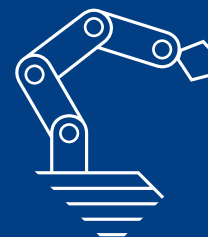
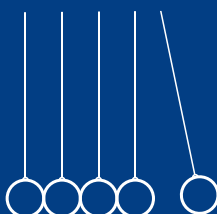
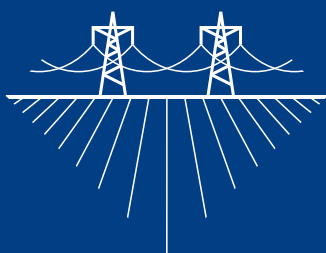
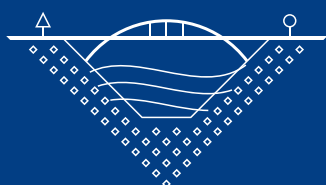




**RZESZÓW UNIVERSITY
OF TECHNOLOGY**

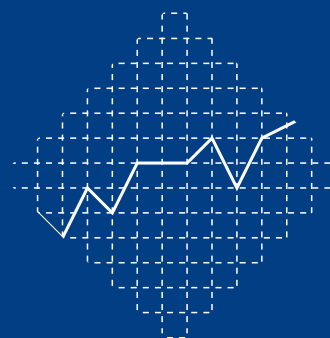


**CENTRUM
TRANSFERU
TECHNOLOGII**
POLITECHNIKI RZESZOWSKIEJ



RESEARCH OFFER

przemysl.prz.edu.pl



Rzeczpospolita
Polska

Unia Europejska
Europejski Fundusz
Rozwoju Regionalnego



**POLITECHNIKA
RZESZOWSKA**
im. IGNACEGO ŁUKASIEWICZA



PREFACE

Rzeszów University of Technology, as a leading innovation centre in Podkarpackie Voivodeship, actively cooperates with industry by conducting joint research projects. This results in stimulating economic growth and regional development, as well as increasing innovation in the economy.

Moreover, as part of its cooperation with companies, the University engages in various cluster initiatives, thus educating specialised staff and providing a variety of research services. Each year the University provides several hundred services for many branches of industry, including: aerospace, engineering, chemical, pharmaceutical, construction, IT, electrical engineering, power engineering, as well as for public administration bodies.

Rzeszów University of Technology also carries out many research projects aimed at practical application of their results in industry, which is the main driver of innovation and competitiveness of enterprises, driving economic development.

The high technological level of solutions developed by the scientists of Rzeszów University of Technology is confirmed by numerous awards won, among others, at international exhibitions in Geneva, Seoul, Brussels, Sevastopol, Cluj-Napoca and Warsaw.

This publication presents the research offer of all departments of the Rzeszów University of Technology. In order to obtain detailed information on specific items or to inquire about the possibility of conducting research work not listed in the catalogue, please contact us.

Technology Transfer Centre of the Rzeszów University of Technology

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**THE FACULTY OF
CIVIL AND ENVIRONMENTAL ENGINEERING,
AND ARCHITECTURE**
RZESZOW UNIVERSITY OF TECHNOLOGY

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RESEARCH OFFER

Faculty of Construction, Environmental Engineering and Architecture

Kasper Weigl Department of Geodesy and Geotechnics

- performing measurements within the scope of:
 - trigonometric levelling and precision levelling (measurement accuracy on 1 km of double levelling when measuring electronically on standard code patches: 1mm);
 - Tachymetry;
 - demarcating, determination of elements in the field;
 - situational, realization and inventory measurements;
 - horizontal displacement surveys;
 - determination of a specified level, height in relation to a reference point;
 - vertical displacement measurements (subsidence of buildings and other engineering structures), also for minor values.
- geotechnical research in the field of:
 - testing of soil strength parameters, testing of the filtration coefficient and complex deformation tests;
 - determination of soil liquidity limits, consistency index and wall strength according to standard requirements;
 - determination of shear strength (cohesion and angle of internal friction)
 - determination of soil granulometric composition by separating individual soil fractions by sieving the sample on a set of standardised sieves
 - soil compaction testing (determination of the degree of compaction of loose soil and control of construction embankments);
 - drilling and sampling of soil to the depth of 5 m.

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Department of Infrastructure and Water Management

- examining of the technical condition of the network infrastructure;
- research on hydrological processes;
- design and optimization of the underground infrastructure facilities and systems;
- development of sustainable drainage systems and rainwater usage;
- research of rainwater harvesting systems;
- development of advanced and sustainable systems and structures in municipal infrastructure of urban area;
- developing and testing technical solutions to eliminate the occurrence of the so-called heat islands effect and disadvantageous microclimate in urban areas;
- public opinion poll on the implementation of pro•ecological solutions;
- PESTEL / SWOT analysis of pro•ecological solutions;
- spatial-temporal analysis of precipitation characteristics;
- hydraulic tests of structures used in municipal engineering;
- building Information Modeling (BIM);
- implementation of Decision Support Systems;
- rainwater and gray wastewater management systems.

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Department of Environmental and Chemistry Engineering

- qualitative and quantitative physical and chemical analyses of water, sewage, sediments and soils in basic and extended scopes, e.g. for heavy metals (ICP), ions (ion chromatography, spectrophotometry), selected organic pollutants such as organochlorine pesticides, polycyclic aromatic hydrocarbons, phthalic acid esters (GC-MS), total organic carbon, Kjeldahl nitrogen
- analysis of stable isotopes of nitrogen and carbon in solid, liquid and gaseous materials (IRMS);
- consulting, technological research in the field of wastewater treatment, designs and starting up wastewater treatment plants;
- analyses of anthropopressure on surface water ecosystems including interpretation of degradation causes and origin of loads;
- consultancy services for the reclamation of aquatic and terrestrial ecosystems;
- water-legal surveys and environmental impact assessments of industrial plants, sewage treatment plants, waste dumping sites;
- mineralogical-petrographic studies of rocks, building materials, mineral resources in the basic scope as well as in the aspect of detailed analysis, e.g.: identification of siliceous reactive minerals, changes in structural and textural characteristics, and evaluation of secondary and mineralisation processes.

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Department of Materials Engineering and Building Technology

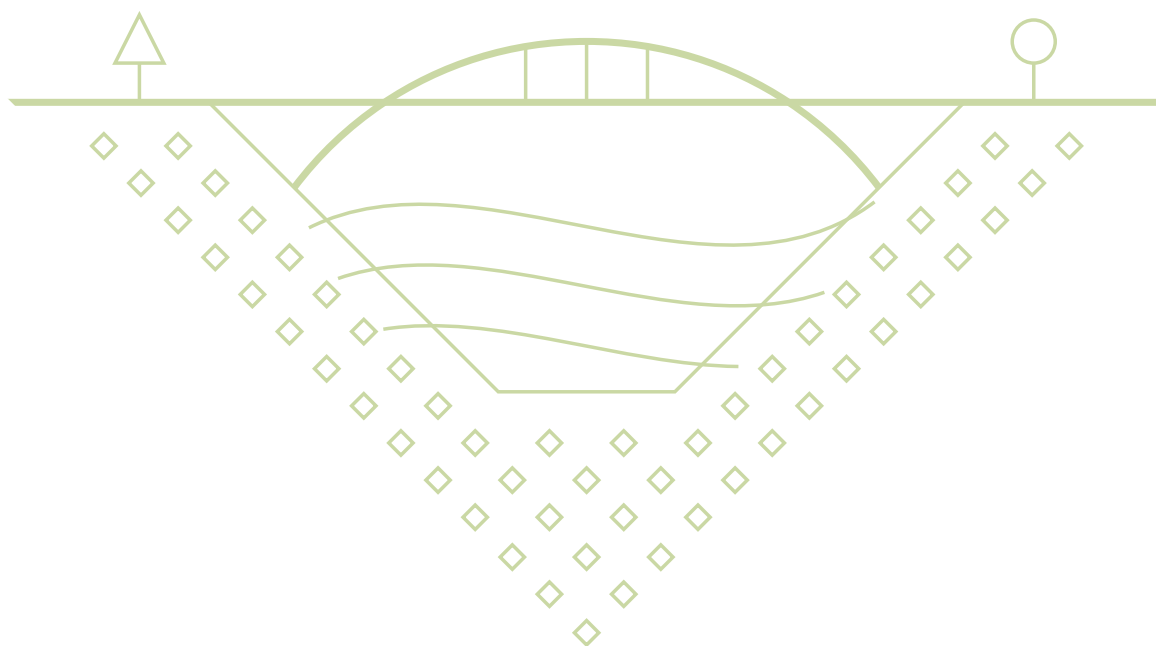
- designing concrete mixtures of various types,
- complex problem solving in concrete technology, testing of binding materials, aggregates, concrete products, concretes and mortars,
- assessment of the technical condition of building structures
- development of repair technologies for concrete and reinforced concrete structures,
- design of anti-corrosion protection of building structures.

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Department of Building Structures

1. Conceptual design* of any type, to any degree of difficulty, of steel, concrete, timber and masonry structures:
 - buildings and cubature objects,
 - steel chimneys, tanks, pipelines, supporting structures, towers and masts and other metal structures (steel, aluminium, stainless steel),
 - reinforced concrete chimneys, tanks, silos, ducts and other engineering structures and cubature structures made of reinforced concrete and prestressed concrete.
2. Analysis services of complex structural systems.
3. Consulting, verification and preparation of corrections to structural designs
4. Optimising structural solutions, proposals to implement new techniques and technologies
5. Evaluation of design solutions, technical consultancy
6. Expert opinions and technical condition assessments** of existing buildings and construction elements
 - e.g. fully non-linear computer finite element calculations,
 - inventory measurements of the shape of tanks and other structures using 3D scanning method,
 - consulting on applications for ITB technical approvals,
 - assistance to business entities consisting in consultations, cooperation in implementation of new technologies and construction materials, technical consultancy,
 - expert opinions and opinions on defects in concrete structures (including industrial floors and concrete surfaces).
7. Research into the properties of construction materials:
 - steel: chemical composition and mechanical properties (yield point, strength, ductility), destructive testing of joints,
 - testing and evaluation of concrete, including concrete in structures (in cooperation with an external accredited [(AB 535)] and notified [(NB 2039)] laboratory),
 - consulting and supervision in the development of technology and organization of concrete works (including complex massive structures and with the use of special concretes) with respect to production, transport, installation and care of the performed elements
 - analyses and opinions regarding the correctness of using construction products.
8. Destructive testing of elements and structures and non-destructive testing of elements and structures***:
 - static-strength, dynamic and fatigue tests of structures, joints and finished construction elements,
 - thickness measurements of steel elements and their coatings, quality of welds,
 - assessment of the quality and condition of concrete in the structure, identification of reinforcement.
9. Technical condition assessment and restoration projects for historic buildings.
10. Training services in interpretation and application of standard provisions (Eurocodes), advanced calculation methods, use of FEM in structural design.

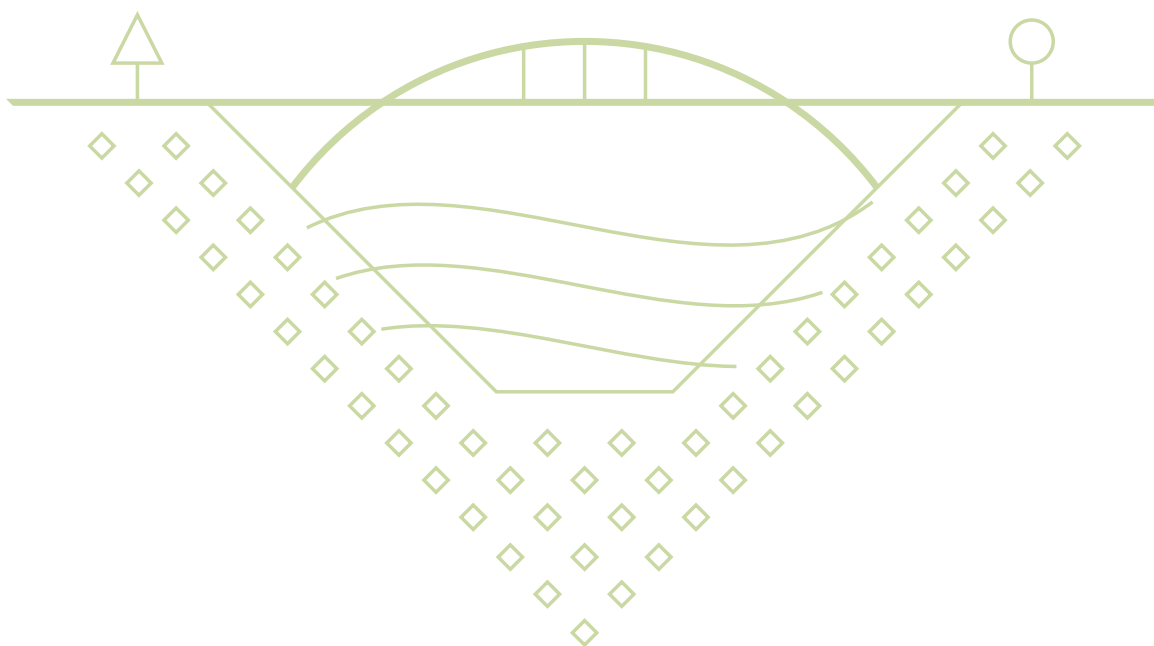
* The majority of employees of the Department of Building Structures have an unrestricted licence to design;

** Many employees of the Department of Building Structures hold the title of Building Surveyor and PZITB Surveyor;

*** A Management System compliant with PN-EN ISO/IEC 17025 has been implemented and is in use at the Faculty Construction Research Laboratory. The Laboratory has an Accreditation Certificate for Research Laboratory issued by the Polish Accreditation Centre.

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Department of Structural Mechanics

Type of research performed:

- slow-motion filming and playback of fast-moving processes and their analysis.
 - recording and analysis of static processes, e.g. non-contact measurement of displacements of building structures, buildings, bridges, etc.
-

Set of colour cameras for observation of fast changing processes:

Operating range:

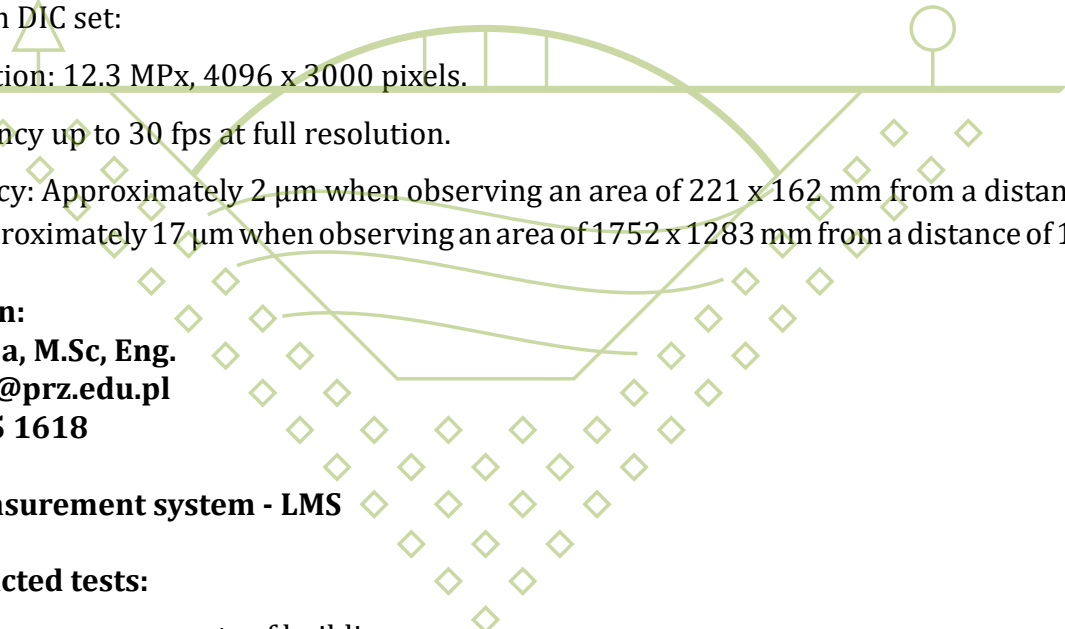
- resolution: 4 MPx, 2560 x 1600 pixels.
 - frequency up to 1400 fps,
-

Black and white camera set for DIC for fast changing processes:

Working range:

- resolution: 4 MPx, 2560 x 1600 pixels.
 - frequency: 800 fps at full resolution or 130,000 fps at reduced resolution.
 - accuracy: approximately 2 μm when observing an area of 143 x 89 mm from a distance of 500 mm, approximately 30 μm when observing an area of 2950 x 1844 mm from a distance of 1500 mm.
-

High-resolution DIC set:

- resolution: 12.3 MPx, 4096 x 3000 pixels.
 - frequency up to 30 fps at full resolution.
 - accuracy: Approximately 2 μm when observing an area of 221 x 162 mm from a distance of 200 mm, approximately 17 μm when observing an area of 1752 x 1283 mm from a distance of 1500 mm.
- 

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Vibration measurement system - LMS

Type of conducted tests:

- vibration measurements of buildings,
- Vibration measurements in machinery,
- vibration measurements of construction elements, caused by technological processes, parasismic, transportation and other impacts.

Operating range

- sensitivity of accelerometers: from 0.1 mV/g to 10 V/g,
- frequency range: from 0.1 Hz to 6 kHz.

Contact person:
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Vibration test system - TIRA

Type of tests performed:

- verification of resistance of elements to dynamic loads (vibrations, shocks),
- keeping tested objects in resonance.

Range of operation:

- maximum excitation force: sinus/noise 89 kN, impact 178 kN,
- frequency range: 5 -- 3000 Hz,
- maximum displacement: 50.8 mm,
- maximum speed sinus/noise: 2.0 m/s, impact 3.0 m/s,
- maximum acceleration sinus/noise: 100 g, impact 200 g,
- maximum mass of test objects: 620 kg,
- working area: 1500 xx 1500 mm.

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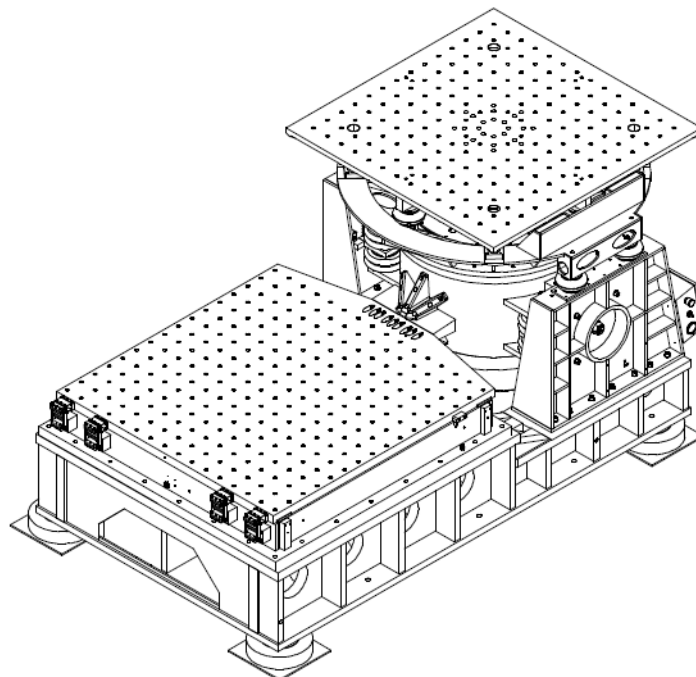


Figure 1: TIRA vibration test system

Thermal imaging system for testing composite materials

Type of tests performed

- non-destructive testing of materials, with particular emphasis on composite structures, for the detection and identification of damage in the form of delamination, dissection, cracks.
- assessment of the condition of metal structures and materials in terms of surface condition testing (corrosion detection, paint coating condition assessment), quality control of welded joints, damage detection e.g. cracks in turbine blades.
- quality control of solar cells - condition assessment of components made of foam, e.g. car dashboards

Scope of work:

- thermal imaging camera with FLIR SYSTEMS SC 6540 cooled detector
 - resolution 640 x 512 pixels
 - frequency
 - 126 Hz at 640 x 512 resolution; 410 Hz at 320 x 256 resolution,
 - 1087 Hz at 160 x 128 resolution; 4011 Hz at 64 x 8 resolution.

Types of thermal excitation:

- 5.2 kW halogen excitation lamp set (for large area excitation) and 2.5 kW halogen lamp,
- a flash generator with a flash energy of 3.0 kJ
- an ultrasonic excitation module at 15-25 kHz with an output power of 2 kW,
- a laser excitation module,
- eddy currents generator.



Figure 2: Thermal imaging system for testing composite materials.

Contact person:

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Mobile thermal imaging system for the inspection of composite structures - C CheckIR

Type of tests performed:

- testing of composite structures and materials, even of considerable size; application in aerospace, naval, wind energy and automotive industries,
- possibility to perform tests on real structures, in their place of work (aircraft skin testing, tank testing).

Scope of work:

- monitored area of 430 x 340 mm,
- 400 mm distance from the tested object,
- thermal imaging camera with a resolution of 320 x 256 pixels and frequency: 9 / 30 / 60 Hz.

Thermal excitation:

- 2.2 kW halogen lamp



Figure 3: Mobile thermal imaging system for the inspection of composite structures

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Department of Water Supply and Sewage Systems

- municipal Systems Modelling, Analysis and Risk Assessment
- water System Design, Data Processing and Analytics
- municipal Systems Failure/Repair Databases Design, Implementation and Maintenance
- water Infrastructure Resilience Modelling, Analysis and Simulation
- water Supply Logistic Chain Techno•Economic Modelling, Analysis and Simulation
- water Treatment & Processes Design, Monitoring, and Diagnosis
- partners with academic institutions, industry, operators, municipalities and public authorities (regulation & control).

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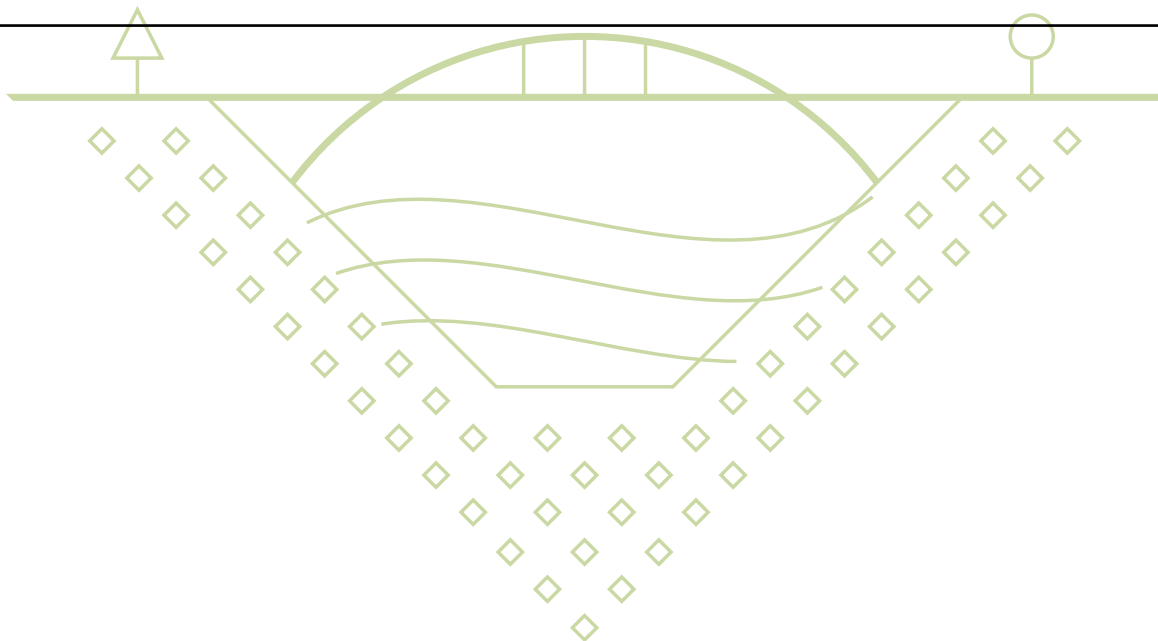
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Structures Research Laboratory

Accredited tests

The laboratory has implemented and applies a management system compliant with the PN-EN ISO/IEC 17025 standard. Since 2013, the laboratory has been accredited by the Polish Accreditation Centre. The scope of accreditation includes:

a) Tests of road and railway bridge structures:

- measurement of vertical displacements by means of mechanical sensors or precision levelling method in the range $0 \div 300$ mm,
- measurement of displacements with an automatic electronic total station from a distance of up to 300 m,
- measurement of deformations/strains under static and dynamic load with electric resistance strain gauge,
- vertical displacement under dynamic load,
- measurement of vibration using accelerometers.

b) Investigations of buildings:

- measurement of maximum vibration of buildings in order to assess the impact of vibrations on buildings,
- measuring the effective value of vibration for assessing the effect of vibrations on people in buildings.

c) Tests on noise in the general environment, i.e. noise from roads, railways and tramways:

- equivalent sound level and exposure sound level measurements by direct method,
- the measurement of the equivalent sound level for T reference time (by calculation).

Additional information concerning accredited tests is available on the website of the Polish Accreditation Centre: www.pca.gov.pl.

Tests not covered by accreditation:

a) Static and dynamic testing of models, structural elements, connections and construction products using a universal, adjustable testing system.

Maximum span of the tested element is 21.0 m, maximum load 2×630 kN. The test stand is constructed according to the needs, using the adjustable elements that are included in the laboratory equipment. During the tests, measurements include:

- the displacement of the structure using mechanical or inductive sensors,
- the angle of rotation using inclinometers,
- strain/stress in elements using electrical resistive strain gauges,
- vibration accelerations by accelerometers.

b) Fatigue tests on components of building structures, joints, vibration isolators, machinery and equipment:

- tests are carried out under alternating load with frequency from 0.2 to 20 Hz and force range up to 630 kN.

c) Field tests of acoustic insulation of building partitions from air and impact sounds.

As part of tests the following are determined:

- apparent sound reduction index R' according to PN-EN ISO 16283-1:2014-05,
- a single-number weighted sound reduction index R'_w and spectrum adaptation indices terms

C and Ctr according to PN-EN ISO 717-1:2013-08,

- evaluation of sound reduction index R'A1 according to PN-B-02151-1:2015-10,

- normalized impact sound pressure level L'n (by direct measurement) according to PN-EN ISO 140-7:200,

- weighted normalised impact sound pressure level L'n,w and the spectral adaptation index CI according to PN-EN ISO 717-2:2013-08,

- evaluation of sound reduction index R'A1 and single-number weighted normalised impact sound pressure level L'n,w according to PN-B-02151-3:2015-10.

d) Tests of the sound absorption coefficient of building materials and products under laboratory conditions.

Determinations include among others:

- single-number rating of sound absorption DL α NRD according to PN-EN 1793-1:2017-05,

- sound attenuation coefficient α according to PN-ISO 9613-1:2000,

- sound absorption coefficient α_w according to PN-EN ISO 11654:1999.

e) Testing of acoustic insulation of building partitions in laboratory conditions.

The laboratory has reverberation chambers which are unique in Poland and designed for testing acoustic insulation of building elements/partitions, including walls, ceilings, windows, glass packages and acoustic screens. The research includes determining, among others:

- the sound reduction index R according to PN-EN ISO 10140-2:2011,

- the weighted sound reduction index insulation R_w and the spectrum adaptation terms C and C_{tr} (calculation method) according to PN-EN ISO 717-1:2013.

Examples of completed tests can be found on the website of the Structures Research Laboratory:
www.wlbk.prz.edu.pl.

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Department of Building Engineering

- consultation and cooperation in the implementation of new building technologies and materials,
- use of solar energy in construction,
- thermal and moisture processes in building partitions,
- analysis of architectural and construction solutions in residential, public and historic buildings.

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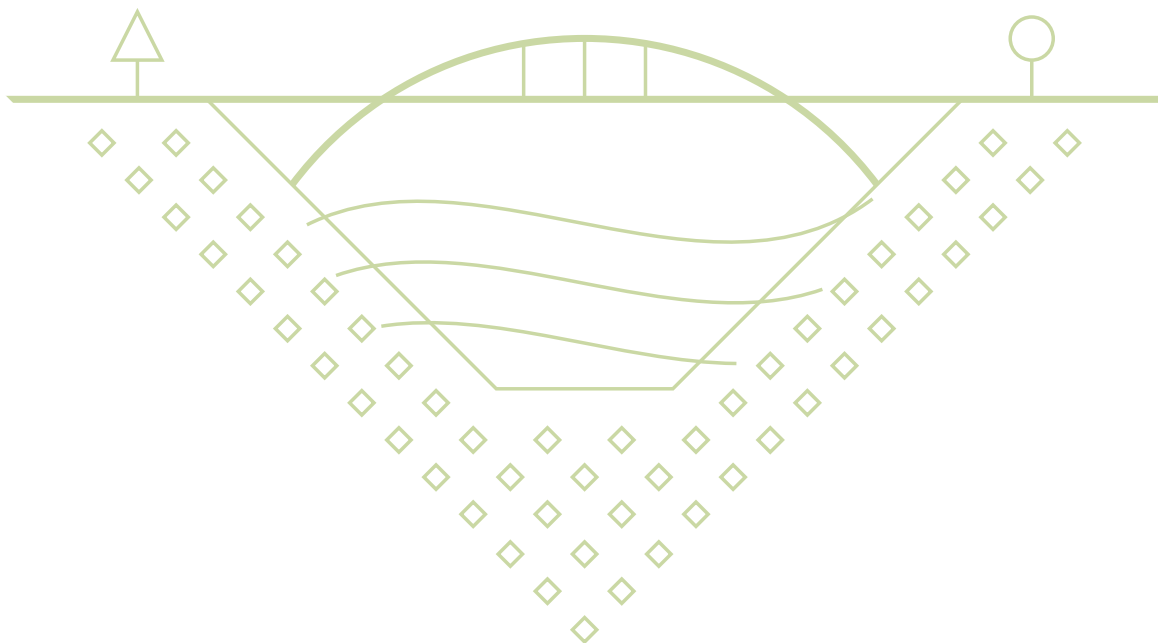
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Division of Heating and Air-conditioning

- testing the thermal conductivity of insulating materials,
- measuring viscosity and density of liquids
- measuring the calorific value of fuels and the heat of combustion,
- measuring the flash-point temperature,
- measuring trace gaseous pollutants in the air,
- measurement of waste gases from the combustion process,
- measurement of volatile organic compounds VOCs,
- testing of temperature measurement sensors,
- measurement of effectiveness of gravitational and mechanical ventilation
- measurement of thermal comfort parameters for PPD, PMV, WBGT.

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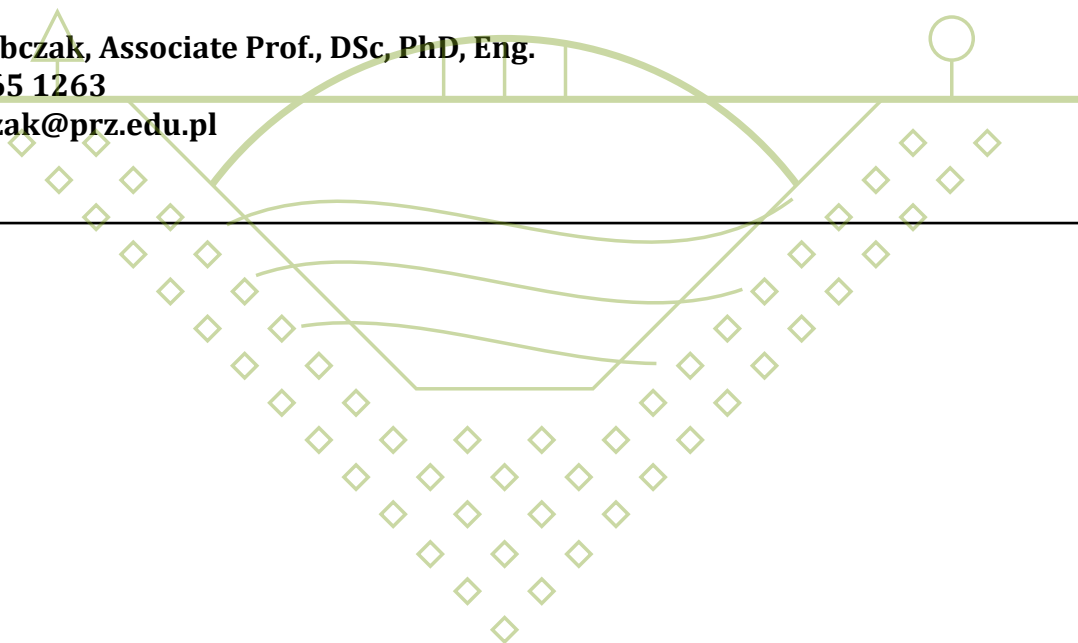
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Department of Roads and Bridges

- laboratory of Bridge Diagnostics and Testing

Selected testing equipment:

- Proceq GPR ground penetrating radar for testing concrete and reinforced concrete structures (detection of reinforcement, concrete defects, etc.);
- PROFOSCOPE - a detector of reinforcement in reinforced concrete elements;;
- CAPO-TEST - a set for non-destructive evaluation of concrete compressive strength with the "pull-out" method;
- BOND-TEST - a set for non-destructive evaluation of peel strength of concrete with the "pull-off" method;
- Hilti drill rig for taking concrete core samples;;
- automatic grinder for surface preparation of concrete samples for strength tests;
- DIGI Schmidt 2000 - a scleroscope for assessing the uniformity of concrete;;
- RCT - a set for field assessment of chloride content in concrete;
- a set for determining the nitrate and sulphate content and the pH value of concrete;
- Olympus technical endoscope and Milwaukee inspection camera for inspecting inaccessible places in buildings, machines and installations (e.g. cable ducts, cable anchorage areas, interiors of box-section elements, etc.);
- a device for estimating corrosion losses of reinforcement by measuring the corrosion current;;
- a device for assessing the probability of corrosion of reinforcement by measuring the corrosion load;;
- an ultrasonic thickness gauge for measuring the thickness of steel elements;;
- an ultrasonic coating meter for measuring the thickness of anti-corrosion coatings;

Selected services provided by the laboratory:

- acceptance tests (trial loads) of bridge structures in accordance with the Regulation No. 47 of the General Director of National Roads and Motorways of 10 August 2011 on "Recommendations for performing tests of road bridges under trial loads";;
- "In-situ" tests of bridge elements (girders, piers, precast elements, piles, etc.);;
- testing of concrete in existing structures (strength assessment, location of reinforcement, etc.) according to PN-EN 12390, PN-EN 13791, PN-EN 12504, PN-EN 1542;
- expert opinions and technical condition assessments of bridge structures;
- assessments of the load capacity of existing bridges;
- assessments of operational and fatigue life of bridges;
- periodical inspections of engineering structures in accordance with the requirements of the Building Law and the "Instructions for carrying out inspections of road engineering structures" (according to the Regulation No. 14 of the General Director of National Roads and Motorways of 7 July 2005);;
- training of bridge inspectors in the scope of current inspections, basic and extended inspections and detailed inspections of bridges.

Contact details :**ul. Poznańska 2****phone: 17 865 1596****e-mail: bc@prz.edu.pl****www.kdim.prz.edu.pl/laboratoria/laboratorium-diagnostyki-i-badan-mostow****The Head:****Leszek Folta, M.Sc, Eng.****phone 17 865 1015, 603 133 702****e-mail: leszfol@prz.edu.pl****• Road Engineering and Technology Laboratory - Division of Roads and Bridges (KDiM)**

The Division of Roads and Bridges of the Rzeszów University of Technology provides the following service-research work:

- expert opinions and technical condition assessments of roads;
- periodic inspections of roads, including condition and load capacity assessments based on the provided deflection measurements
- measurements of road traffic intensity;
- capacity analyses of roads and road junctions (Visum, Vissim);
- analyses and opinions on technological solutions for soil improvement, embankment construction, slope stability, pavement construction
- analyses and opinions on road marking and traffic organisation, including visibility and reflectivity of horizontal and vertical road markings, computer modelling of road traffic.

Characteristics of research and measurement capabilities:

- stationary laboratory equipment for testing samples of pavement construction materials and improved road bed:
- a "small" rut meter for testing the resistance of mineral-asphalt mixtures to rutting*;
- a universal strength testing station with a four-point bending beam fatigue test rig for asphalt mixes, as well as IT-CY cylindrical indirect tensile and triaxial compression tests*;
- Proctor rammer for determining density, optimum moisture content;
- Marshall rammer and press for testing stability and deformation of asphalt mixtures;
- a punch for testing the rutting resistance of hard-surfaced asphalt
- a test station for determining the load-bearing capacity index - CBR;
- a viscosity meter for determining the dynamic viscosity of the asphalt binder and a ductylometer with tensile force measurement for testing cohesion and elastic recoil of asphalt*;
- an automatic penetrometer, a Fraass apparatus, a PiK apparatus
- a gyrator press for determining the modulus of rigidity and resistance to water*;
- an ultrasonic extractor for determining the content of components of the mineral-asphalt mixture*;
- an aggregate polisher for determining the PSV for slip resistance of aggregates for mineral-asphalt pavement mixtures*;

- an RTTL apparatus (English pendulum) for determining the coefficient of friction of the road surface (a possible use in the field)*;
- a chamber for frost resistance testing*;
- a hydraulic press for testing concrete, binder-bound mixtures and road fixtures (kerbs, borders, concrete blocks)*.
- mobile equipment for surface and substrate diagnostics installed on a measuring vehicle:
 - a mobile 15-sensor laser profilograph (evenness, ruts, longitudinal profile, IRI index), precise GPS*;
 - a mobile penetroradar for identification of structural layers of the pavement and its base (simultaneously)*;
 - a drilling rig for taking cylindrical samples from the pavement.
- mobile equipment for diagnostics of horizontal and vertical road markings:
 - marking quality testing: visibility, reflectivity - thin and thick layer horizontal markings, day and night testing, equipment equipped with GPS*.
 - a mobile/stationary ophthalmoscope station:
 - mobile oculometer for testing drivers' states of attention based on eye movement registration together with road image registration (application in road safety analyses)*.
- road software:
 - software for pavement dimensioning using the mechanistic method*;
 - Visum/Vissim software for road traffic analysis and simulation as well as the design of road signs and traffic lights;
 - software for geotechnical analyses*;
 - GPS precision positioners for road traffic surveys (roads, travel times).

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Division of Water Purification and Protection

- physicochemical and bacteriological analysis of water
- elemental analysis of solids and liquids
- microbiological analysis including quantitative tests of environmental samples (water, soil, air)
- technologies for rainwater treatment,
- technological research of water treatment for drinking and special (industrial) purposes,
- evaluation of sorption capacity of sorbents and ion exchange materials
- evaluation of water quality and its suitability for drinking and other purposes,
- evaluation of corrosive nature of water (groundwater and surface waters)
- assessment of physicochemical and biological stability of tap water,
- environmental impact assessment,
- sanitary risk assessment of sediments and harmful substances deposited in the environment,
- nature inventory:
 - floristic and mycological, conducted using the marshalling method,
 - faunistic inventory carried out on the basis of direct and voice observations as well as evidence traces of animal presence.



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Division of Architectural Design and Engineering Graphics

• ARCHITECTURE

- development of architectural and urban planning programmes and projects,
- consultancy, expert opinions, scientific opinions in the field of architecture and urban planning,
- architectural studies and research,
- preparation of architectural documentation,
- adaptation and revalorisation of cultural spaces and degraded areas,
- architectural design of objects of diversified function, form and construction,
- design support by means of graphic computer programmes
- developing architectural visualisations,
- consultations and verification of architectural and urban planning projects,
- conducting training in the field of knowledge of architecture and urban planning.

• ENGINEERING GRAPHICS

- the problem of combining the rationality of a structure and the novelty of its function and architectural form,
- research on rigid tensegrity systems and structures, their geometry and mechanical properties,
- geometric shaping of lightweight bar structures and folded sheet metal roofing,
- Geometric design of systems that can be assembled and disassembled without dismantling into individual elements (deployable structures) and systems whose elements support each other (reciprocal structures),
- geometric design of quasi-surface trusses,
- graphical and analytical methods of implementation of projective representations,
- graphical and analytical methods of realization of projective projections, W3 and W4 space mappings realized as multi-projection mappings,
- Theory and applications of perspective projections, including wide-angle and panoramic projections on developable surfaces,
- technical drawing.

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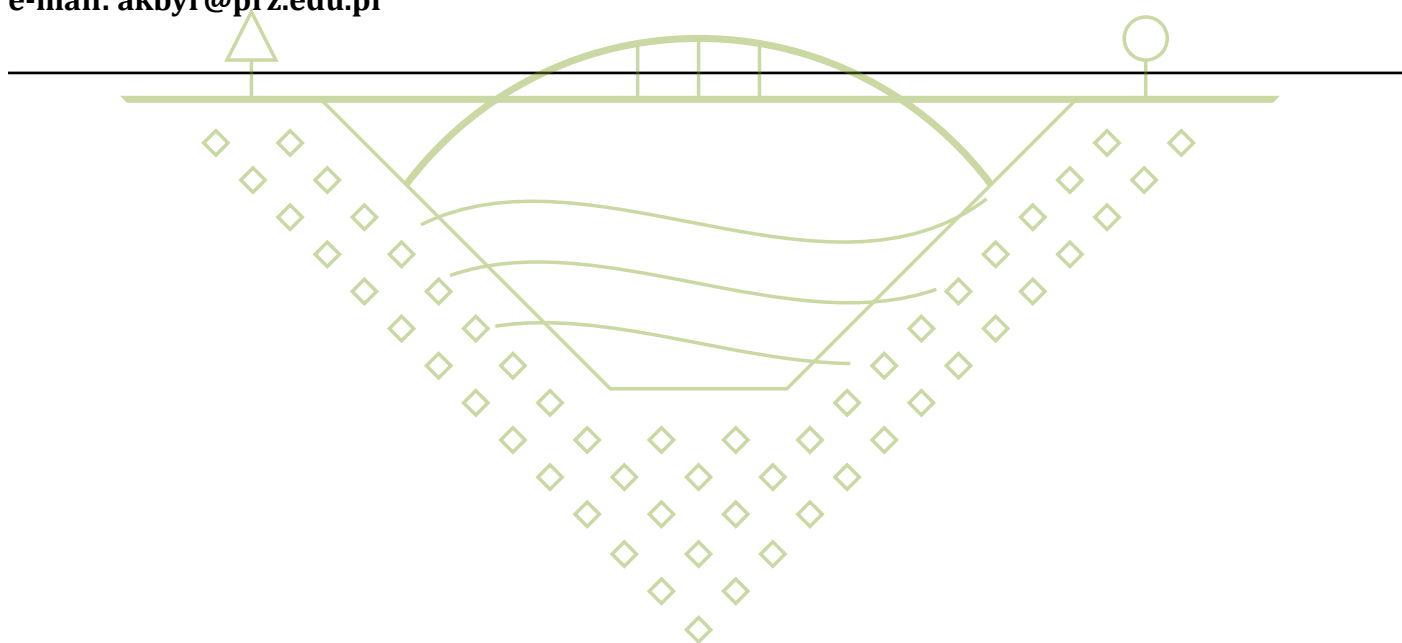
Division of Urban Planning and Architecture

- Consulting, expert opinions, projects in the field of architecture and urban planning, spatial planning and conservation of monuments;
- carrying out conservation supervision on historical buildings;
- carrying out historical studies and architectural research;
- preparation of architectural and conservation documentation
- development of cultural heritage protection programmes;
- supporting local communities and architects by conducting research, popularising its results and developing architectural and conservation programmes and projects.

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Department of Heritage Conservation

- carrying out conservation supervision of historic buildings,
- carrying out historical studies, architectural and archival research,
- preparation of architectural and conservation documentation, adaptation and revitalisation of cultural spaces,
- development of cultural heritage protection programmes, development of analyses, strategies, plans for cultural heritage protection,
- development of architectural and conservation programmes and projects,
- preparation of scientific opinions and conservation expertise,
- carrying out scientific research in the field of historic buildings conservation,
- carrying out training in the field of protection and care of historic buildings.

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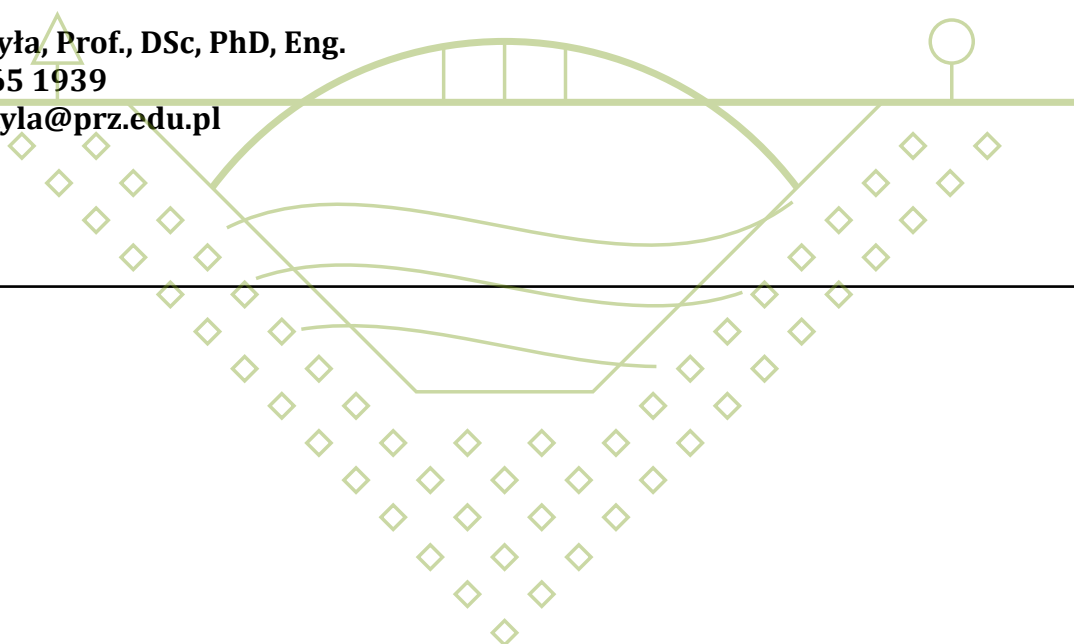
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**THE FACULTY OF
MECHANICAL ENGINEERING
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RZESZOW UNIVERSITY OF TECHNOLOGY

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Department of Avionics and Control Systems

- Thermobarochamber - testing the effects of temperature (from -70°C to +150°C) and pressure (100 hPa-1200 hPa absolute) covering electronic devices;
- Laboratory of Professional Predispositions of an Operator - is based on a computer system, which determines psycho-technical predispositions in terms of resistance to stress, concentration skills, manual skills, and decision-making properties in the process of machine control;
- a simulation station for testing human-machine interface systems and control systems;
- measurement systems - measurement cards and modules with software for creating measurement applications for designing and testing measurement systems of physical quantities;
- experimental research consisting of comprehensive identification experiments resulting in a mathematical model of aircraft motion (or a mathematical model of other aviation equipment);
- creation of real-time object control programs together with a synthesis of control algorithms, in particular for flying objects;
- A test station for testing real-time control systems, especially for flying objects;
- Flying platforms;
- unmanned surveillance system (ultralight aircraft "MP-02" Czajka + Mobile Flight Control Station - Flying Terrain Observer, unmanned aircraft + mobile flight control stations, general purpose aircraft: Piper Seneca V with flight parameters recording system);
- flight testing of avionics equipment, aircraft systems and others;
- radio-modems - data and video transmission - wireless connections for data, video and audio transmission for long-distance testing of moving objects, self-positioning directional antennas;
- flight data recorders, miniature autopilots.

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Department of Mechanical Engineering

- rapid prototyping using fdm technology,
- rapid prototyping using mem technology,
- vacuum casting, silicone mould making,
- reverse engineering, 3d coordinate measuring,
- coordinate measuring of machine parts,
- sheet metal stamping,
- milling, engraving, scanning (numerical control),
- fatigue testing of helical gears,
- measurement of stresses using polarised light,
- measurement/reading of stresses/data from a set of tensiometer sensors,
- fatigue testing of plastic gears.

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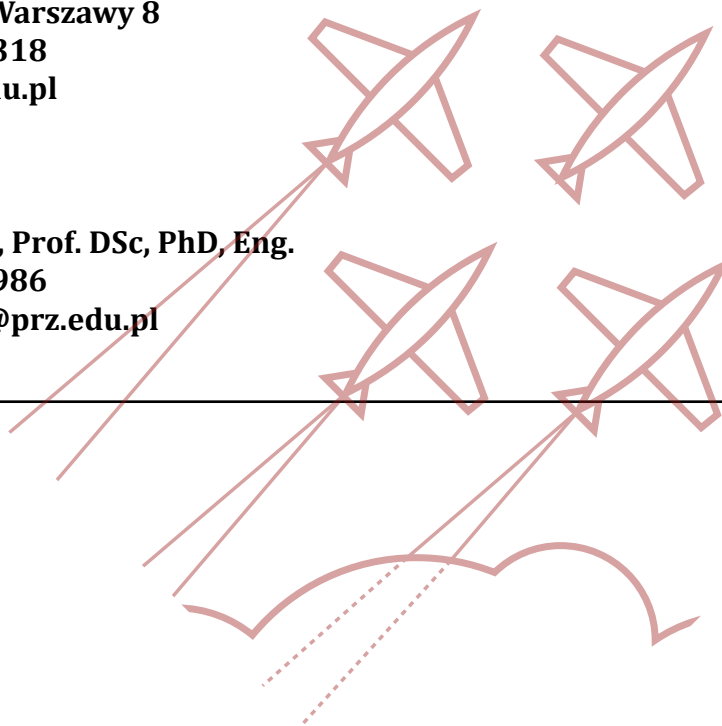
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Department of Materials Science

The research activities of the employees of the Department of Materials Science concern the following issues:

- mechanisms of phase transformations in the solid state, mainly in titanium, nickel, aluminium and iron alloys;
- development of the microstructure and mechanical properties of materials for aeronautics by heat treatment and plastic processing methods;
- formation of protective layers and coatings on components (mainly for the hot part of aircraft engines);
- bulk and directional crystallisation (including mono-crystallisation);
- thermodynamics of alloys;
- mathematical and physical modelling of mass transport processes;
- characterization of physical properties of ceramic materials.

The didactic activity covers education of students of the following faculties:

- Mechanical Engineering and Aeronautics, in the fields of study: materials engineering, mechanics and machine construction, production management and engineering, mechatronics, aviation and aerospace, transport;
- Mathematics and Applied Physics, in the field of study: medical engineering;
- Civil and environmental Engineering and Architecture, in the field of power engineering, in fields of metal physics, fundamentals of materials science, materials science and engineering.

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Research and Development Laboratory for Aerospace Materials

The Research and Development Laboratory for Aerospace Materials (LabMatPL) is an organizational unit of Rzeszow University of Technology conducting interdisciplinary research and training activities in the field of aerospace materials, in particular nickel and cobalt based superalloys, titanium and aluminium alloys, protective coatings and methods of producing single crystals of nickel and cobalt superalloys.

Moreover, the Laboratory is accredited by Nadcap (National Aerospace and Defence Contractors Accreditation Program), issued in March 2009 by Performance Review Institute, USA and by Polish Accreditation Centre (PCA). These include the following tests conducted in the P1 Laboratory: static tensile test at room temperature and elevated temperature, creep test, impact resistance and hardness tests. Nadcap accreditation also covers the process of making samples for strength tests. PCA accreditation, especially Nadcap, recognised worldwide by leading companies in aerospace, defence and related fields, is a confirmation of competence and high quality of conducted research. It opens up the possibility of cooperation in the field of materials testing with both Polish and foreign manufacturers of products for industry.

The laboratory, in its laboratories, offers among others:

P1 Mechanical Properties Research Laboratory:

- static tensile, compression and bending test at room temperature,
- static tensile test at elevated temperature ($T_{max} = 1100^{\circ}\text{C}$)
- creep test,
- low cycle fatigue test (tension-compression) at constant stress or constant strain
- high cycle fatigue test (tension-compression, torsion, bending) at constant stress
- impact test at room temperature (Charpy method),
- hardness measurements by Brinell, Vickers and Rockwell methods.

P2 Laboratory of Chemical and Phase Composition Analysis

- analysis of chemical composition of metallic materials, ceramics, minerals and liquids by X-ray spectrometry (XRF);
- analysis of the chemical composition of metal alloys, including determination of the content of trace elements, and liquids by emission plasma spectrometry (ICP)
- analysis of the chemical composition of conductive and non-conductive materials, full analysis of the chemical composition of diffusive surface layers down to a depth of $100\ \mu\text{m}$ ($5\ \mu\text{m}$ step) by GDS (glow discharge spectrometry);
- analysis of the chemical composition of iron, aluminium and titanium alloys by spark spectrometry;
- analysis of the chemical composition of solids (except organic compounds) in terms of gas content: nitrogen, oxygen and hydrogen;
- quantitative and qualitative analysis of the phase composition of solid materials - mainly nickel alloys, cobalt, steels - and powders, including ceramics - by diffractometry
- determination of the distribution of crystalline orientation on the surface of a monocrystal - including large-size monocrystals - e.g. blades of 1st. and 2. stage of a high pressure turbine of an aircraft engine using a diffractometric method. The diffractometer is equipped with a goniometer, which enables testing on three-dimensional surfaces;
- determination of the characteristic temperature of phase transitions and the coefficient of

linear thermal expansion of a material in the temperature range of 20-1200°C by dilatometry; possibility of additional compression of samples and control of the deformation process (simulation of the thermo-plastic process for a constant value of the deformation velocity and load);

- analysis of residual stresses and austenite by X-ray diffraction (PROTO iXRD COMBO).

P3 Metallographic Research Laboratory:

- preparation of metallographic samples,
- hardness measurements using microindentation method,
- microscopic observations with the use of light (LM) and scanning electron microscope (SEM),
- determination of chemical composition in micro areas (SEM/EDS).

P4 Directional and monocrystalline crystallization laboratory:

- production of products with directional, equiaxial and monocrystalline structure by the Bridgman-Stockbarger method;
- modelling of casting processes - mould filling with liquid metal, directional and volumetric crystallization of cast alloys in the cavity of a casting mould during cooling, as well as occurrence of stresses in a casting and a mould during crystallization. It is also possible to predict the size and shape of solid phase grains, their crystallographic orientation and casting defects, as well as to apply so-called inverse modelling for the determination of thermophysical parameters of materials or boundary conditions (ProCAST software with modules: MeshCAST, Flow Solver, Thermal Solver, Stress Solver, Inverse Solver and CAFE);
- modelling of deformation and cracking processes in metals - the subject of numerical simulations are, among others, the following issues: determination of the influence of the morphology of phase components of the microstructure and their mechanical properties on the distribution of stresses and deformations in micro-areas, determination of the conditions and criteria of damage initiation taking into account the influence of the microstructure of the alloy, determination of the role of the constituted alloy surface layer in the processes of deformation and damage of structural elements (ADINA computational package)
- analysis of fast-changing phenomena, i.e. highly non-linear and short-lived problems, e.g.: explosions, collisions, plastic processing and others (LS-Dyna software of Livermore Software Technology Corporation).

P5 Coatings and Protective Coatings Fabrication Laboratory:

- fabrication of ceramic coatings on components of hot part of aircraft engines by plasma spraying, under reduced pressure conditions (LPPS Low Pressure Plasma Spraying) and physical deposition from the gas phase with evaporation using a plasma torch (PS-PVD Plasma Spray Physical Vapour Deposition);
- fabrication of thermal barrier coatings (TBC -- Thermal Barrier Coatings) by physical vapour deposition (EB-PVD) on hot components of aero-engines, e.g. turbine blades of 1st and 2nd stage;
- fabrication of heat-resistant layers on the matrix of the NiAl phase in the process of low- and high-activity aluminiumizing, including those modified with hafnium and zirconium on the base of nickel and cobalt superalloys
- fabrication of TiN coatings by Chemical Vapour Deposition;
- fabrication of thermal barriers on stationary parts by APS Atmospheric Plasma Spraying;
- spraying of ceramic layers by Suspension Plasma Spraying;

- fabrication of metallic and carbide layers in High Velocity Oxygen Fuel (HVOF) processes;
- metallization using Combustion Powder Flame method;
- selection of thermal spraying conditions of available methods (APS, HVOF) using DPV Evolution measurement systems (particle size and temperature, plume temperature, 2D Mapping of plume, plasma nitriding of selected types of steels);
- determination of mechanical properties (hardness, Young's modulus) and adhesion to the substrate of diffusion layers and protective coatings up to 1 mm by the diamond indenter scratch test, under constant or variable load;
- fabrication of conversion coatings resistant to corrosion and wear under friction conditions on light metal alloy substrates by anodising, hard anodising and glow oxidation processes;
- determination of protective properties of conversion and electroplated coatings deposited on alloy substrates - their mass, thickness, resistance to friction wear and corrosion;
- determination of corrosion resistance of pure metals and alloys: tests in a salt chamber, determination of susceptibility to intercrystalline corrosion of stainless steels, acid-resistant steels and non-ferrous metal alloys, determination of susceptibility of alloys to pitting corrosion, determination of susceptibility of aluminium alloys to laminar corrosion, evaluation of corrosion kinetics with direct and alternating current electrochemical methods, gravimetric method, by measuring the volume of emitted hydrogen.

P6 Heat and thermo-chemical treatment laboratory:

- processes of heat treatment of nickel superalloys, titanium, tool and bearing steels at the temperature up to 1350 °C in vacuum;
- carburising and nitriding processes for low alloy steels using acetylene and ammonia;
- hardening processes are carried out using a modern high-pressure gas method with N₂ and Ar mediums;
- induction hardening;
- thermo-chemical aluminising and nitriding as well as high-temperature treatment.

P7 Laboratory of physical and chemical properties:

- specific density analysis of solids in a gas pycnometer;
- analysis of bulk (apparent) density in a quasi-liquid pycnometer
- determination of particles' size in air;
- measurement of specific thermal conductivity and thermal diffusivity using the laser pulse method - high precision and repeatability, short measurement time, as well as the possibility of performing tests for samples of different shape and cross-section; measurements of samples in solid and liquid state, as well as 2- and 3-layer laminates; measurements in inert atmosphere up to 2000°C;
- TG, TG-DTA, TG-DSC investigations of materials such as: metals, alloys, ceramics, polymers and composites in a wide temperature range from 20°C to 1600°C;
- examination of kinetics of oxidation/reduction of pure metals and alloys;
- examination of composite, metallic and powder materials;
- characterisation of ceramic materials and glass (determination of their purity and percentage of degradation)

- decomposition of polymers;
- analysis of phase transformations
- study of thermal stability and energetic effects of reactions.

P8 Laser and high-speed machining laboratory:

- research and implementation activities in the field of machining of hard-to-machine materials used in aviation technology;
- study of the cutting process in terms of measurement of the cutting force components, temperature in the cutting zone, workpiece surface roughness and vibrations in turning, milling and drilling processes;
- processes for depositing and surfacing metallic powders using a laser beam;
- processes for the cutting of small-diameter holes in both metallic and ceramic materials
- fabrication of protective layers with good resistance to corrosion, including high temperature corrosion, abrasive wear and erosion by the laser deposition method using metal alloy powders as the additive material.

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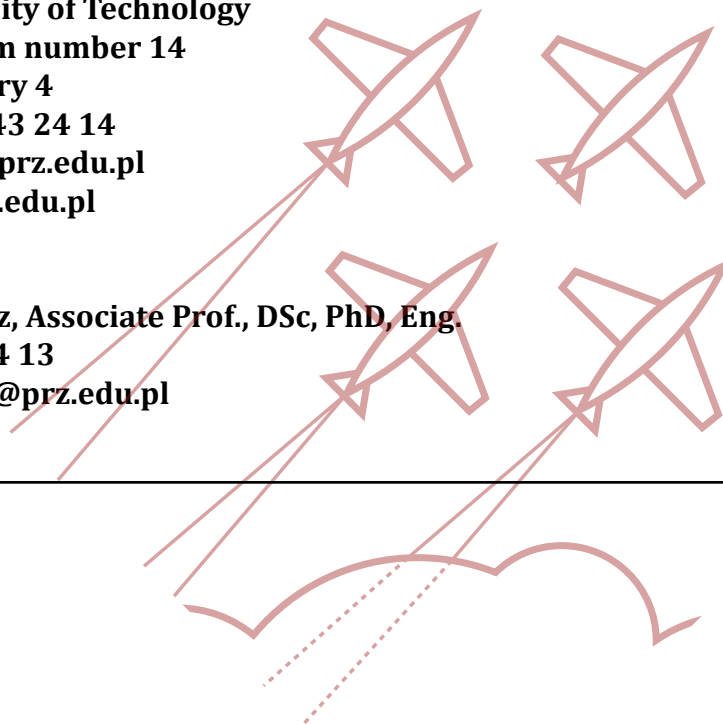
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Department of Applied Mechanics and Robotics

Characteristics of research possible to carry out in the Department of Applied Mechanics and Robotics

Robotic systems

In a wide spectrum of research works undertaken, the main problems are concentrated around the implementation of robotic systems in tasks requiring interaction with the environment, e.g. systems with force control, systems with visual feedback, systems with 3D and 2D scanners. In addition to process development, the objective is multi-criteria optimisation, where the objective function concerns minimisation of time, vibration and tool wear.



Figure 4: Robotic systems

Topics of works carried out:

- machining, deburring, grinding using robots.
- 2D and 3D scanning with the use of robots.
- robotisation of non-destructive testing.
- application of force control in robotics.
- robotised vision systems.

Listing of the main testing equipment of the Industrial Robotics Laboratory:

1. robotic station with ABB IRB2400 robot with force control option, The robot is equipped with a 2.2kW electro-spindle with automatic toolholder changer, Keyence laser profilometer and Schunk grippers.
2. Robotised workstation equipped with ABB IRB140 robot with force control option, and IRB 1600 robot with GOM scanning head. The workstation has a SICK vision system, tool changer, belt grinder, three internal drives with mechanical and pneumatic force compensation.
3. Robotised station equipped with ABB IRB360 robot and vision system with PickMaster software.
4. Robotised station equipped with KUKA robots, type SCARA KR5 Z 550.
5. Robotised station equipped with FESTO pneumatic manipulator.
6. Robotised station equipped with MITSUBISHI RP1 robot.

We have extensive documented experience in implementations carried out as part of R&D works. List of service and research works for the needs of the industrial environment that can be realised in the laboratory:

1. Development of robotic technologies using force control, dedicated in particular to milling along the edges of the workpiece, removal of casting overflows, removal of unevenly distributed excess material after casting, grinding of turbine blades, propeller blades, grinding and polishing of aluminium assemblies.
2. Development of robotic technologies dedicated to packaging operations carried out using vision systems. In particular for the food industry.
3. Development of robotic inspection systems using 3D scanning. Creation of dedicated measurement reports.
4. Development of robotic systems with 2D scanner feedback.
5. Development of robotic systems for ultrasonic thickness measurement of workpieces.

Dynamic systems

Research works are focused on the dynamics of mechanical systems, in particular robots and rotating machines. The works carried out include modelling, simulation, experimental research and analysis of measurement results. The subject of the work is also the monitoring and analysis of phenomena accompanying machine operation and process execution. The latest simulation environments and measuring equipment are used for this purpose. Both conventional analytical and numerical methods and artificial intelligence techniques are used in modelling and analysis of results.

The topics of the conducted work:

- measurement and analysis of vibrations, acoustic signals and forces,
- vibration diagnostics,
- non-contact machine vision measurement of vibrations,
- analysis of phenomena accompanying machining (vibration, noise).

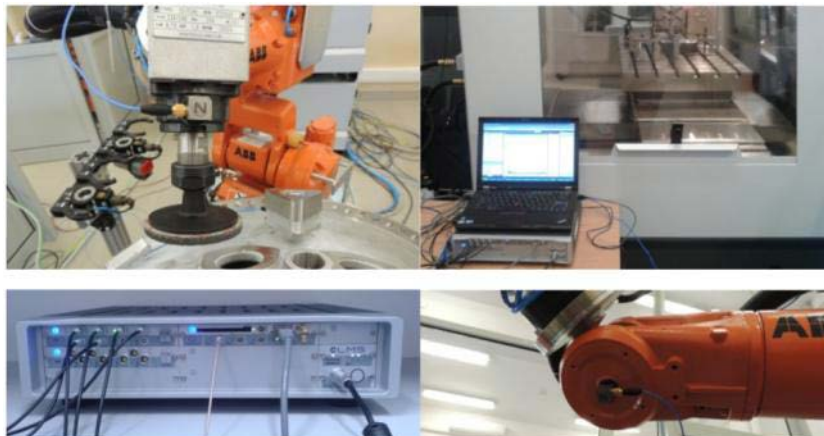


Figure 5: Laboratory equipment of the Department of Applied Mechanics and Robotics.

Specification of the main research apparatus of the Dynamic Systems Laboratory:

1. Vibration and sound measurement equipment - consists of a LMS SCADAS portable multi-channel recorder with data analysis software; acceleration sensors by PCB Piezotronics with different measurement ranges (500 m/s², 5000 m/s²) and frequency response up to 30 kHz; acoustic pressure sensor (microphone) by G. R.A.S. brand acoustic pressure sensor (microphone) with a measurement range of 160 dB and a frequency response of 4 Hz -- 100 kHz; PCB Piezotronics impedance head; The Modal Shop modal vibration exciter, operating in the range of 0 - 9 kHz; ; an additional

four-channel sensor conditioning system.

2. IRIS M (RDI) Vibration Measurement and Analysis System consisting of a high-resolution camera with five interchangeable lenses, a lighting system and software for video recording of vibrations, image analysis with motion amplification technology for visualization of hard-to-see displacements and the ability to visualize individual forms of vibrations.
3. Research and demonstration equipment for the diagnosis of machine components consisting of a machine equipped with an AC motor, gearbox, anti-friction bearings, rotors, coupling, adjustable load system with vibration sensors, data acquisition module and vibration diagnosis software.

We have documented experience in the implementation of research and service works, certificates certifying skills in the field of vibration diagnostics, issued by the Polish Society of Technical Diagnostics, as well as certificates of suppliers of measuring equipment and software.

List of service and research works for the needs of the industrial environment that can be carried out in the laboratory:

1. Measurement of vibrations of machines and equipment during operation (at the client's plant) together with analysis of the results.
2. Non-contact video recording of vibrations with the use of a camera which makes it possible to record movements of both small (cm-scale) and large machines, objects and installations (machine tools, rotors, halls, masts, pipelines, cranes). The result of the analysis are motion-enhanced films, which allow easy evaluation of even very small vibrations (from 0.125 μm).
3. Measurement of phenomena associated with machine operation and process execution, such as: vibrations/noise generated by bearings, gears, machining tools, and their analysis in order to detect anomalies and faults.
4. Testing vehicles during traction tests, including vibration measurement at several measuring points in three perpendicular directions with GPS recording of coordinates.
5. Vibration isolation and damping tests.

Industrial controllers

Research on control algorithms for mechatronic systems, with particular emphasis on artificial intelligence elements, i.e. neural networks and fuzzy logic.

Research work focused on the development of control algorithms for mechatronic systems using a mathematical description of the process. In addition, research work on modelling, simulation and control of continuous industrial processes.

Specification of the main research equipment of the laboratory:

- eight test stands equipped with a computer and:
 1. Siemens S7-300 CPU312C PLC and CP 343-1 Lean module.
 2. Siemens PLC S7-300 CPU312C and CP343-1 Advanced, SM334, SIWAREX FTA modules and TP177B PN/DP 6 CSTN HMI and Siemens PLC S7-200 CPU222 with CP 243-1 Ethernet CP module.
 3. PLC Siemens S7-200 CPU222 with EM 277 Profibus-DP module, power supply SITOP SMART 10A.
 4. Mitsubishi GOT1000 HMI, MR-MQ100 controller, MR-J3-10B servo amplifier.
 5. PLC S7-300 CPU312C, CP 343-1 Lean and SIWAREX U modules, SIMEX SPS-24/5 5A power supply, Siemens TP177B PN/DP 6 CSTN HMI.
 6. Omron SYSMAC CP1H PLC.
 7. Omron SYSMAC CP1H PLC, Siemens S7-200 CPU 222 PLC, SIMEX SPS-24/5 5A power supply.
 8. SYSMAC CJ1M, MAD42, MD263, Power Supply PA205R, Siemens PLC S7-200 CPU222, MD100-T strain gage.
 9. S7-1200 starter kit with KTP400 panel.

10. Ball & barrel system with Banner LT3PU laser rangefinder.

11. PLC Siemens S7-1500 CPU1511-1 PN, and PM 70W 120/230V AC, DQ 16x24 VDC/0.5 A ST, DI 16x24V DC HF.

List of service and research works for industrial environment possible to be carried out in the laboratory:

- PLC programming,
- control of automatic weight measurement systems in static and dynamic processes,

Mechatronic systems

The subject matter of the research carried out in the Mechatronics Laboratory focuses on the implementation of control algorithms for mechatronic systems, with particular emphasis on the issues of safety both in the area of hardware solutions, as well as implemented control algorithms with solutions increasing the safety of workstation operation, also in emergency states. Moreover, the research takes into account issues of implementation of artificial intelligence algorithms, such as neural networks and fuzzy logic algorithms, in control systems using PLC.

The laboratory provides training in Siemens S7-1500 PLC programming with consideration of drive technology applications based on Sinamics G120 inverters, as well as operator panel programming.

Subject matter of performed works:

- control of mechatronic systems with the use of PLC - drive technology application with the use of frequency converters and squirrel-cage induction motors,
- implementation of HMI with the use of operator panels,
- implementation of functional safety solutions in control algorithms realized with the use of PLC,
- implementation of artificial intelligence algorithms in control systems realised with the use of PLC.



Figure 6: Mechatronic systems.

Specification of the main equipment of the Mechatronics Laboratory:

1. 8 test stands equipped with PC and Siemens S7-1500 controller (CPU 1516-3 PN/DP, DI32, DO32, AI8, AO4), operator panel (KTP700 Ba-sic), Siemens Sinamics G120 frequency converter (CU250S-2 PN, PM240-2 module) with three-phase squirrel-cage induction motor, trainer with DI/DO/AI/AO protrusions to facilitate connection of control object to PLC.
2. 4 teaching stations in the form of miniaturised objects such as a sliding gate for verification of con-

trol systems of real mechanical objects with the use of a PLC.

3. Additional research equipment available in the laboratory

- siemens S7-1500 controller (CPU1511-1 PN, DI16, DO16),
- siemens S7-1200 controller (CPU 1212C) with the KTP400 Basic HMI,
- siemens S7-300 controller (CPU 315F-2 PN/DP, SM323 DI16, DO16 module) and TP177B PN/DP HMI,
- siemens S7-300 controller (CPU312C, SM331 AI2 module, CP 343-1 Lean module, SIWAREX U module),
- siemens S7-300 controller (CPU312C, SM334 AI4/AO2 module, CP343-1 Advanced, SIWAREX FTA module) and TP177B PN/DP HMI,
- mitsubishi GOT1000 operator panel, MR-MQ100 controller, MR-J3-10B servo amplifier,
- omron SYSMAC CP1H controller,
- omron SYSMAC CJ1M controller, MAD42, MD263 modules, PA205R power supply,
- 8 Siemens S7-200 (CPU 222),
- banner LT3PU laser distance meter.

List of service and research works for the industrial environment that can be carried out in the laboratory:

- courses and training in PLC programming, operator panels, implementation of drive techniques,
- implementation of control algorithms realised with the use of PLC.

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Figure 7: Mechatronic systems

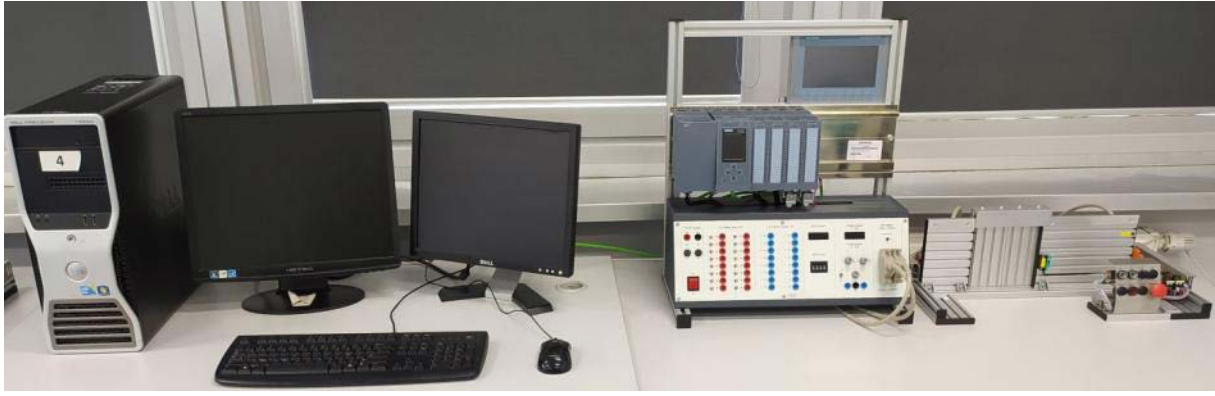
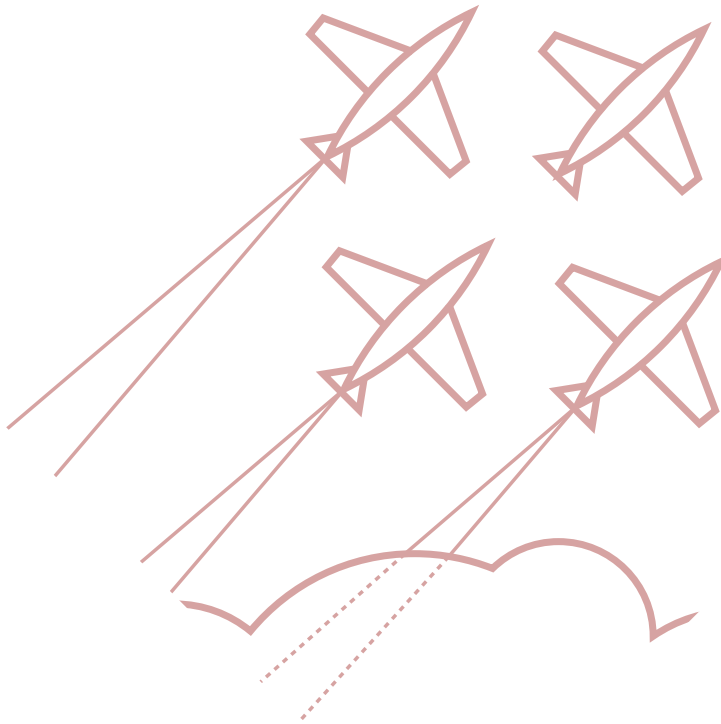


Figure 8: Mechatronic systems



Department of Casting and Welding

- spectral emission analysis of chemical composition of steel, cast iron, non-ferrous metals (Al, Cu, Ni, Co alloys);
- microstructure studies, fractographic studies, microanalysis of chemical composition carried out with the use X-ray energy dispersive spectroscopy (EDS);
- measurements of hardness and microhardness, cohesion and adhesion of coatings, coefficient of longitudinal elasticity, work of plastic and elastic deformation in nano-areas of material, coefficient of friction;
- hardness and microhardness measurements;
- tribological tests using pin on disk and ball on disk method at temperatures up to 800°C;
- simulation of welding and heat treatment processes;
- testing of coating discontinuities, measurement of coating thickness;
- evaluation of ferrite content in steels;
- testing of discontinuity of materials, measurement of conductivity, thermoelectric force in metals;
- profile and geometric structure measurements of surfaces;
- creep resistance tests up to 1100°C;
- heat treatment with temperature control and recording (two chamber furnaces up to 1280°C and one up to 1800°C);
- melting of metals and alloys (capacity of crucible 2 litres, max. melting temperature up to 1500°C);
- heat treatment of flat and round parts in a suitably shaped inductor;
- application of coatings on metal alloy components to improve resistance to oxidation, thermal shock, abrasion resistance, corrosion resistance;
- dilatometric testing;
- expert opinions for industry.

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Department of Materials Forming and Processing

Scientific and research activity of the Department of Materials Forming and Processing covers broadly understood plastic processing of metals (extrusion processes, including KoBo extrusion, forging, rolling, drawing, extrusion), unconventional processes of joining metallic materials (clinching, riveting, friction stir welding), mechanical processing (design and manufacture of tools, e.g. for plastic processing), and plastics processing. The research covers theory and technology of manufacturing various materials, including composites, numerical modelling of materials and processes, as well as studies of mechanical and structural properties of products manufactured from various materials. The subject matter of the scientific and research work carried out at the Department to a large extent results from the implementation of many projects financed from the state budget, EU funds, funds from industrial companies and research services. The results of these works, among others, are the source of many publications, patents and implementations. The scientific output of the Department includes many scientific monographs, several hundred publications and many papers presented at national and international conferences. The didactic activity is related to education of students at various faculties, including: mechanics and machine construction, management and production engineering, transport engineering, medical engineering, mechatronics, material engineering, aviation and aerospace engineering.

A. A. Experimental studies of metal forming processes:

- extrusion (counter-rotating, co-rotating and KOBO)
- rolling
- forging
- extrusion and other sheet metal forming processes (including spinning, rotary extrusion)
- drawing.

B. Theoretical investigation and modelling of plastic forming processes for metallic materials:

- FEA modelling of plastic forming processes, using a number of programs including MSc.MARC, ABAQUS and ANSYS (e.g. material flow analysis, forming tool loading, forming tool wear, stress and strain distributions, fracture prediction, etc.).
- numerical analysis of the additive sheet metal forming process.
- application of neural networks and other algorithms to friction modelling.
- determination of equivalent properties of porous bodies (e.g. aluminium foams) in terms of micro-polar elasticity theory.
- study of the influence of selected parameters on the course of cold spinning and rotary crushing processes and study of the influence of the value of the crumple on the strength and plastic properties of materials after rotary crushing.

C. Unconventional processes for joining metallic parts involving plastic deformation:

- friction Stir Welding (FSW) : linear , spot in different geometric and material arrangements (sheets, sections of different thicknesses / aluminium alloys, magnesium, copper etc.).

Effect of FSW welding parameters on the mechanical properties of the weld:

- analysis of the variation of mechanical properties along the FSW weld line.
- analysis of forces in friction stir welding process.
- clinching of aluminium and magnesium alloy materials, clinching and clinching/adhesive (hybrid) joints of aluminium and magnesium alloy sheets.
- classical and special riveting (two-sided rivets - patent, different types of rivets).
- classical and special bolted joints (including highly stressed joints).

D. Experimental studies of manufacturing processes and shaping of polymeric materials and composites:

- experimental investigations in the scope of manufacturing, evaluation of mechanical and processing properties of polymeric biocomposites with cellulose fibre fillers.
- experimental investigations in the field of evaluation of the influence of the directionality of short fibres in the polymeric matrix on the properties of the composites obtained in the injection moulding process.
- investigations of manufacturing processes of elements made of various types of plastics.

E. Theoretical studies and modelling of manufacturing processes and shaping of polymeric materials and composites:

- computational studies on the optimisation of the manufacturing process of polymer composites by injection moulding.
- numerical modelling of the injection moulding process of polymer composites using Autodesk Moldflow Insight software.
- numerical calculations concerning prediction of mechanical properties for polymer composites with fiber fillers (in the form of short fibers) using homogenization models.
- carbon fibre - epoxy resin composites for energy absorbing components, experimental and numerical studies under quasi-static and dynamic conditions.
- numerical calculations for composites: metal-ceramic, metal-plastic, carbon fibre, glass fibre - thermosetting resin, thermoplastic resin.
- determination of material strengthening parameters using fuzzy logic methods.
- evaluation of the effectiveness of selected constitutive equations for hyper-elastic bodies in the numerical modelling of the first and eighteenth loading cycle of an elastomer for stamping, depending on its loading scheme, strain magnitude and the methodology for determining the material constants in these equations, with the aim of developing guidelines for the selection of the constitutive equation and the methodology for determining the material constants during the numerical modelling of deformation of elastomeric bodies.

F. Recycling of various types of waste, oriented towards material recovery and environmental protection, including polymeric, metallic and composite materials.

G. Scope of the thematic research work in cooperation with the economic environment:

- technologies of shaping super hard materials, including composites based on diamond and regular boron nitride, .
- development of designs and manufacturing technologies for shaping, cutting and measuring tools and instruments, including tools used in friction stir welding and spot welding.
- investigations of processes with the use of manufactured tools - measurement of forces, temperature, microscopic and macroscopic investigations of the structure of the worked/shaped materials and shaping tools.
- design, manufacture, testing of structure and properties of tool materials and materials/products formed in technological processes.
- studies of stresses and deformations in plastically formed metal profiles.
- design, manufacture and testing of welds of various types of metal components, including bolted, clinched, riveted and friction stir welded (FSW) types.

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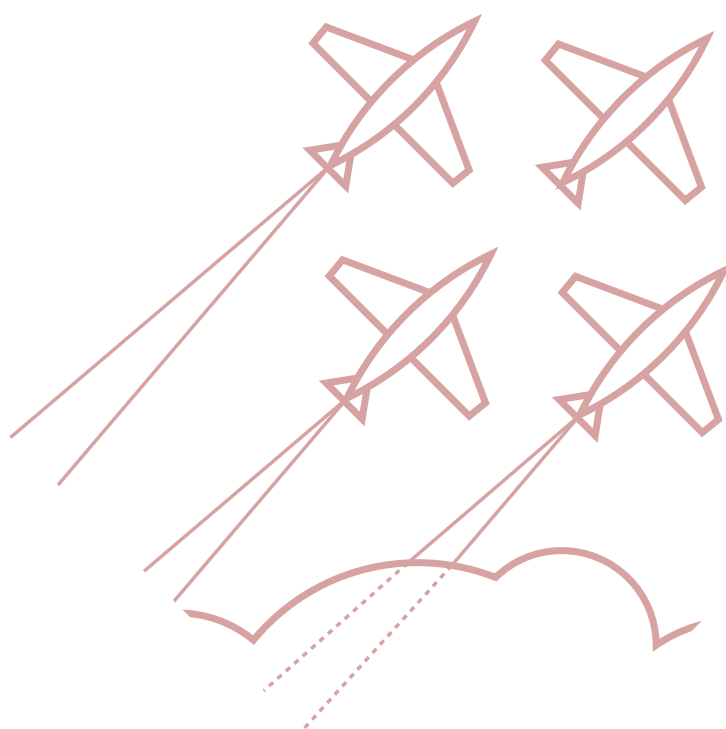
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Department of Aerospace Engineering

- modelling, analysis and optimisation of aircraft performance;
- Optimisation of the aircraft operational characteristics, including flight trajectory;
- Optimal task allocation in a multi-type aircraft fleet;
- Optimal selection of an aeroplane for a transport system taking into account uncertainty of transport demand forecast;
- Optimal design of aircraft and multipurpose aircraft systems,;
- design and construction of unmanned aerial vehicles;
- modelling, analysis and optimisation of the operational characteristics of unmanned aerial vehicles;
- flight testing of unmanned aerial vehicles;
- bench testing and modelling of the operational characteristics of piston and turbine engines and turbine engines for small UAVs;
- landing gear tests of manned and unmanned aeroplanes up to 450 kg;
- damage assessment of aircraft structural elements using non-invasive methods;
- analysis of damage impact on strength and durability characteristics of aircraft structural elements;
- development of concepts, construction and testing of modern solutions for aircraft power units, including:
 - hybrid propulsion systems,
 - fuel cell propulsion systems
 - conceptual solutions of turbine engines,
 - strength and fatigue tests of airframe and engine construction elements,
 - modelling and numerical simulations of strength issues of aircraft structures.

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Department of Motor Vehicles and Transport Engineering

- measurement of operational and environmental parameters of internal combustion engines,
- indication of internal combustion engines,
- testing and evaluation of injection systems of automotive internal combustion engines,
- visualisation studies of engine processes,
- measurement of physicochemical and quality parameters of fuels
- tribological and corrosive properties of fuels and lubricants
- measurements of motor vehicle operating parameters,
- tests in the field of technical diagnostics of vehicles,
- tests in the field of reverse engineering,
- tests on driver behaviour on a driving simulator.

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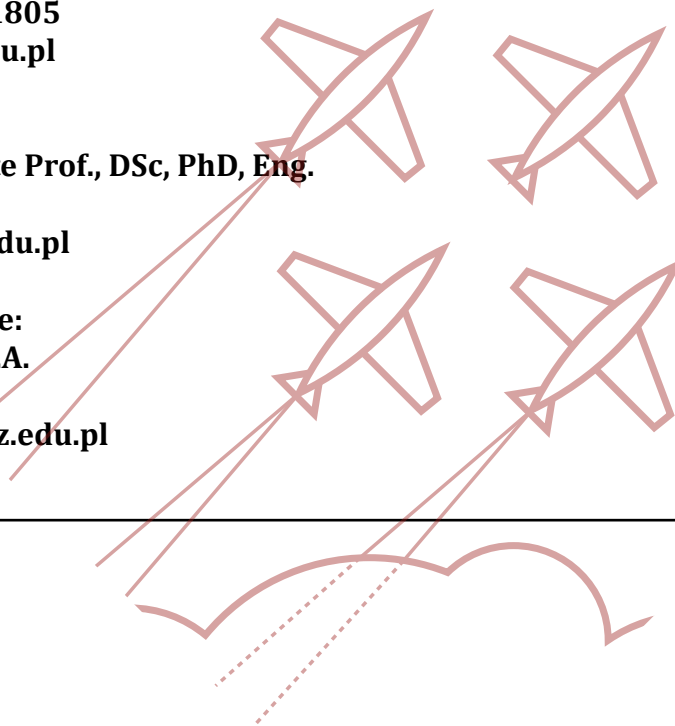
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Department of Manufacturing Techniques and Automation

- research work in the field of selection of parameters and tools for processing metal and ceramic materials
- design of drive and control systems of technological machines
- modernisation of technological machines through application of modern drive and control systems;
- design and construction of special technological machines;
- programming of CNC machines in CAM systems;
- programming and implementation of 5-axis machining of complex surfaces;
- turning, milling, grinding, electrical discharge machining, laser cutting, water jet cutting of basic machine parts
- balancing of cutting tools;
- die making by milling and hollowing;
- machining of spur and helical gears, worm gears and straight worms;
- research and development work related to the treatment of brittle materials, including the application of ultrasonic vibration excitation to tools (grinding and milling);
- research and development work related to the grinding of hard-to-machine materials carried out on numerically controlled and conventional machine tools;
- measurements and analysis of geometric and dynamic errors of CNC machine tools;
- testing of tools and measuring instruments for length and angle;
- contact or optical measurements and topography analysis of machine parts surfaces;
- design and implementation of integrated measuring systems: displacement, force, torque, vibration, acoustic emission and temperature
- coordinate measuring and digitising of objects with regular geometric shapes, curves and curvilinear surfaces of products, blades and gears;
- measurement of free surfaces with a measuring arm with a laser head;
- rapid prototyping using 3DP and FDM methods;
- preparation of independent opinions on the application of technologies with significant market potential - projects financed from European Union funds.

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Department of Machine Technology and Production Engineering

- tribological tests on the T-05 roller-disc tester,
- tests on T-11 bolt-disk tester (for tests at elevated temperatures - up to 300oC),
- tests on a tester for evaluation of tribological properties in reciprocating movement,
- tests of worm gears,
- fatigue tests on a vibrating system,
- shaping of lubricating micro-pockets,
- profilometer tests,
- machining on numerically controlled machine tools,
- machining on conventional cutting machines,
- goniometer tests.

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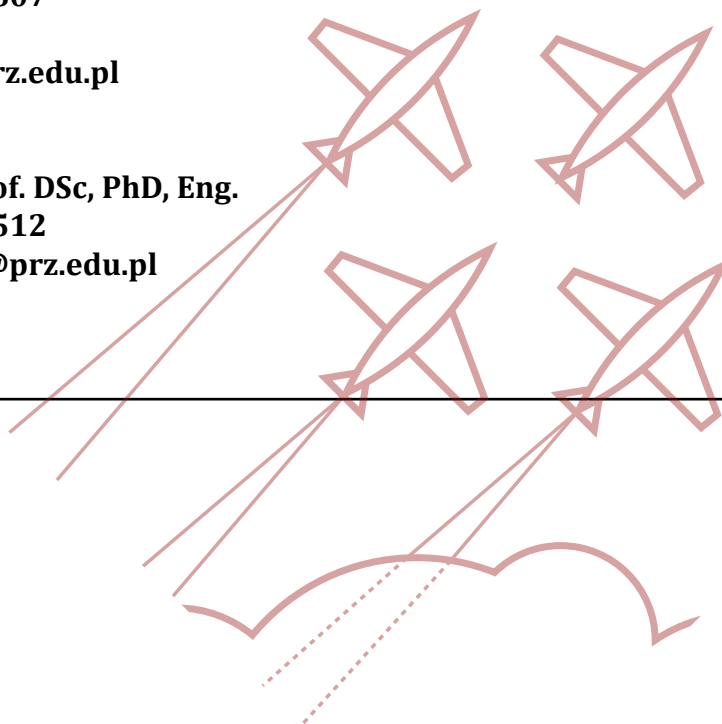
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Division of Thermodynamics

Possibilities and scope for providing R&D and commercial services to external parties.

A. Studies of thermophysical properties:

1. identification of thermal diffusivity of solids using Parker's method, with NETZSCH LFA 427 apparatus.



Figure 9: NETZSCH LFA 427 laser

2. Measurements of the thermal conductivity of solids using the guarded heat flow meter according to ASTM1530 with the UnithermTM 2022 by Anter (now TA Instruments).



Figure 10: UnithermTM 2022.

3. Testing the thermal conductivity coefficient and specific heat of solids, powders and liquids using the so-called "hot thread" method with the KD2 Thermal Properties Analyzer from Decagon Devices Inc.



Figure 11: KD2 Thermal Properties Analyzer.

4. Testing the thermal conductivity of metals and their alloys using the quasi-stationary method.

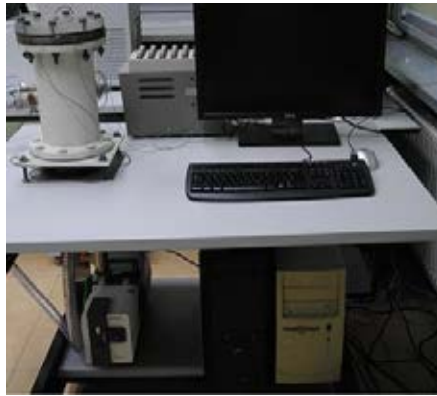


Figure 12: Measurement station for the thermal conductivity coefficient of metals and alloys.

5. Measurement of calorific value and heat of combustion of solid fuels, using the so-called "calorimeter bomb". Determination of ash content in fuel samples.



Figure 13: Automatic calorimetric bomb

6. Identification of biogas composition and flue gas composition using mobile analysers.



Figure 14: IMR 3000 portable flue gas analyser and biogas analyser.

7. Viscosity measurements of Newtonian and non-Newtonian liquids using a Brookfield R/S Plus rheometer.



Figure 15: Brookfield R/S Plus rheometer.

B. Thermal measurements:

1. Thermal imaging measurements of temperature fields, using thermal imaging cameras with non-walking and walking detectors. FLIR P 640 and SC5000 forms.



Figure 16: FLIR thermal imaging cameras.

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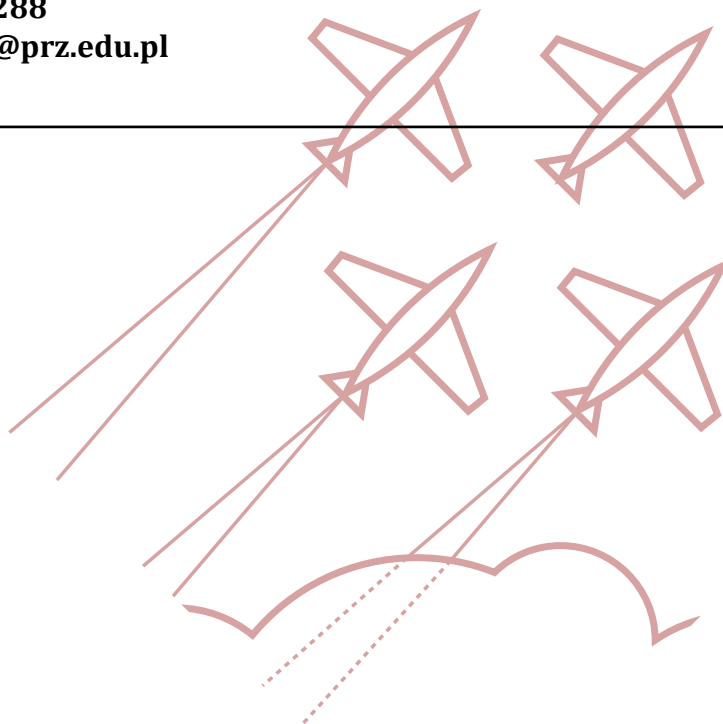
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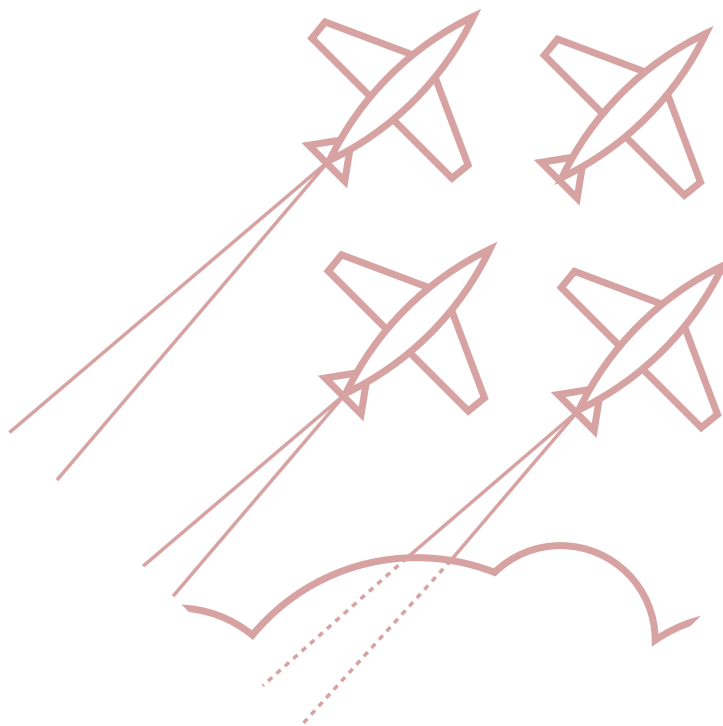
Division of Computer Science

- pre-implementation analyses of IT management systems - extraction and specification of requirements for an IT system, modelling of business processes using BPMN language, creation of domain models, feasibility studies, selection of an IT system in terms of requirements, training of personnel in the scope of operation of an implemented system;
- IT project management using PRINCE2, SCRUM and RUP methodologies;
- coaching teams executing projects in SCRUM methodology;
- developing technical specifications for information systems using object-oriented methodology and UML language;
- development of technical specification of electronic business systems - design of Internet business model and preparation of clickable prototypes of a web application in Axure environment
- preparing concepts for web-based business models, which can be used as a brief for interactive agencies
- preparation of website designs in terms of Web Usability;
- database design taking into account information and transaction requirements of an organisation;
- business modelling - business process modelling, preparation of a business model of an application domain, development of business process models in as-is and should-be variants and running simulation experiments to select the optimum variant in view of established metrics (process execution time, costs, etc.)
- creation of simulation experiments using Monte Carlo simulation, system simulation, system dynamics and multi-agent simulation methods;
- preparation of SEO audits of web systems;
- training in:
 - IT project management methodologies (PRINCE2, RUP, SCRUM, CMMI methodologies),
 - analysis and design of information systems using structural and object-oriented methodologies,
 - design of Internet business models,
 - data modelling,
 - web Usability,
 - business analytics,
 - business modelling,
 - SEO,
 - running Lean, Lean Startup and Lean Analytics methodologies.

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THE FACULTY OF **CHEMISTRY**

RZESZOW UNIVERSITY OF TECHNOLOGY

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Faculty of Chemistry

Department of Biotechnology and Bioinformatics

Research and services related to the engineering of proteins and their biological activity based on experimental data and computer simulations.

- chemical industry:

- design of environmentally friendly production processes and products using enzymes as catalysts;
- improving the efficiency of production processes by using enzymes as reaction catalysts;
- optimization of technologically important enzymes by improving their properties using computational methods.

- pharmaceutical industry:

- identification and characterization of new therapeutic targets;
- design of new therapeutic agents on the basis of structures and 3D models;
- improving the therapeutic properties of existing drugs based on active centre analysis.

- **proteomic analyses:**

- Qualitative and quantitative analysis of the composition of protein-containing materials and products using electrophoretic and ELISA techniques.
- Comparative analysis of gene expression at the proteome level using electrophoretic techniques.
- Detection of protein allergens and identification of other proteins using Western Blot techniques.
- Evaluation of enzyme activity with colorimetric techniques and using zymography.

Biological analysis of synthetic compounds and compounds of plant origin through evaluation

- antibacterial properties against certified and clinical strains of bacteria, including *Staphylococcus aureus* and *Staphylococcus epidermidis*,
- cytotoxicity to normal and cancerous mammalian cells, including skin fibroblasts, prostate and breast epithelial cells,

Genetic analyses and examination of transcriptomes of useful plants with a view to obtaining raw materials and intermediate products for the chemical and pharmaceutical industries.

Quantitative and qualitative analyses of nucleic acids.

Identification and quantitative analysis of plant-derived compounds by high-performance liquid chromatography combined with mass spectrometry (UHPLC-MS/MS).

Research and education services in the field of:

- advanced methods for searching information in on-line chemical databases,
- computer representation (coding), editing and 3D-visualisation of chemical structures,
- computer processing of structural and sequential chemical information.

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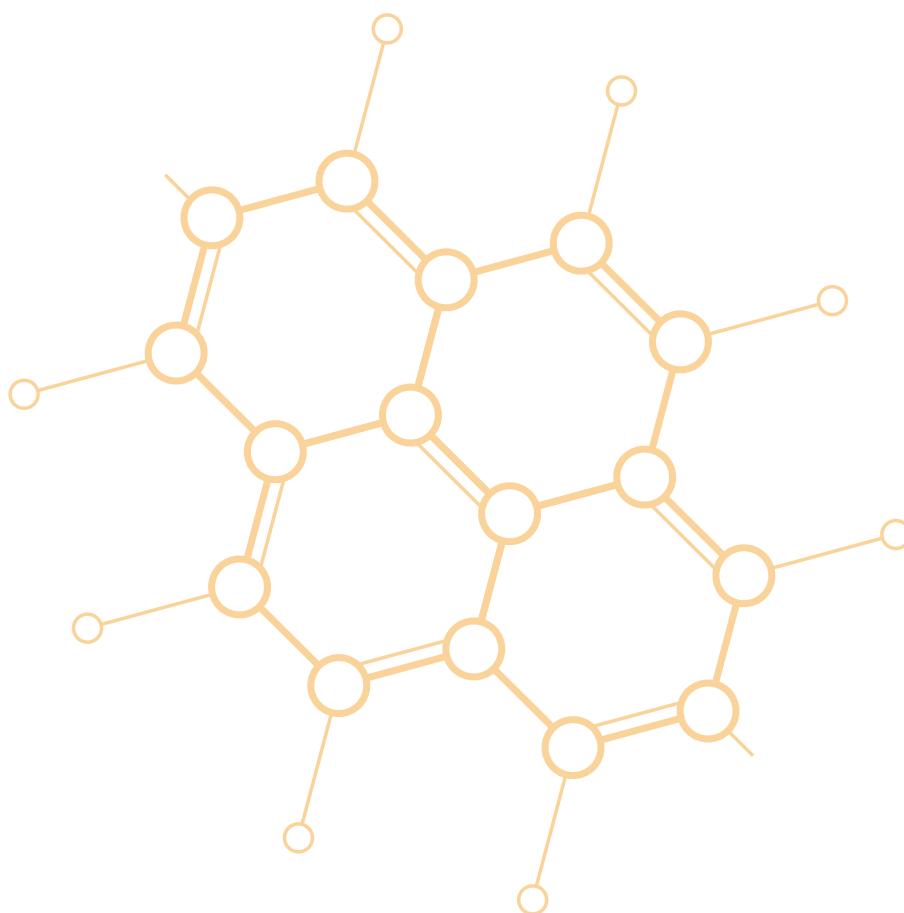
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Mirosław Tyrka, Prof. DSc, PhD, Eng.

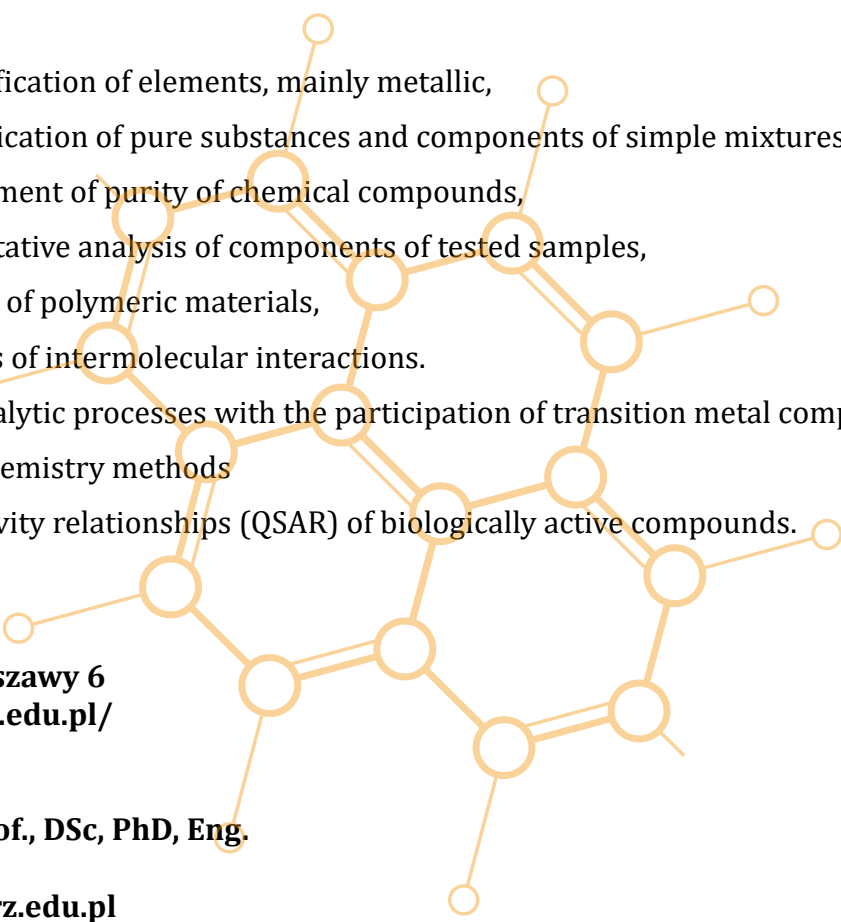
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Department of Physical Chemistry

Research profile::

- voltametric assays,
 - electrochemical impedance spectroscopy (EIS) measurements, including corrosion tests,
 - examination of the surface of materials by electrochemical scanning microscopy (SECM),
 - electrochemically mediated atom transfer radical polymerization (eATRP),
 - synthesis of well-defined macromolecules using ATRP methods,
 - gas chromatography (FID and MS detectors) and high performance liquid chromatography (UV-Vis and MS detectors),
 - spectroscopic studies (UV-Vis, FT-IR, ASA - atomic absorption spectrometry),
- including:
- quantification of elements, mainly metallic,
 - identification of pure substances and components of simple mixtures,
 - assessment of purity of chemical compounds,
 - quantitative analysis of components of tested samples,
 - testing of polymeric materials,
 - studies of intermolecular interactions.
- modelling catalytic processes with the participation of transition metal complexes, by quantum chemistry methods
 - structure-activity relationships (QSAR) of biologically active compounds.
- 

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Department of Chemical and Process Engineering

Advanced Liquid Chromatography Techniques Laboratory

The following services are possible at the Laboratory of Advanced Liquid Chromatography Techniques of the Rzeszów University of Technology:

1. Training in the theory and practice of liquid chromatography:

- theoretical basis of liquid chromatography,
- operation and use of a chromatograph,
- advanced chromatographic techniques, such as: ion-exclusion chromatography (IEC), supercritical chromatography (SFC), chromatography of hydrophilic interactions (HILIC), etc,
- computer assistance in the selection and optimization of chromatographic systems and transferring the scale of this operation from analytical to preparative conditions.

2. execution of research assignments:

- in the field of separation of mixtures of:
 - roteins with the use of:
 - preparative chromatography,
 - single step extraction in an aqueous two-phase ATP system,
 - multistage extraction,
 - ultrafiltration.
 - enantiomers by preparative chromatography,
 - organic compounds by crystallisation,
 - chromatographic analyses of samples performed according to the methodology provided by the Employer.

Laboratory of bulk materials testing

In the Department of Chemical and Process Engineering of the Rzeszów University of Technology it is possible to carry out the following tests/determinations:

1. Determination of particle size distribution in the deposit by laser diffractometry and sieve analysis methods;
2. Determination of deposit parameters of bulk materials and granulates, i.e.: angle of natural discharge, bulk density, compressibility, cohesiveness (cohesion), blade angle, homogeneity, dispersibility, etc;
3. Determination of mechanical and rheological properties of dry and humidified bulk materials (e.g. flow limit, flow index, angle of internal friction, compressive strength, tensile strength, angle of friction with the surface of steel and other construction materials);
4. The study of processing properties of bulk materials in granulation and dry coating processes;

Moreover, the following:

1. Measurements of inter-surface adhesion forces of particles of granulated materials;
2. Measurements of strength properties of granules (static strength, dynamic strength - abrasion);
3. Computer modelling and simulation of processes involving granulated materials using the discrete

element method (DEM).

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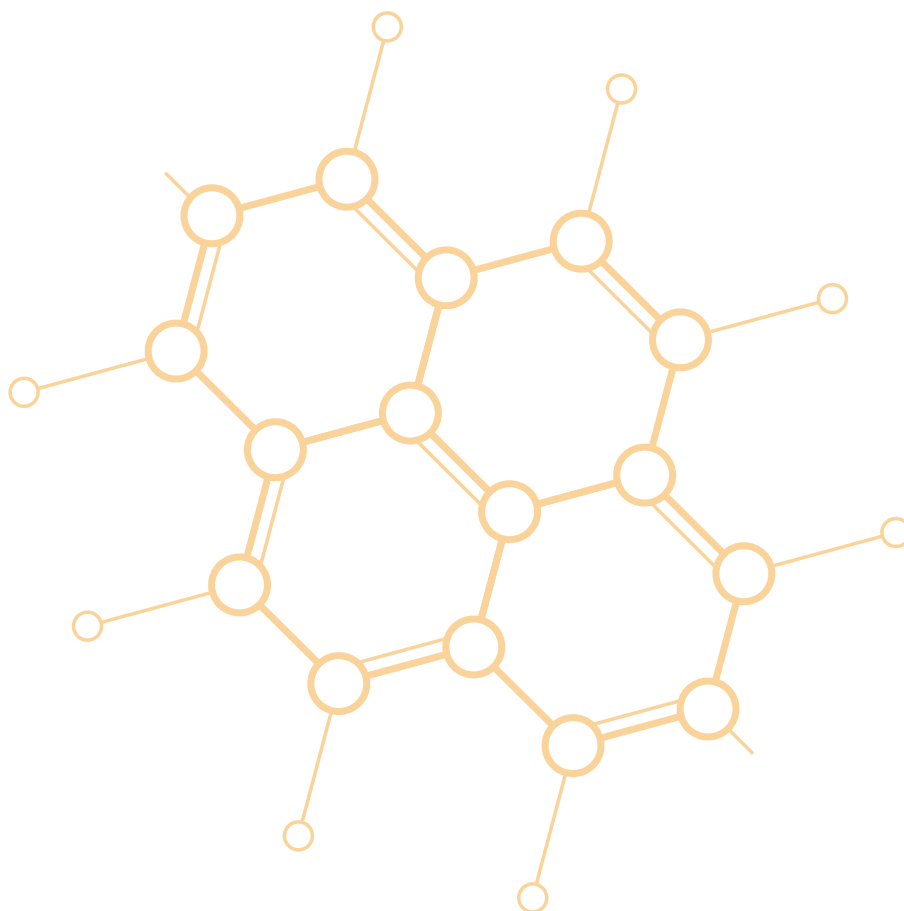
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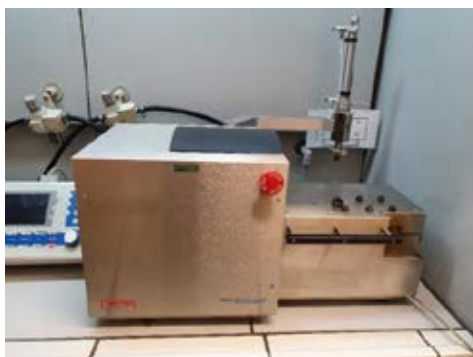
e-mail: ichda@prz.edu.pl



Department of Polymer Composites and Laboratory of Composite and Polymer Materials for Aeronautics

Research directions:

- modification of nanofillers (mainly layered aluminosilicates),
- research into the preparation of polymer nanocomposites and investigation of their functional properties,
- design and manufacture of fibre and sandwich composites used in aerospace, transport and defence industries,
- flame retardancy of polymeric materials,
- design and manufacture of composite materials used in rapid prototyping techniques,
- simulation of processing of polymeric materials,
- numerical analysis of polymer composite properties using CAD/CAE software,.
- recycling of polymeric materials and their composites,
- investigation of rheological properties of polymeric materials,
- modification of polymer composites to improve electrical conductivity and resistance to lightning effects,
- modification and testing of elastomeric materials,
- preparation and testing of thermoplastic nanocomposites used in packaging, including multi-layer materials,
- research on the influence of ageing conditions on the functional properties of polymeric materials,.
- determination of material properties and 3D deformations using the digital image correlation method.



Name of the equipment

Twin-screw microextruder with co-rotating or counter-rotating screws, by Haake Thermo Scientific

Application

Preparation of micro quantities (7 g weighted amount) of polymer blends with different additives



Name of the equipment

Microinjection machine with moulds for paddle (2x50 mm) or barrel (2x50 mm), by Haake Thermo Scientific

Application

Injection of microsamples for strength tests in the form of paddles and beams



Name of the equipment

Co-rotating twin-screw extruder (18 mm) with two gravimetric feeders and granulation line, TSK 18M, Coperion

Application

Preparation of polymer blends with various additives; capacity 1-7 kg/h

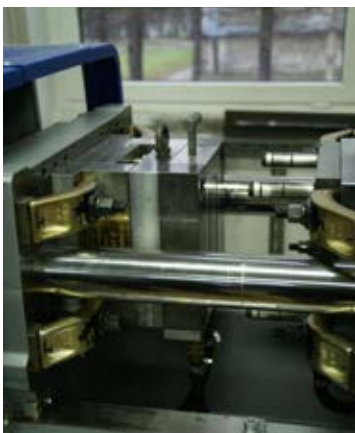


Name of the equipment

Co-rotating twin-screw extruder (25 mm) with volumetric dosing and fibre production line, by Zamak -Mercator

Application

Preparation of polymer blends and testing the fibre production process



Name of the equipment

Battenfeld 350 PLUS injection moulding machine with moulds for paddles (large), beams and plates (1x100 mm) as well as gas injection unit and quick mould heating and cooling unit by Variotherm

Application

Injection of specimens for strength and performance testing in the form of beams, paddles and plates



Name of the equipment

Hydraulic press for thermo- and duroplastics with a pressure of up to 30 T, by Carver

Application

Production of specimens for strength and performance tests and service properties using the extrusion pressing method



Name of the equipment

W32 worm extruder, Metalachem Gliwice together with accessories for extruding blown film and: profiles and fibres, as well as with a rheological head, IIMPiB Toruń

Application

Production of sleeve films and profiles by means of extrusion

Name of the equipment

SMART Rheo 7040 capillary rheometer, CEAST-Instron

Application

Testing of thermoplastic melt flow curves and pVT curves



Name of the equipment

Rheostress 6000 rotary-oscillation rheometer (Haake Thermo Scientific),

Application

Testing rheological characteristics of polymers (thermoplastics and chemosets)



Name of the equipment

Rotor oscillating rheometer (volcometer) MDR 3000, by MonTech

Application

Testing the crosslinking characteristics of rubber compounds



Name of the equipment

Vicat and HDT heat resistance tester, CEAST-Instron

Application

Evaluation of the heat resistance of polymeric materials



Name of the equipment

Rockwell hardness tester, by Zwick -Roell

Application

Determination of sample hardness



Name of the equipment

Hammers for impact testing (Charpy and Izode) with force recording over time

Application

Determination of impact strength (bend or tensile) of polymeric and composite samples



Name of the equipment

Strength testing machine, by Instron with sampling cells: 30 kN, 1 kN and 100 N, coupled to Aramis optical strain measurement system, by GOM

Application

Determination of tensile, flexural and compressive strengths of polymer and composite samples



Name of the equipment
Line for obtaining prepregs

Application
Preparation of fibrous composites in the form of prepregs



Name of the equipment
Line for the production of applied composites and nanocomposites

Application
Preparation of polymeric materials in the form of a filier for use in rapid prototyping technology



Name of the equipment
Atomic force microscope AFM (including STM function)

Application
Examination of the morphology of composite samples using different techniques, e.g.: tapping, QNM



Name of the equipment
Xenotest ageing chamber, by ATLAS

Application
Testing the resistance of polymeric materials to accelerated ageing



Name of the equipment
FFT apparatus for the determination of the oxygen index (LOI) of polymers

Application
Flame resistance of polymeric materials



Name of the equipment

Flammability test chamber for polymers with the UL94 method, by FFT

Application

Tests on fire resistance of polymeric materials using the V and HB method



Name of the equipment

Cone microcalorimeter, by FFT

Application

Testing the influence of combustion conditions of samples made of polymeric materials on the effect of flame retardancy



Name of the equipment

Spectrometer for the colour determination of polymer products, by Konica Minolta

Application

Determination of colour of samples using the Clm scale



Name of the equipment

Hardness testers with exchangeable heads for measuring the hardness of elastomers and thermoplastics by different methods

Application

Measuring set for measuring hardness of elastomers and plastics



Name of the equipment

Twin roll machine with controlled heating, fizzing and rotation speed

Application

Preparation of elastomer blends and other polymeric materials in paste form



Name of the equipment

High-speed and ultrasonic homogenisers

Application

Preparation of low molecular weight polymeric resin matrix compositions



Name of the equipment

Rotational rheometer with plate-to-plate measuring systems

Application

Determination of gelation time and activation energy of tested compositions

Contact details:

al. Powstańców Warszawy 6

The Head:

Mariusz Oleksy, Prof. DSc, PhD, Eng.

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e-mail: molek@prz.edu.pl

Department of Polymers and Biopolymers

- examination of the surface properties of materials:
 - static and dynamic (backward and forward) contact angles,
 - surface free energy,
 - hydrophobicity and oleophobicity,
 - surface tension
 - adhesion performance,
 - determination of surface roughness coefficients Ra and Rz.
- testing the properties of coatings made of paints and varnishes:
 - testing the properties of coatings made of paints and varnishes:
 - gloss in geometry 20/60/85 according to EN ISO 2813 and film thickness on ferro- and non-ferro-magnetic substrates according to EN ISO 2808,
 - flexibility by bending on a cylindrical pin acc. to EN ISO 1519,
 - adhesion by the notch grid method according to EN ISO 2409,
 - hardness using the Persoz and König pendulum according to EN ISO 1522,
 - hardness by the pencil method according to PN-ISO15184:2001,
 - impact resistance of the coatings by the falling weight method according to EN ISO 6272:1994,
 - abrasion resistance using the free falling weight method according to PN-76/C-81516,
 - press formability according to EN ISO 1520,
 - scratch resistance using Clemens tester according to PN-EN ISO 1518.
- Preparation of powder paints and varnishes and application of powder coatings:
 - pre-grinding
 - extrusion
 - basic grinding
 - sieving
 - substrate application.
- thermal decomposition testing of materials - thermogravimetric analysis by (TGA) of:
 - thermal stability of materials,
 - resistance of materials to oxidation
 - composition of polymer composite systems
 - the influence of the atmosphere on the reactivity or corrosion of polymer materials
 - the content of moisture and volatile components in polymer materials.

In addition:

- tests on chemical modification of polyurethanes.

Contact details :

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The Head:

Piotr Król, Prof. DSc, PhD, Eng.

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Department of Industrial and Materials Chemistry

- chemical analysis of liquid and solid samples, including polymeric materials and composites, environmental samples and chiral components using infrared spectroscopy (ATR techniques, KBr tablet method, FTIR microscopy), high-performance liquid chromatography (HPLC) and gas chromatography (GC, GC Headspace, GCMS);
- identification of trace contaminants in food products, food supplements and pharmaceuticals;
- preparation of organic compounds and polymeric substances as well as catalysts for organic reactions;
- synthesis and chemical modification of reactive polymer resins for catalytic and sorption applications;
- opinions and expertise for external stakeholders interested in implementing of new technologies for the production and processing of chemical products;
- expert opinions for the police, prosecution, courts;
- resins for the recovery of precious metals from liquid samples;
- basic works for pharmaceutical industry, medical sciences, food industry and cosmetics;
- analysis of thermal and thermomechanical properties of various types of materials using DSC (Differential Scanning Calorimetry) and DMA (Dynamic Mechanical Analysis) methods;
- determination of phase transition temperature, i.e. melting, crystallization, glass transition, polymorphic transition;
- determination of the degree of crystallinity of crystalline polymers;
- use of characteristic thermal effects for given substances for their identification and determination of their content;
- analysis of reactivity of solid and liquid materials;
- testing the kinetics and mechanism of reactions;
- testing the influence of various auxiliary materials on the properties of polymeric materials;
- determining the compatibility of various components;
- chemical analysis of polymeric material samples using gel permeation chromatography: determination of average molecular masses and molecular mass distribution;
- analysis of nanoparticle size in emulsions, dispersions and solutions by dynamic light scattering method and determination of zeta potential in solutions and emulsions.

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The Head:

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Department of Inorganic and Analytical Chemistry

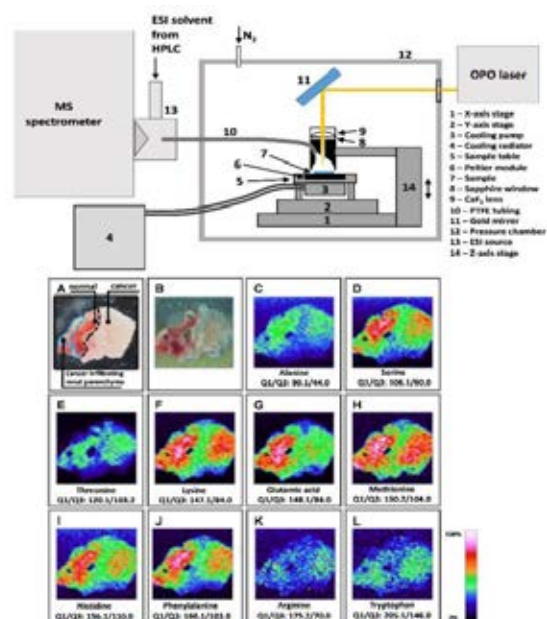
a) LARES MS - a unique mass spectrometry imaging set

Features:

- for synthetic and biological objects.
- sample cooling/freezing system.
- various pulsed lasers available.
- 3000, 1535, 1064 and 355 nm lasers.
- ablation chamber under atmospheric pressure.
- compatible with most MS instruments
- compatible with SRM / MRM / MS / MS2 modes.
- up to 20 mJ per pulse –
- ablation of all materials including metals.
- depth profiling of chemical compounds.

Application examples:

- human tissue analysis.
- biomarker research.
- analysis of photographs, textiles, etc.
- analysis of food samples.

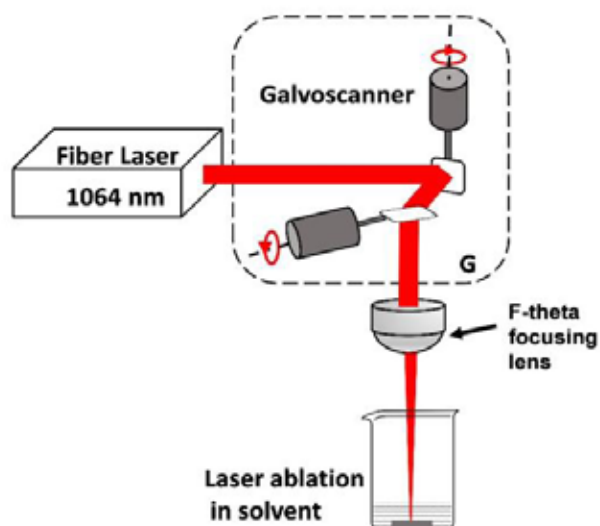


b) MASS SPECTROMETRY LABORATORY

Available equipment:

The MALDI ToF (Matrix Assisted Laser Desorption/Ionization Time of Flight) mass spectrometer allows the analysis of peptides, proteins, oligonucleotides, synthetic polymers, and most solid organic compounds of low and medium molecular weight. Measurements in linear, reflectron and fragmentation modes are possible. Measurement range up to approx. 300 000 Da. Measurements are performed using the following methods:

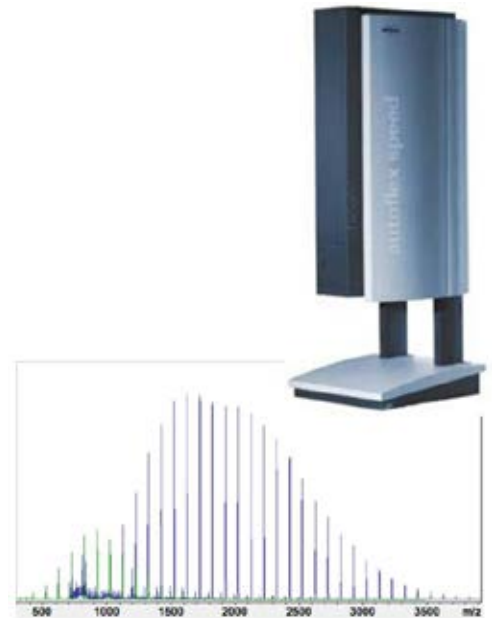
- MALDI ToF and ToF/ToF LIFT
- auNPET
- auNPET+ traditional matrix
- 109AgNPET
- MS imaging.



AB SCIEX QTRAP 5500 – QQQ / triple quad with ion trap with Agilent 1200 series HPLC. Perfect for fast MRM screening and quantitation of chemicals, forensics, biomarkers, pesticides, toxins, pharmaceutical drugs etc

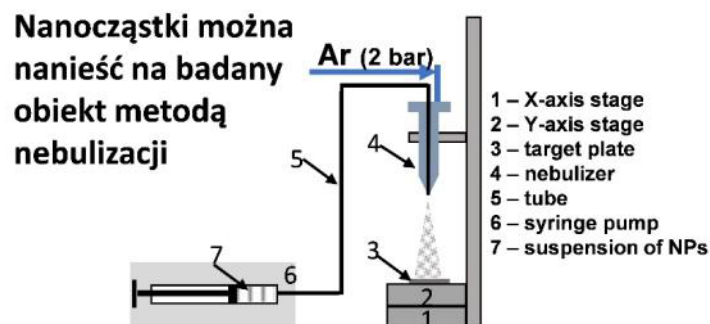
c) LASER SYNTHESIS OF NANOPARTICLES IN LIQUID

- almost all materials can be processed into nanoparticles.
- highest possible purity of nanoparticle suspensions.
- no stabilising agents.
- nanoparticle purity confirmed by LDI MS laser mass spectrometry.



d) The CELL CULTURE LABORATORY performs viability and metabolism tests on normal (BJ lineage dermal fibroblasts), neoplastic (SCC-15 tongue squamous cell carcinoma, U118-MG grade IV glioma) and immortalised (HaCaT lineage keratinocytes) human cells:

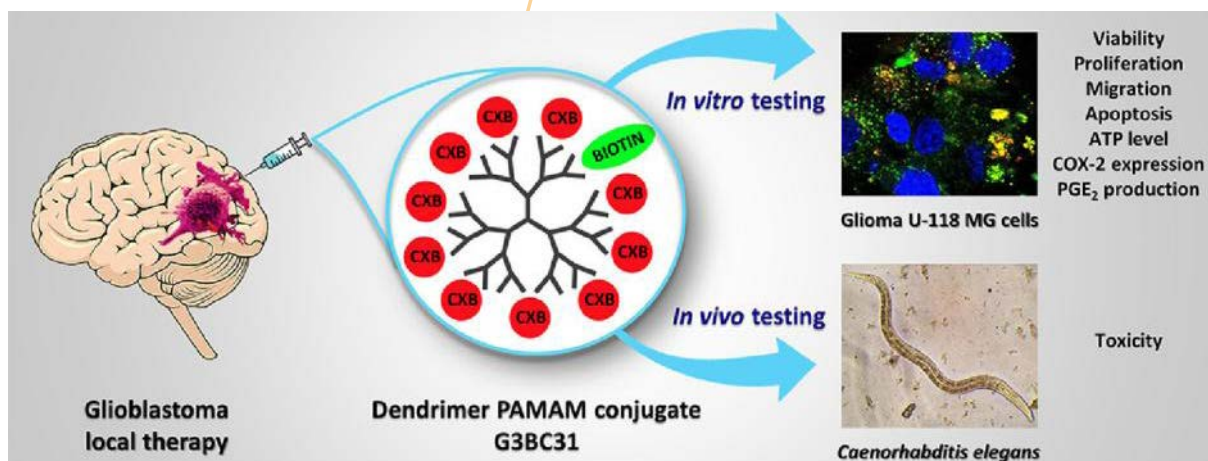
- toxicology tests: XTT, with neutral red;
- proliferation, migration and cell adhesion assays;
- morphological assessment of cells under phase-contrast microscopy;
- evaluation of changes in cellular energy levels;
- definition of cell death pathways (apoptosis, necrosis, autophagy);
- examination of changes in protein expression (ELISA);
- testing the activity of nanoparticles, drugs, biologically active substances;
- testing the biocompatibility of materials (e.g. polyurethanes).



e) Other test options

- spectrophotometric tests (UVVis);
- analysis of natural water - physico-chemical testing of drinking water
- analytical determination of elemental composition (quantitative) of various types of inorganic materials: environmental, chemical industry products, food, industrial waste and in water by ICP-AES;
- development of synthesis conditions and synthesis of new complex compounds of metal ions with bioligands from the flavonoids group (quercetin, morin, chrysin, 3-hydroxyflavone) and their sulfonic derivatives with potential application in pharmaceutical industry and medicine.

- analysis of the composition, structure and antioxidant activity of the isolated compounds;
- application of multiphase systems for separation of mixtures: extraction and equilibrium of metal ions, acids and amino acids in binary and three-phase specific and micellar systems, basic and application tests (heavy and trace metals, phenoxyacids and plant protection products, aromatic amino acids and pharmaceutical preparations);
- analytical control of industrial solid waste and its impact on the environment: industrial ashes, sludge, solid precipitation, soil and its pollution - sequential extraction, chemical composition, environmental mobility of metals, biodegradation of toxic metal forms
- speciation analysis of metals in industrial and environmental materials optimization of analytical conditions
- product quality assessment: influence of sample ageing on analytical result;
- bioflavonoids and their sulfonic derivatives: complexes with metal ions, synthesis, properties, analytical and medical applications
- metal ion complexes with selected flavonoids: synthesis, laser and semiconductor properties, analytical and medical applications.



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Department of Organic Chemistry

Services offered by the Department of Organic Chemistry of the Rzeszów University of Technology

- elemental analysis of chemical compounds (C, H, N, S) using Vario EL III elemental analyser. Determination of percentage content in a sample of carbon, hydrogen, nitrogen, sulphur. Possibility of analysis of polymers, soils, plants, resins, etc,
- performing infrared spectra with the ALPHA FR-IR Bruker spectrometer using the following techniques: ATR (possibility of examining solids and liquids in a wide pH range) and transmission in KBr pastille (examination of solids, e.g. polymers),
- gas chromatography using an Agilent 7890 A gas chromatograph with FID and MS detector,
- determination of oxygen index and heat conductivity coefficient of plastics, .
- determination of basic properties of organic compounds, .
- preparation of polyurethane foams, hydroxyalkylation reactions - synthesis with oxiranes, alkylene carbonates and formaldehyde, synthesis and application of oligoetherols with azacyclic rings, .
- development of conditions for the synthesis of polycondensation and polyaddition polymers, synthesis and modification of multifunctional azacyclic compounds, .
- studies of kinetics and mechanisms of organic reactions, .
- interpretation of: results of kinetic studies in homogeneous systems, IR H-NMR, C-NMR spectra,
- didactics of organic chemistry for teachers and students of secondary schools, including in the field of topics covered in chemistry competitions.

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The Head:

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Laboratory of Spectrometry

- 1D and 2D NMR experiments in solutions
- recording of NMR spectra using such measurement techniques as:

- DEPT
- COSY
- HSQC
- HMBC
- HETCOR
- NOESY
- ROESY
- and other

Contact details :

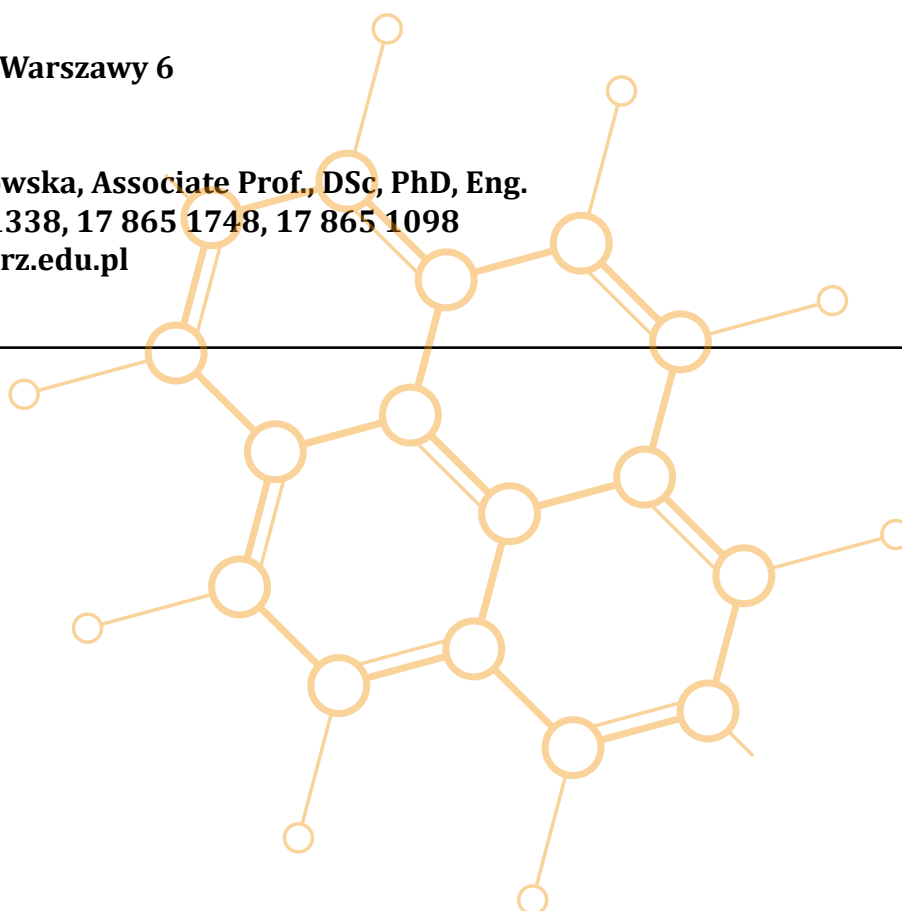
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The Head:

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Research laboratory for bulk materials

The Research Laboratory of Powder Materials operates within the structures of the Department of Chemical and Process Engineering of the Rzeszów University of Technology.

The staff of the laboratory consists of research and teaching staff from the university, who have many years of experience in research on powder materials.

The laboratory carries out tests related to the properties and processing of powder materials:

- determination of particle size distribution in the deposit by laser diffractometry and sieve analysis methods,.
- determination of deposit parameters of bulk materials and granulates, i.e.: natural discharge angle, bulk density, compressibility, cohesiveness (cohesion), blade angle, homogeneity, dispersibility, etc,
- determination of mechanical and rheological properties of dry and wet bulk materials (e.g. flow limit, index and flow function, angle of internal friction, compressive strength, tensile strength, angle of friction with steel surface)
- investigations of processing properties of bulk materials in granulation and dry coating processes,.
- measurement of forces of inter-surface adhesion of particles of granulated materials,.
- computer modelling and simulation of processes involving granulated materials.

Contact details :

Research Laboratory for Bulk Materials

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Contact person:

Marcin Chutkowski, PhD, Eng.

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Computer Laboratory

- designing technological systems,
- technological design,
- controlling chemical processes,
- optimisation in process engineering,
- biomolecular modelling
- bioprocess engineering
- engineering graphics,
- computer aided processing of plastics,
- electrochemical methods in organic reaction tests.

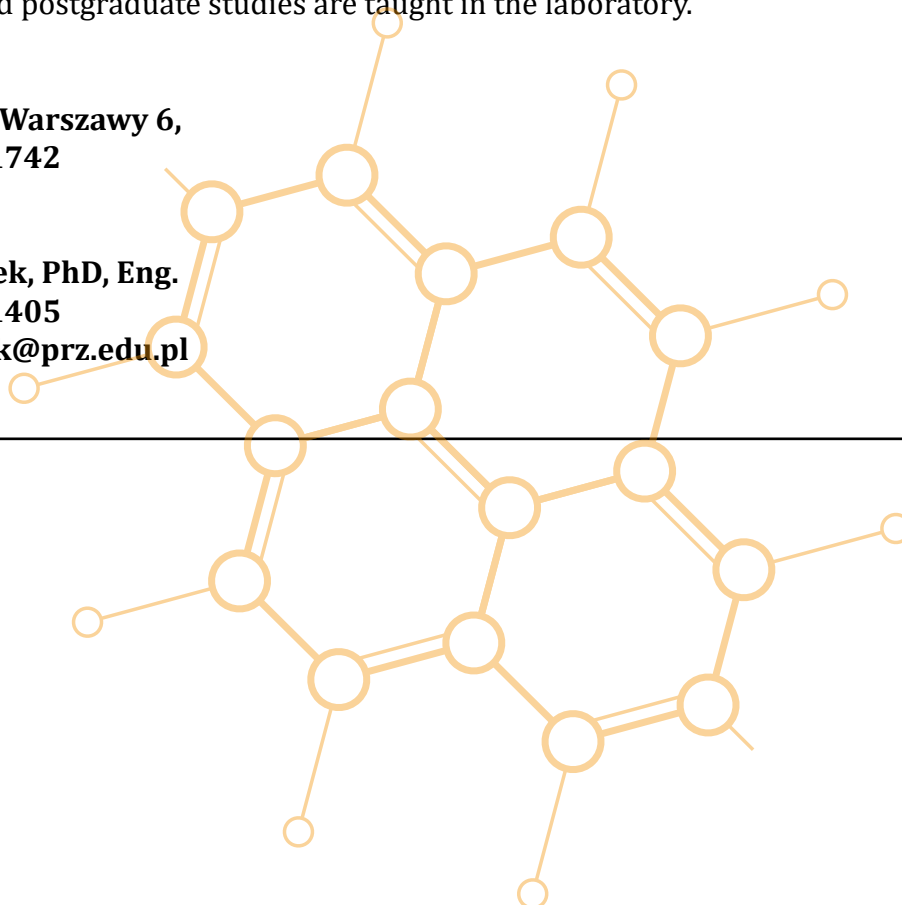
Many courses and postgraduate studies are taught in the laboratory.

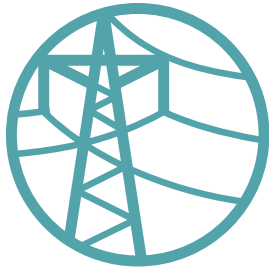
Contact details :

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The Head:

Grzegorz Iwaszek, PhD, Eng.
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**THE FACULTY OF
ELECTRICAL
AND COMPUTER ENGINEERING**
RZESZOW UNIVERSITY OF TECHNOLOGY

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www.wei.prz.edu.pl/

Faculty of Electrical and Computer Engineering

Department of Electrodynamics and Electrical Machine Systems

1. Complex laboratory tests covering the determination of operational and static characteristics of electric motors on stations equipped with:

- a. Magtrol 4PB2.7K dynamometer with $T_N=2.4$ Nm and maximum speed of 10 000 rpm,
- b. Magtrol 2PB43 dynamometer with $T_N=10$ Nm and maximum speed of 4000 rpm,
- c. Magtrol 4WB2.7K eddy current dynamometer with $T_N=0.6$ Nm and 50 000 rpm maximum speed,
- d. Magtrol 2WB43 eddy current dynamometer with $T_N=3$ Nm and max speed of 50 000 rpm,
- e. a set of Magtrol torque meters (1 Nm, 2 Nm, 5 Nm, 10 Nm, 20 Nm) compatible with the dynamometers and eddy current dynamometers to reduce the measurement uncertainty relevant to the determination of the driveline efficiency,
- f. Yokogawa WT1600 or WT1800 six channel power analysers equipped with motor modules and the possibility to connect external current probes,
- g. simultaneous acquisition of all data from 4 power analysers.

2. Complex laboratory tests including electrical measurements (currents, voltages, active, reactive and apparent power, power factor) with the use of Yokogawa WT1600, WT1800 type power analysers with the possibility of simultaneous multi channel data acquisition from four analysers

3. Complex laboratory tests requiring the use of:

- a. High-current direct current power supplies (up to 440A, 30VDC),
- b. DC voltage supplies (up to 600 VDC, 17A),
- c. Single phase AC/DC power supplies with adjustable output voltage frequency up to 5 kHz and sine, trapezoid, rectangular, sawtooth type signals.

4. Complex laboratory tests of electrical parameters (voltage, current, frequency, temperature) with the use of Yokogawa DL850 oscilloscope recorders (possibility of making long-term measurements, e.g. 30 days)

5. Laboratory tests of devices (batteries, power supplies, UPS) requiring programmable loads of DC type with constant-voltage (CV), constant-current (CC), constant-resistance (CR) or constant-power (CP) loads (maximum 600 A in low-voltage mode or 800 V in high-voltage mode). Tests with dynamic load change are also possible.

6. Winding insulation resistance tests with the Sonel MIC-5050 meter and winding resistance tests of e.g. electric machines.

7. Diagnostic tests of electric machines bearings.

8. Laser alignment of drive units.

9. Expertise in the field of diagnostic tests of electrical machines.

10. Cooperation in the development of:

- a. new designs of classical electrical machines,
 - b. brushless solutions:
 - i. switching reluctance machines,
 - ii. machines with permanent magnets.
11. Cooperation in the development of propulsion systems based on:
- a. classic electric motors,
 - b. brushless permanent magnet motors,

c. switching reluctance motors.

12. Cooperation in the development of propulsion systems with increased reliability based on :

a. solutions with one power electronics and one motor;

b. redundant solutions:

i. with duplicate power electronics and one motor;

ii. with duplicate power electronics and motors.

- possibilities of testing machines (up to 4.5 kW and speeds up to 4500 rpm) operating in motor and generator mode and testing these machines in dynamic states.

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The Head:

Mariusz Korkosz, Associate prof., DSc, PhD, Eng.

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Department of Electrical and Computer Engineering Fundamentals

- designing earthing systems and lightning protection systems;
- comprehensive calculations and testing of static and dynamic properties of earthing systems;
- simulation calculations in the field of lightning protection and the impact of electromagnetic disturbances (EMC);
- design of electrical power systems;
- comprehensive calculations of transients in electrical and power systems;
- simulation studies on lightning and overvoltage protection as well as coordination of insulation;
- measurements of the earth resistance and earth impedance of power poles and extensive facilities;
- expert opinions on lightning protection in accordance with PN-EN 62305 series standards;
- measurement and recording of electric and magnetic field strength in the range from 16.7 Hz to 400 kHz occurring in the vicinity of power lines, electrical and electronic equipment;
- advanced time and spectral analysis of non-stationary signals;
- testing of resistance of objects to current impulses:
 - type 1 - oscillatory waveform with current amplitude up to 100 kA,
 - Type 2 - aperiodic 8/20 μ s with peak current up to 60 kA,
 - type 3 - 10/350 μ s aperiodic waveform with peak current up to 3 kA.
- testing of resistance of objects to long-lasting lightning current surge with duration from 10 ms to 100 ms and current amplitude \sim 100 A;
- testing of resistance of objects to 1.2/50 voltage surge with amplitude up to 300 kV;
- generation of voltage waveforms of any shape within the range up to \pm 60 V (maximum current up to 10 A, bandwidth 0-150 kHz)
- generation of sinusoidal waveforms with modulation capability (bandwidth from 9 kHz to 1 GHz);
- conducted disturbance test according to PN-EN 61000-4-6 (150 kHz-230 MHz band);
- tests of avionics immunity to induced single current and voltage surges; testing according to the standard DO-160 (section 22); voltage range: 125 V-3200 V (maximum current 6,4 kA); surge waveforms: W1, W4, W5A, W5B;
- tests of avionics immunity to induced multiple current and voltage surges; tests according to the standard DO-160 (section 22); voltage range: 75 V-1600 V (maximum current 2 kA); surge waveforms: W1, W4, W5A, W5B;
- tests of avionics immunity to induced burst waveforms; tests according to the standard DO-160 (section 22); voltage range: 40 V- 3200 V; surge waveforms: W2, W3;
- high-speed video recording and analysis of high-speed phenomena (up to 7000 frames per second at 1024 x 1024 pixel resolution, up to 1 million frames per second at lower resolution, recording in colour);
- testing of the impact of electrical/electronic equipment on the power network;
- testing of converter systems with regard to the quality of the generated voltage;

- numerical determination of electromagnetic field in linear and non-linear systems with 2D/RS and 3D geometries, and with different boundary conditions using FEM and BEM methods; single and parametric simulations in the time domain and in the low frequency range for various current and voltage excitations, including rotary currents and skin effect, calculation of inductances, capacitances, forces, fluxes, field energies, etc.; areas of application include design and simulation of electrical equipment and electronic components;
- numerical and symbolic analyses of linear and non-linear electric and electronic circuits,
- single and parametric simulations (e.g. in terms of sensitivity, transmittance) in the time domain, frequency domain, for various current and voltage excitations, at zero or non-zero initial conditions; areas of application include design and simulation of electrical systems and devices and electronic components;
- expertise in the design, measurement and simulation of wind turbines, electrical generators for wind turbines, power electronic converter systems and their control;
- expertise in the field of Smart Grids and IT networks and their protection and safety;
- design of information systems, selection of integration solutions and assistance in pre-implementation and implementation processes;
- expert opinions and design of power electronic systems, including: non-controlled multi-pulse converters, converters with reduced content of higher harmonics in network currents, multilevel converters, converters with more than three phases;
- expert opinions on transformers and autotransformers, including multiphase ones;
- expertise and design of induction machines, synchronous machines with permanent magnets and reluctance machines, multiphase machines with three and more phases;
- structural and circuit-field calculations for electrical machines, including: electromagnetic, strength and thermal analyses;
- design of control algorithms for electrical machines and converters, e.g. optimal control, rapid control using characteristics, DTC, FOC, etc;
- expert opinions and synthesis of electric drive, inhibiting elastic vibrations caused by non-rigidity of elements of the motion transfer mechanism;
- expert opinions on stochastic systems;
- synthesis of stochastic automatic control systems based on risk functions.

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Department of Power Electronics and Power Engineering

- design and testing of control and automation systems for electrical power converters based on FPGAs of various families
- design and expertise in the field of power electronic systems, especially industrial ones and their control systems;
- analysis of applications of new elements in thyristor and transistor converters;
- implementation of new solutions for converters in industrial heating devices and equipment with electric drives;
- electric power management, including: industrial electric power auditing, selection of appropriate electric power tariffs, analysis and evaluation of electric power investment efficiency, analyses of financial profitability of undertakings improving energy use and reducing energy consumption, analyses of environmental effects of energy efficiency undertakings and installation of renewable electric power sources
- evaluation of electricity quality, technical solutions for improving electricity quality, expert work on electricity quality;
- optimization of power engineering issues, selection of optimal energy supply systems for facilities;
- testing power electronic converters intended for supplying power systems of low power (up to 10 kW);
- testing power electronic converters cooperating with renewable energy sources of power up to 10 kW (photovoltaic and wind power plants);
- testing the impact of power electronic converters on the power supply line up to 100 kW;
- testing low-power drive systems up to 3 kW;
- expert opinions: power electronic systems, converters, power supplies up to 100 kW;
- technical condition assessment of drive systems;
- surge protection testing of electrical and electronic equipment, based on their digital models;
- conducting trainings for designers and installers of lightning protection and surge protection devices, taking into account the requirements, recommendations of current standards and regulations;

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Department of Computer Science and Automation

- designing domain-specific languages;
- designing microprocessor systems
- analysis, design, evaluation of real-time systems;
- programming of real-time systems for vxWorks and vxWorks 653 operating systems platform
- preparation of "envelope" of real-time operating system (division into real-time processes together with software of RS232, CAN, ETHERNET/TCP/IP communication interfaces) for distributed control applications
- simulation and analysis of real-time systems using Petri nets;
- consultancy on the tuning of industrial PID controllers;
- consultancy on distributed control systems;
- development and testing of industrial communication protocols;
- integration of CPDev software with firmware of the designed PLCs, commissioning of PN-EN IEC 61131-3 standard programs;
- counselling in the area of configuration of industrial logical PLCs;
- designing digital SoC systems and implementation of specialised microprocessors based on FPGA systems. Designing prototype multilayer printed circuits with FPGAs. Soldering and desoldering of components in BGA, LGA and other enclosures;
- Consultancy and design work in the field of technical and medical diagnostics;
- modelling and simulation analysis of discrete systems, in particular production systems, using the CPN Tools package (time-coloured Petri nets);
- design and programming of industrial control systems based on Beckhoff hardware infrastructure and TwinCAT 2 / TwinCAT 3 software;
- integration of industrial automation systems with IT systems;
- designing advanced industrial control systems with the use of the TwinCAT 3 package and MATLAB/Simulink (including Stateflow);
- advice on rapid prototyping technologies with the use of MATLAB/Simulink/Stateflow software;
- selection and tuning of controllers for mechatronic and industrial systems;
- counselling in the scope of designing, implementation and deployment of production monitoring and control systems - designed for production enterprises;
- designing intelligent systems for monitoring, diagnosing and supervision of production processes and devices;
- design and implementation of automated production systems;
- development and implementation of solutions in the field of automatic knowledge acquisition from data originating from production systems (ERP, MES) with the use of data mining techniques and computational intelligence methods;
- optimization methods
- designing optimisation algorithms, in particular related to task scheduling;

- computational intelligence, decision support systems;
- consulting on applications of image processing and recognition;
- expert opinions on uninterruptible power supply systems (UPS) and selection of solutions;
- audits of IT systems for local government units, health care units and cooperative banks by an expert of IR SEP;
- preparation of expert opinions on "Digital machines and systems".- including advice on the development of ToR and adjudication of tenders for the purchase of computer hardware, as well as system and application software by an expert of IR SEP;
- advice on information systems for cooperative banks;
- calculations using a cluster environment (High Performance Linux) based on the MPI library;
- code compilation and running coarse-grained calculations in multi-node architecture;
- consultancy on control systems and industrial computer networks, system security
- counselling on design and implementation of database information systems for enterprises;
- modelling of distributed information systems by formal methods, simulation, estimation of effectiveness of existing and designed systems;
- modelling and effectiveness testing of distributed industrial automation systems;
- designing and launching efficient and cost-effective analytical systems. Solutions based on modern methods and techniques for analysing large data sets, while providing the possibility of using tools available on a non-commercial basis. The offer is addressed mainly to small and medium-sized enterprises and public administration as well as health care units:
- consulting in the field of implementation of IT management systems;
- research and design work in the field of traffic control systems
- research and design work in the field of medical robotics;
- analysis and modelling of complex dynamic systems;.
- research and design work in the field of computer graphics and animation.

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The Head:

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Department of Metrology and Diagnostic Systems

- calibration of electronic frequency/time meters (up to 400 MHz).
- calibration of electronic generators (up to 400 MHz).
- calibration of analogue and digital electronic multimeters.
- calibration of electronic measurement channels with analogue information carrier.
- calibration of electronic measurement channels with a pulse information carrier.
- calibration of electronic measurement channels with analogue-pulse information carrier.
- multi-channel acquisition of measurement data in the form of independent voltage, current and resistance signals as a function of time.
- determination of voltage and current characteristics of electronic components and systems at temperatures up to 100°C.
- measurement of resistance (range up to 200 TΩ) and surface resistivity (range up to 100 PΩ) and volume resistivity (range up to 1 EΩ-cm) of dielectric materials at voltages up to 1000 V.
- calibration of analogue and digital pressure gauges (range up to 16 bar) and pressure transducers with current and voltage outputs.
- calibration of temperature transducers with resistance sensors and thermoelectric sensors with current and voltage outputs.
- measurement and simulation of resistance and voltage signals corresponding to standard values for resistance and thermoelectric sensors.
- calibration of voltage, resistance, temperature and pressure transducers in industrial facilities and production plants.
- temperature measurements of objects with a thermovision camera.
- measurements and analysis of acoustic signals.
- testing, error determination and expertise of electricity meters.
- measurement of liquid flows in pipelines by means of an ultrasonic method.
- testing of devices with random operating algorithm (game machines, simulators, etc.).
- determination of current and angle errors of current transformers, construction of measurement systems for testing of transformers.
- research work in the field of new techniques in processing selected biomedical signals.
- research work in the field of measurement processing of stochastic signals.
- estimation of numerical accuracy measures of measuring systems using Monte Carlo simulation.
- conducting courses and training in the calibration of measurement equipment and the estimation of measurement result uncertainty.

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The Head:
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Department of Electronics Fundamentals

- noise of electronic materials and components, in particular low frequency noise in the 1 MHz - 1 MHz frequency range;
- electrical conductivity of electronic materials and devices - experimental investigations and modelling;
- modelling of electrical transport and properties of optoelectronic nanoelectronic devices at quantum level, in particular quantum cascade lasers, second-order superlattices, superlattice detectors;
- electrical transport and noise studies of electronic materials and components at low temperature and in a magnetic field;
- synthesis of measurement control software;
- investigations of fluctuation phenomena in materials and electronic components and systems in the temperature range 77 - 650 K;
- design and construction of test stations in this field.

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The Head:

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Department of Electronic and Telecommunications Systems

- complex research in the field of radio frequency identification systems for RFID objects:
 - determination of parameters of tags and RFID systems operating in the HF and UHF bands,
 - designing, prototyping and testing system devices
 - operation tests of various types of single and multiple RFID systems in static and dynamic states,
 - expert work in solving RFID technology problems,
 - planning automatic object identification processes,
 - customised training courses,
 - expert services in market analysis and development and implementation of RFID systems in typical and atypical areas of their application.
- research in the field of antenna technology:
 - design and prototyping of antennas realized with different technologies,
 - field and laboratory measurements of antenna parameters and their operation in various radio-communication systems
 - fast spherical measurements of radio equipment parameters (near-field/spherical) in a reflection-free chamber in the band from 400 MHz to 18 GHz.
- determination of the combined electrical permeability of thin dielectric materials in the band from 1 MHz to 6 GHz;
- research in electronic and telecommunication systems:
 - support in solving practical problems encountered in various electronic and telecommunication systems,
 - research in radio communication processes,
 - research on radio paths in electronic systems,
 - evaluation of projects concerning the construction and extension of mobile telephony base stations,
 - substantial assistance in solving investment problems related to the installation of mobile telephony base stations, field measurements of electromagnetic field parameters of radio-communication systems of various applications.
- assistance in adapting electrical and electronic devices and systems to the requirements of the EMC directive and related standards;
- expertise of devices and systems in identifying potential sources of electromagnetic disturbances;
- testing electrical and electronic devices and systems in compliance with the requirements specified in the general and specific EMC standards in terms of
 - measurement of the disturbance level at the power supply terminals of tested equipment in the frequency range of 9 kHz - 200 MHz, in circuits with load capacity up to 63 A/phase, using the LISN equipment and considering the civil, military and aviation standards requirements;
 - measurement of disturbance level at the terminals of communication interfaces in the frequen-

cy range from 9 kHz to 30 MHz with consideration of the civil standards requirements;

- measurement of harmonic emissions of supply currents as well as fluctuations and flickering of light for single- and three-phase receivers, according to the requirements of PN/EN 61000-3-2, -3-3, -3-11, 3-12 standards, among others;

- measurement of the susceptibility of electrical and electronic equipment to a uniform radiated electromagnetic field with a strength of up to 10 V/m with any modulation in the system - antenna distance from 1 m to 3 m, respectively in the frequency range from 80 MHz to 6 GHz, in an anechoic chamber in accordance with the requirements of PN/EN 61000-4-3 civil standard;

- measurements of resistance of single-phase and three-phase devices to standardized types of electromagnetic disturbances, in compliance with the requirements of PN/EN 61000-4-2, -3, 4, -5, -6, -7, -8, -9, -10, -11, -14, -16, -27, -28, 29 standards in most of the tests in circuits with load capacity up to 63 A

- design work in the field of synthesis of electronic circuits and systems using standard PCB substrates (including multilayers) and flexible substrates, low- and high-temperature co-fired ceramics (LTCC, HTCC), using jet printing (Ink-Jet) and vacuum vapour deposition (PVD) techniques
- simulations and measurements of static and dynamic temperature fields in electronic systems;
- tests of resistance of electronic devices and systems to environmental exposure.

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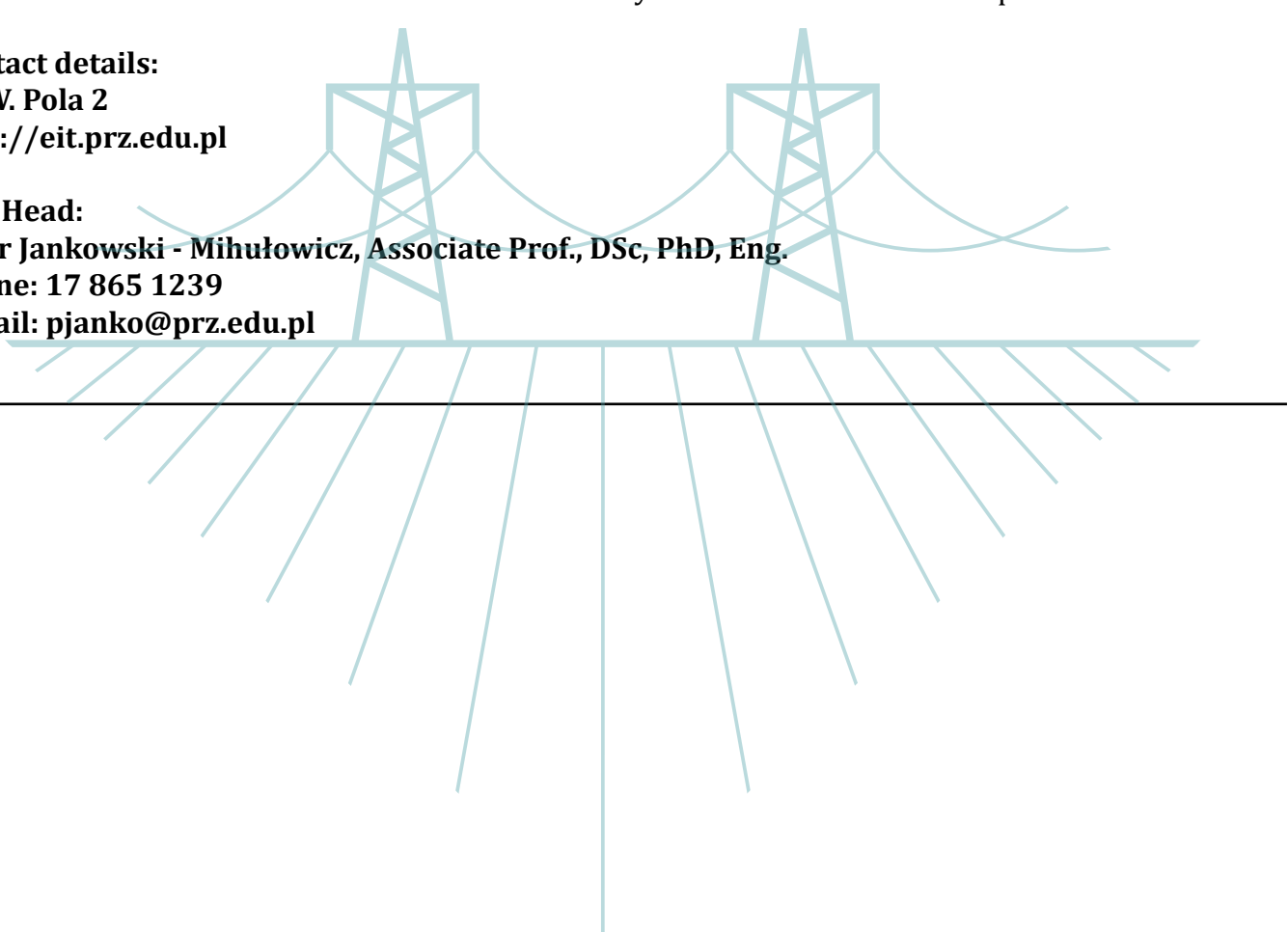
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Department of Complex Systems

- evaluation of effectiveness and resistance to attacks of modern operating systems and database systems. Security policy design;
- selecting of solutions ensuring information security in ICT systems, increasing effectiveness and security of operating and database systems (security audit of database configuration, security of operating system configuration, penetration tests);
- tests of flows, performance, fit and stability of complex systems using non-extensive methods of non-equilibrium thermodynamics;
- performance analysis of network devices and their available functionality;
- design of high-performance converged networks, both wired and wireless. Development and analysis of computer network models;
- researching phenomena occurring in computer networks, e.g. in the context of optimal use of limited resources;
- training in design, management and security of computer networks, based on open standards as well as selected commercial solutions;
- description of the ICT infrastructure development concepts:
 - określenie oraz klasyfikacja potrzeb,
 - identification and classification of needs,
 - defining stages of implementation,
 - analysis of available solutions,
 - analysis of available project management methodologies,
 - benefit analysis,
 - risk analysis.
- analysis of opportunities for development of areas with high level of digital exclusion:
 - identification of causes of current state,
 - analysis of available solutions,
 - definition of an implementation plan,
 - analysis of effects of implemented changes.
- works in the field of: routing, switching, queuing, counteracting congestion, etc;
- authorised training in network equipment management;
- testing the compatibility and interoperability of heterogeneous network environments, including:
 - testing the ability of a given device to interoperate according to network standards,
 - testing its compatibility with other indicated network devices within the scope of specified protocols and functionalities,
 - evaluation of the quality and scope of implementation of a given protocol in the indicated device.

- cybercesurity

Moreover

- within the framework of the devices owned and the devices supplied by the client, a test environment is built, consisting of actual network devices, on the basis of which tests are carried out for specific services that the client plans to implement. The report prepared on the basis of such evaluation contains conclusions allowing for assessment of the usefulness of the proposed solution before its purchase and implementation (proof of concept tests).

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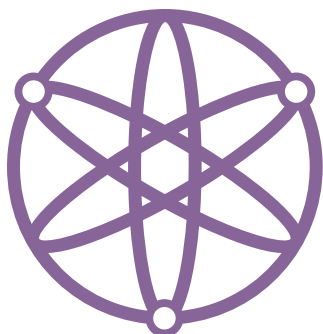
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**THE FACULTY OF
MATHEMATICS
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RZESZOW UNIVERSITY OF TECHNOLOGY

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Faculty of Mathematics and Applied Physics

Biophysical Laboratory

- rheological studies on biomaterials (thermoreology, viscoelasticity, biomaterials, "banking")
- rheological studies on nanomaterials (electro-rheology, nanosuspensions, nanofluids);
- optical research (microscopy, light polarisation, thermo-optical properties).

Laboratory of Nonlinear Dielectrics

- measurements of electrical parameters of pyroelectric materials (charge measurement, compensation method);
- measurements of small charge and current signals (charge measurement, compensation method).

Laboratory of Dielectric Spectroscopy

- measurements of electrical parameters (electrical measurements, liquid crystals).

Laboratory of Laser Techniques

- optical length measurements (contactless length measurement);
- investigation of thermo-mechanical properties of solids (modulus, damping, creep, stress relaxation)
- determination of thermal conductivity of liquids (thermal conductivity coefficient, infrared laser, fibre optic temperature sensor).

Laboratory of fibre optic sensors

- temperature measurement with an interferometric fibre optic sensor (temperature measurement, electromagnetic interference)
- stress measurement with an interferometric fibre optic sensor;
- measurement of refractive index and fluid pressure with an interferometric fibre optic sensor (refractive index, pressure).

Faculty of Mathematics and Applied Physics of the Rzeszów University of Technology

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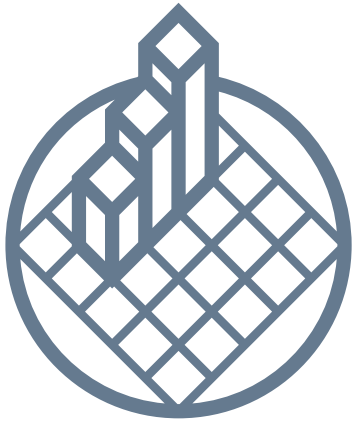
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THE FACULTY OF MANAGEMENT

RZESZÓW UNIVERSITY OF TECHNOLOGY

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Faculty of Management

The offer of the Faculty of Management is a specialised collection of training, consulting, implementation services and management support expertise. Each of the products has been appropriately selected and matched to market standards. Thanks to this, the knowledge and skills possessed by the professionals from our department may prove extremely useful, or even crucial, in the further development of your business.

The offer includes, among others:

- consulting:
 - political consulting,
 - consulting in the field of system, forms and means of administration, consulting in the field of forms of conducting business activity,
 - consulting in the field of tasks and competences of the administration,
 - consultancy and training in the field of internal security
 - consulting and training in the field of economic agreements
 - consultancy in the field of merchandising
 - implementation of information systems and information technology.
- expert reports:
 - labour market analysis,
 - currency market analysis,
 - marketing research,
 - social research:
 - community research,
 - political research,
 - labour market research
 - media market research,
 - public and general security research,
 - opinion polls.
 - H&S risk level surveys,
 - customer satisfaction and loyalty surveys,
 - opinions on innovation of solutions and technologies,
 - demand forecasting,
 - database implementation support.
- training:
 - health and safety training,
 - training in the field of communication,
 - training in the field of trade fair marketing
 - training in the field of negotiation and mediation

- training in the field of personal development
- self-presentation training
- customer service training
- training in sales techniques
- implementations:
 - process optimisation,
 - preparation of local and regional development strategies,
 - company restructuring,
 - commodity quality assessment of animal source food,
 - implementing activity-based budgeting
 - implementing management control
 - implementing company ethics programmes
 - implementing agribusiness development strategies
 - implementing ISO/EMAS systems
 - implementing motivation schemes
 - implementing quality and environmental management systems
 - implementing project management systems
 - implementating a promotion strategy for local government units
 - implementating a sales service system
 - support for implementation of business management systems.

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Dean:

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Department of Management Systems and Logistics

CONSULTING

Consulting in the field of:

- logistic management of transport and forwarding companies,
- recording of drivers' working time, as well as interpretation and implementation of legal acts in force in this area.

TRAINING

Training in forwarding activity

The training in forwarding activity covers the knowledge of, among others: terminology, activities, tasks and functions of a forwarder; conventions, contracts and commercial formulas; forwarding and transport documents, forwarding organizations, management of a forwarding company, drivers' working time, access to the market of forwarding services.

Training in transport operations

Training in transport operations includes knowledge of, among others: transport documents, transport organisation, transport company management, drivers' working time in the light of current legislation, access to the market of transport services, organisation of cargo transport (including the transport of dangerous goods (ADR) and perishable foodstuffs (ATP)). The training also includes a complex management of a transport company and an in-depth analysis of its functioning on the competitive market, using a modern platform of industry business simulations.

Training in professional development of employees

The training covers the subject of managing professional development of employees, taking into account the individual (employee) and organisational perspective. An important element of the training is the knowledge concerning various forms of supporting employee development, such as: consulting, coaching, mentoring, action learning.

Issues related to the use of coaching and/or mentoring in organisations may constitute a separate training offer.

Training in stress management

The training concerns issues of recognition of causes, symptoms and consequences of stress. In addition, it covers the topic of mental resilience (ability to cope effectively with challenges, stress, pressure) and resilience (ability to cope with adversity, difficult situations, failures), i.e. important competences in a dynamically changing reality.

Laboratory of Logistics and Integrated Management Systems

In the laboratory it is possible to carry out research concerning supporting and optimising processes of:

- transparent integration of all channels of sales and distribution of goods within the framework of implementing an integrated omnichannel strategy
- merchandising and flows within a distributed goods sales and distribution network with the use of modern IT systems and dedicated devices, with particular consideration given to innovative ordering algorithms and Big Data
- Production logistics with the use of modern IT systems and dedicated equipment;
- logistics of high storage warehouses including support for online ordering functions, using modern information systems and dedicated equipment;

- comprehensive management of a transport company and in-depth analysis of its functioning in a competitive market using a modern platform of industry business simulations.

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Division of Computer Science in Management

Services offered by the Centre for Forensic Analyses of the
Ignacy Łukasiewicz Rzeszów University of Technology

The Centre for Forensic Analyses of the Rzeszów University of Technology is an institution specialising in preparing expert opinions for the needs of litigation bodies, legal institutions and individuals. The Centre offers a wide range of expert services in the field of engineering and material technology, physics, chemistry and computer science. Opinions are prepared by academic staff of Rzeszów University of Technology, as well as by external experts having at their disposal modern and unique research facilities of the university.

RESEARCH OFFER

CHEMICAL ANALYSIS

- preliminary composition identification of polymeric material samples.
- spectral analysis of the composition of organic and polymeric material samples.
- determination of volatile organic compounds (VOCs) in paints and other organic products.
- analysis of beeswaxes for adulteration of these products with foreign hydrocarbons.
- determination of ethyl alcohol concentration in alcohol products and detection of organic impurities.
- identification of volatile organic compounds by GC-MS method.
- comparative analysis of fuels by gas chromatography
- determination of ash content in plastics (according to PN-EN ISO 3451-1)
- determination of molecular weight and its distribution in polymers and plastics as well as determination of the content of plasticizers, antioxidants, preservatives or dyes in plastics by GPC gel chromatography
- study of particle size and distribution in emulsion and dispersion systems using dynamic light scattering. Study of emulsion and dispersion stability (determination of zeta potential).
- characterisation of thermal properties, identification of different types of materials and determination of the presence of impurities and other components.
- detection of polycyclic aromatic hydrocarbons and quantitative analysis of these compounds.
- determination of chemical composition of foodstuffs
- detection of controlled substances and quantitative analysis of these compounds
- detection of toxins, poisons, etc.
- detection of key compounds for identification of type and origin of test sample
- analysis of the composition of liquids and solids for the content of desired chemical compounds
- analysis of the structure of chemical compounds that are in the composition of test samples.

IT ANALYSIS

- data recovery from digital data carriers.
- data recovery from electronic communication devices (mobile phones, social networks, e-mail).
- examination of computer hardware and peripheral devices.
- determining the purpose of computing devices and the contents of their memory.
- determining and analysing the content of digital data carriers.
- examination of GSM phones - reading and copying data from memory and SIM cards.
- securing data from computers and disks.
- making copies of data carriers.

MECHANOSCOPIC ANALYSIS

- identification of tools on the basis of traces left.
- carrying out tests of locks and other locking tools.
- determining ways and techniques of damaging objects.
- identification of counterfeit coins and jewellery.
- identification of numberers, markers, sealers.
- identification of vehicles involved in a criminal event (on the basis of secured traces and examination of the scene of the event).
- investigating the authenticity of vehicle identification markings.
- disclosure of removed marks and numbers present on different substrates.

TECHNICAL ANALYSIS OF DOCUMENTS

- determining the authenticity of documents.
- identification of document production techniques.
- group and individual identification of devices.
- examination of destroyed documents.
- analysis of forms of document forgery.
- identifying materials used to produce documents.
- revealing traces of indented writing, erased and blurred records.
- identifying stamps, seals, stamps, stamps, facsimiles and their prints.
- identification of persons based on comparative handwriting and signature tests.
- assessment of the uniformity of handwriting, determining the number of handwriters.
- verification of the authenticity of signatures and identification of their makers.

TRASEOLOGICAL ANALYSIS

- identification studies of footwear on the basis of indented, superficial traces, etc.
- inference of a person on the basis of footwear traces.

- identification of persons on the basis of the manner of gait.
- examination of shoes on the basis of pairs juxtaposition.
- identification studies on the basis of tyre tracks.
- studies on footprints.
- identification of persons on the basis of the interaction of foot and shoe.

ROAD ACCIDENT ANALYSIS

- post-accident examination of components and sub-assemblies of motor vehicles.
- testing clothing of accident participants.
- testing light source receivers and luminaires.
- testing motor vehicle tyres.
- determining the occupied position of passengers and drivers of vehicles at the time of accident and post-accident displacement.
- examination of luminance and range of visibility in connection with road accidents.
- conducting trial and expert experiments.
- participation in visual inspections at road accident scenes.

ANALYSIS OF AUDIOVISUAL RECORDS

- taking photographs for the purpose of recognition of persons and things based on visual records.
- creating reference materials from visual records.
- analysis of digital records and analogue photographs in terms of alteration and falsification of recorded images.
- Identification of objects on the basis of visual records.
- securing records from recorders.
- collection of comparative material from audiovisual research and research of other specialties on the basis
visual recordings.
- digitalisation of analogue images.
- reconstruction of shapes and sizes and mutual position of objects in the field from photographs based on photogrammetry.
- analysis of visual records in terms of selection of material, determination of the time of image registration, place of registration, equipment used for registration, speed of moving objects.
- masking fragments of visual records.
- improving the quality of visual records.
- forensic technical support of procedural activities.
- providing consultations to representatives of law enforcement agencies

ANALYSIS OF LIGHTNING PROTECTION, OVERVOLTAGE AND ELECTRIC SHOCK PROTECTION

- assessment of the principles of design and implementation of lightning protection devices (LPS),

effective at the level of acceptable risk of loss of: human life, public service, cultural heritage and material value.

- assessment of the correctness of the calculation of safe separation distances, application of the principles of potential equalization and determination of the shielding zones of complex systems of vertical and horizontal short-circuits.

- assessment of the resistance of elements of technical infrastructure to the effects of lightning current and electromagnetic lightning pulses (LEMP).

- assessment of the correctness of the design and implementation of earthing as an anti-shock protection device.

ANALYSIS OF COMPLIANCE WITH LEGAL REGULATIONS CONCERNING WELFARE AND TRANSPORT OF FARM ANIMALS

- assessment of animal housing and transport conditions, equipment and maintenance of specialised means of animal transport.

- analysis of compliance with animal welfare standards at the production and marketing level.

Services or research for industry that can be commercialised (know-how) in the Division of Computer Science in Management.

COMMODITY AND QUALITY ASSESSMENT OF ANIMAL SOURCE FOOD

The offer has remained unchanged since 2015 and is as follows.

Expertise in commodity quality assessment of food of animal origin is addressed to meat processing companies, commodity farms and public and private institutions of the agribusiness sector environment.

Expertise concern the quality of meat products and include sensory, physicochemical and ozone characteristics of the meat product. Advice is also provided on drawing up strategies, development plans and hygiene safety of enterprises in the agri-food sector.

The Laboratory of Instrumental Food Quality Analysis has the ability to conduct research in the field of:

- assessing the chemical composition of meat and meat products (water, protein, fat, sodium chloride, ash),

- assessing the physico-chemical properties of meat, ozone treatment of meat - to extend shelf life,

- assessing the degree of bleeding and blood residues in the muscles of slaughter animals,

- assessing the chemical composition and physico-chemical properties of milk,

Research offer for industry

The range of research services offered by the Department of Computer Science in Management of the Faculty of Management:

Offer addressed to business and individual entities operating in the food production and processing sector:

- assessment of chemical composition of food products, including determination of water, protein, fat, ash, sodium chloride content, colorimetric and refractometric analysis of food products, texture parameters,

- evaluation of the degree of bleeding and blood residues in the muscles of slaughter animals,
- evaluation of the chemical composition and physico-chemical properties of milk and its products, including determination of fat, protein, lactose, SNF (non-fat solids), minerals
- testing and evaluating the suitability of methods for extending the shelf life of food products using ozone therapy
- expert opinions on compliance with animal welfare conditions during transport.

Offer addressed to companies and public institutions connected with agribusiness and rural areas:

- advice on development strategies for farms and agri-food enterprises. It includes: drawing up business plans, assessment of the economic efficiency of planned investments, making agricultural calculations, analysis of the effects of changes and optimisation of agricultural production on farms,
- consulting in the area of obtaining public funds supporting the process of development and modernisation of agriculture, as well as agri-food enterprises.

Offer dedicated to plastics production companies, machinery industry, packaging sector:

- thermo-shrinkability testing of plastic films,
- precise measurements of layer thickness of various industrial materials with the use of ultrasound method,
- measurement of surface gloss of varnish, galvanic coatings, paints, plastics, leather, printing,
- strength tests (load 50kN),
- measurement of material hardness (hardness scales: Rockwell, Brinell, Vickers).

Offer dedicated to enterprises and local government units working in a hybrid or remote system:

- consulting and implementation of software for distributed teamwork. The service uses leading Microsoft technologies in the areas of project support and communication, including Ms Teams, Ms SharePoint, Power Automate and T&C documents.

Offer addressed to the logistics sector:

- selection and implementation in the TLS sector of integrated IT systems and advanced information technologies such as ERP, HRM, WMS.

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Department of Technical Systems Engineering

Within the Department it is possible to carry out research and development work in the following areas:

- statistical analysis of the flow of goods and passengers;
- development of mathematical models for the flow of goods
- mapping of transport processes
- optimisation of internal and external transport tasks and networks;
- making forecasts and determining demand for particular logistic services, such as: storage, forwarding, transport;
- using and analysing the profitability of applying modern storage and transport technologies;
- sustainable and intelligent transport of people and goods;
- development of an automated freight transport network using automatically guided transport vehicles.

The Department of Technical Systems Engineering includes:

LABORATORY OF MODERN TECHNOLOGY IN LOGISTICS

The laboratory allows scientific research and training of future qualified personnel in the field of:

- automatic product and area identification systems (bar codes, RFID, magnetic tracks, OCR, image and voice recognition);
- integrated IT systems supporting supply chain management such as MRP, MRP II, ERP;
- simulation of economic processes related to the transport of goods, storage and forwarding with the help of the Enterrpice Dymanamics and DOSIMIS packages;
- registration of selected parameters of the storage process and warehouse space protection;
- cargo identification;
- optimization of loading processes and arrangement of goods;
- vehicle location and analysis of its basic operating parameters;
- use of 2D and 3D laser measuring techniques in production and storage processes
- automation of warehouse processes including robotisation and automated transport processes;
- study of the mobility, operating parameters and accuracy of the navigation process in automated transport vehicles;
- selection and configuration of navigation systems in automatically guided transport vehicles.

The Head of the Division:

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Department of Marketing

1. Training in the field of:

- managerial competences (e.g. team management, relationship building, leadership, motivation, communication, delegation, conflict resolution, managerial coaching),
- psychology of management
- self-presentation and public speaking
- professional customer service (including customer service in social media)
- cooperation and communication in a team,
- building relationships with the environment,
- management and communication in crisis situations,
- anti-mobbing for employees and management,
- merchandising
- appearing at trade fairs as an exhibitor,
- conducting marketing research,
- modern tools of promotion,
- designing a marketing strategy,
- ways of using social media in company management,
- research and creation of customer satisfaction and loyalty,
- e-commerce,
- launching new products on the market,
- brand building (own brand, artist's brand),
- building an employee development path (in terms of binding an employee to the company, motivation, etc.)
- setting up and running a business, acquiring external funds, building a development strategy for ventures,
- implementation of marketing activities by local governments,
- social responsibility of organizations,
- recognizing symptoms of professional burnout and ways to deal with it,
- managing oneself in stress - ways of dealing with stress in the cognitive and somatic aspect
- developing emotional and social intelligence - for managers who aspire to become leaders,
- building a culture of commitment in the team.

2. Consultancy in the field of:

- communication strategy with the environment (including social media),
- communication in crisis situations,
- development and implementation of anti-bullying procedures in companies and institutions,
- modern marketing management of a company,
- implementation of marketing research,

- the importance and use of modern tools of promotion
- designing a marketing strategy,
- areas and ways of using social media in company management
- identifying levels of customer satisfaction and loyalty
- creating customer satisfaction and loyalty
- specificity of contemporary consumer behaviour
- importance and application of experience marketing
- merchandising,
- exporting products to foreign markets
- clustering,
- brand management,
- conducting business activity, acquiring external funds, building development strategies for ventures,
- planning and implementing a company's appearance at a trade fair as an exhibitor.

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Division of Enterprise Management

offers services in the field of:

1. Research and development studies of new ventures.
2. analysis, assessment and evaluation of innovativeness of enterprises and the level of technology innovation
3. Preparation of applications for funding of business activities
4. Preparation of business plans
5. Building teams.
6. Organisational consulting in the field of building organisational structures and human resources management.
7. Carrying out research - surveys, interviews, focus groups - among company employees in the field of human resources management from the point of view of job involvement, job satisfaction or employee entrepreneurship.
8. Preparation of expert opinions on enterprise management problems, in particular in the fields carried out by employees of the Department of Scientific Research, such as:
 - strategic company management, strategic forecasting (strategic foresight);
 - research into strategic and sectoral conditions of enterprise and organisation development in the context of a closed loop economy;
 - green management in the enterprise, environmental management;
 - research and design of different aspects of environmental strategy and policy and sustainable development, for example environmental management systems, environmental labels and declarations, waste management, water management;
 - environmental analysis and business models;
 - business innovation;
 - systemic, integrated, organic, networking, multi-level and sustainable approaches;
 - digitalisation of processes;
 - human resources management in an enterprise - leadership, managerial decisions, organisational pathologies, management ethics;
 - enterprise in the context of corporate social responsibility;
 - entrepreneurial (creative) behaviour of enterprise employees;
 - cooperation in the implementation of traditional and modern methods and tools of quality management in enterprises.

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The Head:
Krystyna Kmiotek, Associate Prof., DSc, PhD.
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Department of Enterprise, Management and Eco-innovation

The Department's staff are national and international experts in innovation, especially eco-innovation and regional development strategies, as well as business acceleration (micro, small and medium enterprises, startups and corporations).

The Department and its staff provide services in the field of:

- developing opinions on innovativeness for projects co-financed by the European Union and governmental funds (due to the fact that the employees are national experts on innovativeness, each opinion consists of two components: a technical opinion on a given product or service and an opinion on innovativeness of the product or service, which significantly increases the probability of obtaining positive results of applying for co-financing);
- developing roadmaps for digital transformation of enterprises (especially production enterprises), both for the purposes of competitions for co-financing and for internal purposes;
- preparation of regional development strategies, including in particular smart specialisation strategies and voivodship development strategies;
- internal and external audits according to ISO standards: 9001 (Quality Management), 14001 (Environmental Management), 45001 (Occupational Health and Safety), 22301 (Business Continuity), 31000 (Risk Management), 50001 (Energy Management), 22000 (Food Safety), 26000 (Social Responsibility), 13053 (Lean Six Sigma)
- strategic analysis of companies, cities, regions and countries;
- consulting in the field of environmental management, in particular food safety, energy security and information flow;
- business acceleration consultancy using IT management tools, including growth hacking tools;
- consultancy on design thinking, business models and management of innovative projects using lean startup methods (Running Lean, Lean Customer Development, Lean Analytics, Lean Product, Business Model Canvas, De-sign Sprint and others);
- consultancy on preparing applications for public funding (EU and governmental);
- consultancy on acquiring external financing for innovative activities, startups (venture capital funds, business angels, crowdfunding);
- consultancy on financial analysis of companies, regions and countries, with particular emphasis on financial analysis of technology companies;
- consultancy in the field of cluster development strategies, cluster management, support of cluster initiatives and aspects related to the analysis of the effectiveness of cluster activities;
- broadly understood consulting and support in the field of business development, strategic analyses and corrective actions in crisis situations.

The Department's staff offer training on the topics mentioned above.

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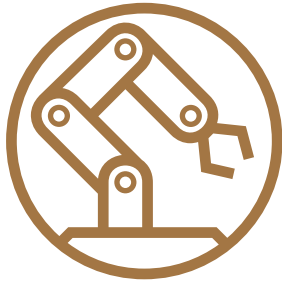
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"Arcus" building room 403

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The Head of the Department:
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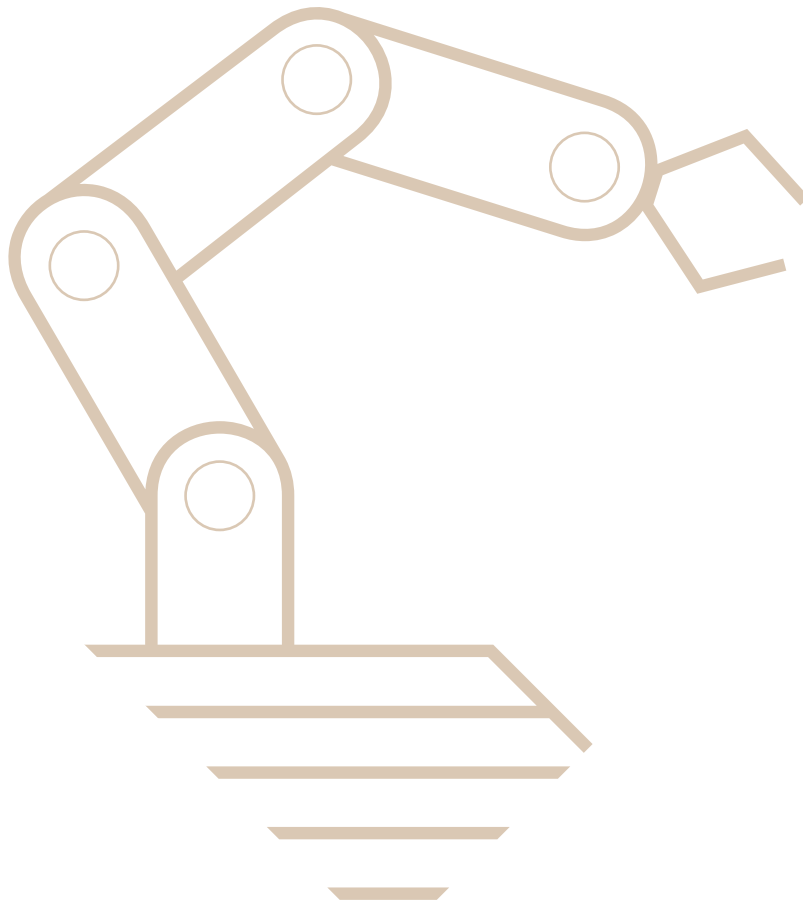




**THE FACULTY OF
MECHANICS
AND TECHNOLOGY**
RZESZOW UNIVERSITY OF TECHNOLOGY

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Science and Research Laboratory

LASER LABORATORY

TRU LASER ROBOT 5020 by TRUMPF



Robotised station for welding, cutting, surfacing with wire and metal powders. Lifting capacity of 2-axis positioner 410 kg. Power output: 4 kW.

SISMA SWA 300 micro-laser



Precision welding and/or surfacing of injection moulds, stamping dies, punches, models, model plates, metal moulds in high-alloy steels, aluminium alloys, bronze and titanium, using laser light. Laser beam power: 300 W, laser spot diameter: 0.6÷2.0 mm.

COMPUTERISATION AND ROBOTISATION OF INDUSTRIAL PROCESSES

- implementation of advanced software for signal processing and measurement data analysis.
- implementation of advanced software for IT security (cryptography, security protocols).
- development of IT tools to support business management in the field of: MES - Manufacturing Execution System, CMMS.
- computerised Maintenance Management Systems.
- statistical modelling of reliability and maintenance issues together with implementation of appropriate IT tools.
- development of customised large-scale database solutions.
- developing solutions for wireless sensor networks (architecture, security protocols, data acquisition, data processing and presentation).
- methods of artificial intelligence in industrial applications.
- development and simulation of robotic production lines.



Fanuc LR Mate 200iD/4.



Kuka KR3 Agilus.



HANWHA
HCR-5.



HUMERO – A robotic arm constructed by the students from the Faculty of Mechanics and Technology.

NON-DESTRUCTIVE RESEARCH LABORATORY

Phoenix v|tome|x m tomograph by GE



The high-resolution X-ray tomograph has two X-ray tubes of: 500 W with 300 kV and 15 W with 180 kV. High resolution - (voxel size 3 μ m). 3D X-ray imaging, coordinate measurement, wall thickness analysis, porosity and inclusion analysis.

FERITSCOPE® FMP30 by Fischer



Ferrite content measurements in Duplex steels, in welds of austenitic steels (pipes, sheets, tanks), ordinary steels clad with chromium alloyed austenitic steels (heaters, tanks).

DUALSCOPE FMP150 by Fischer



Measurement of coatings with thicknesses of several micrometres on non-ferrous metal, iron or steel substrates.

KARL DEUTSCH RMG 4015



Testing crack depths in materials using the electrical potential method.

Mobile temperature recording station - 16-channel - temperature recorder with signal optoisolation



Measurement and recording of temperature field distribution in welded joints, machining processes, heat treatment, casting moulds. Temperature measurement range: -200°C to $+850^{\circ}\text{C}$.

TROTEC TP10 pyrometer



Non-contact temperature measurement based on the analysis of thermal radiation emitted by the tested bodies. Temperature range -50°C \div $+1\ 850^{\circ}\text{C}$.

DESTRUCTIVE RESEARCH LABORATORY

Strength research laboratory

Zwick/Roell Z100 strength machine



Static tensile and compression tests on flat and round specimens. Shear test. Fracture toughness and fatigue crack propagation speed tests. Bending test.

Laboratory for hardness measurements
NR3 DR Stationary hardness tester



Load capacity: 10÷187.5 kg. Measuring scale: HRA, HRB, HRC, HRD, HRF, HRG, HRH, HRE, HRK, HB30, HB5, HV100.

Handy Esatest X portable hardness tester for hard-to-reach places



For use in hard-to-reach areas such as grooves or gear recesses. Load capacity: 1÷10 kg. Measuring scale: HV, HRA, HRB, HRC, HB5, HB10, HB30, HRF.

Dynatest SCX hardness tester



Portable hardness tester with a unique head for dynamic high pressure application anywhere, such as on the face, side or underside. Diamond or ball indenter. Load capacity: 100 kg. Measuring scale: HRC, HB30.

SHORA hardness tester



SHORE A and D digital hardness tester, designed for measuring the hardness of plastics and rubber.

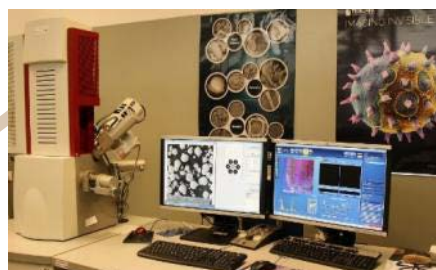
POLDI HAMMER hardness tester



Dynamic method for measuring the hardness of metals, a variation of the Brinell method. Measurement of hardness of large-size components, materials at elevated temperatures.

MICROSCOPE LABORATORY

TESCAN MIRA3 scanning electron microscope with EDS attachment



High-resolution imaging of objects in the micrometre and nanometre range. Microanalysis of chemical composition (EDS X-ray spectroscopy attachment). Maximum magnification up to 1 000 000x. Large depth of field. Morphological analysis - assessment of shape, size and distribution.

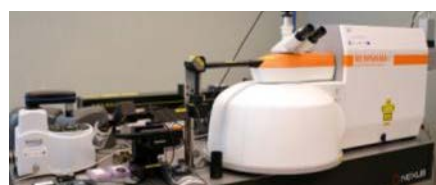
CHEMICAL ANALYSIS LABORATORY

FT-Raman spectrometer with integrated FT-IR attachment by Thermo Fischer Scientific



Chemical analysis of liquid and solid, hard, brittle, environmental samples, including polymer materials and polymer composites, solutions, emulsions, pastes, thin films, oils and greases, films, textiles, fibres, crystals and soft powders, using infrared spectroscopy (ATR techniques, tablet in KBr, FTIR microscopy).

Raman confocal microscope inVia™ by Renishaw



Raman spectroscopic studies of macroscopic and microscopic samples down to resolutions below μm : molecular composition testing of samples, 2D and 3D maps, depth profile, identification and structural studies of most mineral and inorganic samples, e.g. geological samples, semiconductors.

XPS K-Alpha photoelectron spectrometer by Thermo Fisher Scientific



Qualitative analysis of chemical composition, determination of chemical composition of surfaces and study of changes occurring on them, analysis of impurities. Possibility of analysis of samples such as: metal alloys, soil, minerals, various thin layers and coatings, archaeological objects, filter condensates, vessels, chemical reagents, foodstuffs, etc.

Ultrapyc 1200e automatic gas pycnometer by Quantachrome



Measurement of true volume and density of powders, foams and bulk materials. Appropriate expansion (reference) volume is automatically chosen by microprocessor according to sample cell selected. Reports include density and volume results with statistics.

Empyrean X-ray diffractometer by PANalytical



Analysis of powders, polycrystalline as well as poorly crystalline or amorphous materials, nanomaterials and thin films:

- qualitative and quantitative phase identification,
- determination of crystallinity (degree of structural ordering of the solid)
- identification of crystallographic structure
- determination of average size and size distribution of crystallites,
- monitoring (in situ) of changes occurring in a material sample under other than ambient temperature, pressure and / or gas phase composition,
- epitaxy analysis, thin film and multilayer thickness measurements.

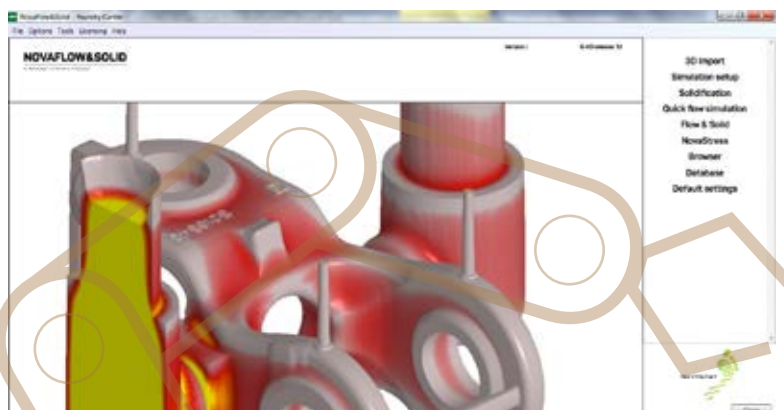
NOVA 1200e surface area and pore size analyser by Quantachrome



Measurement of adsorption and desorption isotherms, specific surface area by BET, STSA, Langmuir, determination of pore size and distribution, total volume and average pore radius. Analysis can be performed on samples such as: carbon, catalysts, organic materials, minerals, powdered metals and ferrites, composite materials, fibres, rigid foams, soil, sludge, ceramics, among others.

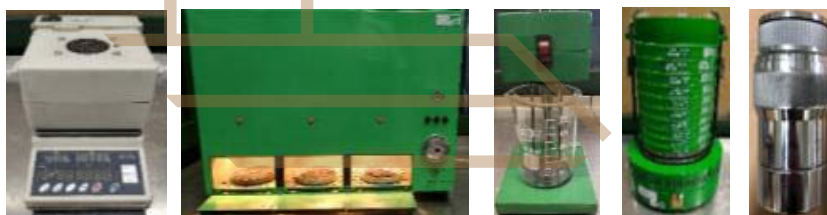
LABORATORY OF FOUNDRY

Simulation of mould cavity filling and solidification of castings - NovaFlow&Solid program



Mould cavity filling and casting solidification simulation: gravity moulds (sand and metal), high pressure die casting, low-pressure casting, centrifugal casting, shell casting, investment casting, mould cavity metal flow analysis, mould solidification analysis, shrinkage porosity analysis, stress simulation in castings.

Bulk material testing



Determination of humidity, determination of binder content (grains < 0.02 mm), sieve analysis (main fraction, average grain size, degree of homogeneity), determination of actual and theoretical specific surface area and grain shape index.

Testing of moulding compounds



Preparation of moulding sand and moulded parts for testing, permeability determination, hardness measurement, strength tests, friability test, flowability and compactibility tests, gas-formability measurement.

Making precision castings



Making precision castings from wax models, making plaster moulds, pouring moulds with negative pressure (vacuum), melting metals and alloys to max. 1500 °C in a protective atmosphere.

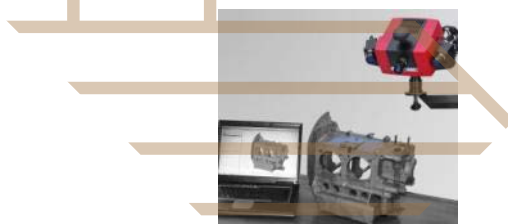
LABORATORY FOR REVERSE ENGINEERING

FARO EDGE measuring arm



Coordinate 3D measurements using a 7-axis FARO EDGE measuring arm with CAM2 Measure 10 software. Single point accuracy - 0.029 mm. Multipoint accuracy - +/-0.041 mm. Measuring range up to 3.5 m.

3D ATOS Compact Scan 5M portable scanner



3D scanner: minimum measurement area: 115 mm x 120 mm; maximum measurement area: 600 mm x 600 mm; measurement resolution: 0.061 mm÷0.250 mm.

LABORATORY OF METROLOGY

Hommel-Etamic T8000RC stationary profilometer



Performing measurements of roughness (R), waviness (W) and primary profile (P) parameters in 2D and 3D.

MECHANICAL SYSTEMS LABORATORY

Modal analysis



Determination of dynamic parameters of mechanical systems (natural frequency, natural vibration form, damping).

Acoustic emission measurement system



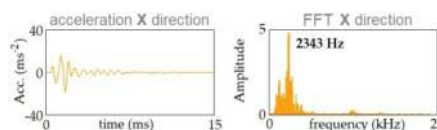
Detection, localisation and classification of sources of acoustic emission signals generated by surface and internal defects in the structures of technical equipment. Possibility of performing tests during the operation of equipment. Monitoring of plastic forming processes (stamping), machining (fracture, cutting tool chipping), jacket cracks in pressure vessels, cracks in loaded structures, insect activity in wood.

Strain gauge measurements



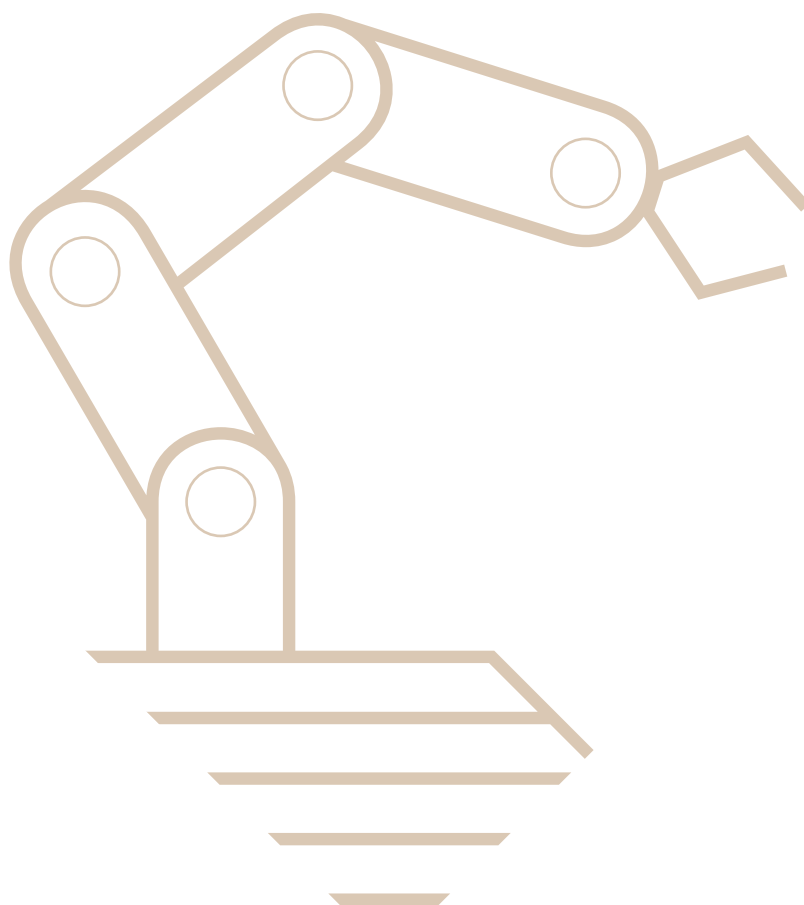
NI cDAQ - 9132 controller with NI 9236 stress measurement module and software for archiving and analysing data recorded during tests. Direct strain measurements (relative strain up to 1%) using strain gauges at temperatures up to 200°C, in a quarter-bridge system, with 24-bit resolution. Static, quasistatic and dynamic measurements. Strain gauge measurements enable real strain values to be compared with calculated values, causes of premature cracks to be determined, indirect measurements of forces, moments of force in the system.

VIBRATION MEASUREMENT - vibrodiagnostics



Vibration measurement equipment. PCB 482C05 four-channel signal conditioner together with PCB 356A16 triaxial acceleration sensor (accelerometer) and software for analysing vibration signal data.

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Mirosław Tupaj, Associate Prof., DSc, PhD.
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Faculty Gear Wheel Research Laboratory

Possibilities and scope of providing R&D and purely commercial services to external entities by the Faculty Gearwheel Research Laboratory:

- grinding of bevel gears on a KLINGELNBERG G27 grinding machine.
- strength and fatigue tests and vibration analysis of bevel gears on the world's only KLINGELNBERG TS-30 machine.
- measurement and quality control of bevel and helical gears on a KLINGELNBERG P40.
- designing planetary, bevel and helical gears.
- designing gears for aerospace and automotive applications.
- conducting complex drive work incorporating bevel gears, particularly dedicated to aerospace and automotive technology.
- assessing wear and carrying out repair and overhaul work on gearboxes.
- possibility of testing and verifying technical parameters of new gearbox developments and verifying test results obtained by computer simulation methods, e.g. using KISSsoft.
- designing mechanical drives.

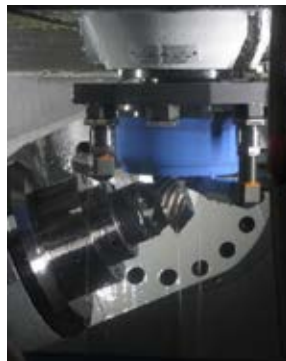


Figure 21: KLINGELNBERG G27 grinding machine.



Figure 22: KLINGELNBERG TS-30.



Figure 23: KLINGELNBERG P40.

Contact details :
al. Powstańców Warszawy 8
www.gear-lab.prz.edu.pl

The Head:
Adam Marciniec, Associate Prof., DSc, PhD, Eng.
phone: 17 8651415
e-mail: amarc@prz.edu.pl

Laboratory of Computer-aided Research and Design of Aeronautical Structures and Alternative - Renewable Energy Sources

The Laboratory is a specialist research centre for widely understood aviation technology and alternative renewable energy sources. The offer of the Laboratory is addressed to economic entities involved in the design and manufacture of innovative aeronautical structures, which do not maintain their own specialist research centres. In its structure there are two laboratories:

1. Laboratory of research and design of aeronautical structures.
2. Laboratory for designing alternative - renewable energy sources.

The laboratory is, by definition, oriented towards systemic design work in both the structural sphere and the study of interdisciplinary phenomena. These studies include:

- structural studies (strength, vibration, noise - of the aircraft and aircraft engine),
 - control systems and avionics research,
 - research relating to optimisation of energy systems incorporating alternative energy sources (wind power plants, solar panels, thermal energy recovery systems) to increase the efficiency of conversion and utilisation of the primary energy source.
-

Laboratory of Applications of Information Systems in Diagnostics

The laboratory carries out research for companies in the aerospace industry, the automotive industry, the environmental protection construction industry and for medical institutions. There are two laboratories in its structure:

1. the Construction and Equipment Diagnostics Laboratory (PDKU):

- measurements and computational analyses of composite elements and components of aeronautical structures,
- non-invasive, non-contact measurement tests,
- research, the results of which are of interest to companies from the aerospace industry, automotive industry, environmental protection construction industry and medical institutions.

2. Laboratory of Medical Informatics (PIM).

Within the Laboratory, tasks are carried out on the creation and testing of software for medical and technical diagnostics, on the use of wireless and camera-free measurement of human movement in 3D space, and on the construction of digital equipment with the use of FPGA structures. The services offered relate to research that is innovative and ahead of the competition, which is not carried out by IT companies or national hospitals. The reason for this is the lack of scientific staff that could devote themselves to such research and the lack of technical facilities.

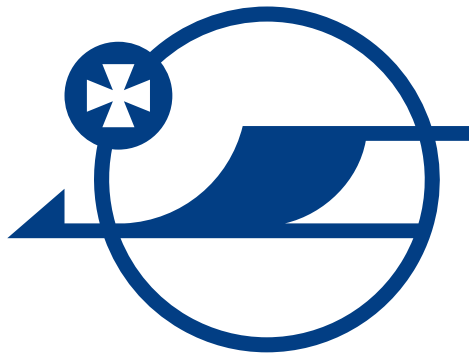
Laboratory of Composite and Polymer Materials for Aeronautics

The offer of the Laboratory is addressed to economic entities involved in the production of innovative polymeric materials and their processing. It applies mainly to the aeronautical industry and to companies working for aeronautical constructions in the field of application and design of various structural and functional plastic products. The laboratory also conducts research that can be used to characterise polymeric materials currently produced by the Podkarpackie industry, especially by companies that produce goods for the EU markets or plan to win these markets. In this area there is a severe lack of certified laboratories which can issue certificates of conformity of the tested products with Polish and/or European standards. Its structure includes the following laboratories:

1. The Composite Materials Laboratory
2. The Polymer Materials Laboratory
3. Auxetics laboratory

The research carried out includes:

- determination of flame resistance of polymers and polymer composites using the ul94 method in accordance with the following standards: IEC 60707, 60695-11-10, 60695-11-20 and ISO 9772, 9773 and ASTM (E162);
 - determination of flame resistance of polymers and polymer composites using a cone microcalorimeter. Possibility to measure: rate (HRR), total heat of combustion (THR), DDO time of sample ignition (TTI), mass change of samples and rate of mass change of samples (MLR);
 - rheological tests of melted thermoplastic polymers - determination of viscoelastic properties of polymers (modules: loss and stiffness; apparent and composite viscosity)
 - rheological tests and crosslinking characteristics of chemically-cured polymers: epoxy resins, unsaturated polyesters, polyurethanes, phenoplasts, etc;
 - the possibility of preparing small batches of granulated polymer blends with various additives: fillers, other polymers, modifiers, etc;
 - the possibility of producing short series of polymer fibres by extrusion through a filament head with the possibility of their orientation by means of take-up rollers;
 - measurement of thermal conductivity of polymer composites in the form of plates with small dimensions of 10 mm -20 mm, in a wide temperature range: 20°C -250°C
 - determination of tensile, flexural and compressive strength properties;
 - measurement of surface and/or cross resistivity of polymers or polymer composites
-



**OŚRODEK
KSZTAŁCENIA
LOTNICZEGO
POLITECHNIKI RZESZOWSKIEJ**

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Rzeszów University of Technology Aviation Training Centre

Flight crew training:

- IR(A)/SE - Single-engine aeroplane instrument rating licence;
- MCC - Multi-crew cooperation course;
- Courses and training as individually agreed with the client.

Training for technical personnel

The Rzeszów University of Technology Aviation Training Centre has within its structures the MTO Part-147 Maintenance Personnel Training Organisation. The organisation started operating on 1 October 2014.

Aviation services

The Aviation Training Centre holds an Aviation Services Certificate (AWC) No. 025/13. Within the framework of the AWC certificate, the Centre can carry out the following flights:

- survey, scientific and teaching flights,
- patrol and surveillance of transmission lines, ground installations, etc,
- combined with filming and picture taking.

Flights can be performed on TB-9 and M-20 aircraft.

Base and line maintenance of aircraft

Rzeszów University of Technology Aviation Training Centre has within its structures AMO Part-145 Maintenance Organisation with certificate number PL.145.065.

The Maintenance Organisation carries out base and line maintenance of aircraft in accordance with the Scope of Approval:

- PZL-110 Hummingbird,
- piper PA-34-220T Seneca V,
- socata TB-9 Tampico,
- scata TB-10 Tobago,
- socata TB-20 Trinidad,
- piper PA-28R-201 Arrow,
- piper PA-31-310 Navajo,
- PZL-M20-03,
- liberty XL-2,
- zlin 242L.

Research and flight tests

Rzeszów University of Technology is equipped with a specialised aircraft - a research platform designed for flight testing of characteristics and performance of aircraft or its equipment. The method of its use can be agreed individually with the customer.

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36-001 Trzebownisko

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Director:

Arkadiusz Rzucidło, Associate Prof., PhD, Eng.

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W BEZMIECHOWEJ
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Academic Gliding Center

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38-600 Lesko

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TRAINING MANAGER RESPONSIBLE MANAGER ATO AOS ABSOLUTE

Arkadiusz Bulanda

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HEAD OF AOS AIR AND SPACE RESEARCH LABORATORY

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Academic Gliding Center in Bezmiechowa

OSL in Bezmiechowa conducts training for licenses for glider pilots and training for aviation mechanics for gliders, motor gliders, gyroplanes, ultralight aircraft, and balloon aircraft. We hold all the certificates required in this area issued by the President of the Civil Aviation Office.

Contact details:

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Arkadiusz Bulanda

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e-mail: arekbulanda@prz.edu.pl

Examples of Innovations

Friction heating of metal sheets of materials difficult to deform undergoing spinning

Creators of the technology:

Tadeusz Balawender

Jan Banaś

Romana Śliwa

1. Description of the innovation

General characteristics

Spinning is a method of plastic forming of thin-walled products with axial symmetry. It is used to make extrusions with complex shapes that are difficult to make using classical extrusion methods and in small and medium series production.

Forming of extrusions from materials difficult to deform, e.g. aluminium and magnesium alloys at ambient temperatures, is very difficult due to low deformability of these materials. Both stamping and spinning require heating of such material in order to lower its plastic resistance and increase its deformability.

In the case of spinning, frictional heating can be used by applying a fixed buttress in the flange area to a rotating disc of sheet metal. The buttress may cover the whole flange area or only part of it. The amount of heat release depends mainly on the size of the friction surface, the friction conditions, the speed and the type of disc material. For each material to be shaped, the optimum temperature of the spinning process can be achieved by selecting the appropriate rotational speed of the disc (intensifying the friction phenomenon).

2. Potential markets

The innovation can be used in the manufacturing industry, particularly in the automotive and aerospace sectors due to the use of high-strength materials.

3. Market interest

Manufacturers of thin-walled, axisymmetrical products made of deformation-resistant materials that require material preheating may be interested in the friction heating spinning technology.

4. State of innovation development - technology maturity level

Level of technological readiness: TRL 6.

5. Intellectual property protection

Pat.228176 from day 13.10.2017 r.

6. Competing technologies and competitors

Heating can be carried out by various methods, e.g. electrical, fire (gasoline or acetylene-oxygen burners).

Bimetallic screws and methods of producing them

Creators of the technology:

Andrzej Kubit

Tomasz Trzepieciński

1. Description of the innovation

Development tendencies in the automotive industry are directed towards the search for new material technologies and innovative processing methods, ensuring manufacturing of vehicles that are increasingly environmentally friendly in terms of energy intensity of production and ecology of operation. One of the ways of lowering the emission of pollutants in the form of exhaust gases is to introduce new energy-saving materials on the market, which are lighter in weight, economically viable and ensure appropriate durability properties. Another way is to replace commonly used materials with equivalents that are lighter in weight without losing strength properties. The aim to reduce the weight of automotive vehicles, requires the use of components made of various materials based on light metal alloys, such as aluminium, magnesium, titanium and composite materials.

The developed technology for manufacturing bi-metal screws for connecting elements makes it possible to reduce the weight of vehicles while ensuring high load bearing capacity of the connections.

The invention relates to a bi-metal screw comprising a head and a shank, both of which are made of different materials. The bolt shank may have a thread on part or all of its length. When using this type of bi-metal screw, where the shank is connected to the nut by welding or gluing, there is the problem of low strength of the connection. In the proposed solution, a formed connection is used between the shank and the head of the bolt.

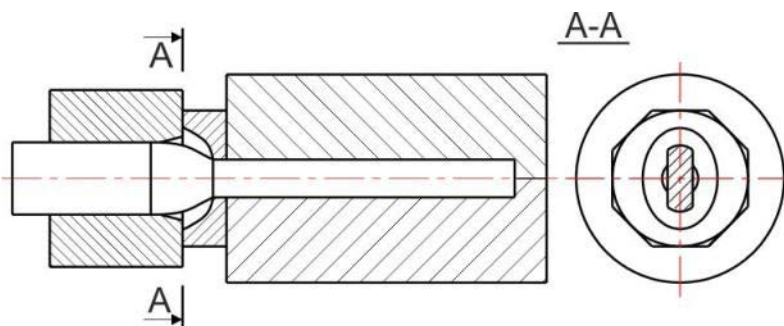


Figure 24: Forming a bi-metal screw.

2. Potential markets

Automotive industry, engineering industry, aerospace industry.

3. Market interest

The idea to develop a technology for manufacturing bi-metal screws originated from discussions with representatives of a fasteners manufacturer, mainly for the automotive industry. Due to the large number of fasteners used in automotive vehicles and aviation structures, any way to reduce their weight is desirable..

4. State of development of innovations - technology maturity level

TRL2 technology readiness level.

5. Intellectual property protection

Bimetal screws developed within the technology are covered by applications for invention: P.431733, P.431732, P.431731, P.431734, P.431735, P.431121.

Bimetal screw and method of manufacturing bimetal screw - patent application number P.431121.

Bimetal screw and method of manufacturing bimetal screw (5 patent applications with the same title) - P.431733, P.431732, P.431731, P.431734, P.431735.

6. Competing technologies and competitors

Despite the existence of advanced technologies for the shaping of automotive components, there are limited possibilities to apply these technologies to produce or join components with different properties, using friction welding or high-energy methods such as laser welding, plasma welding, electron beam welding, among others.

The analysis of the state of the art of fasteners has not revealed the existence of similar solutions.

Supporting devices for the cultivation and processing of shoots, especially of purple willow and *salix viminalis*.

Creators of the technology:

Witold Niemiec

Tomasz Trzepieciński

1. Description of the innovation

The developed device for debarking logs, incorporating electromechanically powered rotary cutting tools, according to the invention application P.428765, is characterised by the fact that it contains independent coarse and fine cutting units. In this way, it is possible to use the individual bark layers more efficiently for, among other things, salicin extraction.

The device in the form of a debarking head, covered by the invention claim P.430634, ensures uniform debarking of shoots with variable diameters by using pulling and debarking inserts, the position of which is automatically adjusted to the diameter of the debarked shoots. The invention provides a significant increase in debarking efficiency with respect to manual work and the possibility of using it in automated lines for processing lignified shoots of plants, especially wicker, also contributing to a reduction in manual labor costs.

The advantage of the device for removing impurities from wicker shoots, presented in the invention application P.430635, is primarily the reduction or, in many cases, elimination of the need for herbicide weed control in plantations, the increase in processing efficiency in relation to manual human work and the high reliability associated with the uncomplicated design of the device.

The manual segregation of wicker used so far is cumbersome, requires considerable force and is reluctantly undertaken by workers. This inconvenience has been eliminated in the device for sorting lignified plant shoots (application for the invention P.430629) by the use of elastic pressing tapes containing appropriately shaped protrusions on the external surface. This innovative device is characterised by the ability to sort flaccid shoots, with variable curvature and cross-section, often entangled with each other. None of the known devices has this feature.

The developed planter for cuttings, covered by application for invention P.433871, using an actuator with transverse-longitudinal working range (application for invention P.433870), does not require soil loosening and always guarantees vertical positioning of the cuttings. By eliminating the furrow shaping coulters for the placement of cuttings, the recompacting wheels and the mechanical drive of the planter mechanisms, the working resistance during the operation of the machine has been minimised.

Wicker harvesting solutions, as known from the state of the art, are not suitable for cutting wicker shoots on small or medium-sized farms. They are not suitable for use during harvesting due to their high weight, poor ergonomics and unsuitability for long-term use. These problems are overcome by the pneumatically driven shoot cutter according to invention application P.437242, which is characterised by the fact that it is pneumatically driven and attached to the arms of the operator. The elimination of

the combustion or electric drive requiring heavy batteries has improved the working ergonomics of the operator.

2. Potential markets

The equipment can be used:

- on farms and businesses growing and processing wicker and other plants with lignified stems,
- on wicker plantations to remove impurities from growing shoots before the harvest stage,
- during the pruning of fruit trees,
- in companies that manage green areas and maintain the greenery surrounding streets, airports, railway and industrial facilities and road infrastructure.

3. Market interest

The devices have been developed on the basis of talks with representatives of the Cooperative Group of Energy Plant Producers in Boguchwała and with a company dealing with the cultivation and processing of purple willow - HEJS from Rudnik nad Sanem, the capital of the wicker industry in Poland.

4. State of innovation development - technology maturity level

TRL2 level of technological readiness.

5. Intellectual property protection

The developed technology of works mechanisation on plantations of energy crops with lignified shoots, especially purple willow and *salix viminalis* includes the following technical solutions (authors: Witold Niemiec, Tomasz Trzepieciński):

- a device for debarking flaccid shoots of lignified plants - invention application P.428765 (2019),
- a device for mechanical removal of impurities from lignified shoots of plants, especially wicker - invention application P.430635 (2019),
- a device for debarking lignified shoots of plants, especially wicker - invention application P.430634 (2019),
- a device for sorting lignified plant shoots and a method for sorting lignified plant shoots using this device - invention application P.430629 (2019),
- a planter for cuttings - invention application P.-433871 (2020),
- mechanical actuator with control unit - invention application P.433870 (2020),
- pneumatically driven shoot cutter - invention application P.437242 (2020).

6. Competing technologies and competitors

There are no commercial competitive solutions on the market adapted to small and medium scale wicker production. It is uneconomical for most *salix viminalis* or purple willow producers to purchase professional machinery.

Biodegradable thermoplastic composites and a method to produce biodegradable thermoplastic composites

Creators of the technology:

Grzegorz Janowski

Wiesław Frącz

Łukasz Bąk

Anna Czerniecka-Kubicka

1. Description of the innovation

A significant problem is the constantly increasing amount of plastic waste in the world, where these materials are mostly of petrochemical origin. The presented solutions are a way to produce and manufacture polymer biocomposites designed for extrusion and injection moulding processes. These materials are of natural origin, consisting of both natural and biodegradable matrix and biodegradable fillers of natural origin, where the mass share of the filler in the polymer matrix can be in the range from 15 to 45%. The developed biocomposites are an innovative solution according to a common trend related to the search for modern, ecological substitutes for plastics of petrochemical origin, commonly used in injection moulding and extrusion products.

2. Potential markets

The amount of plastic waste, which is mostly of petrochemical origin, is increasing year by year. Most of them are of petrochemical origin and are not biodegradable. Due to the ever expanding problem, on 18.04.2018 the European Parliament approved a package of legal proposals, the requirements of which are supposed to induce the development of technologies for developing new materials based on natural resources - the developed biocomposites qualify strictly in the aforementioned assumptions. The biocomposites produced can be widely used in the manufacture of parts produced by injection moulding and extrusion technology. In this context, manufactured and tested biocomposites, protected by a patent (as a product and/or manufacturing technology), can be made available in the form of a sale of rights, granting a license for the method of their obtaining.

3. Market interest

Questionnaires/consultations on the interest in the described solutions were conducted among companies specializing in plastics processing. The surveys were positively evaluated as the companies noticed the innovation potential of the studied materials in the context of their commercialisation.

4. State of the art of innovation development - TRL 5 technology maturity level

A procedure has been developed for manufacturing biocomposites in the extrusion and processing in the injection moulding process. The recommended geometry of fillers and mass proportions of fillers and polymer were determined in order to reduce manufacturing costs and improve certain properties.

5. Protection of intellectual property

On behalf of PRZ, applications have been filed to the Patent Office of the Republic of Poland for granting patents for the following inventions: P.434163, P.434164, P.434165.

6. Competing technologies and competitors

Currently, the only material from the group of double-green polymers commonly used is PLA (polylactide), therefore, due to the current trend concerning the need to search for new materials of plant origin and biodegradable, the developed biocomposites have a very good chance to be commercialized at the global level.

Swing gate located on sloping ground

Creator of the technology:

Stanisław Kut

1. Description of the innovation

Swing gates, due to their advantages (simple, reliable, durable and, in comparison with other solutions, cheap construction) are by far the most frequently used in construction of fences. In practice, however, due to varied terrain types, in many cases it is necessary to install this type of gate on a sloping ground. The slope can be either towards the entrance or perpendicular to it, i.e. across the width of the entrance. In the first case the gate cannot be opened in the direction of the rising ground, but only in the direction of the slope. According to the building law, gates and wickets in the fence cannot open to the outside of the plot, which means that such solutions can be applied only to plots located with a slope below streets and roads. However, on all plots with a gradient above streets and roads, the use of swing gates is limited and requires additional measures. When swing gates are used, it is necessary to level the entrance road in front of the gate on the inner side of the fence, which results in a steeper entrance road in its further part. Such a solution is not beneficial especially in winter. In the case of small slopes it is necessary to position the gate at a much greater distance from the ground, with the result that the clearance between the gate and the entry road when the gate is closed is too large and the fence does not fulfil its function, making it possible, for example, for animals to pass under it. Similar difficulties are encountered with lateral sloping terrain, i.e. in the direction of the gate width. In this case the problem of gate construction concerns not both, but one leaf of the swing gate.

The subject of the innovation is an original construction solution for a swing door located on a sloping site. A typical swing gate has at least one fixed leaf and gate posts, and the leaf of the gate is connected to the gate post by an upper hinge and a lower hinge, and when the gate is opened, the leaf of the gate rotates in relation to the axis of the upper and lower hinges. In the case of the door to be innovated, in addition to the rotational movement, there is a pivoting movement of the gate leaf in the plane of the gate leaf relative to the base plane of the gate. This rotary and tilting movement of the door leaf is possible thanks to the use of original hinges. The advantage is that the door can be easily opened on sloping terrain and opened in the direction of the slope. When the ground slopes in the direction of the gate's width, using a double-leaf swing gate, only one of its leaves makes an additional movement. The other door leaf only rotates as in a classic door.

Unlike solutions used so far on sloping terrains, the gate has fixed wings like in a classic swing gate. Therefore, it is possible to use elements of typical system gates, such as wings or posts, which are available on the market in many different sizes and designs, as well as factory-protected against corrosion. The developed gate may be available in two variants. In the first variant, additional swing movement of the leaf is forced by the use of a cam mechanism, while in the second variant, by the use of a support wheel rolling on the ground. Both these solutions and the design of the hinges ensure very high reliability.

2. Potential markets

The innovation can be used, among others, by companies that offer gates and fencing systems in their product range.

3. Market interest

No data available.

4. State of the development of the innovation - technology maturity level

TRL 2 level of technological readiness.

5. Protection of intellectual property

The developed solutions, related to the subject of innovation, are protected by a patent and two patent applications:

- set of hinges for a swing gate. Patent of the Republic of Poland no. P.234336 of dd. 03.03.2020 r.
- method of opening a swing gate. Patent application P.424529 as of 02.08.2018.
- swing gate. Patent application P.424528 as of 07.02.2018.

The technology is owned by Ignacy Łukasiewicz Rzeszów University of Technology.

6. Competing technologies and competitors

In principle, only one solution for an upward-opening swing gate is known so far, being the subject of patent no. P.L 217400 B1. Unlike simple swing gate solutions with fixed wings, this gate has hinged leaves. It is constructed in such a way that it has a hinged section in the lower part, separated from the whole by two diagonal slats connected to each other by hinges, the hinges connecting the edges of the slats on the outside of the door. The bottom hinged section is fitted with one or two caster wheels which guide the hinged section along the carriageway during opening and closing of the door. In the final closing phase, when the wheels are no longer in contact with the track, the bottom crossbar of the door meets the buffer installed in the track, which causes the tilting section to take up a vertical position. No further deviation is possible as the two diagonal cross bars, which are linked by hinges, meet with each other on their surfaces. This results in the tilt section becoming more rigid in relation to the main section. This is ensured by an actuator that exerts constant pressure on the door against the buffer. A manually operated door must be fitted with a locking device, e.g. a locking slide, which is mounted on the inside of the door and sinks into a suitable hole in the carriageway when the door is closed. However, this solution has a number of disadvantages, notably a lack of versatility, as it is necessary to make a broken leaf with a geometry dependent on the degree of slope. The gate also has a more complex, and thus more expensive, design of the wings, while they are not interchangeable with each other. In addition, in order to achieve full clearance, the gate leaves must open much wider than 90°. The use of wheels is also impractical, and the ground on which the leaf wheels roll must be smooth and paved, and there must be no objects in the way on which the wheels roll, especially stones or twigs, as these can block the gate. Special problems may also occur in winter. In conclusion, the innovative gate has a simple structure in the form of typical fixed wings, not bent, and moreover, fencing system components can be used for its construction. It is also free of the disadvantages and limitations occurring in the gate described above.

Dynamic extractor for extraction of components from mineral and organic matter

Creators of the technology:

Witold Niemiec

Tomasz Trzepieciński

1. Description of the innovation

An extractor is a device used for separating mixtures of solids and liquids. Extractors known from the state of the art are insufficiently adapted to the processing of logs, willow shoots or wicker, especially on small and medium farms and in the field. At the same time, these devices are not very versatile and often their application to an extraction process other than the one for which the device is dedicated is impossible or ineffective.

A dynamic extractor for the extraction of chemical components from a solid matter, comprising a vessel with an extraction chamber, a combustion chamber, an extraction basket for loose settling in the extraction chamber and a stirrer, according to the invention application P.437243 is characterized by the fact that its agitator has a cylindrical body, which on its periphery contains a toothed ring, cooperating with a toothed wheel connected to an electric motor, and a basket in working position is located inside the body of the agitator. The dynamic extractor for the extraction of chemical components from solid matter is a multifunctional device enabling the steaming, boiling or heating of logs of wood standing for the production of veneer, intarsia materials, steaming, boiling willow shoots and wicker to obtain salicin. It can also be used for extraction from mineral materials, sintered barium sulphide by leaching or extraction in organic solvents.

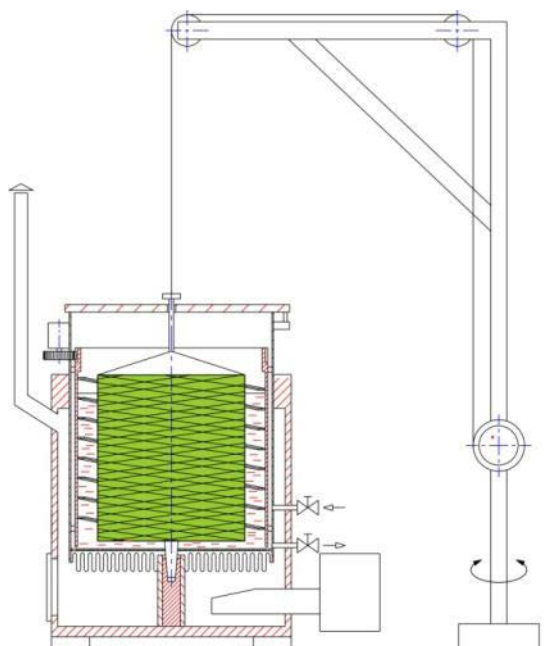


Figure 25: Dynamic extractor.

2. Potential markets

The equipment may be used for the extraction of components from mineral and organic matter, in particular in plants for the extraction of from the bark of energy willows and wicker.

3. Market interest

The market niche for low-cost equipment for extracting components from organic matter was reflected after discussions with representatives of the Cooperative Energy Plant Producers Group in Boguchwała. The increasing pharmacognostic use of active substances, mainly salicylic acid, contained in the bark of willow wicker in animal diets is desirable in traditional livestock farming. Extracts prepared by appropriate methods guaranteeing obtaining the highest possible amount of biologically active chemical compounds found in this raw material and other compounds accompanying them may constitute dietary supplements in organic animal husbandry.

4. State of innovation development - technology maturity level

TRL2 level of technological readiness.

5. Protection of intellectual property

Dynamic extractor for extraction of chemical components from solid matter. Invention application P.437243.

6. Competing technologies and competitors

Lack of competitive solutions adapted to small-scale agricultural production.

Geopolymers using waste products, including machining waste

The creator of the technology:

Marta Wójcik

1. Description of the innovation

The need to utilise waste, including waste from machining processes, as well as the pressure to implement the idea of a closed-circuit economy, necessitate the search for new methods of recycling waste. Taking into account ecological and economic as well as technical aspects, the possibility of using various waste fractions to produce geopolymers, the so-called new generation concrete, was proposed.

The proposed geopolymer contains from 60% by weight to 70% by weight of ash from biomass combustion with a calcium content <20%, from 25% by weight to 39% by weight of cullet and from 1% by weight to 5% by weight of iron dust. The production method of the geopolymer is as follows: fly ash from biomass combustion is crushed in a ball mill and sieved, glass cullet is crushed in a ball mill and sieved, then iron waste is crushed in a ball mill and the obtained iron dust is sieved. Subsequently from 60% by weight to 70% by weight of fly ash with a particle size of 100 µm or less, from 25% by weight to 39% by weight of cullet with a particle size of 50 µm or less and from 1% by weight to 5% by weight of iron dust with a particle size of 50 µm or less of iron dust with a particle size of 50 µm or less - is initially mixed with each other and then an alkali solution is added to the mixture of dry components at a ratio of 1:3 by weight of this alkali solution to the mixture of dry components, and water at a ratio of 1:3 by weight of water to the mixture of dry components. Mixing is carried out under dynamic conditions in a mixer at a speed of 150±5 rpm for 5-10 minutes, then the obtained mixture is wet-moulded by hand, thickened by mechanical means and cured for 28 days at room temperature.

The geopolymer obtained by the above method has a compressive strength of 25--42 MPa, depending on the weight fraction of the individual dry components as well as the concentration of the alkali solution used. The material shows similar mechanical properties to concrete (compressive strength for concrete 30--50 MPa).

The presented geopolymer is an alternative to concrete in applications in construction and civil engineering sectors. Due to its ability to be produced from waste materials such as fly ash, glass cullet and iron dust, the production of the geopolymer contributes to their recycling, in accordance with environmental, economic, legal and social requirements. The proposed geopolymer is also an ecological alternative to conventional concrete. The advantage is also the prevalence of substrates for the production of geopolymer and the low cost of their acquisition, as well as the possibility of producing the material using the technological sequence for the production of conventional concrete.

2. Potential markets

The construction sector, including road construction.

3. Market interest

Due to the limited resources of natural raw materials for concrete production, the construction sector, in particular road construction, is interested in the implementation of this solution. Due to the possibility of recycling different fractions of waste, the solution is also supported by the waste management sector.

4. State of the development of the innovation - TRL3 technology maturity level

TRL3

5. Intellectual property protection

Patent application No. P.437124 "Geopolymer and a method of manufacturing this geopolymer".

Applicant: I. Łukasiewicz Rzeszów University of Technology, Rzeszów, Poland.

6. Competing technologies and competitors

Currently, geopolymers are the only alternative to concretes produced based on Portland cements. Work carried out in various research centres on the production of geopolymers is based mainly on the use of coal or clay ash as the main substrate, with their mechanical properties being significantly inferior to those of concrete. So far, there has been no research into the possibility of producing geopolymers using ash from biomass combustion, glass cullet and iron dust produced from the appropriate processing of machining waste. Therefore, it can be concluded that the proposed geopolymer as well as the method of its production is an innovative solution, in relation to which there are no competitive solutions.

Clinching of metal sheets

Creator of the technology:

Tadeusz Balawender

Piotr Myśliwiec

1. Description of the innovation

Currently there are many ways of joining metal sheets less than 3 mm thick, which result in similar geometrical and mechanical joint parameters, e.g. bolting, riveting, welding. Twisted and riveted joints require holes to be made in the metal sheets to be joined (drilling or punching), while welding and spot welding involve the action of high temperature in a localized area, which changes the mechanical properties of the materials to be joined and generates residual stresses. Resistance spot welding has been widely used for many years in the automotive industry to join car body parts. It has many advantages (e.g. high joint strength), but the sheets to be joined must be weldable. When joining zinc-coated sheet metal, which is used on a large scale in the automotive industry, overheating of the copper electrodes and their rapid wear is a disadvantage. The thickness of the protective zinc coating also decreases, which significantly reduces the corrosion resistance of metal sheets at the joint. Therefore, other joining methods of similar strength and durability have been sought, allowing various materials to be joined in a more energy-efficient and economically viable manner. One of these is the fastenerless joining technique, which involves localised pressing of the sheets to be joined. This is an alternative technology to traditional spot welding and is somewhat similar in that it does not use a fastener, plus it is considerably cheaper. Although such a joint is weaker than welded and riveted joints, interest in this method is high due to its advantages. A diagram of a clinch joint is shown in Stamping joining as a technology for joining sheet metal has been known for many years. The first patent for this joining method was filed as early as 1897, but it was not until the 1980s that the process was adopted on a mass scale for industrial practice. The forerunner in the use of clinching was Mercedes-Benz, which used this type of joint in the series production of passenger car bodies. Its cost-effectiveness and environmentally friendly nature encourage the use of this method not only in the automotive industry, but also in the engineering, household and construction industries.

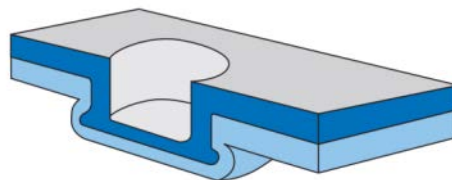


Figure 26: Diagram of a clinch joint (connection point geometry).

Technology development in KPPi:

- Joining of different metallic materials.
- Hybrid bonding (clinching and adhesive).
- Joining materials of different thicknesses.
- Investigating the impact of the placement of connection points.

2. Potential markets

Clinching can be used in a wide range of manufacturing industries to join thin-walled components.

3. Market interest

Manufacturers of thin-walled products looking for simple, cost-effective and environmentally friendly technology solutions should be interested in clinching technology.

4. State of the innovation development - technology maturity level

Level of technological readiness: TRL 9.

5. Protection of intellectual property

Developed know-how potential , so far without patent claims.

6. Competing technologies and competitors

The clinching method may be an alternative to bolting, riveting, welding.

Design and manufacture of high precision tools and tooling using super-hard materials

Creators of the technology and its development:

Robert Ostrowski

Marek Zwolak

Piotr Myśliwiec

Romana Ewa Śliwa

1. Description of the innovation

A new solution is the treatment of advanced tool shapes

The technology of shaping advanced geometries is carried out by micro milling with PCD, CVD and PCBN tools and by electro-discharge machining. The technology of shaping advanced geometries is carried out by micro milling with PCD, CVD, PCBN tools and by EDM. The surface quality obtained after machining does not require additional operations such as polishing, and even the polishing process is not advisable due to uncontrolled blunting of the edges.

2. Potential markets

Manufacturers of:

- injection moulds,
- Cutting tools,
- precision tooling,
- tools and tooling for plastic working processes.

3. Market interest

The domestic market does not have sufficiently good machinery and knowledge of high-precision tools and tooling. Most of them are Western companies, where such solutions are created, and they come to Poland in the form of finished products intended for implementation. Companies are interested in implementing a complete technology based on ready semi-finished products intended for implementation or in developing new significantly improved ones.

4. Level of the development of the innovation - technology maturity

Level VI (TRL 6) - the technology has been demonstrated in near-real conditions. Prototype tools of the whole system have been tested in near-real conditions. Preliminary tests of the prototype have been carried out in laboratory conditions replicating with high accuracy the real conditions and in simulated operational conditions.

5. Protection of intellectual property

Successive development of technology and creation of know-how resources in the field of forming highly specialised tools with the use of advanced materials. So far, the technology is not protected by any claim - patent applications will be prepared. The developed technology is a result of own R&D works conducted in the Laboratory of Advanced Material Technologies in the Department of Metal Forming.

6. Competing technologies and competitors

From the analysis of the state of the art and national R&D works carried out, the technology is not available in Poland, only some elements of the technology are available (tools of Western manufacturers).

Recycling of production waste in the form of metal swarf by KOBO extrusion

Creators of the technology/a KPP team dealing with the development of technology:

Marek Zwolak

Romana Ewa Śliwa

Beata Pawłowska,

Tadeusz Balawender

1. Description of the innovation

The recycling of post-processing swarf, in particular light metals and their alloys, in a conventional process consists of collecting and separating swarf, and then putting it through conventional metallurgical processes, remelting it, in order to obtain the input for subsequent plastic working processes, leading to full-value products. The problems of conventional processes are mainly economic and energy-related. It turns out that the whole process of collecting, sorting, cleaning, remelting and then manufacturing products is more complex and costly than the extraction of raw materials and smelting of their alloys. In addition, the fact that the post-processing swarf is small and has a highly developed surface is subject to corrosion and oxidation, so that in some cases up to about 40% of the originally collected swarf is lost. The processes are further complicated by the use of cooling and lubricating fluids in the depletion process, out of which the collected swarf must be cleaned and which must be disposed of so as not to pollute the environment. An alternative to metallurgical processes is plastic processing, in particular extrusion. The proposed method of recycling of post-processing swarf consists in preliminary cleaning of the feedstock and then subjecting it to the innovative KOBO extrusion process, preceded by a process of preliminary consolidation or conventional extrusion to obtain material in a form suitable for further operations (briquettes).

The innovative KOBO extrusion method enables the extrusion of metallic materials in a "cold" process, without preheating the charge and the press components, with the possibility of obtaining a high degree of reduction in the cross-sectional area of the press in relation to the cross-sectional area of the feedstock. The essence of the method is the use of a mechanical system introducing the die into an oscillating motion with a preset angle and frequency. This leads to the creation of a favourable stress system in the extruded material and, as a result, significantly facilitates the plastic flow of the material through the die mesh.

Experimental studies have shown that it is possible to recycle post-processing swarf by extrusion using the KOBO method in a "cold" process, with a high cross-section reduction factor, and thus to obtain a full-value product in the form typical of extruded products (rod, section).

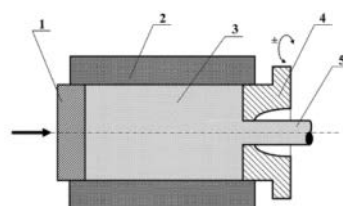


Figure 28: Scheme of extrusion by the KOBO method; 1 - punch, 2 - container sleeve, 3 - feedstock, 4 - cyclically twisted die, 5 - product.

2. Potential markets

Metal industries of all sectors: mechanical engineering, aerospace, automotive and others.

3. Market interest

Companies in the broadly defined metal industry of all sectors: engineering, aviation, automotive and others interested in targeted recycling of production waste in the form of swarf.

4. State of the development of the innovation - TRL 6 technology maturity level

TRL 6.

5. Protection of intellectual property

Gradual development of technology and creation of Know-How resources for the solution

6. Competing technologies and competitors

Traditional methods of waste remelting, much more energy- and cost-intensive and with possible adverse effects on the environment.

Method for laser hardening of outer corners of bending tools with light beam distribution

Creators of the technology:

Stanisław Kut

Krzysztof Kogut

1. Description of the innovation

Due to its numerous advantages, the laser hardening technique is increasingly used in the technology of machinery and equipment, including bending tools. It allows hardening of individual tool surfaces, usually only those in contact with the workpiece material. The advantage of laser hardening of bending tools is that, in contrast to induction hardened tools, they do not require finishing treatment, i.e. grinding, after hardening. Moreover, the hardening of only selected tool surfaces significantly reduces the occurrence of hardening stresses, which are the cause of permanent tool deformation after hardening. Therefore, in practice, when using laser hardening, the hardened surface of the tool is reduced to a minimum.

Unfortunately, the laser hardening equipment available on the market and the existing laser hardening technology, despite its many advantages, have serious limitations in the case of hardening bending tools. They result from the shape and dimensions of the hardened tool surfaces. The tools have flat surfaces located at various angles, which are connected to other surfaces by surfaces that are usually cylindrical. In the longitudinal section of the tool or on its profile, the flat surfaces are straight lines, while the cylindrical surfaces are the radii of rounding. The rounding radii can be external, i.e. those forming the corners of these tools, and internal. In the case of bending tools, it is common to harden only the outer corner with radius r and the surfaces adjacent to it over a specified length. This length depends on the size of the contact area between the material to be shaped and the tool.

Up to now, several methods of laser hardening of this type of tools have been known in terms of setting and guiding the laser hardening light beam in relation to the hardened tool surfaces. They have been described with their disadvantages detailed in the patent document (item 5). The difficulties and limitations of the laser hardening methods used so far can be eliminated by using an innovative technology consisting in simultaneous heating of the corner and adjacent surfaces at the desired length, in a single pass of the laser light beam with the same parameters. The developed method of laser hardening consists in splitting the hardening laser light beam into two symmetrical or asymmetrical light beams and, using a set of mirrors, directing them (preferably at right angles) at the surfaces of the tool to be hardened. This solution eliminates the disadvantages of previously applied solutions. It allows hardening of the surface in the desired area in a single pass of the hardening laser head, so there is no tempered or unhardened area in the corner of the tool, as is the case with previously known methods of laser hardening of bending tools. Moreover, the possibility of controlling a split beam of the hardening laser light enables directing the rays perpendicularly to the heated surfaces adjacent to the tool corner. This allows to obtain the same parameters of heating of hardened surfaces adjacent to the corner regardless of their inclination angles. The proposed method enables also hardening of surfaces adjacent to the corner of different length, through the possibility of asymmetric division of the laser light beam. Both in the case of heating with symmetric and asymmetric distribution of the laser hardening light beam, the distributed light beams should fall on the tool in such a way that they do not cover the very tip over a certain width depending on the heating parameters. It is important in this method that the very tip of

the tool of a certain width is heated as a result of heat penetration into it during the heating of adjacent surfaces. This ensures a uniform hardness distribution on the corner and the adjacent surfaces. If the entire corner of the tool is covered with laser light, the temperature on the corner surface after heating will be higher than on the other hardened surfaces, and this will result in an uneven distribution of hardness after hardening.

The developed hardening method uses one laser light generator and the original laser light beam splitter.

2. Potential markets

The innovation can be used in companies that manufacture bending tools or other tools and parts of machinery and equipment that require simultaneous surface hardening of the outer corners together with the surfaces adjacent to them.

3. Market interest

No data available.

4. State of the development of the innovation - technology maturity level

TRL 9 level of technological readiness.

5. Protection of intellectual property

The technology is protected by a patent and utility model:

- method of laser hardening of outer corners of bending tools, with light beam splitting. Patent of the Republic of Poland No. P.233215 dated 04.06.2019.
- hardening laser light beam distributor for hardening tools, especially bending tools. Utility model RP Ru.071205 dated 19.09.2019.

The technology is owned by Ignacy Łukasiewicz Rzeszów University of Technology and Przedsiębiorstwo Produkcji Maszyn i Urządzeń PLASMET SP. Z O.O.

Extrusion method and extrusion device for extruding plated rods and tubes

Creators of the technology:

Stanisław Kut

Irena Nowotyńska

1. Description of the innovation

Two-component materials called bimetallics are very commonly used in many industries. A typical bimetallic rod or tube consists of a core and a plating layer. Bimetallic rods and tubes are characterised by specific physical and mechanical properties that cannot be achieved with the separate metals that make up the bimetal. Their use is based on the differences in the properties of metals forming bimetallics, such as thermal expansion, electrical conductivity, mechanical strength or even resistance to environmental factors causing corrosion. Bimetallic rods and tubes of various cross-sectional shapes are obtained, in particular, in extrusion or drawing processes.

The subject of the innovation is an original method of plating rods and tubes during their extrusion. The developed technology for extrusion of plated rods and tubes in the original extrusion device is characterised by the fact that in the process of extrusion of a plated rod or tube in the extrusion device, from a core charge and a sleeve charge, extrusion of the core of the plated rod is carried out simultaneously, with a preset first outflow velocity of the core material, while extrusion of its cladding layer is carried out with a preset second outflow velocity of the cladding layer material in the same extrusion device during the core extrusion, with the concurrent and countercurrent extrusion of the plated rod or tube being controlled separately. The advantage of the developed technology is that the core material and the plating layer material, although in one container, are separated from each other and can be extruded practically independently. This is an unquestionable advantage because, in contrast to previously known methods, such a solution enables independent control of the process of extrusion of the core and the plating layer. This eliminates a number of drawbacks and limitations in the implementation of previous extrusion processes through the ability to ensure uniform speed of outflow of the core material and the plating layer. Such a solution ensures a stable course of the process from the very beginning, which enables obtaining a plating layer of uniform thickness along the entire length of the moulded part, and thus almost completely eliminates considerable material losses occurring in previous processes. It allows for an easy realisation of the plating process for a predetermined thickness of the plating layer. For a given diameter of the extruded bar, plating layers in a wide range of thicknesses can be obtained in a targeted and predictable manner.

2. Potential markets

The innovation can be used in companies that produce plated rods and tubes with different cross-sectional shapes that are used, among others, in the following industries: electrical engineering, energy, chemical, machinery, aeronautics, automotive and many others.

3. State of the development of the innovation - technology maturity level

TRL 2 level of technological readiness.

4. Protection of intellectual property

The technology is protected by four patents:

- extrusion device for extruding plated rods. Patent no. P.236043 as of 16.12.2020.
 - method for extrusion of plated tubes. Patent no. P.235940 as of 08.12.2020.
 - extrusion device for extrusion of plated pipes. Patent of the Republic of Poland no. P.235941 as of 08.12.2020.
-

Spinning method and pattern for spinning conical or curvilinear extrusions, especially with a high spinning ratio

Creator of the technology:

Stanisław Kut

1. Description of the innovation

Conical and curvilinear extrusions with concave or convex contours can be shaped by various methods, including stamping. In the case of axisymmetric extrusions, spinning and rotary crushing may be alternative, and in some cases the only, method of shaping. The use of these methods is also justified economically, especially in unit or small batch production. In the technology used so far, obtaining extrusions with high deformation coefficients by the spinning method, with the use of a single template corresponding to the shape and dimensions of the finished part, is not possible due to the occurrence of undesirable phenomena, such as folding or cracking of the material of the sheet being formed.

The object of the innovation is a method of spinning conical and curvilinear extrusions with a much higher degree of deformation than obtained so far, using a special template. The template, also called a mould, is a basic component of the tooling, necessary for the implementation of the spinning process. The essence of the innovation is the application of a multi-operation spinning process using an original modular template. This pattern book is characterised by the fact that it is divided in a plane perpendicular to the axis of symmetry of the moulded part and consists of parts called modules. The number of modules of the template is determined individually when designing the technological process and can be practically any. In fact, the number of modules corresponds to the number of operations necessary for the spinning of a given moulded part and depends on many factors including: the total spinning coefficient, geometrical parameters of the moulded part including the thin wall coefficient, technological parameters of the process and the type and properties of the spun material. A characteristic feature of the pattern is that all its modules assembled together form the external surface of the pattern, corresponding to the internal surface of the finished extrudate or close to it. The method of spinning, on the other hand, is characterised by the fact that the extrusion is shaped in stages in several operations on the same template, which makes it possible to obtain a high total degree of deformation, previously impossible to obtain on a single template, regardless of the number of passes of the spinning tool.

2. Potential markets

The innovation can be used in companies that produce this type of sheet metal stampings, including for the aerospace and automotive industries.

3. Market interest

No data available.

4. State of the development of the innovation - technology maturity level

TRL 2 level of technological readiness.

5. Protection of intellectual property

The technology is protected by two patents:

- Method of spinning conical or curvilinear extrusions, especially with a high spinning coefficient. Patent of the Republic of Poland No. Pat.235513 of 17.04.2020.

- Template for spinning conical or curvilinear extrusions, especially with a high spinning coefficient. Patent of the Republic of Poland no. Pat. 235512 as of 17.04.2020.

The owner of the technology is Ignacy Łukasiewicz Rzeszów University of Technology.

Technology for subsurface application of liquid fertilisers and municipal sewage sludge

Creators of the technology:

Magdalena Adamczyk

Marek Sugier,

Feliks Stachowicz

Witold Niemiec

Tomasz Trzepieciński

1. Description of the innovation

Fertiliser dispenser according to utility model W.68444 developed by the staff of Rzeszow University of Technology in cooperation with the leading manufacturer of agricultural machinery in Poland, Sipma S.A. in Lublin, makes it possible to introduce solid mineral and organic fertilisers of loose consistency into the ground to the desired depth and to cover them immediately with soil, which eliminates sometimes troublesome odour effects and limits the loss of volatile fertiliser components. It allows the use of municipal sewage sludge or other solid fertilisers of loose consistency for fertilisation without any impact on the environment. Using this device, the fertiliser is delivered close to the root mass without damaging it, which facilitates the assimilation of nutrients by plants.



Figure 29: Functional model of a fertiliser dispenser for soil application of loose organic and mineral fertilisers (W.68444).

Surface splash application is still the most common way to fertilise fields with slurry and manure, mainly because of the high costs associated with the purchase of soil applicators. However, this method has significant drawbacks: it generates a noxious odour and significant ammonium nitrogen losses. From this perspective, a soil application of liquid natural fertilizers by means of a slurry tanker covered by the invention P.236250 is much more advantageous. The device attached to an agricultural tractor is equipped with an agitator supporting the process of uniform distribution of fertilizer components.

2. Potential markets

The set for injection dosing of fertilisers may find application for agricultural utilisation of produced sludge in municipal sewage treatment plants. The potential market for the slurry tanker for subsurface application of organic and mineral fertilisers are medium and large farms engaged in livestock production.

3. Market interest

The set for injection soil application of loose organic and mineral fertilizers has been developed on the initiative and in cooperation with representatives of the leading Polish agricultural machinery manufacturer SIPMA S.A. in Lublin. The prototype of the set was manufactured by this manufacturer and tested in real working conditions on the premises of the Sewage Treatment Plant in Świlcza.

4. State of the development of the innovation - technology maturity level

Set for injecting loose organic and mineral fertilizers into the soil - TRL8.

Slurry tanker for subsurface application of liquid fertilizers - TRL2.

5. Protection of intellectual property

The developed technology of subsurface application of liquid fertilizers and municipal sewage sludge includes the following technical solutions:

- set for injecting loose organic and mineral fertilizers into the soil, utility model W.68444 (2016)
- slurry tanker for subsurface dosing of liquid fertilizers, invention P.236250 (2021)

6. Competing technologies and competitors

The obtained patent for the slurry tanker for subsurface application of liquid fertilizers proves the lack of devices with similar technological features on the market. Slurry tankers of a similar type found on farms are used for spreading fertiliser directly on the surface of cultivated areas. The patent for the invention P.236250 was granted to the authors this year and so far, due to restrictions related to the spread of the SARS-CoV-2 virus, no steps have been taken to commercialise the idea.

Crop drying technology based on renewable energy sources

Creators of the technology:

Witold Niemieć

Tomasz Trzepieciński

1. Description of the innovation

Drying food and fodder is a long-established method of preserving agricultural produce. Natural drying methods using the heat of sunlight are the cheapest and generally available methods, which are still being improved.

Scientific developments have made it possible to identify many of the biologically active substances found in plants, even those that are not considered herbs, such as energy willow and wicker. Herbal plants, mainly used as feed additives, are characterised by many therapeutic properties. Herbs stimulate the secretion of digestive juices in animals, increase appetite and gastrointestinal peristalsis. Currently, crushed shoots of medicinal plants are added to the daily feed, which is not the optimal way to absorb therapeutic or disease-preventing substances into the animal organism. When used prophylactically, herbal mixtures make animals more resistant to disease and by reducing disease incidence, livestock welfare is improved.

The guiding idea behind the innovative solutions for crop drying equipment is to adapt their operating parameters to drying processes on small and medium-sized farms. As part of the development of this food preservation technology, a dryer for volumetric agricultural crops (Figure 29) and a dryer for drying herbs, supported by a modular air solar collector and an air heating furnace, have been developed. The mobile container dryer uses renewable energy sources in the form of an air solar collector with photovoltaic cells to ensure that an efficient drying process is carried out and that thermal energy is recovered and electricity is produced for the dryer's own use.

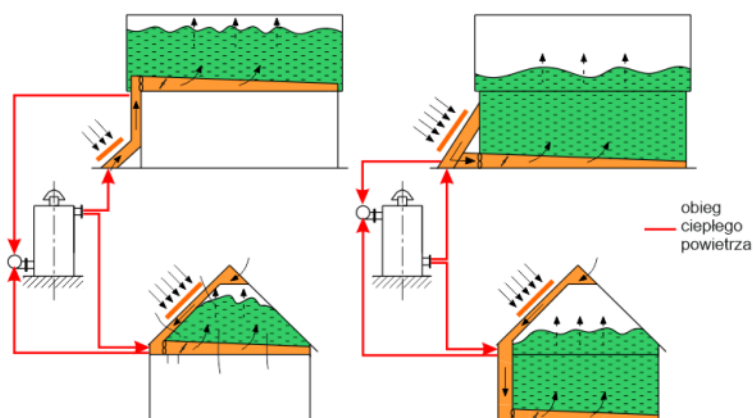


Figure 29: Diagram of a dryer for drying voluminous agricultural crops.

2. Potential markets

The equipment included in the crop drying technology is based on renewable energy sources and can be used in crop processing plants to support crop drying operations and on livestock farms. Dryers powered by renewable energy are also desirable in small family processing plants of agricultural products,

where the use of devices that are easy to operate and do not require specialist service is economically justified. A container dryer, which is energy-independent of mains electricity, can be used in forestry districts for drying undergrowth intended for feeding wild animals.

3. Market interest

The above-mentioned devices were developed as part of the authors' long-term cooperation with representatives of the Cooperative Group of Energy Plant Producers in Boguchwała, who indicated increasing interest among growers in the development of herbal production. The devices available on the market for mass (industrial) drying of agricultural crops are financially inaccessible for an average herb grower. A need has arisen to develop equipment adapted to small-scale production of herbal agricultural crops.

4. State of the development of the innovation- technology maturity level

TRL2 level of technological readiness.

5. Protection of intellectual property

The developed technology for drying agricultural crops includes the following technical solutions:

- air heating furnace - utility model W.71062 (2019).
- burner for burning biomass, especially in the form of woodchips - utility model W.71140 (2019).
- dryer for voluminous agricultural crops - invention P.234814 (2017).
- dryer for agricultural crops especially herbs - invention application P.428516 (2019).
- modular solar collector and method of controlling this collector - invention P.236504 (2021).
- container dryer - invention application P.424894 (2018).

6. Competing technologies and competitors

Dryers suitable for almost any scale of production are available on the market, but unfortunately they are highly energy intensive, as they are most often powered by natural gas or electricity. The solutions proposed by the authors make use of renewable energy and the energy of burning biomass, which can be found in almost every farm in various forms. The container dryer (invention application P.424894) does not require mains electricity and enables drying in hypsographically diverse terrain, practically in the place where the herbal crop occurs. Based on the device covered by the invention application P.424894, the authors have also developed a mobile version of the dryer, mounted on a light transport trailer.

Log debarking equipment

Creators of the technology:

Witold Niemiec

Tomasz Trzepieciński

1. Description of the innovation

The bark of *salix viminalis* is rich in bioactive components used in phytopharmacology as well as in veterinary pharmacotherapy, e.g. salicortin, fragilin, salicin, proanthocyanidins and naringenin derivatives. The primary way to recover the active substances found in the willow bark is to extract these components in water baths. While debarking thin willow shoots to separate the bark from the phloem is not cost-effective, debarking shoots with a diameter of several to several hundred millimetres, where the layer of bark and phloem can reach 5-15 mm, can bring measurable economic benefits. Known devices for debarking logs do not allow or allow only to a limited extent for effective debarking of willow shoots with a diameter of several centimetres. The device developed for debarking logs, incorporating electro-mechanically powered rotary cutting tools, is characterised by containing a coarse cutting unit and a fine cutting unit, thus enabling independent cutting of bark layers of the desired depth.

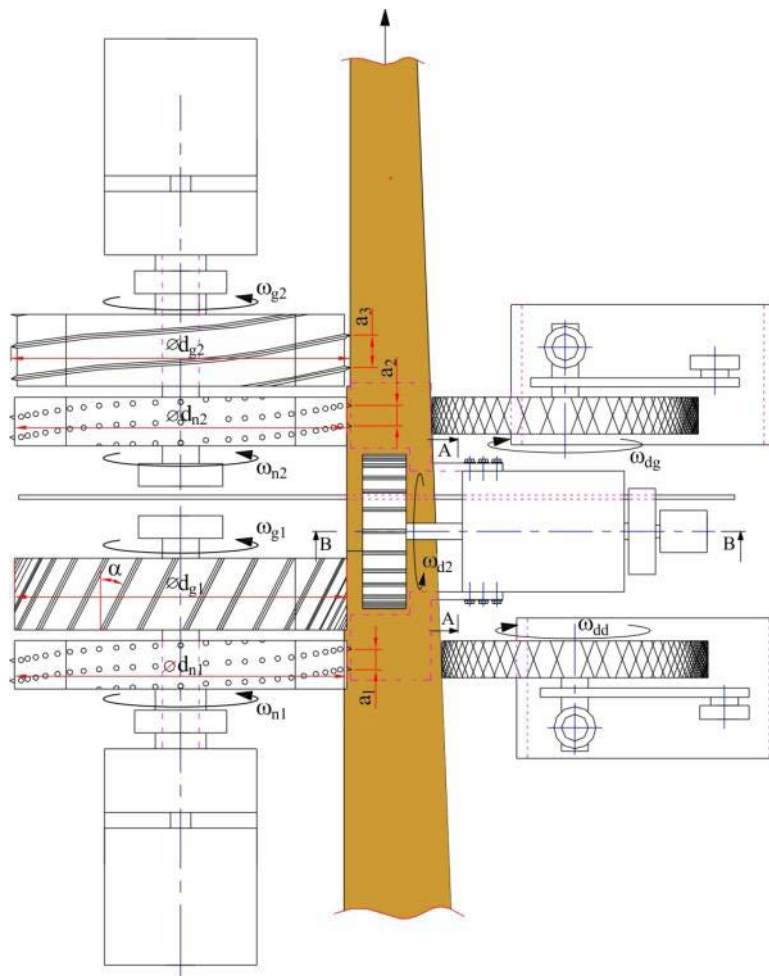


Figure 31: Diagram of the log debarking machine.

2. Potential markets

The device can be used:

- on farms and in companies growing and processing wicker and other plants with ligneous shoots,
- in timber processing plants.

3. Market interest

The device has been developed on the basis of discussions with representatives of the Cooperative Group of Energy Plant Producers in Boguchwała and the company dealing with the cultivation and processing of purple willow - HEJS from Rudnik nad Sanem, the capital of the wicker industry in Poland

4. State of the development of the innovation - technology maturity level

TRL2 level of technological readiness.

5. Protection of intellectual property

Device for debarking flaccid shoots of lignified plants - invention application P.428765 (2019),

6. Competing technologies and competitors

There are no commercial competing solutions on the market.

Device for removing impurities from lignified plant shoots

Creators of the technology:

Witold Niemiec

Tomasz Trzepieciński

1. Description of the innovation

The pro-ecological trend in agricultural production makes it necessary to search for effective non-pesticide methods of ensuring the cleanliness of woody plant shoots, on the way to ensuring high quality weaving material. The main disadvantages of the equipment known from the state of the art analysis are that the cleaning of the shoots takes place after the plants have been cut. This makes it difficult to remove impurities, mainly in the form of vines, which become hard as a result of moisture loss. The additional technological operation of removing weeds from the shoots of plants with lignified stems, mainly wicker, prolongs their processing and reduces the economic productivity of processing. The device for removing impurities from lignified shoots of plants, especially wicker, is devoid of this drawback. The device is mounted on the front linkage of tractor tools and ensures removal of impurities from growing shoots, preceding the process of cutting and tying them into sheaves. The advantages of the device include, first of all, reduction or, in many cases, elimination of the necessity to remove impurities from shoots manually, increase in processing efficiency as compared to manual work of a person, high reliability connected with an uncomplicated construction of the device and a possibility of cooperation with a typical agricultural tractor.

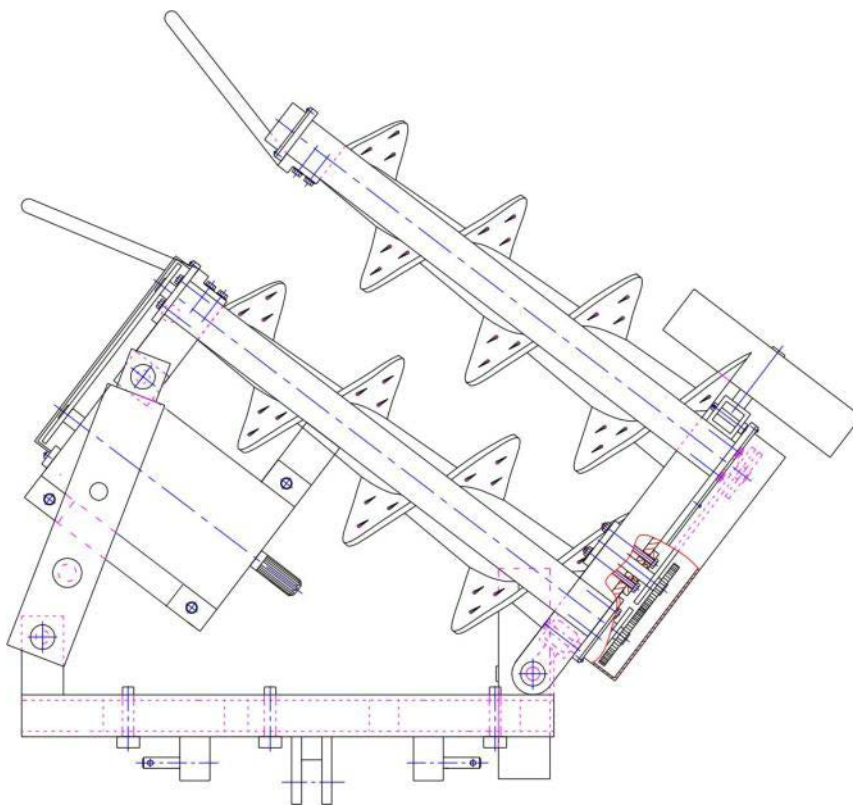


Figure 32: Diagram of the device for removing impurities.

2. Potential markets

The equipment can be used:

- on farms and in businesses growing energy willow, as well as other plants with ligneous shoots,
- on wicker plantations, for removing impurities from growing shoots before the harvest stage.

3. Market interest

The device was developed on the basis of discussions with representatives of the Cooperative Group of Energy Plant Producers in Boguchwała and with the company dealing with the cultivation and processing of purple willow - - HEJS from Rudnik nad Sanem, the capital of the wicker industry in Poland.

4. State of the development of the innovation - technology maturity level

TRL2 level of technological readiness.

5. Protection of intellectual property

Device for mechanical removal of impurities from lignified shoots of plants, especially wicker

- invention application P.430635 (2019).

6. Competing technologies and competitors

There are no commercial competing solutions on the market.

Devices for debarking lignified shoots of plants

Creators of the technology:

Witold Niemiec

Tomasz Trzepieciński

1. Description of the innovation

The debarking device for debarking flaccid shoots of lignified plants is characterised by the fact that inside its body there is a tripartite ring with a pair of three inserts with screw-shaped projections with different pitch of the screw line fixed on the circumference, the position of which is automatically adapted to the diameter of the shoots to be debarked. The advantages of the device for debarking lignified shoots include, above all, the possibility of mechanising traditional manual debarking, which is commonly applied to wicker shoots. By using the device, it is possible to achieve an increase in debarking efficiency in relation to manual work. Screw-shaped protrusions on the retracting inserts provide additional peeling of the bark, increasing the efficiency of the processing. The positioning of the intake and debarking inserts relative to the tripartite ring and to each other allows the head to be personalised for specific types of shoots with different bark thicknesses.

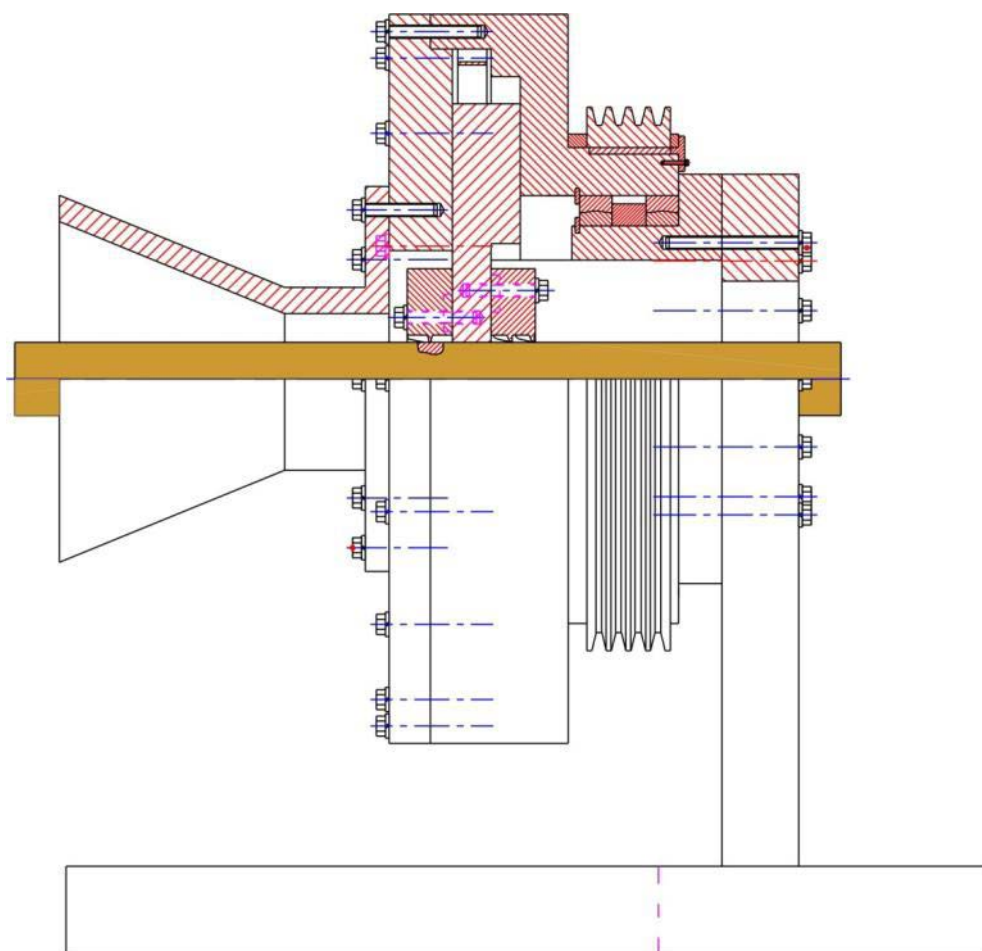


Figure 33: Diagram of a device for debarking lignified shoots of plants.

2. Potential markets

The device can be used:

- on farms and in companies growing and processing wicker and other plants with lignified shoots,
- in wood processing plants.

3. Market interest

The device has been developed on the basis of discussions with representatives of the Cooperative Group of Energy Plant Producers in Boguchwała and the company dealing with the cultivation and processing of purple willow - HEJS from Rudnik nad Sanem, the capital of the wicker industry in Poland.

4. State of the development of the innovation - technology maturity level

TRL2 level of technological readiness.

5. Protection of intellectual property

Device for debarking lignified shoots of plants, especially wicker - invention application P.430634 (2019).

6. Competing technologies and competitors

There are no commercial competing solutions on the market.

Device for sorting lignified plant shoots

Creators of the technology:

Witold Niemiec

Tomasz Trzepieciński

1. Description of the innovation

Sorting is one of the most labour-intensive technological operations. Automation of sorting slender elements into a specific range of length changes is particularly desirable in the production of elements from willow wicker. The manual work carried out so far while sorting willow is tedious, requires the use of considerable force and is reluctantly taken up by employees. Moreover, the work performed is most often burdened with low accuracy, geometric variation of resilient shoots, and its effectiveness depends on the individual, usually poorly efficient workers.

Mechanisation of the process of sorting wicker, due to the length of shoots, is economically justified by the production of products of different sizes and for different purposes. Until now, long shoots have usually been cut by hand into specific lengths for the manufacture of small products, which is associated with high losses of valuable weaving material.

Willow shoots intended for the manufacture of weaving products can have a diameter of less than 7 mm, which is why a device has been developed to sort shoots with a diameter of between 4 and approximately 20 mm. Sorting small diameter shoots is difficult due to the high flexibility of the shoots. This disadvantage is eliminated by using flexible pressure bands with appropriately shaped projections on the outer surface. The innovative device is characterised by the ability to sort flaccid shoots with a variable curvature and cross-section, often entangled with each other. The value of the pressure force of the sorted products on the table can be controlled by changing the number of bands on the width of the table and the position of their guides.

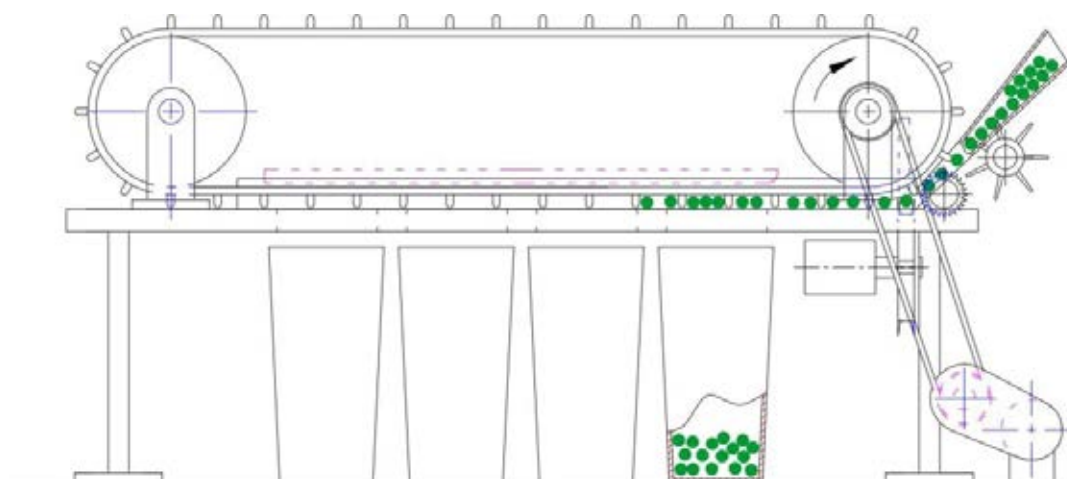


Figure 34: Diagram of the sorting device.

2. Potential markets

The machine may be used by farms and businesses growing and processing wicker and other plants with lignified stems.

3. Market interest

The device has been developed on the basis of discussions with representatives of the Cooperative Group of Energy Plant Producers in Boguchwała and a company involved in the cultivation and processing of purple willow - HEJS from Rudnik nad Sanem, the capital of the wicker industry in Poland.

4. State of the development of the innovation - technology maturity level

TRL2 level of technological readiness.

5. Protection of intellectual property

The device for sorting lignified plant shoots and the method of sorting lignified plant shoots using this device - invention application P.430629 (2019).

6. Competing technologies and competitors

There are no commercial competitive solutions on the market.

Pneumatically driven shoot cutter

Creators of the technology:

Witold Niemiec

Tomasz Trzepieciński

1. Description of the innovation

The long-lasting tradition of wicker weaving in Poland and the growing interest in products made of natural raw materials are encouraging the development of this economic sector. Harvesting wicker consists of three main stages: cutting the shoots, binding them into sheaves and transporting them to the processing site.

The developed pneumatically driven shoot cutter is a multifunctional device which makes it possible to cut shoots at a specific height and store them in a handy container. The use of the accumulator is limited to shoots with little curvature, and wicker shoots meet this requirement. While it is not economically justified to use a shoot cutter on large plantations, on small plantations and under conditions of plantation thinning, the cutter will fulfil its function perfectly. The device is supplied with compressed air directly from the pneumatic system of an agricultural tractor, through an air tank connected to the compressor of the tractor, or alternatively, by means of a backpack container with compressed air.

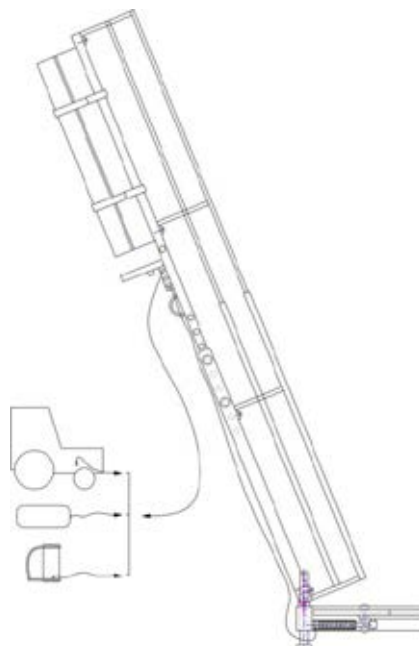


Figure 35: Diagram of a pneumatically driven shoot cutter.

2. Potential markets

The device can be used:

- on farms and in companies growing and processing wicker and other plants with lignified shoots,
- on wicker plantations to remove impurities from growing shoots before the harvest stage,
- during the pruning of fruit trees,
- in companies that manage green areas and maintain the green areas surrounding streets, airports, railway and industrial facilities and road infrastructure.

3. Market interest

The device was developed on the basis of talks with representatives of the Cooperative Group of Energy Plant Producers in Boguchwała and a company dealing with the cultivation and processing of purple willow - HEJS from Rudnik nad Sanem, the capital of the wicker industry in Poland.

4. State of the development of the innovation - technology maturity level

TRL2 level of technological readiness.

5. Protection of intellectual property

Pneumatically driven shoot cutter - invention application P.437242 (2020).

Method of preparing polyetherols with a 1,3,5-triazine ring

Creators of the technology:

Dorota Głowacz-Czerwonka, PhD, Eng.

Jacek Lubczak, Prof., DSc, PhD, Eng.

1. Description of the innovation

The object of the invention is a method for producing multifunctional polyetherols with a 1,3,5-triazine ring using reactive melamine solvents. These polyetherols are used in the production of polyurethanes, especially polyurethane foams characterised by increased heat resistance.

2. Potential markets

The proposed method can be used in those industries where rigid polyurethane foams are produced and used as insulation materials. The innovation is an increased thermal resistance of the foams (even up to 200C). This allows them to be used, among others, for insulation of pipelines transporting heating media

3. Market interest

Market analysis has not been conducted so far.

4. State of the development of the innovation - technological maturity level

3 or 4.

NanoForms server: analysis and assembly of small genomes using Oxford Nanopore technology

Creators of the technology:

Michał Piętał

Dominik Strzałka

Anna Czmił

Sylwester Czmił

Michał Wroński

Michał Ćmił

1. Description of the innovation

General characteristics:

The bioinformatics server solution is a device for processing 'raw' sequencing data from small genomes (e.g. bacteria), using Oxford Nanopore technology, into DNA sequences. The server also enables hybrid assembly of the genome, together with Illumina sequencing data.

The server is dedicated for biologists - users of Oxford Nanopore sequencing technology (NGS), who do not have bioinformatics (computer science) knowledge, but need to obtain the DNA sequence of the organism being tested. The alternative to using a server is to install a number of console (Linux) tools and run them from the command line, which is often an insurmountable barrier for people not trained in programming and/or Linux.

2. Potential markets

- scientific laboratories (worldwide) studying small genomes (bacteria, yeast),
- commercial laboratories (worldwide) studying small genomes,
- pharmaceutical and biotechnology companies studying small genomes.

3. Market interest

Nanopore technology is finding more and more new customers and, due to its low cost and ability to sequence long fragments, is becoming popular at an exponential rate.

As a result, a number of entities (as mentioned above) are condemned to use either external services to process their raw genomic data, or to use similar solutions at a lower cost than dedicated external analysis.

4. State of the development of the innovation - technology maturity level

Currently, a scientific publication is under reviews, which will probably popularise the solution.

The current maturity level is assessed at TRL 4 - TRL 5.

5. Protection of intellectual property

The solution is protected under the Copyright and Related Rights Act as a work (computer program). The solution is distributed in a SaaS formula, as a bioinformatics server, without making the sources available. External components (bioinformatic programs) incorporated in the server are made availab-

le under open licences (e.g. GPL v.2), however, as it is a service, the server code may be closed source. The software is released under a royalty-free licence for scientific use, which is a sine qua non for publishing the server as such. Publication, in turn, is an important part of marketing the solution; moreover, this is the overriding objective behind the research funding for the development of this server (PCI grant, 2020).

It is possible in the future, to make the server available under a commercial licence to commercial entities.

6. Competing technologies and competitors

There are similar solutions on the market, i.e. CGE, Enterobase, Galaxy Tools, Patric or EPI2ME, but they do not offer comparable functionality, only some similarities.

Direct competition - the Nano Galaxy server. This solution offers the same or similar functionality, so at this point, you can count on about 50% of the target market.

Social interaction matrices for pandemic development forecasting

Creator of the technology:

Michał Piętał

1. Description of the innovation

General characteristics

The solution is to use the author's previous basic research (Piętał et al., 2015) to model and forecast pandemics (coronavirus and others). Data from a plethora of currently available location sources (e.g. cellular data - the scope beyond technology) can provide real-time information about contacts between individuals in a population (e.g. country). This can be done using GPL or LBS technology (the latter - less accurate, but works better in buildings), or BlueTooth.

Given a daily list of people (I_1, I_2) staying in contact (e.g. for 5 minutes at a distance of less than 5 m), we can store this data in a large matrix ($38,000,000 \times 38,000,000$) while preserving anonymity. By determining an additional "attenuation factor", the distance on this matrix can be counted (distance 1 = direct contact, distance 2 = two people contacted a third person at the same time, etc.) and in this way we can, depending on the "infectiousness" of the pathogen, designate "risk groups", e.g.

- 1,2,3 – persons in close proximity, high risk;
- 4,5,6 – medium risk;
- 7,8,9 – low risk;
- ...
- e.g. above 10 - "safe" persons.

The last group can be used for the safety of the so-called VIPs.

Now, receiving information about infection (e.g. with coronavirus) of a single person with a K-index in the matrix, it is possible to find appropriate distances between K and all other persons, in order, e.g., to alert persons (SMS) in close proximity about the risk of infection. As mentioned above, on a daily basis, all values can vary in time, in the form of a "suppression" of the signal (all values) by a fixed 1-d parameter.

The solution can be combined with high-level forecasts (number of infections in the country), providing them with a tuning parameter (e.g. in the form of: an average "social" distance in the matrix population).

2. Potential markets

- local government institutions (districts, provinces, government, abroad).

3. Market interest

Taking into account the social and market costs of the COVID-19 pandemic, it can be expected that the tool, if effective, i.e. better than currently used, has commercial potential.

4. State of the development of the innovation - technology maturity level

Currently, the innovation is at TRL 2 level as its commercial potential has been recognised, but no relevant research has been conducted beyond (limited) literature research.

The technology should be upgraded to TRL 4 -TRL 5 by the end of 2021.

5. Protection of intellectual property

The solution, for the time being, is protected as know-how (Unfair Competition Act).

In the situation of the development of a prototype / MVP, which will be tested in laboratory conditions (the above-mentioned PCI grant), it is possible (and advisable) to patent the technology (calculations on matrices linked to the mobility coefficient).

Non-extensive population growth models

Creator of the technology:

Dominik Strzałka

1. Description of the innovation

General characteristics:

A solution based on the application of the concept of non-extensive statistics in the modelling of processes and phenomena occurring in complex systems. The main objective is to be able to generalize in mathematical formulas the exponential function by means of its non-extensive counterpart (q-exponent), based on the C. Tsallis thermodynamics.

A solution with potential applications in modelling non-exponential phenomena and processes with respect to populations and pandemics. The proposal is dedicated in particular to scientists involved in process modelling, specialists in crisis management, public administration, for hospital directors. It includes: data processing, fitting data to different curves, determination of critical parameters, approximation, interpolation, extrapolation and prediction. The solution can be based on freely available Python and R libraries.

2. Potential markets

- emergency management centres,
- hospitals,
- public administration.

3. Market interest

Recently, the issue of modelling the rate of development of various types of populations and phenomena has become crucial, in connection with the COVID-19 epidemic. The possibility of effective management of human and material resources in the fight against the new threat is extremely important, given the seriousness of the situation and the impact on the economy and the economic situation, as well as the long-term effects on the population.

4. State of the development of the innovation - technology maturity level

Currently the proposed solution has a maturity level of TRL 2.

5. Protection of intellectual property

The base solution refers to a generalization of a mathematical function and as such cannot be protected by a patent, but its use requires the construction of an appropriate data processing system in the form of a computer program. Under copyright and related rights law, it can be protected like any work. The solution can be distributed in a SaaS formula, e.g. as a server, without making the sources available in the form of a royalty-free licence for scientific or commercial applications for emergency centres.

6. Competing technologies and competitors

There are other epidemic development modelling solutions on the market, based on SIR, SIS, SEIR, etc. models, but they do not use the generalization of the equipotential function. They are therefore similar, but do not offer a solution relating to non-extensive thermodynamics and anomalous diffusion.

ICT system for the analysis of spa treatment efficiency

Creator of the technology:

Dominik Strzałka

1. Description of the innovation

A solution based on the acquisition, via an ICT server, of anonymous medical data and questionnaires for the analysis of health status and progress of spa treatments and so-called complementary treatments based on spa cosmetics. The main goal of the solution is to collect a large set of data, in order to use methods based on machine learning to develop mathematical and statistical methods for analysing these data and algorithms for their visualisation and preliminary recommendations, in order to determine the optimal treatment.

The fundamental innovation of the solution is also the construction of a unique mathematical apparatus, the creation of a procedure for collecting (questionnaire) data from patients (medical interview: "before" and "after" plus individual anonymous questionnaires), the design of algorithms of the Data Mining class, which, often on the basis of incomplete, contradictory data, will allow to resolve inaccuracies in the form of decisions "to improve health". For this purpose, a server will be built, capable of collecting data from the spa, which will be in the given segments of the type: gender / age group / spa collect and provide reliable, statistical data, in the form of the degree of effectiveness of treatment procedures in spas and the use of spa cosmetics. This will allow for a much better selection of variants, ranges, frequency, duration and possible repetition of spa treatments.

2. Potential markets

- public health resorts in Poland,
- institutions and companies providing therapeutic services and spa treatments,
- public administration.

3. Market interest

According to CSO statistics, in 2017 in Poland 271 spa treatment facilities admitted 808.1 thousand patients.

The proposed solution should improve many important parameters in the health resort, e.g. a possible increase of 10% in the number of patients, a possible increase of 15% in the number of patients using the services of all treatments, a reduction of waiting queues by 20%, an improvement in the effectiveness of the treatment measured by an increase in patient satisfaction (e.g. average score), an improvement in the financial status of the health resort, etc. If we refer to the CSO data from 2017, only a 1% increase in the number of patients in Poland means an in-plus change for 8,000 people. The operating costs of spas in 2018 are 683,894 thousand; an improvement of only 1% means savings of around 7 million. Furthermore, according to a report by The Global Wellness Institute (2018), the global wellness market is worth \$4.5 trillion, including spas - \$56 billion (market growth 10% y/y). In addition, once the COVID-19 outbreak is over, due to its as yet unknown side effects, interest in spa stays is expected to increase significantly. This will be partly due to restrictions in their operation and partly due to possible complications after the COVID-19 disease. Interest in the commercial use of the obtained results

has been expressed by the Latoszyn Health Resort. Commercialisation of the implemented R&D works may consist in sale of rights or granting licenses, e.g. to the Association of Health Resort Communities of the Republic of Poland or the Union of Polish Health Resorts Association, or construction of a (mobile) application of personalised medicine type.

4. State of the development of the innovation - technology maturity level

The solution is at the TRL 2 level. On the basis of conducted analyses a concept of construction and implementation of a system collecting and analysing data from anonymous questionnaires of spa patients has been created in order to develop a strategy for the functioning of the centre and optimisation of the scope and time of selected spa services, with reference to the range of basic therapies in the spa, as well as additional ones using spa cosmetics.

5. Protection of intellectual property

Patent protection is not envisaged. The project will create an information system (software) that, based on developed mathematical (statistical) models and prepared specific rules of reasoning, can be used to optimize the operation of health resorts and the range of treatments provided to patients. The developed system (data base, software) is protected without additional formalities as a work in accordance with the Act on Copyright and Related Rights. Since there is a possibility of commercialisation of the system after its preparation (e.g. under a commercial licence), its source code and structure will be protected as know-how (closed source software distribution model). Additional protection is the protection of know-how (Act on Unfair Competition). For this reason, a dedicated license audit can be performed for use in e.g. the cloud - SaaS model (e.g. licenses: GPL, LGPL, BSD, MIT, etc.). Additional protection is the protection of the database itself (Copyright Act and Database Protection Act, cumulatively).

6. Competing technologies and competitors

There are no other similar solutions on the market.

Method for measuring intramuscular fat content in pork meat

Creators of the technology:

dr hab. inż. Krzysztof Tereszkiwicz, prof. PRz

dr inż. Henryk Wachta

dr inż. Łukasz Kulig

1. Description of the innovation

The object of the invention is a method for measuring the intramuscular fat content in pork meat. The method uses the phenomenon of luminance and allows for determination of the surface intramuscular fat content on the basis of the collected image, and due to the occurrence of strict correlations, allows for determination of the volume fat content in the examined meat sample. Measurement of fat content in meat consists in taking an image with a luminance matrix meter and analysing it using proprietary software. The procedure yields a result with a high correlation coefficient with the reference evaluation of intramuscular fat content. The method allows results to be obtained quickly, cost-effectively and non-invasively.

2. Potential markets

The meat processing and packaging sector.

3. Market interest

The meat processing industry is increasingly using IT methods to assess the course of the processing process. This type of rapid technology for quality assessment has great potential for implementation, which is also confirmed by the results of the application of this type of solution in food raw material processing plants.

4. State of the development of the innovation

TRL 3 technology maturity level

5. Protection of intellectual property

Rzeszów University of Technology

Application numbers: P.431551, P.431552

6. Competitive technologies and competitors

Competing technologies - colorimetric, ultrasound, near infrared.

Mobile 3D-Mobile additive manufacturing system

Creators of the technology:

prof. dr hab. inż. Grzegorz Budzik

dr inż. Łukasz Przeszłowski.

1. Description of the innovation

The mobile additive manufacturing system is designed for stand-alone operation outside of normal manufacturing facilities and can be an important addition to a service or repair system in harsh field conditions, such as for military applications.

The system consists of a 3D printer, an impact- and weather-resistant transport case, a photovoltaic panel, a gel battery, and a power inverter. The 3D printer operates using the FFF process and is designed to process different types of materials under varying conditions of use. The system's power supply is multi-source, including standard mains power (110V and 230V), battery power supported by a photovoltaic panel and the possibility of power supply from other sources. The set also includes a data processing computer, equipped with a shock-resistant case. The mobile system can be used in field factories or workshops as a support element for energy, railway or transport companies. It can also serve uniformed services, including the army, as an element of support for the field system of repair and production of spare parts, in conditions of isolation from standard supplies.

2. Potential markets

The solution has a universal character and can be an element of laboratory equipment, a production line and a system of independent work for the power industry, transport, rescue and uniformed services.

3. Market interest

Market interest may arise in many aspects due to the wide application of additive technologies, including 3D printing. Potential buyers may include companies that have not previously used 3D printing systems and would like to implement a mobile system that is versatile in nature. Additionally, the marketing sector may be interested, where unconventional manufacturing activities in unusual places are often needed, as well as the area of repair services in companies that do not have permanent production and workshop facilities.

4. State of the development of the innovation - technology maturity level

The solution is at the stage of completing tests in the environment simulating real conditions, thus the level of technological readiness can be defined at the TRL 5- 6 level.

5. Protection of intellectual property

The solution has been created as a result of work of a team composed of: Grzegorz Budzik, Prof., DSc, PhD, Eng., Łukasz Przeszłowski, PhD, Eng., in the Rzeszów University of Technology, Faculty of Machine Construction.



Figure 36: 3D-Mobile additive manufacturing system.

REMOTE 3DPV1 remote additive manufacturing system

Creators of the technology:

Prof. dr hab. inż. Grzegorz Budzik

dr inż. Łukasz Przeszłowski

1. Description of the innovation

The system of remote additive manufacturing is based on technological and software solutions, which may include: 3D-CAD design and modelling, numerical data processing, process automation, additive process monitoring and process computerisation. The combination of these elements gives the possibility to use the full potential of remote systems within the INDUSTRY 4.0 structure. The construction of the system is based on technical solutions allowing to use network tools and technologies for integration.

Additive manufacturing as a set of universal technologies integrated in a remote mode can be used for the production of light and resistant supporting structures, for the design of which it is possible to use elements of topological optimisation, used as final products and semi-finished products intended for further processing. In the remote system, the way in which monitoring processes are integrated based on multiple software and visual inspection using a camera system is important. This makes it possible to follow the process and to react depending on the stage of the process and the occurrence of possible irregularities. The system has a modular structure, hence modules can be combined to achieve increased production capacity.

2. Potential markets

The solution is intended for small and medium-sized enterprises, as well as factories which have 3D printers in their stock, plan to make such investments, or are looking for remote system solutions in the area of additive technologies.

3. Market interest

The solution has a universal character, e.g. for companies where the main place is occupied by additive technologies, and other devices and equipment are used for production preparation and finishing, as well as for companies which have not used additive manufacturing systems so far. Taking this into account, a solution has been developed in such a way that it can be quickly modified according to the needs of the company.

4. State of the development of the innovation - technology maturity level

The solution is at the stage of completing tests in the environment simulating real conditions, thus the level of technological readiness can be defined at the TRL 5-6 level.

5. Protection of intellectual property

The solution has been created as a result of work of a team composed of: Grzegorz Budzik, Prof., DSc, PhD, Eng., Łukasz Przeszłowski, PhD, Eng., in the Department of Machine Construction of Rzeszów University of Technology.



Figure 37: REMOTE 3DPV1 remote additive manufacturing system.

Integrated system for additive manufacturing and coordinate measuring system

Creators of the technology:

Grzegorz Budzik, Prof., DSc, PhD, Eng.

Tomasz Dziubek, DSc, PhD, Eng.

Łukasz Przeszłowski, PhD, Eng.

Andrzej Paszkiewicz, PhD, Eng.

1. Description of the innovation

The integrated system of additive manufacturing and coordinate measurement of processes is based on the methodology of transfer and analysis of measurement data in the so-called real time mode, where it introduces the time dimension as an element of the design process of manufacturing and measurements, understood as a multi-layer element with the use of Real Time type operations and operations performed in the background, based on information coming from the system data cloud. This type of approach can significantly shorten the design and manufacturing process using feedback loops, e.g. in the area of analysis of data obtained from the spatial scanning process using network tools and systems. The system's methodology is dedicated to the INDUSTRY 4.0 structure, which defines the integration of manufacturing systems, based on their automation using integrated numerical and IT tools linked in networks of different integration scales. The system includes additive technologies selected from the Rapid Prototyping package and computer-aided measurement technologies selected from the Rapid Inspection package. The integration of additive systems and 3D scanning allows for rapid measurement results of prototypes and products, as well as the use of feedback in the design and manufacturing process.

2. Potential markets

The solution is intended for small and medium-sized enterprises, as well as companies that have 3D scanners and 3D printers in their resources and are planning to make such investments, so they are looking for solutions integrating in the area of additive technologies and fast measurement technologies.

3. Market interest

The solution is universal for, among others, enterprises where coordinate measuring and 3D scanning services are dominant, also where additive technologies occupy the key position. Companies that have not yet used 3D scanning and additive manufacturing systems may also be interested. Taking this into account, a solution has been developed which, in a modular way, enables rapid application, depending on the needs of a given company.

4. State of the development of the innovation - technology maturity level

The solution is at the stage of testing in an environment simulating real conditions, thus the level of technological readiness can be defined at TRL 5.

5. Protection of intellectual property

The solution has been created as a result of work of a team consisting of: Grzegorz Budzik, Prof., DSc, PhD, Eng., Tomasz Dziubek, DSc, PhD, Eng., Łukasz Przeszłowski, PhD, Eng., Andrzej Paszkiewicz, PhD, Eng. in the Rzeszów University of Technology, Faculty of Machine Construction.

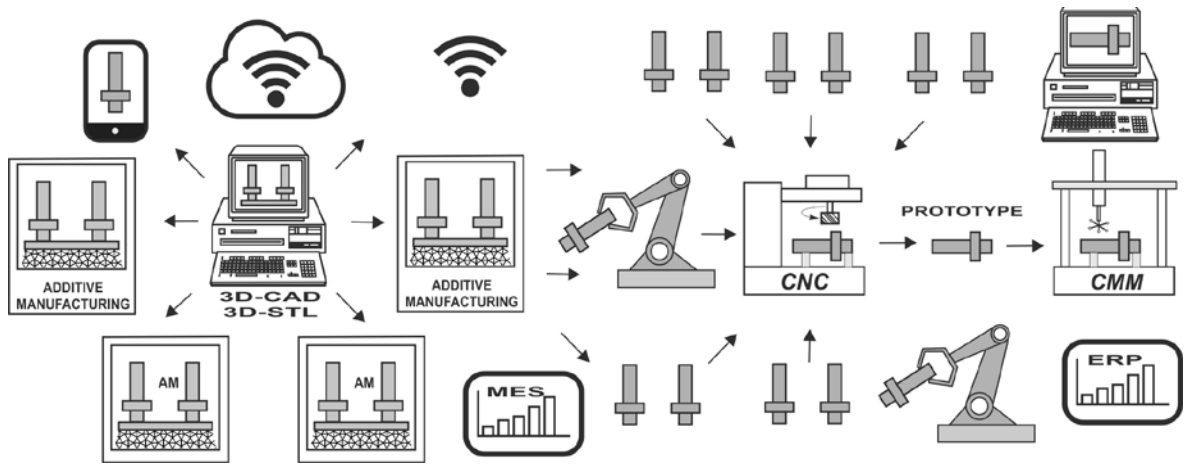


Figure 38: Schematic diagram of an integrated additive manufacturing and coordinate measurement system.

Method of designing and manufacturing shell gears using additive technologies

Creators of the technology:

Grzegorz Budzik, Prof., DSc, PhD, Eng.

Tomasz Dziubek, DSc, PhD, Eng.

Bartłomiej Sobolewski, PhD, Eng.

Łukasz Przeszłowski, PhD, Eng.

1. Description of the innovation

The developed constructional and technological solution allows to produce gear wheels with reduced weight by using a shell structure of the wheel disc. The shell structure reduces weight while ensuring high rigidity of the gear wheel, comparable to classically applied structures and traditional, cavity manufacturing methods. This solution is based on incremental technologies.

The application of incremental technology allows to produce a shell geometry of a gear wheel with complex geometry, with pre-made toothing and hub, in a single manufacturing process, while maintaining high dimensional and shape accuracy. In the case of wheels with lower dimensional accuracy, it is possible to produce finished products without additional machining.

When using the available classical methods of gear wheel manufacturing, the limitations result from the technology of removal machining and consist in the impossibility of introducing a tool into the wheel disc and removing the superfluous material.

In the newly developed method, this problem has been solved by using holes of a size selected in such a way as to minimise their influence on the amount of deformation of the structure, which enables the removal of non-composite material from the interior of the gear wheel disc. The removal process will be carried out by gravity or by a pressurised medium.

2. Potential markets

The solution is intended for gear wheel manufacturers, both small and medium enterprises, as well as companies that have 3D printers in their stock, plan to make such investments, or are looking for solutions in the area of incremental technologies and their implementation to produce this kind of machine parts. The main recipients of this technology for manufacturing gears could be the aerospace and automotive industries, whose goal will be to minimise the mass of components while ensuring their strength parameters. In the group of potential buyers of the solution there are also widely understood producers of household appliances.

3. Market interest

The developed solution is dedicated mainly to companies, where additive technologies play a key role. Companies that have not used this type of technology so far, but are involved in the production of gear wheels, may also be interested. By introducing additive manufacturing into a group of such machine parts, companies will be able to significantly broaden their offer, and thus increase their competitiveness on the market. Taking this into account, the developed solution makes it possible to produce gears with reduced weight without the need for dedicated machine tools and enables its rapid application depending on the needs of a given company.

4. State of the development of innovation - technology maturity level

The solution is at the stage of testing in an environment close to the real one, thus the level of technological readiness can be defined at TRL 6 level.

5. Protection of intellectual property

The solution has been created as a result of works of a team consisting of: Grzegorz Budzik, Prof., DSc, PhD, Eng., Tomasz Dziubek, DSc, PhD, Eng., Bartłomiej Sobolewski, PhD, Eng., Łukasz Przeszłowski, PhD,

Eng., in the Rzeszów University of Technology, Faculty of Machine Construction and has been protected by patent number DPP.425201.6skwa.

6. Competing technologies and competitors

In relation to the developed technology, there are no alternative solutions allowing similar results, resulting from the proposed manufacturing technology.

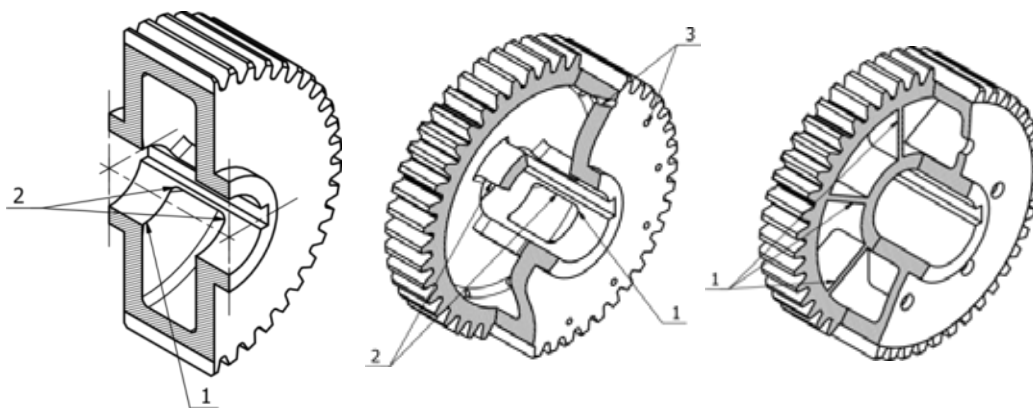


Figure 39: Geometry of a reduced mass gear made using additive manufacturing methods, with holes in the wheel hub to allow material to be removed from the interior.

SMART CLOUD QUALITIES (AM-SCQ)

Platform for quality control of additive manufacturing products

Twórcy technologii:

Grzegorz Budzik, Prof., DSc, PhD, Eng.

Joanna Woźniak, PhD, Eng.

Łukasz Przeszłowski, PhD, Eng.

Paweł Fudali, PhD, Eng.

1. Description of the innovation

The SMART CLOUD QUALITIES (AM-SCQ) platform is a modern solution that includes a quality control procedure for products manufactured incrementally. It allows to create a report consisting of a set of cards.

The view of the platform is presented in Figure 40.

The platform also gives the possibility to preview the model saved in STL format (Figure 41).

When starting to fill in the report, the user first needs to specify basic information such as: the order, the printing method, the equipment and material used for the printing process, as well as process parameters. Then the user can fill in the quality control card, which has been divided into 7 main stages:

Procedura kontroli jakości wyrobów wytwarzanych przyrostowo
SMART CLOUD QUALITIES (AM-SCQ)

THINK VIEW

0 - Parametry procesu

1 - Wstępna ocena wizualna

2 - Dokumentacja fotograficzna

3 - Kontrola za pomocą czujki

4 - Skanowanie optyczne

5 - Skanowanie automatyzowane

6 - Tomografia

7 - UMIŁA

Operowanie raportem

reset

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Figure 40: View of the SMART CLOUD QUALITIES platform.

- initial visual assessment,
- photographic documentation,
- tool checking,
- manual scanner inspection,
- inspection by automated scanner,
- inspection by means of tomograph,
- inspection using coordinate measuring machines.

For each stage, a separate sheet has been prepared with information on how the process is to be carried out and what health and safety precautions need to be taken. It is important that the user selects the

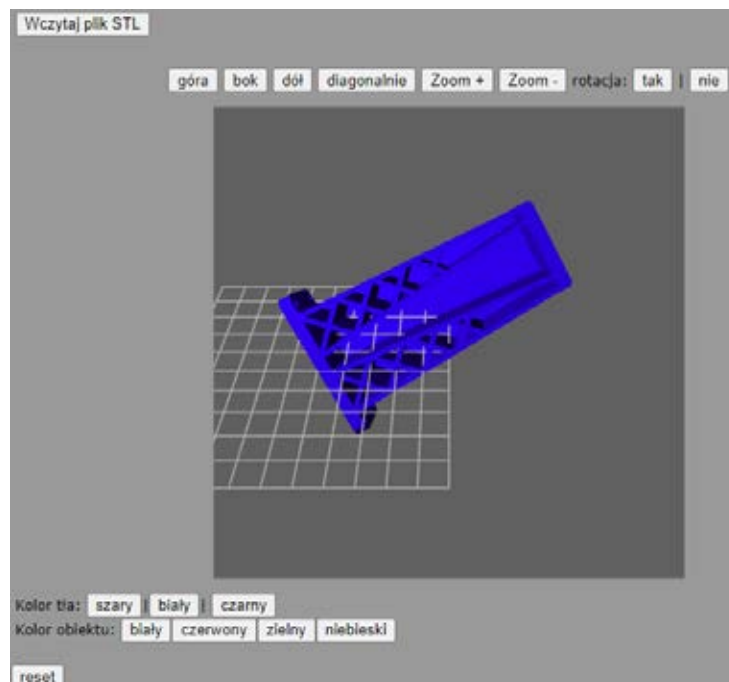


Figure 41: Viewing the model in STL format using the SMART CLOUD QUALITIES platform.

quality control methods according to his own needs. It is therefore not necessary to fill in all the sheets. After completing the card, the qualification of the model (compliant/non-compliant model) must be carried out and the name of the person who approved the step must be given.

The last quality control step is the final qualification of the model and any comments for the customer. After filling in the desired parameters, it is possible to generate a report as a pdf file.

2. Potential markets

The SMART CLOUD QUALITIES platform for quality control of additive manufacturing products is dedicated to companies in the 3D printing industry.

Its advantage is the integration of network distributed components of additive manufacturing quality control processes. It provides a ready-made form template that can be used in the internal cloud. The platform facilitates the task of inspectors, who receive guidance on how to carry out particular processes, while allowing a certain freedom in choosing ways to verify the quality of 3D models. At this point, it is also justified to present the division of responsibilities of individual persons and units at each stage of quality control implementation. Division of responsibility in individual processes will allow to systematize the course and mode of work and introduce corrective actions in case of receiving a complaint from the customer. The use of such solutions is extremely necessary and will positively affect the functioning of companies in the 3D printing industry. In addition, receiving a fully professional quality control report can significantly increase customer satisfaction and loyalty to the company.

3. Market interest

Recent years show that the number of studies on incremental techniques is increasing year by year. Changes are evident in the quality and variety of materials for 3D printing, increased productivity, and improvements in the quality of manufactured components. In addition, further standards are being created across the value chain. This signals a growing need for systematisation of processes in the industry. Although significant progress has been observed in the 3D printing industry, it seems that it has not yet reached the stage of widespread implementation. At sector meetings, attention is drawn to the fact that 3D printing methods are constantly evolving and becoming a serious alternative or complement to existing manufacturing methods. Through the application of incremental technologies to the manufacturing of finished products, there has also been a need to set certain standards for quality control of 3D prints. In the era of the Fourth Industrial Revolution, it is also extremely important to use modern IT systems that allow for the integration of manufacturing processes.

A survey conducted by the authors at the turn of 2019-2020 on a group of 100 companies and scientific

and research institutions using incremental technologies showed that 61% of the surveyed companies verify the quality of prints, and 39% of companies do not foresee such activities. 36% of the 61 companies use only visual verification of print quality, while 64% of the companies prefer additional ways of product quality control, such as: the use of measuring tools, gauges, automated scanning, handheld scanners, tomography, or coordinate measuring methods. The survey further verified the use of cloud-based applications for measurement data analysis.

The results show that 76% of the respondents do not use the possibilities of Cloud Computing. Only 24% of the respondents declare using this technology to assess and analyse the quality of models/finished products.

Based on the knowledge gained at sector meetings and by conducting and analysing surveys, it can be concluded that the 3D printing industry lacks ready-made IT solutions, related to the quality control of incrementally manufactured products, which integrate processes while assigning responsibilities to people for each of them.

Therefore, it seems reasonable to develop a quality control procedure and a report template, as well as to present the division of responsibilities of individual people and departments at each stage of the processes.

The authors, developing the SMART CLOUD QUALITIES platform, meet the expectations of the market by presenting the quality control procedure for products manufactured using additive manufacturing, which includes a ready-to-use form template that can be used in the internal cloud. Additionally, by assigning an employee with the execution of a given process, it increases his/her level of responsibility for the execution of the tasks entrusted to him/her. Such a solution also allows for quick identification of the place where the error occurred, in the case of receiving a complaint from a customer.

4. State of the development of the innovation - technology maturity level

The SMART CLOUD QUALITIES (AM-SCQ) platform is at level VII of the TRL scale (Demonstration of a prototype in operational conditions).

The tests were conducted for a research model created at the Rapid Prototyping Systems Laboratory of the Rzeszów University of Technology. The tests showed that the developed technology is feasible to be used in operational conditions. Currently, the platform is made available to the employees of the Rzeszów University of Technology. The authors are constantly working on improvement activities, which will allow the introduction of additional functions.

5. Protection of intellectual property

The owner of technology is I. Łukasiewicz Rzeszów University of Technology

**Technology Transfer Centre
of the Rzeszów University of Technology**

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