



CTU
CZECH TECHNICAL
UNIVERSITY
IN PRAGUE

R&D ACTIVITIES OF THE DEPARTMENT OF PROCESS ENGINEERING

**Faculty of Mechanical Engineering
Czech Technical University in Prague**

Assoc. Prof. Ing. Lukáš Krátký, Ph.D.
Department of Process Engineering



proceskacvut





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IN PRAGUE

FACULTY OF MECHANICAL ENGINEERING

STUDY PROGRAMMES:

Bachelor study programme

- Mechanical Engineering

Master study programme

- Aeronautics and Astronautics
- Applied Science in Mechanical Eng.
- Automation and Instrumentation Eng.
- Energy and Process Engineering
- Environmental Engineering
- Automotive Engineering
- Manufacturing Engineering
- Robotics and Production Techniques
- Intelligent Buildings
- Nuclear Power Engineering Equipment

Ph.D. study programme

- Applied Sciences in Mechanical Engineering
- Energy and Process Engineering
- Design Engineering and Mechatronics
- Machine and Process Control
- Production and Material Engineering



Practise in ORLEN Unipetrol RPA, Litvínov 9/2022



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FACULTY OF MECHANICAL ENGINEERING

17 DEPARTMENTS:

- **Department of Technical Mathematics**
- **Department of Physics**
- **Department of Mechanics, Biomechanics and Mechatronics**
- **Department of Instrumentation and Control Engineering**
- **Department of Fluid Dynamics and Thermodynamics**
- **Department of Designing and Machine Components**
- **Department of Energy Engineering**
- **Department of Environmental Engineering**
- **Department of Process Engineering**
- **Department of Automotive, Combustion Engine Engineering**
- **Department of Aerospace Engineering**
- **Department of Materials Engineering**
- **Department of Manufacturing Technology**
- **Department of Machining, Process Planning and Metrology**
- **Department of Production Machines and Equipment**
- **Department of Management and Economics**



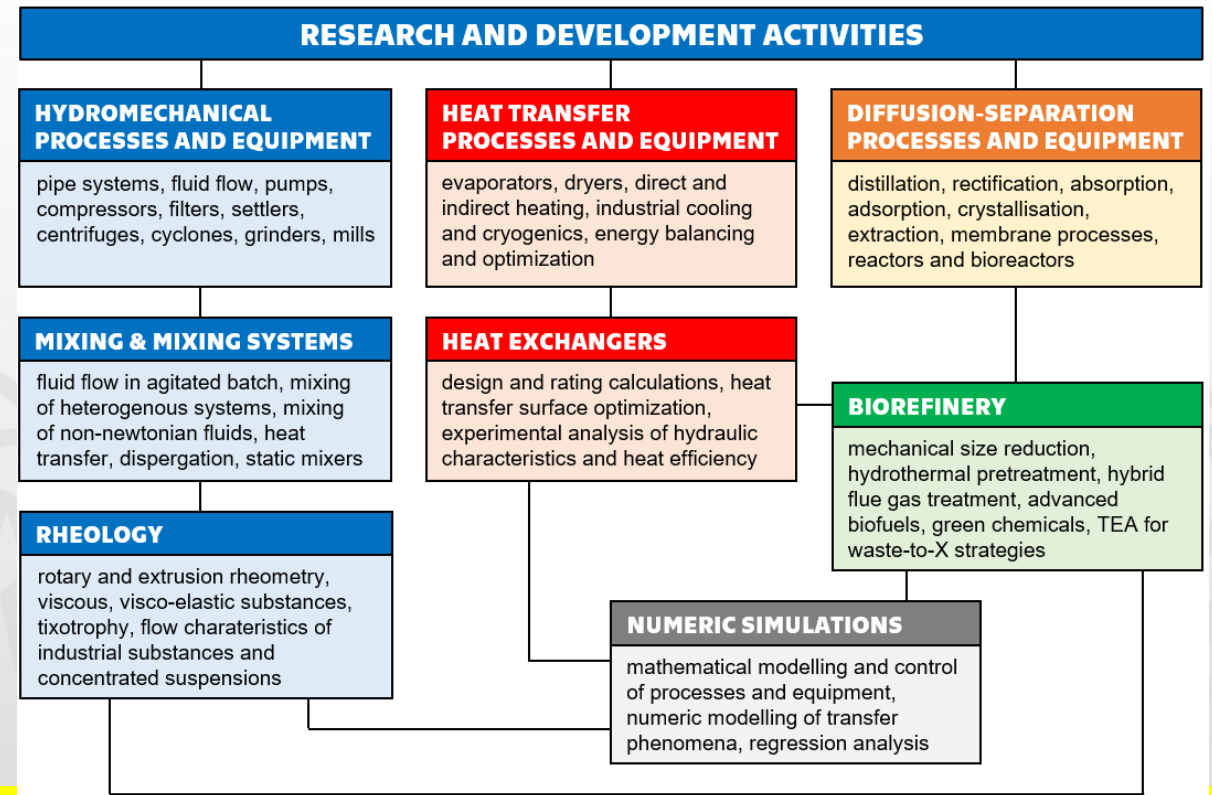
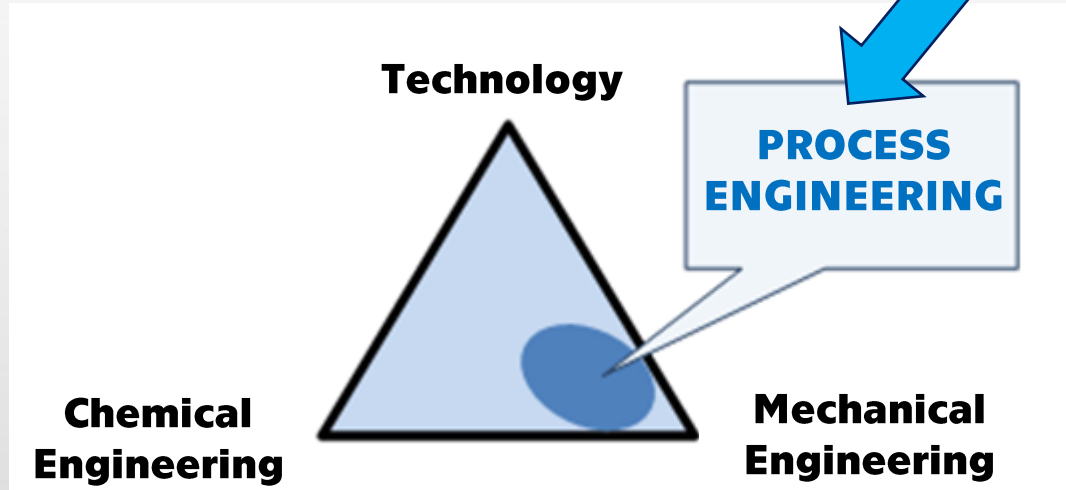
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**CTU**CZECH TECHNICAL
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DEPARTMENT OF PROCESS ENGINEERING

- **Designing equipment and technologies for chemical, food, processing, pharmaceutical industry and biorefinery since 1951.**

**R&D ACTIVITIES
FOR A SUSTAINABLE
CHEMICAL INDUSTRY?**



- **MULTIDISCIPLINARY TRANSFER OF CHEMICAL ENGINEERING AND TECHNOLOGY KNOWLEDGE TO MECHANICAL DESIGN OF APPARATUSES AND PROCESSING LINES.**



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HYDROMECHANICAL PROCESSES

KEY ACTIVITIES

- pipeline systems and networks
- **pumps and compressors**
- filtration, settlers, centrifuges and cyclones
- **grinding and milling**
- agglomeration of particular materials
- **transport and storage of particular materials**



EXAMPLES OF CURRENT PROJECTS:

- Research and development of technology for purification and recycling of used cooking oils (2021-2024)
- Process characteristic of coalescer (2023-2024)
- Biofilter with dielectric heating (2016-2019)





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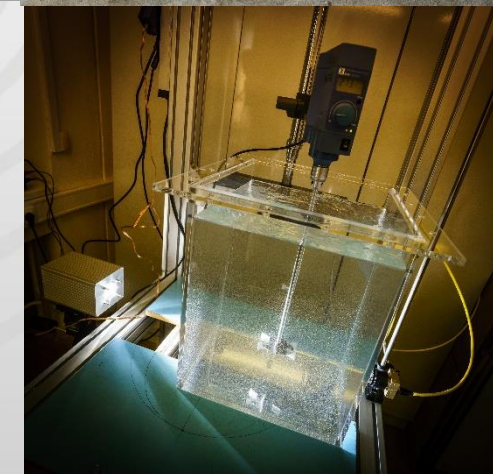
MIXING AND MIXING EQUIPMENT

KEY ACTIVITIES

- **flow in agitated batch**
- **mixing of heterogeneous systems**
- **mixing of non-Newtonian fluids**
- **heat transfer in agitated batch**
- **dispersion**
- **static mixers**

EXAMPLES OF CURRENT PROJECTS:

- **Development of new homogenisation technology for high viscous dispersion of the non-newton type (2018 – 2020)**
- **Design of mixer optimised for water purification and water treatment processes (2019 – 2020)**
- **Development of separation technology for the processing of radioactive sludge. (2018 – 2020)**
- **Local turbulent energy dissipation rate in dispersion systems (2016 – 2018)**





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RHEOLOGY

KEY ACTIVITIES

- **rotary and extrusion rheology**
- **viscous, visco-plasticelastic fluids, thixotropy**
- **rheological properties of industrial substances and fine grained suspensions**
- **polymer processing technologies**

EXAMPLES OF CURRENT PROJECTS:

- **Model of fibre segregation in dependence on rheological properties of fresh HPC (2021-2023)**
- **Control and optimization of selected wastewater treatment devices based on inline rheological properties of batch measurement focused on the development of innovated thickening and dewatering equipment (2019-2022)**
- **Treatment of concentrated waste suspensions from energetic equipment (2015 – 2017)**
- **Physical and rheological properties of collagen matter (2014 – 2016)**





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HEAT TRANSFER PROCESSES

KEY ACTIVITIES

- **evaporators**
- **drying and dryers**
- **direct and indirect ohmic heating**
- **industrial furnaces**
- **industrial cooling and cryogenic**
- **energy balancing of processes, optimization**

EXAMPLES OF CURRENT PROJECTS:

- **Laboratory demonstration unit to dry biologically active substances by nebulization using compressed carbon dioxide (2020-2021)**
- **Optimization of equipment for biological matter drying by atomization using carbon dioxide (2017-2018)**
- **Experimental and theoretical study of the convective heat transfer in turbulent swirling impinging jet (2014 – 2016)**





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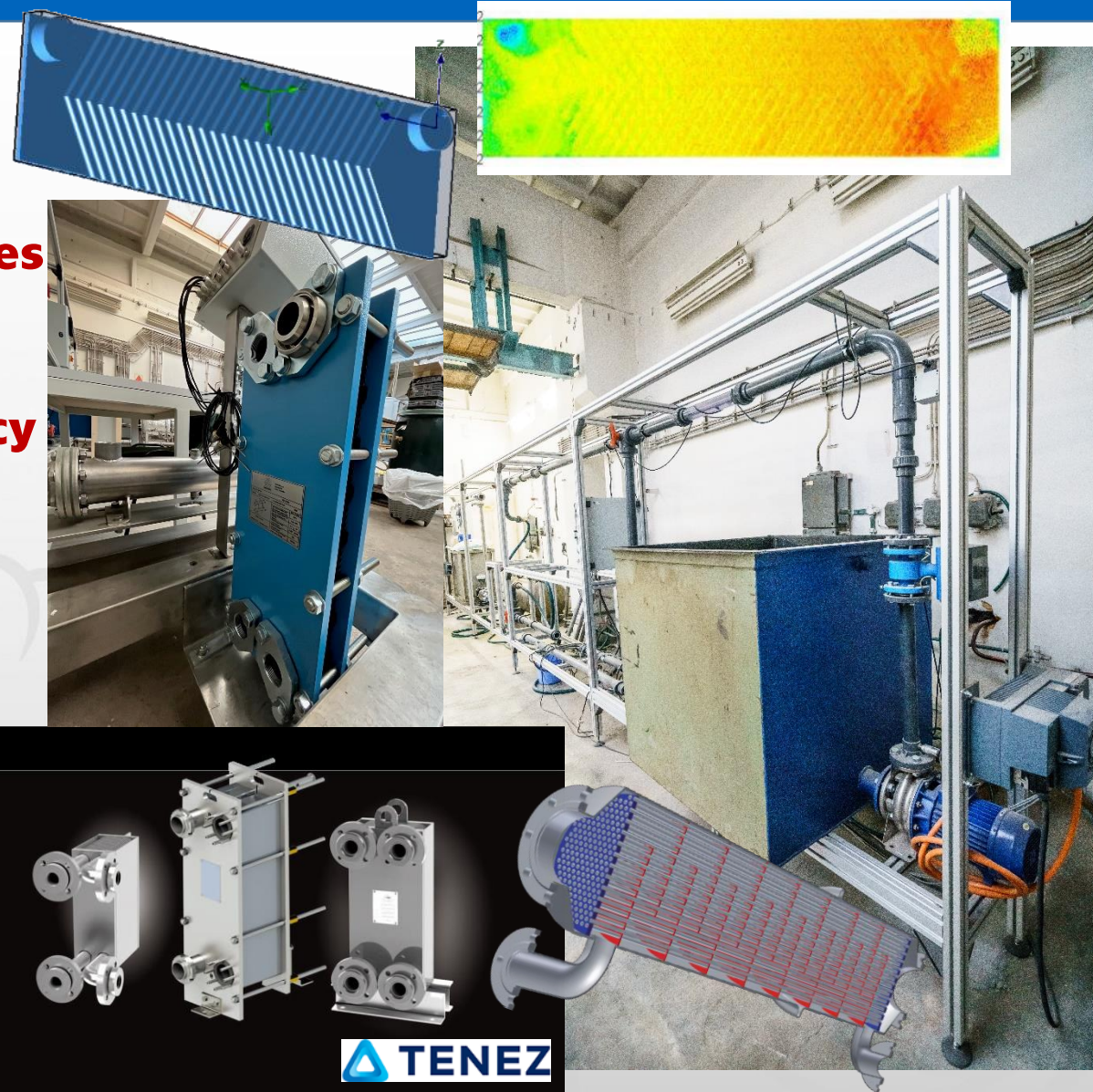
HEAT EXCHANGERS

KEY ACTIVITIES

- design and rating calculations
- **design, optimization of heat transfer surfaces**
- experimental verification of hydraulic characteristics and of heat transfer efficiency

EXAMPLES OF CURRENT PROJECTS:

- **Plate heat exchangers – experimental verification of hydraulic characteristics, heat transfer efficiency, optimisation of heat transfer surface**
 - cooperation with TENEZ (from 2014)
- **Industrial dryers (fluidised, spray,...)**
 - cooperation with MEGA, Bochemie (from 2015)





DIFFUSION SEPARATION PROCESSES

KEY ACTIVITIES

- **distillation, rectification**
- **absorption, adsorption**
- **crystallisation, dissolution, extraction**
- **membrane gas cleaning processes**
- **design of reactors and bioreactors**
- **technology design, balancing and optimization**



EXAMPLES OF CURRENT PROJECTS:

- **The innovative system for coke oven wastewater treatment and water recovery with use of clean technologies. (2016-2019)**
- **Research and Technology Development in Nitric Acid Production (2011 – 2013)**
- **Innovation and Optimization of the Technologies for Natural Gas Drying (2009 – 2012)**





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BIOREFINERY

KEY ACTIVITIES

- waste water treatment and gaseous pollution control technologies
- **waste processing in biorefinery concept, biofuels 2+, CCU technologies**
- analysis and intensification of transport phenomena in equipment
- **pretreatment of wastes**
- design of equipment, scale-up/down rules
- **biorefinery - design, optimization, TEA studies**

EXAMPLES OF CURRENT PROJECTS:

- **CCUV4 – Green Deal strategies for V4 countries: The needs and challenges to reach low-carbon industry (2022-2023)**
- **Research centre for low-carbon energy technologies (2018-2023)**





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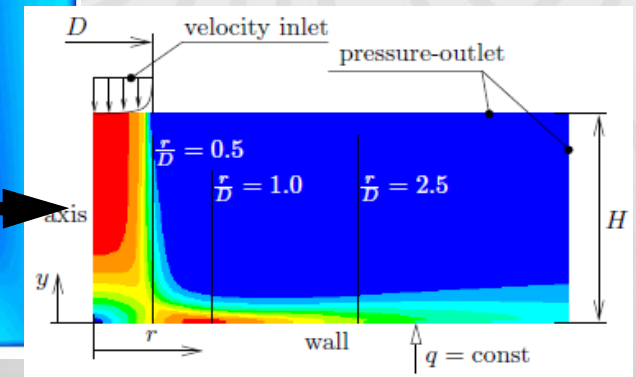
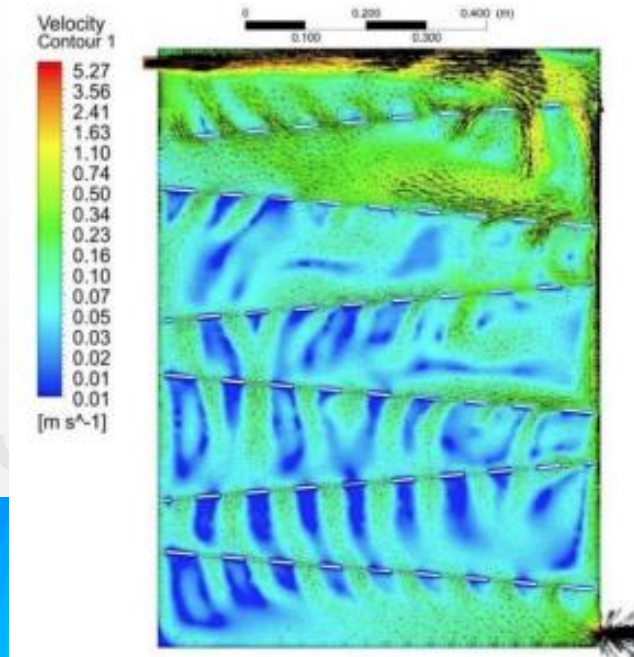
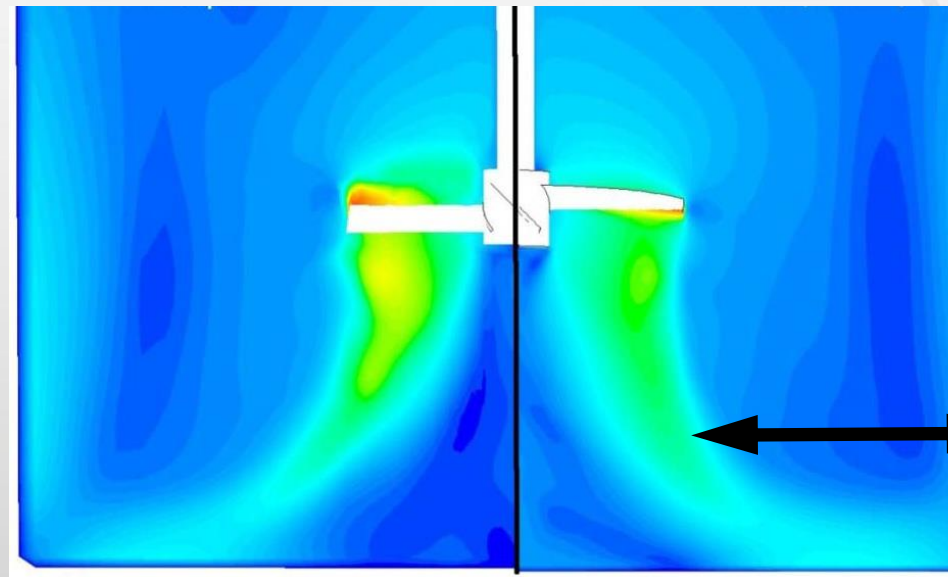
NUMERIC ANALYSIS OF PROCESSES

KEY ACTIVITIES

- **mathematical modelling and control of processes and equipment**
 - *use of software Ansys, Femina, Matlab, Fluent*
- **numerical simulations of mass, momentum and heat transfer**
- **regression analysis of models**

EXAMPLES OF CURRENT PROJECTS:

- **Cooperation at the projects being simultaneously solved at R & D activities.**





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DEPARTMENT OF PROCESS ENGINEERING

RECENT RESEARCH CHALLENGES

- Reactors and bioreactors.
- **Heat transfer apparatuses.**
- Special treatment of biomass and flue gas for biorefinery.
- **Biopolymers, bioplastics and biocomposites.**
- Virtual model technologies, digital twins.





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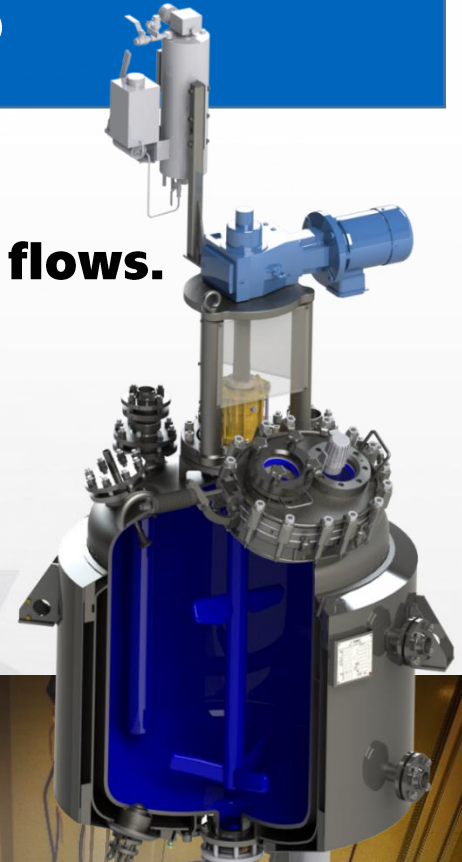
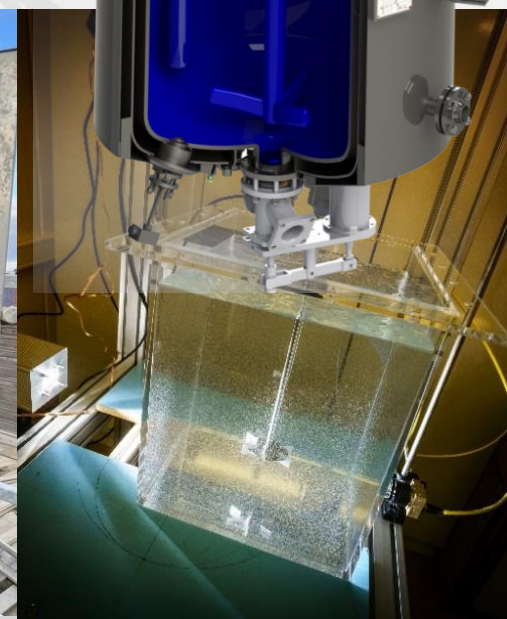
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RESEARCH CHALLENGES

REACTORS AND BIOREACTORS

artic conditions

- **Process-intensified reactors, photo- and photobio-reactors for multiphase flows.**
- **Modern, process and energy-effective mixing systems.**
- **Innovative multiphase contactors.**
- **Experimental and numeric analysis of simultaneous transfer phenomena.**
- **Dynamic process modelling.**





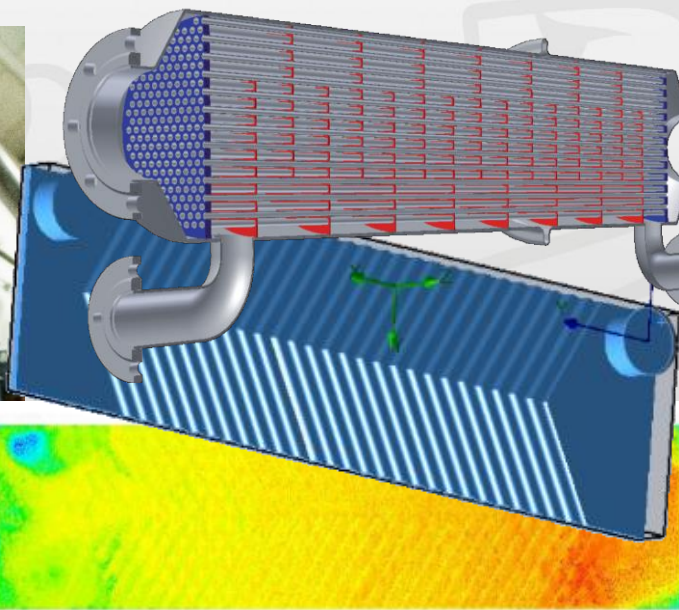
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RESEARCH CHALLENGES

HEAT TRANSFER APPARATUSES - HEAT EXCHANGERS, DRYERS, EVAPORATORS

- Experimental identification and numeric modelling of transfer phenomena.
- **Design and rating calculations, mass and energy balancing, and heat recovery.**
- **Development of heat exchangers for special applications.** *extreme conditions -50°C for turbopropeller aircraft engines*
- **Design and optimization of heat transfer surface shapes, experimental and numeric analysis.**
- **Ohmic and microwave heating for special applications.**





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RESEARCH CHALLENGES

SPECIAL TREATMENT OF BIOMASS AND FLUE GASES FOR BIOREFINERY

- **Grinding and milling of brittle and fibrous materials** - *experimental particle size analysis, modelling specific energy requirements and particle characteristics.*
- **Reactors for hydrothermal pre-treatment** - *experimental studies concerning product quality, effect of cooling/rapid batch decompression, numeric and dynamic process modelling.*
- **Experimental analysis and designing simulation models of hybrid technologies for CO₂ capture in concept membrane-X for industrial flue gases.**



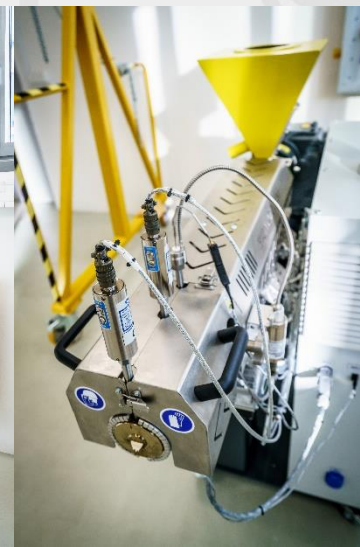
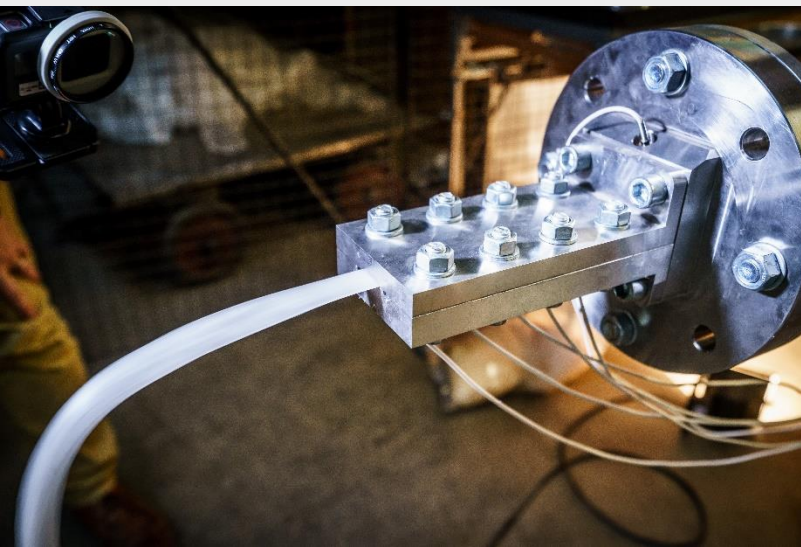


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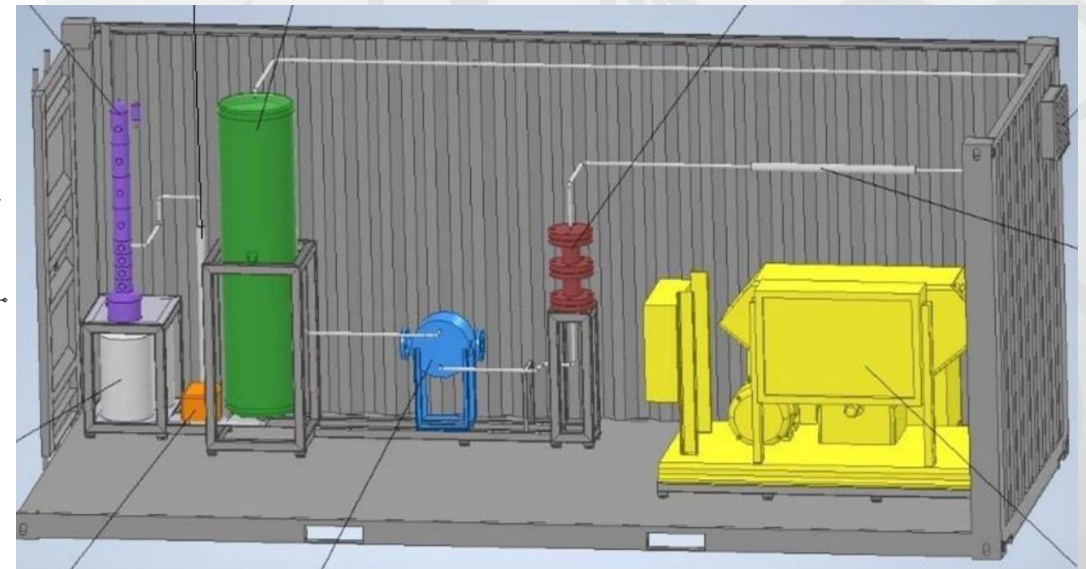
RESEARCH CHALLENGES

BIOPOLYMERS, BIOPLASTICS AND BIOCOMPOSITES

- **Forming and mixing of substances.**
- **Mechanical, thermo-physical and rheological properties of formed substances.**
- **Experimental analysis, numerical modelling and simulation of process characteristics for its production by extrusion, injection moulding, and stamping.**
- **Design, optimisation and scale-up of equipment.**
- **Sustainable design of processing lines, energy recovery.**



-
- The diagram illustrates a complex chemical process with the following components and streams:
- Inputs:** CO₂ and H₂ feed into compressor M-110.
 - Compressors:** M-110, X-110, and SNG.
 - Reactors:** R-110, R-120, and R-VODA.
 - Heat Exchangers:** E-110, E-120, E-130, E-140, E-150, and E-R120.
 - Separators:** S1, S2, S3, and SC.
 - Storage/Transfer:** 10-K, 12-K, and 1020.
 - Streams:** Labeled with numbers (e.g., 20, 1, 118, 140, 200, 1, 140, 86, 1, 140, 10, 200, 1, 140, 589, 1, 77, 450, 40, 144, 297, 10, 77, 250, 40, 144, 100, 1, 144, 75, 40, 144, 84, 1, 114, 30, 1, 48, 30, 1, 66, 20, 1, 1020, 60, 1, 1020, 40, 1, 144) and names (e.g., H2, CO2, E-110, X-110, H-110, 10-K, SPLIT, NP, TEMP, WP1, WP2, CW1, CW2, SC, SNG, R-VODA).
 - Control Loops:** Indicated by green arrows and labels like 14, 1, 1020, 60, 1, 1020.
 - Legend:**
 - Temperature (°C): Circle with 'C'
 - Pressure (Bar): Circle with 'B'
 - Flow Rate (kg/hr): Circle with 'kg/hr'





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