: prof. Oleksandr Jewtuszenko, DSc, PhD, Eng
- Analysis of stress caused by contact pressure in a homogeneous body with a gradient coating – project coordinator: Adam Bajkowski, PhD, Eng
- Analytical and numerical modeling of deformation and fracture of solids with notches – project coordinator: Andrzej Kazberuk, DSc, Phd, Eng
- Micromechanical modeling of failure in fiber-reinforced polymer matrix composites – project coordinator: Marek Romanowicz, PhD, Eng
- Investigation of dynamics of interactions between bubbles departing from nozzles – project coordinator: Romuald Mosdorf, DSc, PhD, Eng
- Two-phase flow patterns in minichannel identification using the non-linear method of data analysis – project coordinator: Romuald Mosdorf, DSc, PhD, Eng
- Analytical methods of fields temperature and thermal stress calculation in friction components of braking systems – project coordinator: Michał Kuciej, DSc, PhD, Eng
- Methods of forecasting of damage materials with complex thermo-mechanical properties – project coordinator: prof. Roman Kulchytskyy, ScD, PhD
- Selected problems of thermomechanics for materials with temperature dependent properties – project coordinator: Dariusz M. Perkowski, PhD, Eng
- Thermal problem of friction for strip-semi-space with thermal sensitivity materials - project coordinator: Ewa Och, PhD, Eng
- The dynamics of liquid movement inside the nozzle during the bubbles departures – project coordinator: Paweł Dzienis, MSc, Eng
- Numerical modelling of the frictional heating in the braking system taking into account mutual dependence of the velocity, temperature and thermal sensitivity of materials– project coordinator: Piotr Grześ, PhD, Eng
- Analysis of boiling instability in parallel minicannels – project coordinator: Hubert Grzybowski, PhD, Eng
- Experimental identification of yield surface of two-layer metallic composite subjected to directional pre-deformation – project coordinator: Robert Uścinowicz, DSc, PhD, Eng
- Properties of h-difference control systems of fractional order – project coordinator: Ewa Pawłuszewicz, DSc, PhD, Eng
- Autonomous, integrated reconnaissance system with autonomous micro aero vehicles – project coordinator: prof. Zdzisław Gosiewski, DSc, PhD, Eng
- Design and investigation of mechatronic components for automation and robotics – project coordinator: prof. Zdzisław Gosiewski, DSc, PhD, Eng
- Investigation of sensors and actuators for the automation, robotics and diagnostics demands – project coordinator: prof. Zdzisław Gosiewski, DSc, PhD, Eng

- Research of subassemblies and algorithms for the intelligent technical systems demands – project coordinator: prof. Zdzisław Gosiewski, DSc, PhD, Eng
- Networked reconnaissance and command supporting system with autonomous unmanned aerial vehicles for disasters in urban areas – project coordinator: prof. Zdzisław Gosiewski, DSc, PhD, Eng
- Application research in the area of navigation, control, communication and data exchange between an autonomous maritime vessel and an aircraft - project coordinator: Cezary Kownacki, PhD, Eng
- Modern technologies for food and agriculture industry with reduction of greenhouse gases emission (consortial project leading by BUT, supported by European Regional Development Fund and National Operational Programme Innovative Economy) – project coordinator: prof. Dariusz Butrymowicz, DSc, PhD, Eng
- Comprehensive technologies for vegetables cold storage (consortial project leading by BUT) – project coordinator: prof. Dariusz Butrymowicz, DSc, PhD, Eng
- Design of set of three units of heat pumps of heating capacity from 80 kW to 300 kW (Sun Energy) – project coordinator: prof. Dariusz Butrymowicz, DSc, PhD, Eng
- Modelling and experimental investigations of one-phase ejectors in application to solar cooling systems – project coordinator: Jerzy Gagan, PhD, Eng
- Investigations of reduction of throttling losses in compression refrigeration systems by means of application of two-phase ejector – project coordinator: prof. Dariusz Butrymowicz, DSc, PhD, Eng
- Modern technologies in refrigeration, air-conditioning, and food processing engineering – project coordinator: prof. Teodor Skiepko, DSc, PhD, Eng
- High-efficiency refrigeration and air-conditioning systems with low emission of greenhouse gases – project coordinator: prof. Teodor Skiepko, DSc, PhD, Eng
- High-efficiency refrigeration and air-conditioning systems operating with pro-cological working fluids – project coordinator: prof. Teodor Skiepko, DSc, PhD, Eng
- Modern materials and technologies for technics and – project coordinator: prof Jan R. Dąbrowski, DSc, PhD, Eng
- Contemporary constructions and functional materials and technologies in machinery designe – project coordinator: prof. Jan R. Dąbrowski, DSc, PhD, Eng
- Investigations of implant surface – bone tissue interactions – project coordinator: Jarosław Sidun DSc, PhD, Eng
- The construction of an electrical mini-generator taking under consideration the flow of the operating medium as the working environment – project coordinator: Roman Kaczynski, DSc, PhD, Eng
- The coordinate measurement and the analysis of geometrical errors of complex surfaces – project coordinator: Malgorzata Poniatowska, DSc, PhD, Eng
- Effect of metallic biomaterials surface layer on functional properties – project coordinator: Magdalena Łępicka, PhD, Eng
- Effect of co-doping bismuth-germanate glasses with lanthanides on their luminescence properties in the 2 - 3 um region – project coordinator: dr inż. Tomasz Ragiń, PhD, Eng
- Investigation into friction and wear of implant alloys and corundum ceramics in fretting conditions – project coordinator: Marcin Klekotka


MTS
858 Table Top System

ACTA MECHANICA ET AUTOMATICA

Since 2007 the Faculty of Mechanical Engineering has been actively involved in the process of publishing Acta Mechanica et Automatica. The journal presents theoretical as well as experimental works within the scope of mechanics, automatic control engineering and robotics. Additionally, the journal includes works and findings focusing on the practical application of the aforementioned disciplines in the design and operation of machinery equipment. Moreover, Acta Mechanica et Automatica cooperates with scientists specializing in various scientific research including biocybernetics, biomedical engineering and IT systems. The academic council guarantees the highest technical level of published articles, which undergo strict review procedures.

Acta Mechanica et Automatica is covered by the following services: Clarivate Analytics - Web of Science, Clarivate Analytics - Emerging Sources Citation Index, Arianta, Baidu Scholar, BazTech, CNKI Scholar (China National Knowledge Infrastructure), CNPIEC, DOAJ (Directory of Open Access Journals), EBSCO (relevant databases), EBSCO Discovery Service, Elsevier - SCOPUS, Genamics JournalSeek, Google Scholar, Index Copernicus, J-Gate, JournalGuide, JournalTOCs, KESLI-NDSL (Korean National Discovery for Science Leaders), Microsoft Academic, Naviga (Softweco), POL-index, Primo Central (ExLibris), Publons, ReadCube.

Sherpa/RoMEO, Summon (Serials Solutions/ProQuest), TDNet, TEMA Technik und Management, Ulrich's Periodicals Directory/Ulrichsweb, WanFang Data and WorldCat (OCLC). The journal is assessed at 14 points by the Polish Ministry of Science and Higher Education. Since 2013 Acta Mechanica et Automatica has been published by De Gruyter Open.

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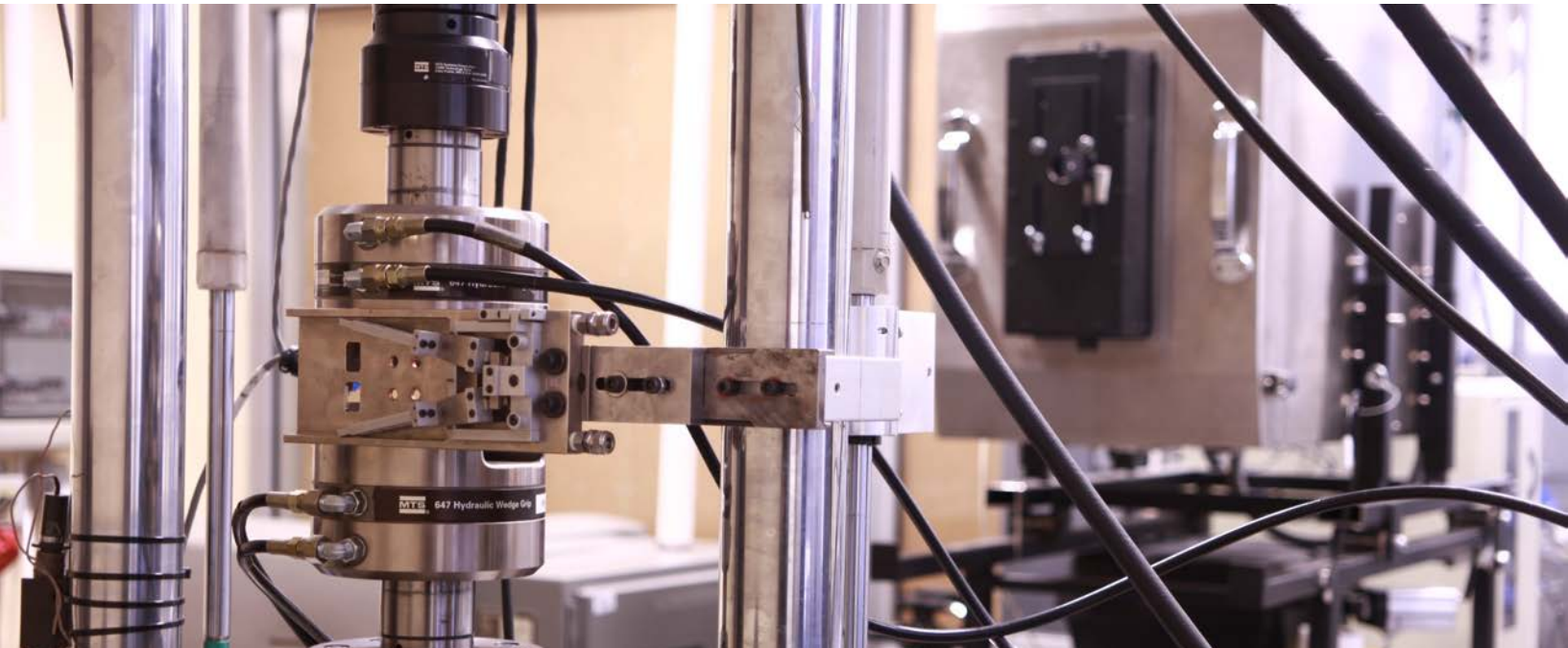


SCIENTIFIC CONFERENCES AND SEMINARS

International Conference on Mechatronic Systems and Materials - MSM (since 1995)

Faculty of Mechanical Engineering is a co-organizer of the annual International Conference on Mechatronic Systems and Materials (MSM). This event attracts researchers and practitioners engaged in widely understood mechatronics and materials engineering. The topics include: robotics (industrial robots, mobile robots, micro-robots), unmanned aerial vehicles, sensors, actuators and control systems for mechatronics, smart materials, biomaterials, composite and piezoelectric materials, nanomaterials, and teaching problems in the field of mechatronics and materials engineering. The attendees are from Poland, Austria, Bulgaria, The Czech Republic, Estonia, Finland, France, Japan, Lithuania, Latvia, Germany, Slovakia, The United States and Turkey.

International Conference BIOMDLORE (since 2000)

International Conference Biomdlore (biomechanics, artificial organs, locomotion, orthopaedics, rehabilitation) is organized jointly by the Bialystok University of Technology, Vilnius Gediminas Technical University, Polish Society of Theoretical and Applied Mechanics, IEEE Lithuania Section, Lithuanian Society of Biomechanics and European Society of Engineering and Medicine. The aim of the conference is to provide a forum for the exchange of scientific ideas in the field of biomechanics and biomedical engineering between researchers from different centres in the world. The members of the Scientific Committee are from Belarus, Canada, Italy, Lithuania, Poland, Russia, Switzerland and the USA. The topics include widely understood biomedical sciences, with particular emphasis on biomechanics of human locomotion, orthopaedics, traumatology, rehabilitation equipment, medical diagnostics, biomedical signal analysis and mathematical modelling of biomechanical systems.

International Symposium of Mechanics and Materials Structures (since 1999)

Department of Mechanics and Applied Computer Science, Faculty of Mechanical Engineering is the main co-organizer of the International Symposium of Mechanics and Materials Structures in Augustow which takes place every two years. The Symposium is held under the patronage of The Committee on Mechanics of the Polish Academy of Sciences. The topics of the Symposium include the problems of analytical, numerical and also experimental methods used in processes of plastic deformation and creep, damage accumulation and failure of materials and structures, the problems of dynamic, the reverse problems associated with identification of damage state, the problems of biomechanics and advanced materials. Presented papers are the specific review of research subject matters and scientific achievements of the most research centers in Poland and also from USA, Canada, Italy, Israel, Belarus, Lithuania, Ukraine, Slovakia, Romania, Germany, Great Britain and Russia.

Scientific Conference PNEUMA (since 1974)

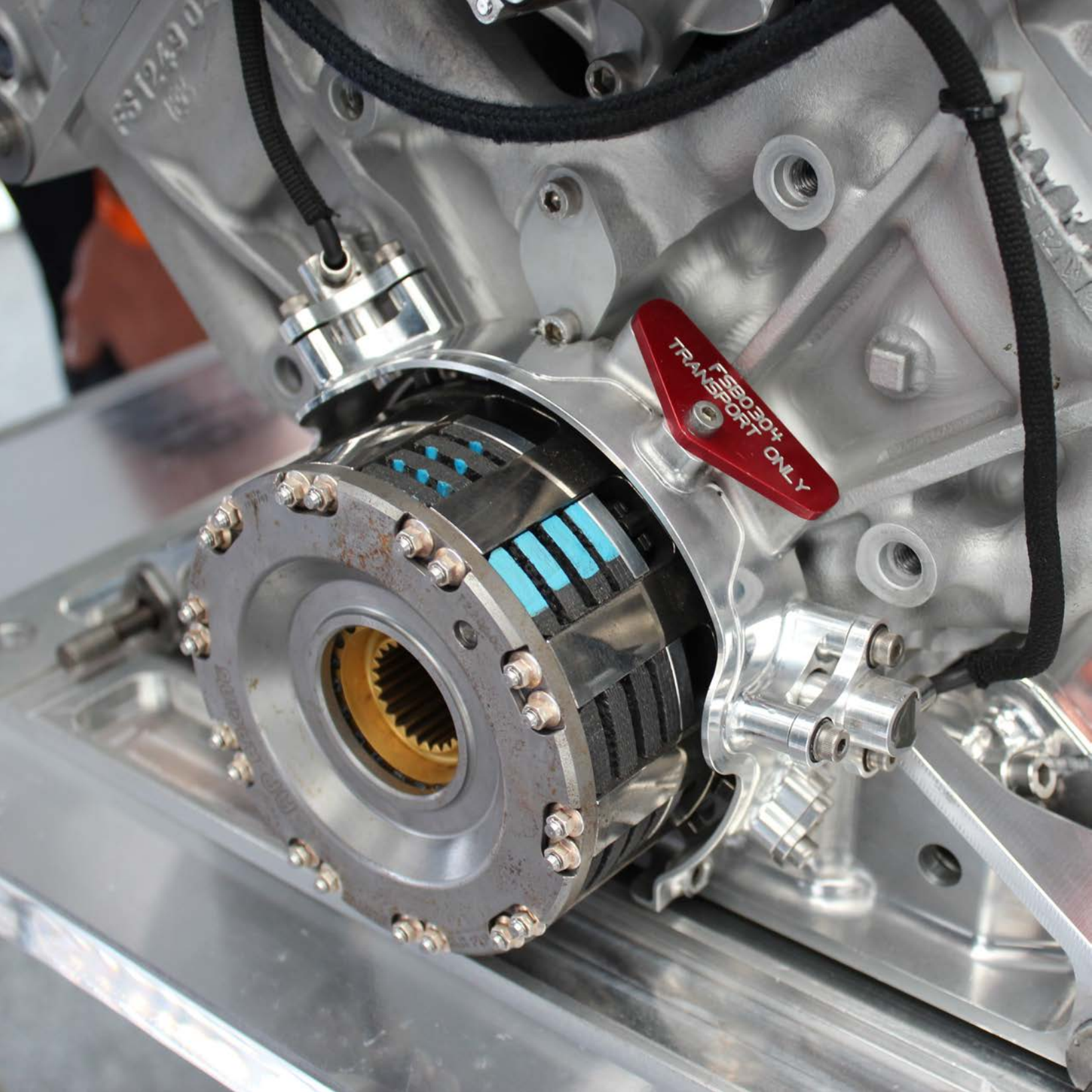
Department of Automatic Control and Robotics, Faculty of Mechanical Engineering is an organizer of the bi-annual Scientific Conference on pneumatic drive and control systems, PNEUMA. The aim of the conference is to review current research activities and achievements of international academic centers and industrial companies working in the field of widely understood pneumatics. The topics include: compressed air production and treatment, pneumatic components and systems design, pneumatic components and systems modelling and simulation, pneumohydraulic components and systems, hydraulic components and systems, mechanical structures in manipulators and robots, industrial process control and measurements, mechatronics components and systems, pneumatic conveyor systems, and pneumatics in education. The attendees are from Poland, Czech and Slovakia.

DOMESTIC COOPERATION

- AGH University of Science and Technology in Cracow, Faculty of Materials Science and Ceramics, Faculty of Mechanical Engineering and Robotics;
- Air Force Institute of Technology, Warsaw;
- Bialystok Medical University;
- Children's Memorial Health Institute, Warsaw;
- Czestochowa University of Technology, Faculty of Mechanical Engineering and Computer Science;
- Gdańsk University of Technology, Faculty of Mechanical Engineering;
- Institute of Aviation, Warsaw;
- Institute of Fundamental Technological Research Polish Academy of Sciences, Warsaw;
- Institute of Precision Mechanics, Warsaw;
- Kielce University of Technology, Faculty of Mechatronics and Mechanical Engineering;
- Lublin University of Technology, Faculty of Mechanical Engineering;
- Medical University of Silesia,;
- Military Institute of Medicine, Warsaw;
- Military University of Technology, Faculty of Mechanical Engineering;
- Motor Transport Institute, Warsaw;
- Opole University of Technology, Faculty of Mechanical Engineering;
- Poznan University of Technology, Faculty of Mechanical Engineering; Faculty of Mechanical Engineering and Management, Faculty of Machines and Transportation;
- Rzeszow University of Technology, The Faculty of Mechanical Engineering and Aeronautics;
- Silesian University of Technology in Gliwice, Faculty of Mechanical Engineering, Faculty of Biomedical Engineering, Faculty of Materials Engineering and Metallurgy;
- Tadeusz Kosciuszko Cracow University of Technology, Faculty of Mechanical Engineering;
- The Institute for Sustainable Technologies – National Research Institute in Radom;
- University of Technology and Life Sciences in Bydgoszcz, Faculty of Mechanical Engineering;
- University of Warmia and Mazury in Olsztyn, Faculty of Food Sciences, Faculty of Technical Sciences;
- University of Warsaw, Faculty of Geology;
- Warsaw University of Life Sciences, Faculty of Veterinary Medicine;
- Warsaw University of Technology - Faculty of Power and Aeronautical Engineering, Faculty of Materials Science and Engineering, Faculty of Mechatronics, Faculty of Automotive and Construction Machinery Engineering, Faculty of Transport , Faculty of Production Engineering, Faculty of Electrical Engineering;
- Wrocław University of Technology, Faculty of Mechanical Engineering, Faculty of Mechanical and Power Engineering.

FOREIGN COOPERATION

- Belarus, Belarus Academy of Sciences, Center for Resources Retaining - Gait analysis of children suffering from selected foot pathologies.
- Belarus, Physical-Technical Institute of National Academy of Sciences of Belarus, Minsk - Surface modification
  of metal structural materials using high-energy methods in order to obtain a new properties.
- Belarus, Yanka Kupala State University of Grodno – Mechanics of granular media compaction; mechanics of fragmented materials contact reaction with hard ground.
- Denmark, University of Southern Denmark, Odense - Vision systems in robotics; application of cognitive vision systems and position tracking sensors for parallel manipulators control.
- Estonia, Tallin University of Technology, Institute of Cybernetics - Nonlinear control systems on time scales, algebraic methods in nonlinear control.
- Finland, Lappeenranta University of Technology, LUT Energy - Robust control application of active magnetic bearings blower.
- Finland, VTT Technical Research Centre of Finland, Oulu - Cooperative flight control methods for small quadrotor unmanned aerial vehicles; real time location systems using ultra wide band (UWB) techniques; modelling and control methods for a small quadrotor unmanned aerial vehicle.
- Germany, Leibniz University, Institute of Dynamics and Vibration Research, Hannover - Active and semi-active vibration control of a bladed turbine with piezo-elements.
- Kanada, Glenrose Rehabilitation Hospital Research and Technology Development, Edmonton - Gait analysis of children suffering from cerebral palsy.
- Lithuania, Vilnius Gediminas Technical University - Human gait biomechanics; human gait biometry based on EMG signals.
- Russia, Institute of Mechanics Moscow State University - Examination of the properties of noise attenuation and vibration of sandwich construction elements; experimental determination of the mechanical properties of composite materials and layered structural elements sandwich type; study of wave propagation in the electromagnetoelastic bodies; modeling of non-stationary processes of contact interaction of deformable bodies.
- Russia, Moscow Aviation Institute (MAI) - Design of structural elements made of fiber composites; modelling
  of friction and life prediction of kinematic nodes using nanomaterials cover.
- Slovakia, Technical University of Kosice - Analysis and synthesis of mechatronic measurement systems of translational movement, design and manufacturing of medical devices.
- South Korea, Kyung Hee University, Suwon Campus - Hierarchical control systems.
- Sweden, Uppsala University - High performance, efficient and safe modular flywheel.
- Ukraine, Karpenko Physico-Mechanical Institute of The National Academy of Sciences of Ukraine -Fracture mechanics problems in solids with notches.
- Ukraine, Lutsk National Technical University, Lutsk - Analytical, numerical and experimental methods of analysis of solid mechanics problems for elastic media and selected composite materials.
- USA, Cleveland State University - Modeling, control and diagnostic methods for active mechanical structures; shaft crack modeling and detection methods for rotating machinery.
- USA, University of North Carolina, Department of Computer Science - Knowledge discovery from incomplete information systems.
- Wietnam, Ho Chi Minh City University of Technology - Action rules mining.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TRANSPORT ONLY

SELECTED IMPLEMENTED PROJECTS

Modern technologies for storage of fruit and vegetables limiting emission of greenhouse gases

An innovative solution for an indirect refrigeration system was developed to achieve a stable, low temperature of stored vegetables and a stable relative humidity in the chamber. An additional innovation was the use of propane as a working fluid with almost 20-fold reduction in the system charge with working fluid. The system has been applied to improve the energy efficiency through the use of a waste heat storage (used in the defrosting process of the air coolers) and a so-called free-cooling. Storage tests confirmed the high storage efficiency of the proposed system solution. Construction of the innovative facilities in Dąbrowice near Skierniewice was completed.

AVAL - Autonomous Vessel with an Air Look

Białystok University of Technology, in particular the Faculty of Mechanical Engineering, and the Faculty of Computer Science, is a leader of a multidisciplinary scientific and industrial consortium organized for implementation of the project: *Application research in the area of navigation, control, communication and data exchange between an autonomous vessel and an aircraft* - financed by the European Development Fund Regional as a part of the Intelligent Development Operational Program 2014-2020. The consortium also consist of Foundation for Safety of Shipping and Environmental Protection in Iława and academic companies: Sup4NAV sp. o.o. and UpLogic sp. z o.o. spin-off of the Białystok University of Technology.

The aim of the project is to conduct industrial and development research, the effects of which will be applied in the technology of an autonomous maritime vessel. A system of innovative maritime navigation integrating information received from navigation devices installed on the vessel and data from visual observation performed by a unmanned aerial vehicles will be the main element of the developed technology.

Close cooperation of autonomous vehicles (the unmanned aircraft and the maritime vessel) requires to solve the following problems: operation of devices in difficult weather conditions, interactions between two moving objects i.e. sailing and flying – especially in critical phases of take-off and landing – maintaining a constant radio communication between components of the system, obtaining the desired flight time / operating range.
Two different kinds of unmanned aerial vehicles (UAV) will be used to observe the surroundings of the vessel: a multi-rotor helicopter, whose a characteristic feature will powered by a wired power supply system, and an hybrid airplane that is equipped with additional rotors enabling its possibility of vertical take-off and landing, and allows identification of objects located at a considerable distance from the vessel (up to 8 nautical miles). The information obtained during the observation flight will be compared with the information received from the vessel's navigation systems (AIS or ARPA).
The results of the project will be introduced to the maritime transport market in 2021.
The following technologies will be developed in the project:

- technology of unmanned maritime vessels (UMV). The heart of UMV is a anti-collision component with a data link between UMV and unmanned aerial vehicle (UAV),
- UAV technology that will support the maritime navigation system in collision situations.
- image processing technology (IPT), the key element of which will be the algorithm able to detect and recognize objects on the surface of the sea (e.g. rescue boats, icebergs, whales, etc.) in images acquired by the UAV camera.

SELECTED IMPLEMENTED PROJECTS

Design and technical documentation of a series of heat pumps of thermal capacity 80kW to 300kW, building and testing of a prototype

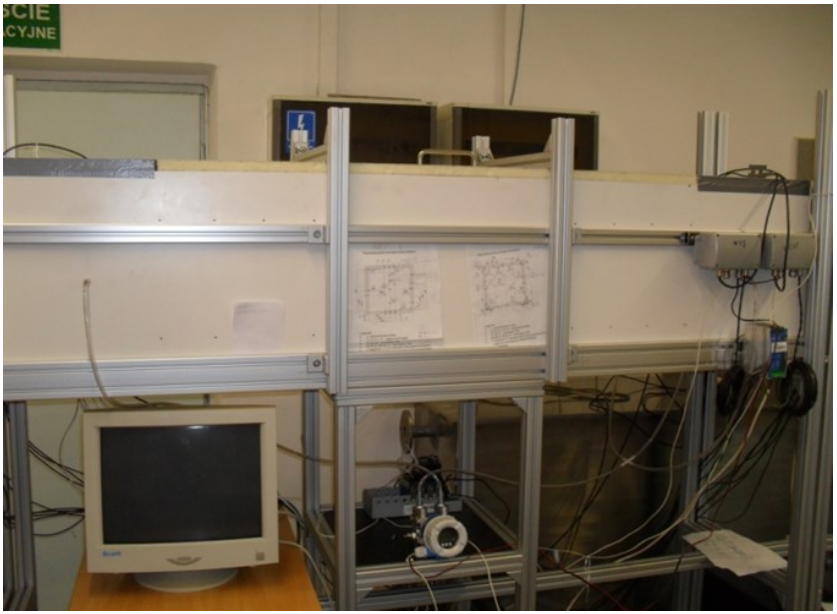
Complete technical documentation of a series of innovative high power heat pumps has been developed. In the heat pumps modern screw compressors were used together with the economizer, which enabled the systems to work in high-efficient cycle that is analogous to two-stage cycles. In addition, a modern solution of the control system of heat pumps operation has been applied, resulting in high energy efficiency and compactness of the system. The developed solution of a series of high capacity heat pumps is the first one to be manufactured in Poland.

SUN ENERGY

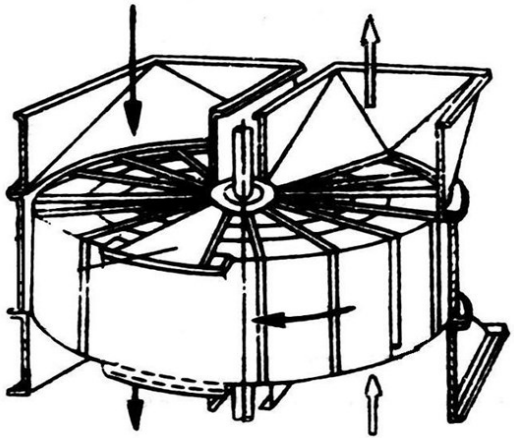
Measurement technique of heat transfer coefficient and flow resistance for rotary air heater matrices

The Department of Heat Technology and Refrigeration was developed for Rafako S.A. method of the measurement of heat transfer in the bed of matrices in application to regenerative heat exchangers, including rotary air heaters applied in large steam generators.

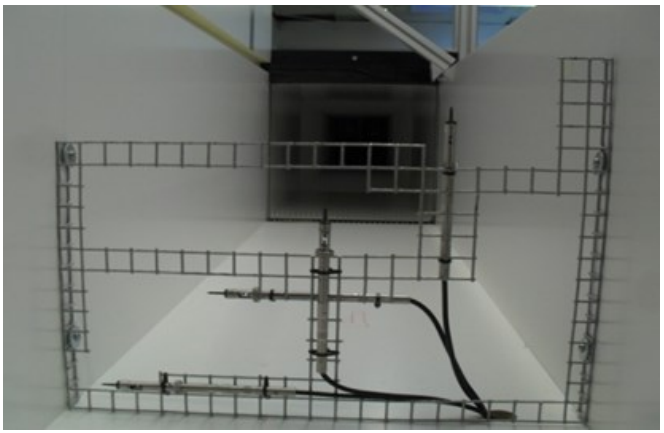
The proposed approach made possible to design new types of the heating elements for modern air heaters for application to the steam generators of the high capacity. The application of the so-called single blow technique was developed and a dedicated measurement channel has been built. The developed method along with the measuring system have been used to identify the heat transfer for new types of rotary air heater thermal elements that allowed them to be applied in boilers used in large thermal power plants in Europe.



A part of the tunnel dedicated to developed measurement technique



Regenerative air pre-heater



Prototype refrigeration system driven by low-grade heat source

The Department of Thermal Technology and Refrigeration developed in cooperation with EDF Polska S.A. a prototype refrigeration system dedicated to generate chilled water for air-conditioning systems. The system is driven by hot water of a temperature that not exceeds 65 °C as a source of heat. The system is therefore designed to cooperate with the central heating system during the summer allowing generation of cold. The system uses environmentally-friendly working fluid R-1234ze(E) which complies with the excessively restrictive national and European regulations that are currently in force. The developed unit is based on the ejection refrigeration cycle. In the ejector the working fluid is accelerated to supersonic velocity and the critical part of the compression process is carried out using the shock wave principle. The designed refrigeration system starts operation at a heating temperature of about 55 °C, assuming the typical chilled water temperature required by conventional air conditioning systems, i.e. chilled water at temperature 6 °C, return temperature 12 °C. In developed solution the heating capacity is 90 kW, the design cooling capacity of the system is about 25 kW. Under high temperature conditions, the system achieves a cooling capacity up to 45 kW. This is the first application of a ejection refrigeration system on a technical scale with an environmentally safe working medium that uses a low-grade heat source to drive.

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Research Paper

Experimental investigation of the first prototype ejector refrigeration system with HFO-1234ze(E)

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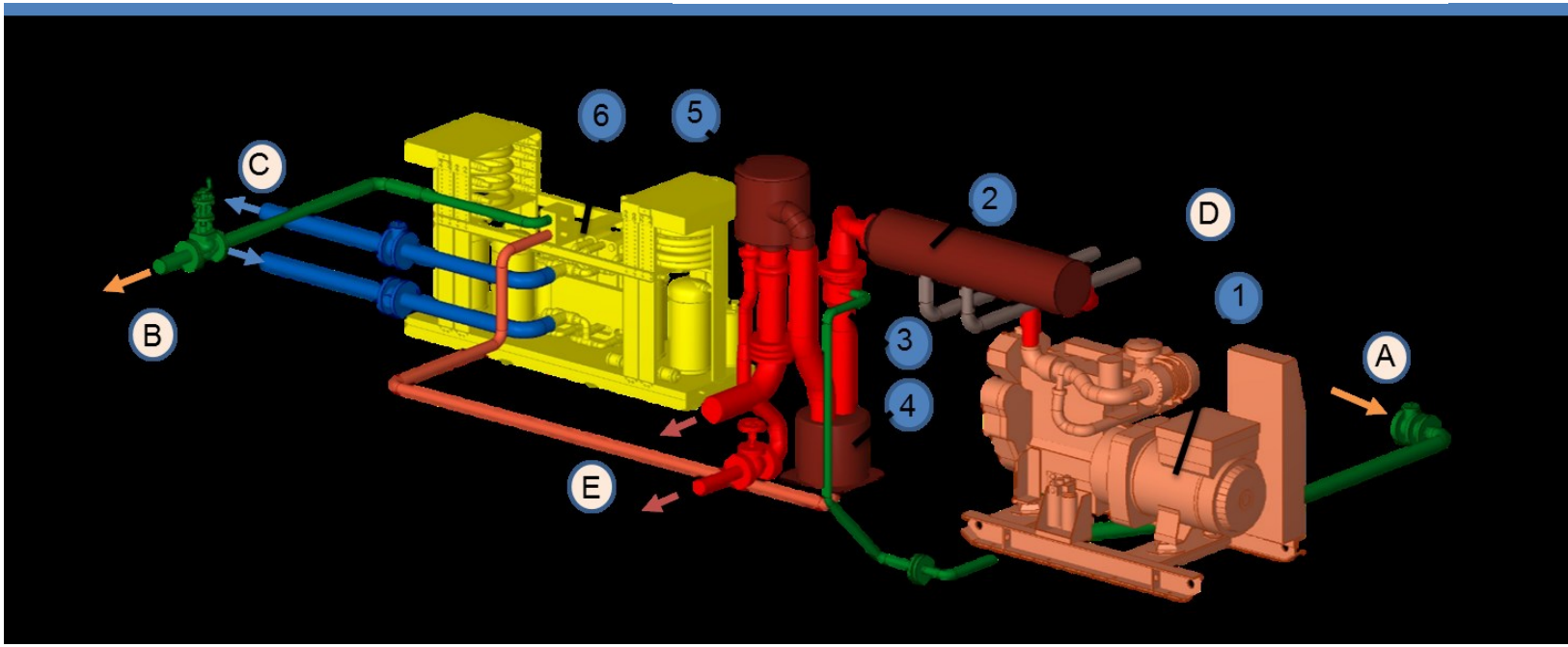
Marine Projects Ltd.



View of an engine equipped with the exhaust system

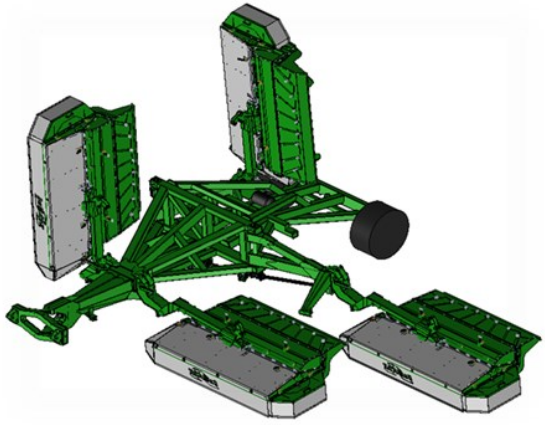
The Department of Heat Technology and Refrigeration developed along with the shipyard Marine Projects Ltd. a comprehensive solution for the exhaust system dedicated for diesel engines for to small and medium-sized vessels. The fully innovative solution for the flue gas cleaning system and waste heat management for such vessels was developed.

Construction design using computer systems and CAD modeling methods

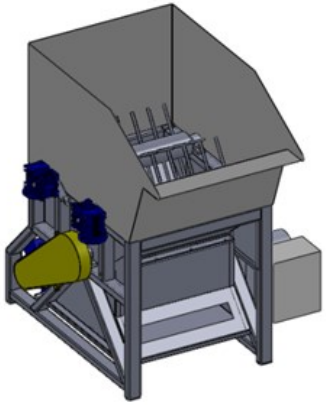
We offer design using modern computer techniques and CAx systems using 3D software (SolidWorks), including:

- conceptual projects,
- technological projects,
- detailed projects,
- implementation projects.

WWe carry out works using sequential or concurrent design techniques. In addition, we carry out implementation projects using reverse engineering technology (scanning the surface of the detail, recreating its geometry, building a 3D model, material verification). We create 3D documentation based on the provided details or flat drawings including freehand drawings. There is also the possibility of visualizing the developed models by presenting on 3D projectors or printing in rapidprototyping technology. We advise and train engineers in the field of modern design and manufacturing techniques.



A conceptual model of a lawnmower

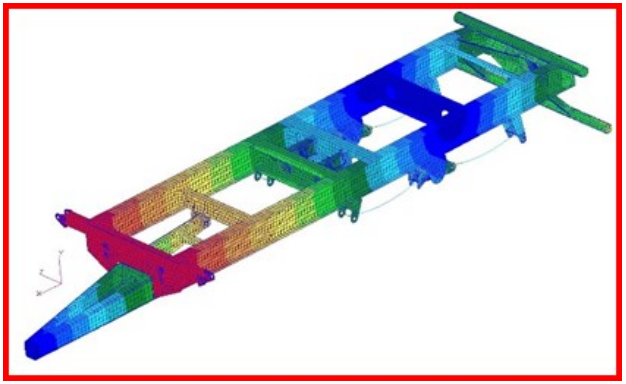


Model of the styrofoam regranulator

Model of a car transporter

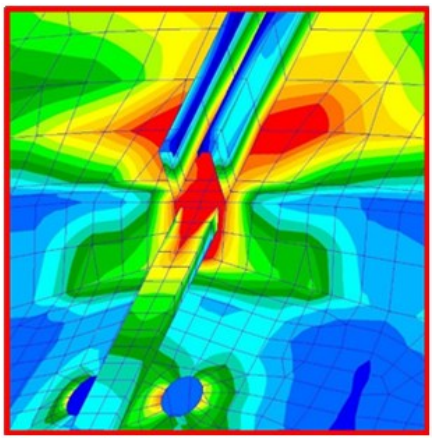
Model of the adapter that allows filling the bags with sand

Numerical calculation of structure strength using the finite element method

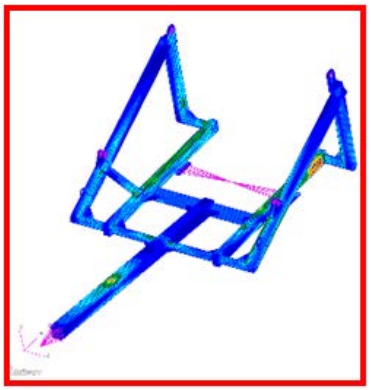


Frame deformation of loading trailer

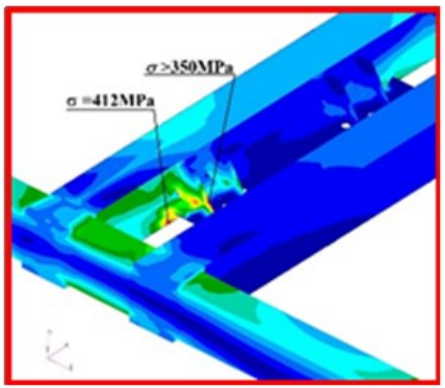
The CAE laboratory of the Faculty of Mechanical Engineering has numerical software using the finite element method (FEM). MSC.AFEA is the package of two leading computer programes for modelling and numerical calculations. It joins the power of pre- and post-processor MSC. Patran, used for FEM modelling and calculation solver MSC. Marc which solves a number of advanced issues in the field of linear and non-linear structural and thermal problems, including coupled thermo-structural problems. MSC.AFEA provides access to all MSC. Patran tools related to the creation of finite element meshes. In addition, many advanced material models are supported, including composites as well as viscoelastic materials. The software makes possible to model complicated boundary conditions, allows modelling of non-linear contact problems which are necessary in calculations of multibody systems. The adaptive finite element mesh modelling makes possible to solve difficult problems related to extreme deformations. The MSC.AFEA software allows to verify the stability of the structure in the entire range of the equilibrum path. FEA calculations can be carried out for rods construction (1D), plate-shell (2D), solid (3D). Engineers who use numerical calculations are able to determine the optimal level of construction work in terms of strength as well as stiffness. In most cases such calculations lead to the elimination of structural errors.



Stress concentration in shell of grain silo



Stress distribution in a frame



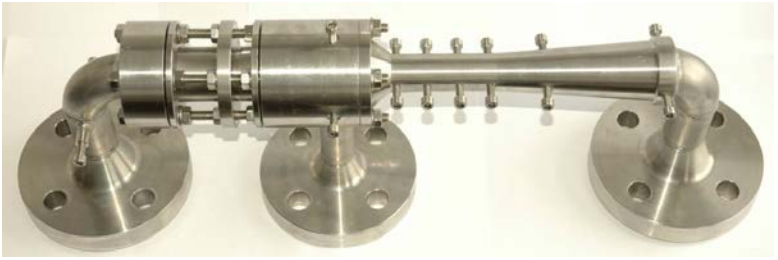
Stress concentration in the main frame

Design of refrigeration, air conditioning and heat pump systems

We offer research and development activities in the areas of: research, technological and technical projects, refrigeration, air conditioning, heat pumps, solar and heating systems, including natural (and ecological) working fluids meeting current EU legislation. We propose innovative technical solutions that allow the use of thermal waste energy, which is one of the main directions of research work carried out in the Department of Thermal Engineering and Refrigeration. This particularly applies to systems that use renewable energy or low temperature waste heat from a wide range of technological processes. In the design we use modern numerical modelling tools to simulate thermal and flow processes. We offer numerical evaluation of the operation of the system or device at the design stage, which eliminates a significant portion of the later studies and, as a result, reduces the overall cost of the project. Prototypes of innovative equipment and systems are being developed which are then subjected to experimental evaluation research.

Prototpye of the high-effective compression heat pump of a heating capacity 100kW

Prototype refrigeration system operating with propane as a refrigerant



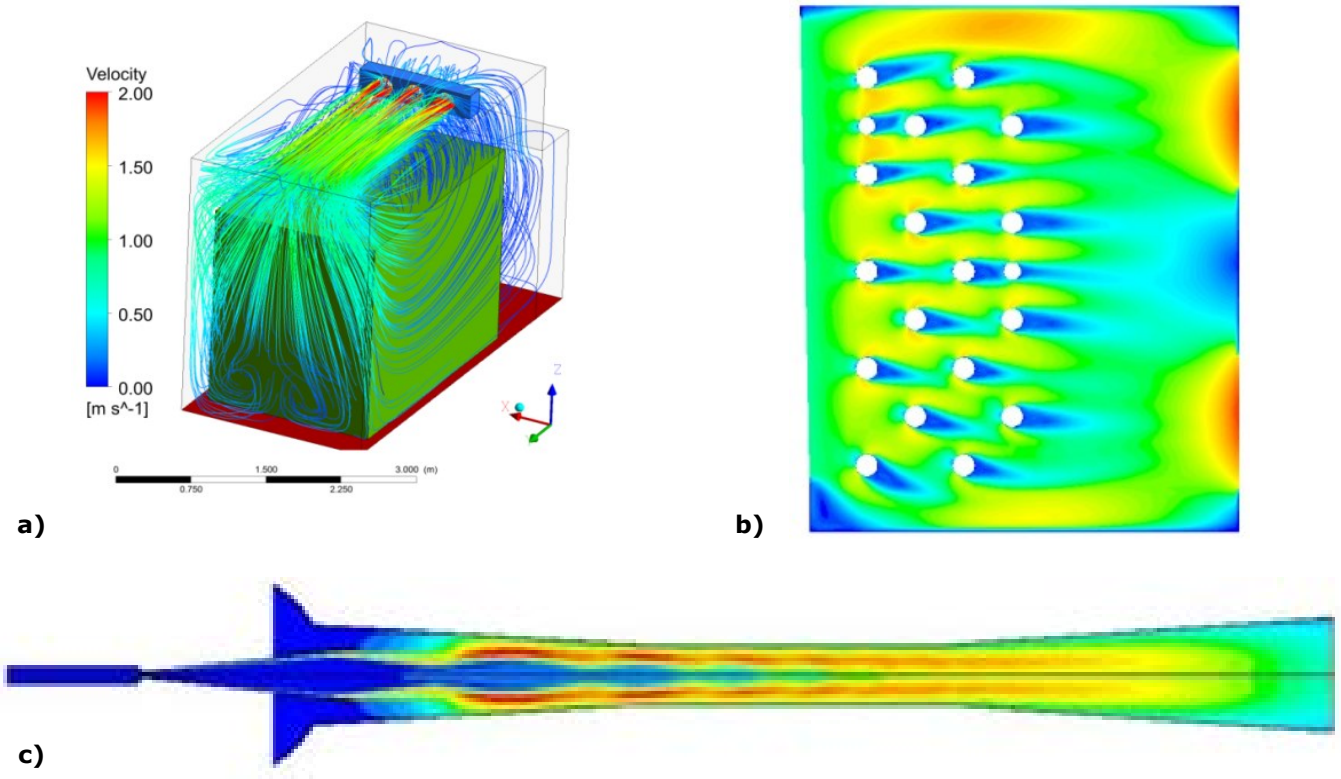
Ejection refrigeration system driven by low-grade heat source

Numerical modelling of thermal and flow porcesses

We offer numerical modelling of thermal and flow processes in a wide range of technical issues, in particular:

- thermal and flow processes in cold storage chambers of agricultural products,
- heat exchangers for refrigeration, air conditioning and heat pump systems,
- flows in refrigeration systems components.

Numerical analysis uses advanced simulation software, the scope of its use and the associated licensing costs are individually set for each project.

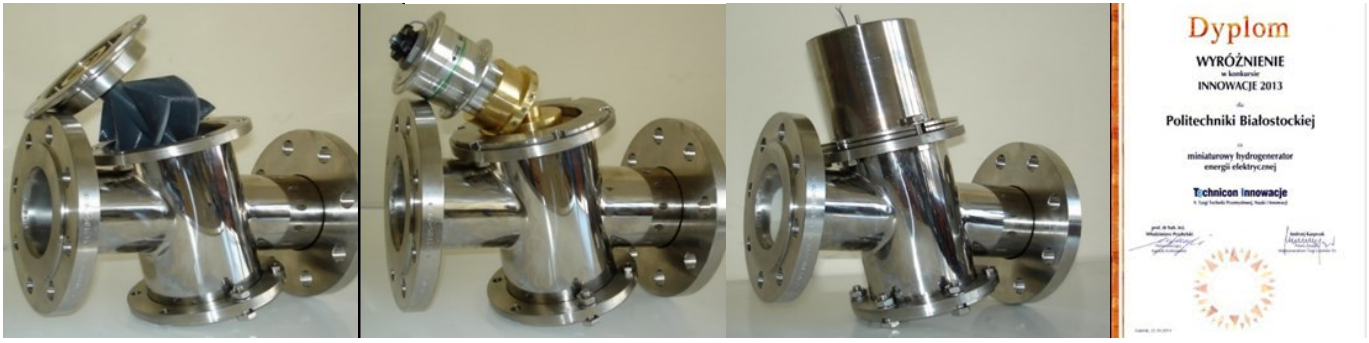


Examples of applications of numerical modelling of thermal and flow processes: a) cold storage chamber; b) fan air cooler; c) flow in supersonic ejector

Manipulator for trenchless servicing of the water supply infrastructure elements

We offer a manipulator used in installations for replacement and service of the pressure transducers. The device consists of two modules: an anchor module and a module for dismantling and mounting of the pressure transducer. The modules are connected to each other by means of a flexible clutch enabling the manipulator to work in the curved pipe sections. The manipulator has a miniature video camera located in the gripper and allows monitoring of the correctness of service operations and inspection of the connection and the technical tube.

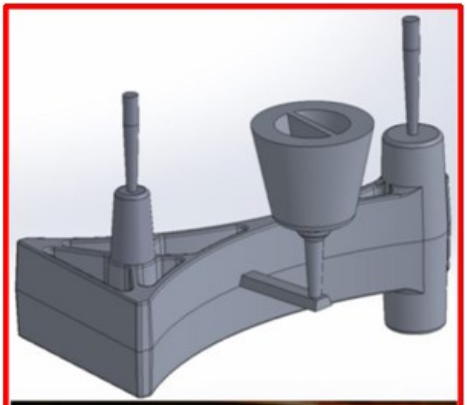
Mini-generator of electrical energy using the working medium flow as the working environment

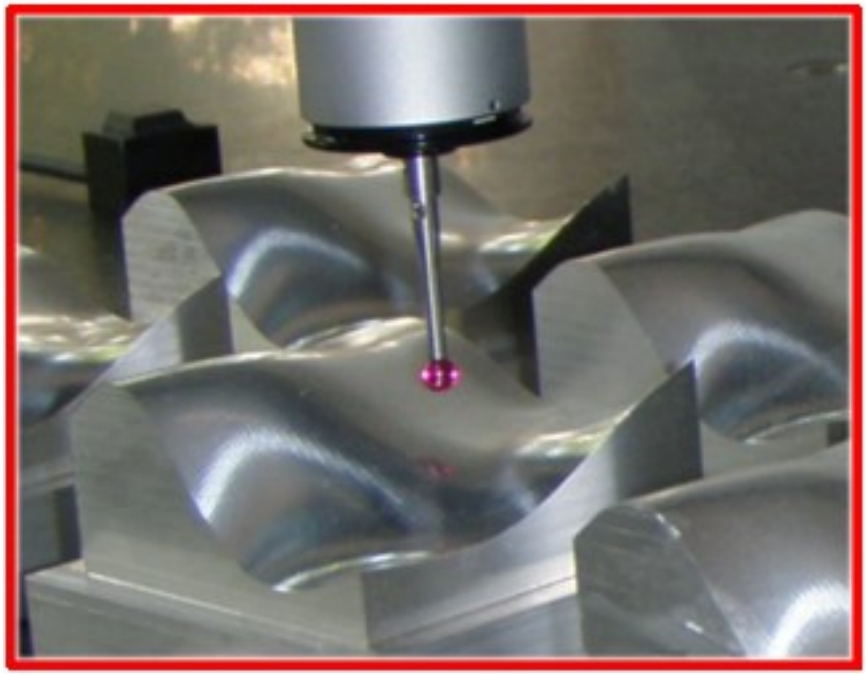


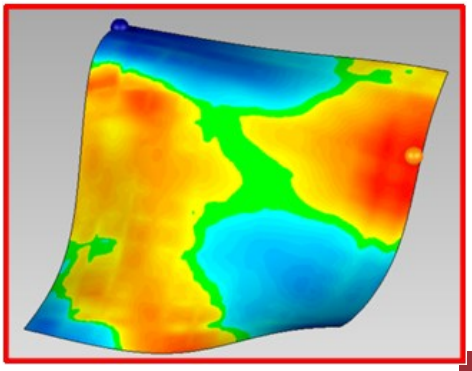
The subject matter of the implementation is a mini-hydrodynamic generator of electrical energy, using the flowing medium. It can be installed in water supply systems to power monitoring devices if mains power supply is not easily available or unavailable at all.

Manufacturing of the complex shapes by reverse engineering

We manufacture prototypes, single and serial products using reverse engineering technology. Using this method, we offer: parts scanning using a 3D scanner, reconstruction of their geometry, creation of the geometrical models of the reconstructed objects with their digital CAD documentation, CNC machining and quality control. We have advanced CNC machine tools, including CNC machining centers, WEDM machine tool, water cutting machine and others with CAD / CAM MasterCAM software and coordinate measuring machines. We create 3D parts documentation, we visualize the created models by presenting them on 3D projectors or manufacturing them in Rapid Prototyping technology. We train on modern manufacturing techniques, measuring techniques and CNC machine tools.





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