

University of Ljubljana  
Faculty of *Mechanical Engineering*



Annual Report

2019

University of *Ljubljana*  
Faculty of *Mechanical Engineering*



University of Ljubljana  
**Faculty of Mechanical  
Engineering**

---

Aškerčeva cesta 6

1000 Ljubljana

Slovenia

Telephone: +386 1 4771 200

Fax: +386 1 2518 567

E-mail: [dekanat@fs.uni-lj.si](mailto:dekanat@fs.uni-lj.si)

# TABLE OF CONTENTS

<b>UNIVERSITY OF LJUBLJANA FACULTY OF MECHANICAL ENGINEERING</b>	<b>4</b>
Faculty management	4
Supporting services	5
Mechanical engineering is entering a new era	6
<b>INTRODUCTION</b>	<b>10</b>
University of Ljubljana	10
Faculty of Mechanical Engineering, University of Ljubljana	12
Chairs and laboratories at the Faculty of Mechanical Engineering	14
<b>THE FACULTY OF MECHANICAL ENGINEERING IN NUMBERS</b>	<b>16</b>
<b>PUBLISHING AND JOURNALS</b>	<b>21</b>
Publishing	21
Journals	22
<b>STUDY PROGRAMMES</b>	<b>25</b>
<b>RESEARCH</b>	<b>28</b>
<b>PRESENTATION OF PROGRAMME GROUPS AND ACTIVITIES OF LABORATORIES</b>	<b>30</b>
Modelling in Technics and Medicine	31
Laboratory for Modelling Machine Elements and Structures <b>LAMEK</b>	32
Transient two-phase flows	34
Laboratory for Fluid Dynamics and Thermodynamics <b>LFDT</b>	35
Energy Engineering	38
Laboratory for Internal Combustion Engines and Electromobility <b>LICeM</b>	39
Laboratory for Heat and Power <b>LTE</b>	41
Laboratory for Hydraulic Machines <b>LVTS</b>	43
Laboratory for Pumps, Compressors and Technical Acoustics <b>LEDSTA</b>	46
Development evaluation	47
Laboratory for Machine Elements <b>LASEM</b>	48
Laboratory for Structure Evaluation <b>LAVEK</b>	50
Heat and mass transfer	52
Laboratory for Measurements in Process Engineering <b>LMPS</b>	53
Laboratory for Heating Technology <b>LTT</b>	54
Laboratory for Refrigeration and District Energy <b>LAHDE</b>	56
Laboratory for Heating, Sanitary, Solar and Air Conditioning Engineering <b>LOSK</b>	58
Laboratory for Sustainable Technologies in Buildings <b>LOTZ</b>	60
Tribology	62
Laboratory for tribology and interface nanotechnology <b>TINT</b>	63
Laboratory for Fluid Power and Controls <b>LFT</b>	66

Synergetics of complex systems and processes	67
Laboratory for Synergetics <a href="#">LASIN</a>	68
Innovative production systems and processes	70
Laboratory for Alternative Technologies <a href="#">LAT</a>	71
Forming Laboratory <a href="#">LAP</a>	72
Laboratory for Handling, Assembly and Pneumatics <a href="#">LASIM</a>	73
Engineering design	75
Laboratory for Engineering Design <a href="#">LECAD</a>	76
Laboratory for Material Handling and Machine Structures <a href="#">LASOK</a>	79
Mechanics in engineering	80
Laboratory for Dynamics of Machines and Structures <a href="#">LADISK</a>	81
Laboratory for Non-Linear Mechanics <a href="#">LANEM</a>	84
Laboratory for Numerical Modelling and Simulation <a href="#">LNMS</a>	85
Laboratory for aeronautics <a href="#">AEROL</a>	87
Sustainable polymer materials and technologies	88
Laboratory for Experimental Mechanics <a href="#">LEM</a>	89
Advanced manufacturing technologies for high quality and sustainable production	91
Laboratory for Cutting <a href="#">LABOD</a>	92
Laboratory for Quality Assurance <a href="#">LAZAK</a>	94
Production systems, laser technologies and materials welding	95
Laboratory for Heat Treatment and Materials Testing <a href="#">LATOP</a>	97
Laboratory for Welding <a href="#">LAVAR</a>	99
Laboratory for Digital Systems and Electrical Engineering <a href="#">LDSE</a>	101
Laboratory for Process Automation <a href="#">LPA</a>	102
Laboratory for Manufacturing Cybernetics and Experimentation <a href="#">MCE</a>	103
Laboratory for Manufacturing Systems and Production Process Planning <a href="#">LAPS</a>	104
Laboratory for control and manufacturing systems <a href="#">LAKOS</a>	105
Optodynamics	107
Laboratory for Laser Techniques <a href="#">LASTEH</a>	108
Laboratory for photonics and laser systems <a href="#">FOLAS</a>	111
Unit for supplementary division	113
Unit for supplementary division <a href="#">EDZ</a>	114
Mathematics Research Team <a href="#">RSMAT</a>	115
<b>PROMOTION OF MECHANICAL ENGINEERING</b>	<b>117</b>

# UNIVERSITY OF LJUBLJANA FACULTY OF MECHANICAL ENGINEERING

## FACULTY MANAGEMENT



Dean  
Prof. Mitjan Kalin, PhD



Vice Dean for Education, 1<sup>st</sup> Cycle  
Assoc. Prof. Matija Jezeršek, PhD



Vice Dean for Education, 2<sup>nd</sup> and 3<sup>rd</sup> Cycles  
Prof. Andrej Kitanovski, PhD



Secretary  
Tone Češnovar, PhD



Vice Dean for Research and International Relations  
Prof. Tomaž Katrašnik, PhD

# SUPPORTING SERVICES

Faculty secretariat

Andreja Koban Domitrovič

---

Student office

Danijela Kotnik, MSc

---

Accounts and financial department

Barbara Bergant Kaučič, MSc

---

Human resource department

Lojzka Baranašič / Anja Novak

---

Department of international cooperation,  
scientific and research work

Tanja Mavrič Rušt, MSc

---

Department of Economic Affairs and  
Communications

Andreja Cigale / Katja Pustovrh

---

Library

Zorka Kešelj

---

Technical and maintenance department

Vinko Tomc

---

IT department

Srečko Obradović

---

Publishing department

Pika Škraba, MSc, Roman Putrih

---

# MECHANICAL ENGINEERING IS ENTERING A NEW ERA

Usually, the thoughts and activities of our faculty are focused on progress and development, in short, on the future. The year 2019, when the University of Ljubljana and its Mechanical Engineering Studies celebrated their 100th anniversary, has encouraged us to look back into the past. An important anniversary was celebrated with the solemn academy in Cankarjev dom, held under the honorary patronage of the President of the Republic of Slovenia, Borut Pahor. We recalled our predecessors, the pioneers of Slovenian mechanical engineering, who contributed significantly to the successes we achieve today.

Mechanical engineering are people, associates, teaching assistants, professors, researchers, students and graduates who help shape our image with our creativity, innovation and ambition. Together we have become the leading Slovenian and internationally recognized institution in the field of mechanical engineering. But not only that, we have also become a place where friendships are made in a relaxed, stimulating and positive environment, which gives the Faculty a soul.

Modern mechanical engineering requires interdisciplinary, adaptability, teamwork and, at the same time, a high level of individual knowledge of engineers. We have systematically integrated all this into a new course of study, which we have symbolically updated in 2019. Our goal is to equip students with the appropriate skills to weave engineering knowledge, achieve groundbreaking scientific breakthroughs and transfer them directly into business. We are aware that science is not an end in itself, so it is our goal, our challenge and our mission to create knowledge for a better life for all of us. We have already shown that through excellent scientific work we can help Slovenian industry and thus influence economic growth, living standards and prosperity. It is this connection with the environment that must be a fundamental and irreplaceable goal of every university!



Faculty of Mechanical Engineering of the University of Ljubljana is ranked as one of the 200 best mechanical engineering faculties in the world. We reach for the highest awards and awards in Slovenia and internationally. The scientific and research achievements published in the best journals show that we as a Faculty have matured scientifically and professionally.

In 2019, we received two prestigious state awards. The Committee of the Republic of Slovenia for Awards and Recognition of Excellence in Scientific Research and Development awarded Prof. Matevž Dular, PhD the Žiga Zois Award for his important contribution to the understanding of the phenomenon of cavitation. Assoc. Prof. Matija Jezeršek, PhD and Prof. Niko Herakovič, PhD and the Yaskawa team received the Puh Award for excellence in Industrial Robotic Technology.

In less than a year we also published two anniversary publications. We created an Interpretation Dictionary of Mechanical Engineering with 11,960 passwords in Slovenian and English and updated and supplemented the Kraut Mechanical Manual in places. We have acquired the material copyright for Kraut's Handbook, thus taking on the constant task of publishing, updating and maintaining this legendary publication. We have concluded a long-term cooperation agreement with Slovenian Institute for Standardization, which also includes access to all SIST standards in the field of remote-controlled mechanical engineering, giving all our students and employees a simple and direct insight into the standards, which is unique in the Slovenian scale.



This year, we can also be proud of the visit of the President of the European Research Council (ERC), Prof. Dr. Jean-Pierre Bourguignon. We were chosen to host the central event of the visit because we are one of the most successful research organizations in obtaining ERC projects. In the last two years we have received two such projects, whereas in Slovenia only a handful have been awarded in the last two decades. It is the ERC projects that represent the most prestigious part of the European Research Area, combining cutting-edge science and the applied value of science in the wider social environment, thus perfectly fitting the mission and holistic approach of our Faculty.



Photo: Daniel Novakovič/STA

Not only our professors and researchers, but also our students have achieved remarkable results. A team of students from the Faculty of Mechanical Engineering, nicknamed the Edvard Rusjan Team, developed the world's best drone with vortexes using the "Pretty boy" aircraft. They thus defeated the entire University elite in the Design/Build /Fly competition in the United States. The achievement did not go unnoticed at home either, as the President of the Republic of Slovenia, Borut Pahor, presented an "Apple of Inspiration" to a team of our students in a special ceremony.

Such results can only be achieved in an organized and stimulating environment that is internationally related and comparable. To create the right conditions, we need a much better infrastructure and much more material resources than we have today. With the number of staff and students and with its achievements, the Faculty has exceeded the capacity of its current premises, so we took the initiative and launched a public competition to select a future building at Brdo. Throughout history, it has been shown that each time the Faculty has been provided with new premises, it has received a new impulse that has had a decisive influence not only on its activities but also on the economy and the environment in general. Based on our experience to date, we are convinced that this time both the state and the business community will listen to our wishes and help us to fulfil them.

This year, the anniversary year, will be remembered for its outstanding scientific and student achievements, unforgettable events and promising changes. I believe that at the end of next year we will look back with pride and enthusiasm, and that we will continue to build on a solid foundation from the past, which together with knowledge, cooperation and the right decisions will lead us into the bright future of mechanical engineering.



Prof. Mitjan Kalin, PhD

Dean of the Faculty of Mechanical Engineering,  
University of Ljubljana

# INTRODUCTION

## UNIVERSITY OF LJUBLJANA

The University of Ljubljana is the oldest and largest higher education and scientific research institution in Slovenia. Since its foundation in 1919 it has been an important pillar of the Slovene society and the development of the Slovene scientific terminology. The university is striving to deliver the highest quality of knowledge and to fulfil its ethical standards in all areas of science and art, which is proven by its 370th place in the CWUR rankings among the 18,000 universities in the world.

Today, the University of Ljubljana is the central and largest educational institution, with almost 40,000 students, employing more than 5,800 higher education teachers, researchers, assistants, and administrative staff at 23 faculties and 3 art academies. The students can choose among several hundred study programmes, which are structured in accordance with the Bologna Declaration guidelines. The number of joint programmes is also on the rise, which aim to increase internationalisation and closer cooperation with foreign educational institutions. This encourages interdisciplinary study and facilitates mobility of lecturers and students in the international university environment.

The University of Ljubljana is the central and largest educational institution in Slovenia. It is also the central and largest research institution in Slovenia with 30 percent of all registered researchers (according to the data from the SICRIS database).

It also actively encourages the strengthening of the academic community of teachers, researchers and students, who are striving to use their knowledge and achievements in Slovenia and abroad. Its research, educational, professional and public activities are founded on the following values of:

- Academic excellence, namely ensuring the highest quality,
- Academic freedom of faculty and students, especially creative freedom,
- Autonomy from the state, political parties, corporations and religions,
- Humanities and human rights, including equal opportunities, and solidarity,
- Ethical and responsible relationship to the world.



# FACULTY OF MECHANICAL ENGINEERING, UNIVERSITY OF LJUBLJANA

The Faculty of Mechanical Engineering is a member of the University of Ljubljana, and an important educational and research institution with high international standards in the field of mechanical engineering in Slovenia and the wider region of the Central and Southeast Europe. Through the history and with development the faculty overcame the classic understanding of mechanical engineering, since today it offers programmes from numerous specialised engineering fields.



## Foundation

Throughout history, technical occupations were well established among the Slovenes, although until the establishment of the University in Ljubljana in 1919, students had to attain their knowledge abroad, mostly in the Austrian universities. After the end of the World War 1, which also meant the end of the Austro-Hungarian rule, the wish to establish our own university, which would include a faculty of technical sciences also came to life. Even before the formal establishment of the University of Ljubljana there were organised lectures for the students of mechanical, electrical and civil engineering. The Faculty of Technical Sciences in Ljubljana was established through the effort by Milan Vidmar, PhD, and it remained in such form until 1957, when the departments of electrical and mechanical engineering were united. In October 1960, under the resolution of the University Board, the Faculty of Mechanical Engineering became an independent member of the University of Ljubljana with study programmes on all three levels. In the beginning it had four chairs – organisational units – where the faculty and assistants performed teaching and scientific work. The faculty was at first housed in the so called old building on Aškerčeva cesta 6; in 1971 it moved into a new building at the same location. Today, the Faculty of Mechanical Engineering of the University of Ljubljana is still located in both buildings.

## Today

The Faculty of Mechanical Engineering of the University of Ljubljana is today the largest institution for education and research of mechanical engineering in Slovenia. In-house design and research work, and quality transfer of knowledge to the students and research partners enables a competitive integration into the international environment.

The Faculty of Mechanical Engineering carries out its **educational activities** for all three study cycles in accordance with the Bologna Declaration guidelines. Two first cycle study programmes, the professional and academic programmes, deliver an insight into a wider field of mechanical engineering; the second cycle master's programme is a continuation of the first cycle; the individually tailored third cycle doctoral programme is based on solving problems at the highest scientific level. The educational process in the first and second cycles is carried out in the form of lectures and practicals, where the lectures provide theoretical knowledge, and the laboratories perfect practical skills. The degree, obtained at the Faculty of Mechanical Engineering, is internationally accredited on the European level (ASIIN, ENUA, EUR-ACE), and is equal to other degrees in Europe.

**Scientific research work** at the Faculty of Mechanical Engineering is carried out in the fields of power and process engineering, design, mechanics and maintenance of machines, production engineering, mechatronics, micromechanic systems and automatisations. The researchers are involved in national basic and applicative projects, and in numerous international projects, actively working with scientific research centres and the industry. Through cooperation with the industry and other institutions the faculty is contributing toward higher economic growth, and is publishing the results of innovation potentials in international scientific journals. Special attention is also given to the education of young and promising researchers, who decide on the career path in research also because of the tenders from ARRS (Slovenian Research Agency).

# CHAIRS AND LABORATORIES AT THE FACULTY OF MECHANICAL ENGINEERING

## CHAIR OF SYNERGETICS

Laboratory for Synergetics  
[LASIN](#)

1

## CHAIR OF MACHINE ELEMENTS AND DEVELOPMENT EVALUATION

Laboratory for Machine  
Elements [LASEM](#)

Laboratory for Structure  
Evaluation [LAVEK](#)

2

## CHAIR OF POWER ENGINEERING

Laboratory for Internal  
Combustion Engines and  
Electromobility [LICeM](#)

Laboratory for Heat and  
Power [LTE](#)

Laboratory for Hydraulic  
Machines [LVTS](#)

Laboratory for Pumps,  
Compressors and Technical  
Acoustics [LEDSTA](#)

3

## CHAIR OF CYBERNETICS, MECHATRONIC AND PRODUCTION ENGINEERING

Laboratory for Control and  
Manufacturing Systems  
[LAKOS](#)

Laboratory for Digital Systems  
and Electrical Engineering  
[LDSE](#)

Laboratory for Process  
Automation [LPA](#)

Laboratory for Manufacturing  
Systems and Production  
Process Planning [LAPS](#)

Laboratory for Manufacturing  
Cybernetics and  
Experimentation [MCE](#)

4

## CHAIR OF MANUFACTURING TECHNOLOGIES AND SYSTEMS

Laboratory for Forming [LAP](#)

Laboratory for Alternative  
Technologies [LAT](#)

Laboratory for Handling,  
Assembly and Pneumatics  
[LASIM](#)

5

## CHAIR OF MATERIALS, SCIENCE AND TECHNOLOGY

Laboratory for heat treatment  
and materials testing [LATOP](#)

Laboratory for Welding  
[LAVAR](#)

6

## CHAIR OF HEATING AND PROCESS ENGINEERING

Laboratory for Measurements  
in Process Engineering [LMPS](#)

Laboratory for Heating  
Technology [LTT](#)

7

## CHAIR OF MECHANICS

Laboratory for Non-Linear  
Mechanics [LANEM](#)

Laboratory for Numerical  
Modelling and Simulation  
[LNMS](#)

Laboratory for Dynamics  
of Machines and Structures  
[LADISK](#)

8

## CHAIR OF MECHANICS OF POLYMERS AND COMPOSITES

Laboratory for Experimental  
Mechanics [LEM](#)

9

**CHAIR OF OPTODYNAMICS AND LASER APPLICATIONS**

Laboratory for photonics and laser systems [FOLAS](#)

Laboratory for laser techniques [LASTEH](#)

10

**CHAIR OF TRIBOLOGY AND MAINTENANCE SYSTEMS**

Laboratory for tribology and interface nanotechnology [TINT](#)

Laboratory for Fluid Power and Controls [LFT](#)

11

**CHAIR OF FLUID DYNAMICS AND THERMODYNAMICS**

Laboratory for Fluid Dynamics and Thermodynamics [LFDT](#)

12

**CHAIR OF THERMAL AND ENVIRONMENTAL ENGINEERING**

Laboratory for Heating, Sanitary, Solar and Air Conditioning Engineering [LOSK](#)

Laboratory for Refrigeration and District Energy [LAHDE](#)

Laboratory for Sustainable Technologies in Buildings [LOTZ](#)

13

**CHAIR OF MACHINING TECHNOLOGY MANAGEMENT**

Laboratory for Cutting [LABOD](#)

Laboratory of Quality Assurance [LAZAK](#)

14

**CHAIR OF ENGINEERING DESIGN AND TRANSPORTATION SYSTEMS**

Laboratory for Engineering Design [LECAD](#)

Laboratory for Material Handling and Machine Structures [LASOK](#)

15

**CHAIR OF MODELLING IN ENGINEERING SCIENCES AND MEDICINE**

Laboratory for Modelling Machine Elements and Structures [LAMEK](#)

16

**AVIATION DIVISON**

Laboratory for aeronautics [AEROL](#)

17

**UNIT FOR SUPPLEMENTARY DIVISION**

Mathematics Research Team [RSMAT](#)

Unit for Supplementary Division [EDZ](#)

18

The Faculty of Mechanical Engineering has been broken into units called chairs since the very start of its independent operations. The organisational structure derives from the basic courses, which further spread and evolved into specific areas or subunits called laboratories with the development of research engineering.

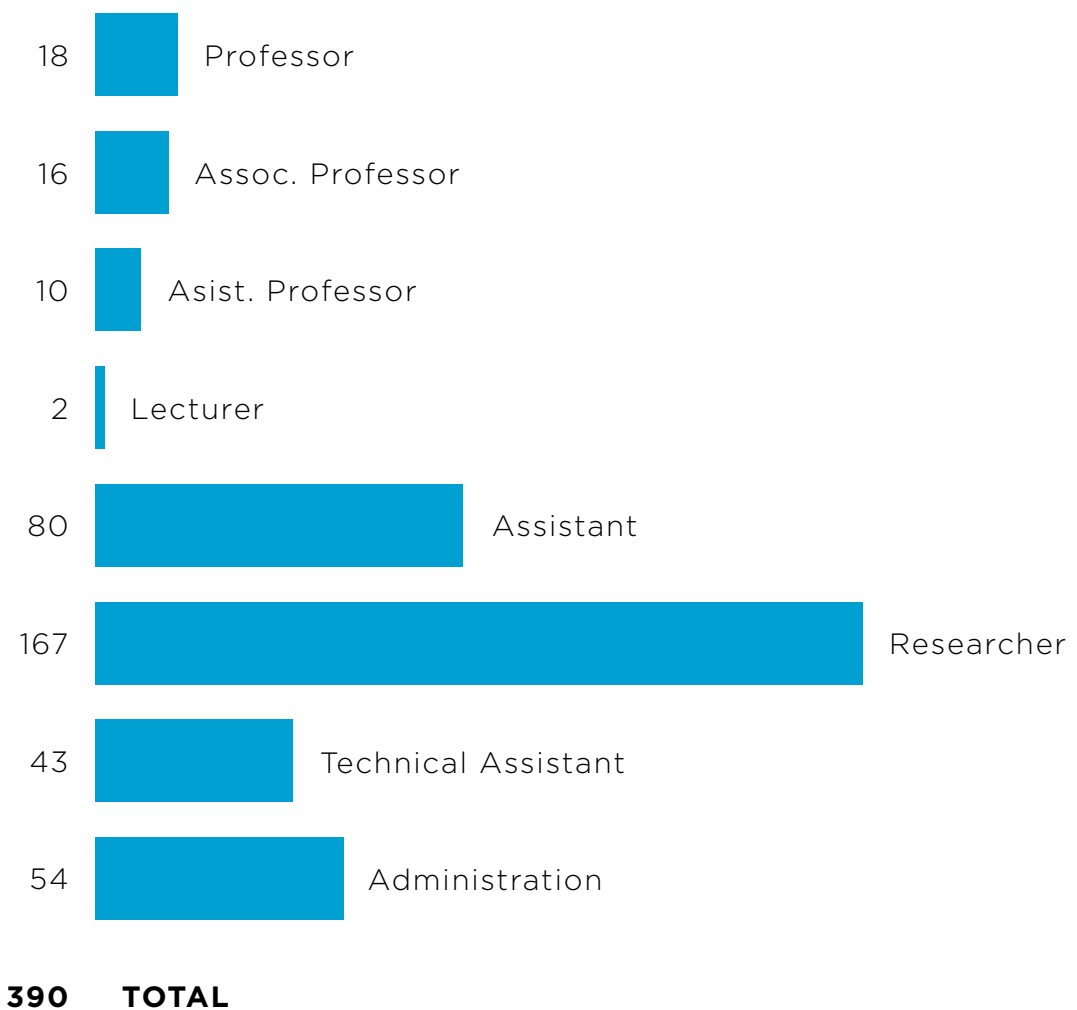
In 2019, 37 laboratories and a Unit for Supplementary Division operated within the scope of 16 chairs.



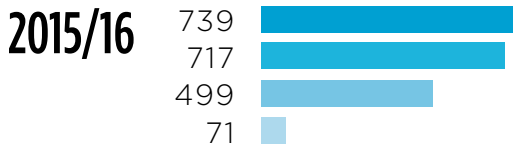
# THE FACULTY OF MECHANICAL ENGINEERING IN NUMBERS

## EMPLOYEE STRUCTURE

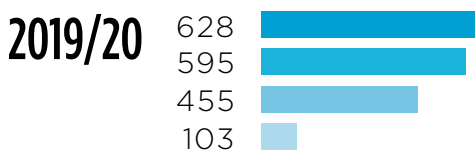
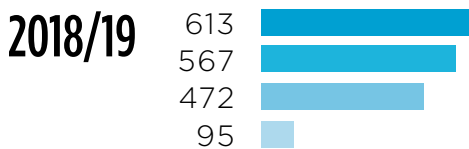
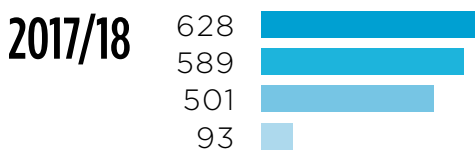
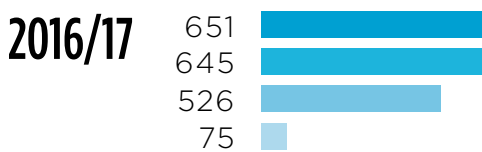
2019



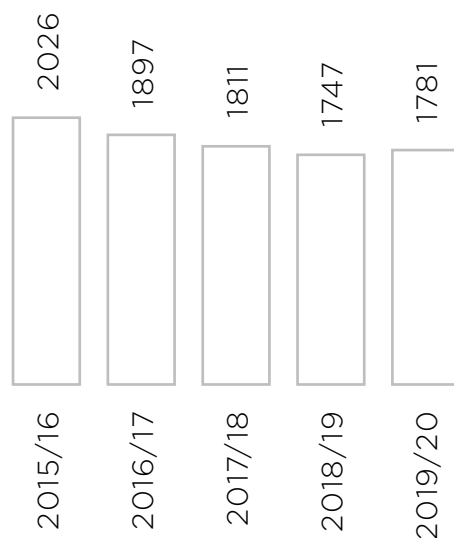
## NUMBER OF ENROLLED STUDENTS



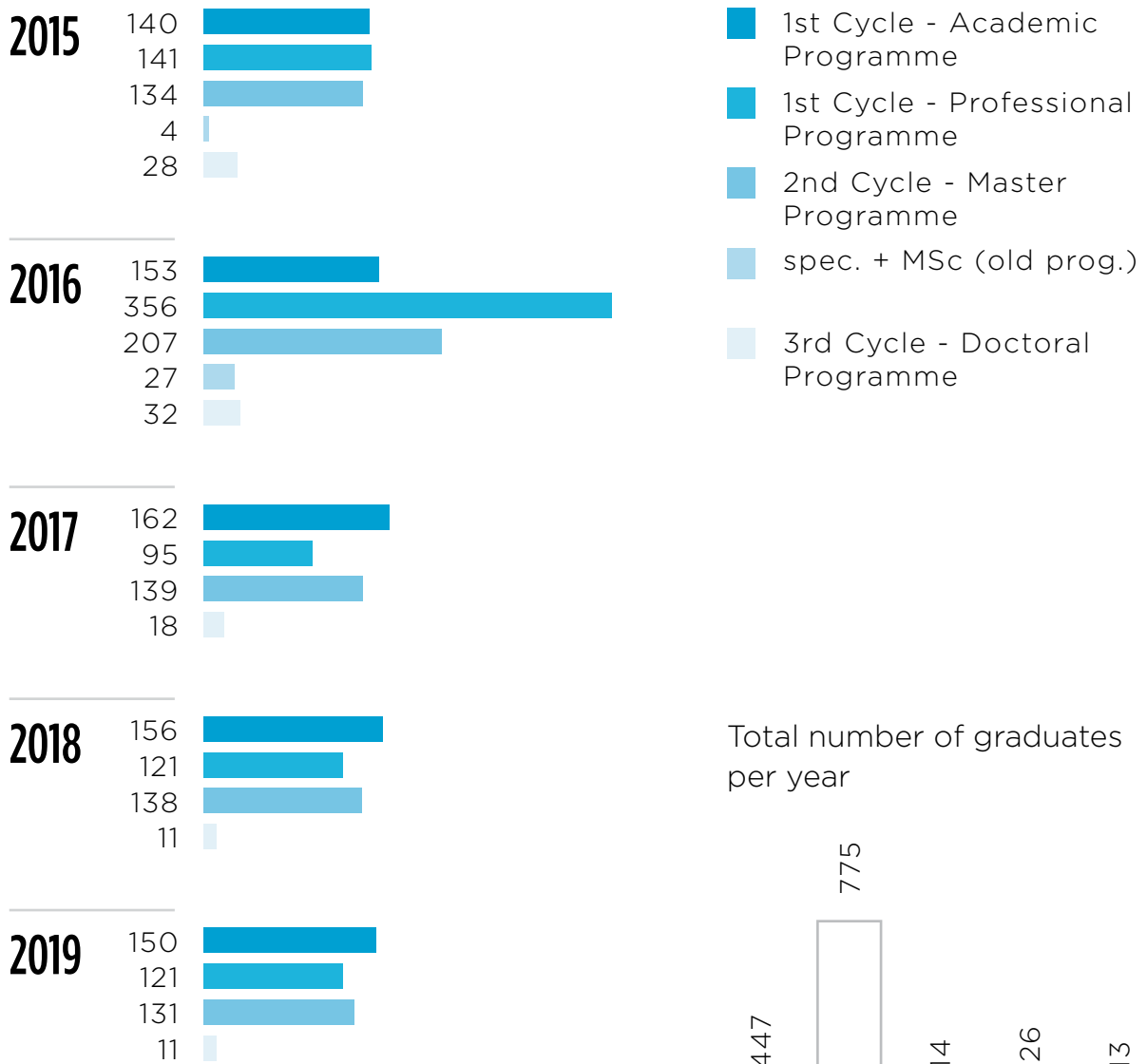
- 1st Cycle - Academic Programme
- 1st Cycle - Professional Programme
- 2nd Cycle - Master Programme
- 3rd Cycle - Doctoral Programme



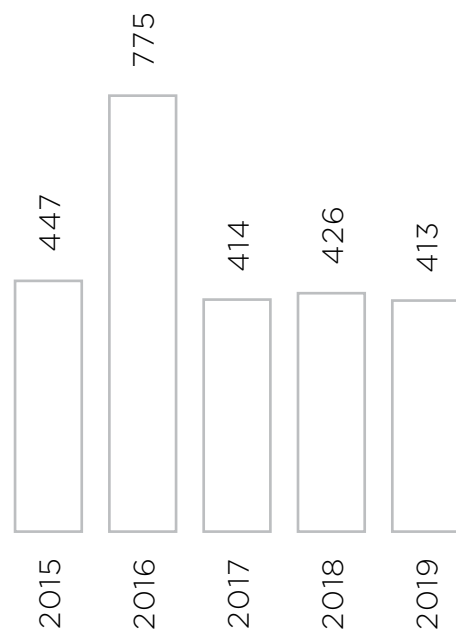
Total number of enrolled students per year



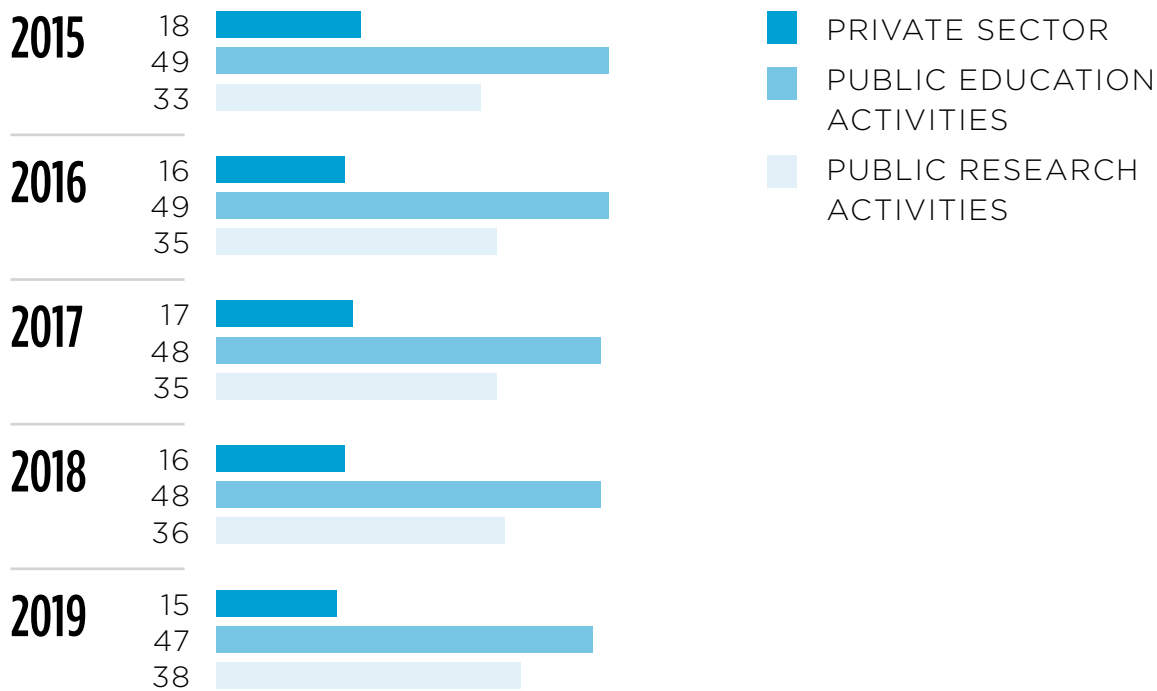
## NUMBER OF GRADUATES



Total number of graduates per year



## FINANCING STRUCTURE IN %



## NUMBER OF INTERNATIONAL RESEARCH PROJECTS

Programm	2015	2016	2017	2018	2019
Horizon 2020	3	5	7	11	<b>11</b>
ERDF - European regional development fond	0	6	7	9	<b>10</b>
ERA NET M-era.Net	0	0	1	1	<b>1</b>
Life+	0	1	1	1	<b>1</b>
Erasmus +	2	3	5	6	<b>9</b>
ESA - European space agency	1	1	2	1	<b>1</b>
Eureka	2	0	1	1	<b>1</b>
COST - European Cooperation in science and technology	4	6	8	8	<b>8</b>
Other: LLP lifelong learnig programme - Erasmus Mundus, ITER, FGG - The Austrain Research and Promotion Agency, COMET - Competence Centers for Excellent Technologies	4	6	8	5	<b>6</b>
EIT - European Institute of Innovation & Technology	0	0	0	2	<b>2</b>
<b>TOTAL</b>	<b>16</b>	<b>28</b>	<b>40</b>	<b>45</b>	<b>50</b>

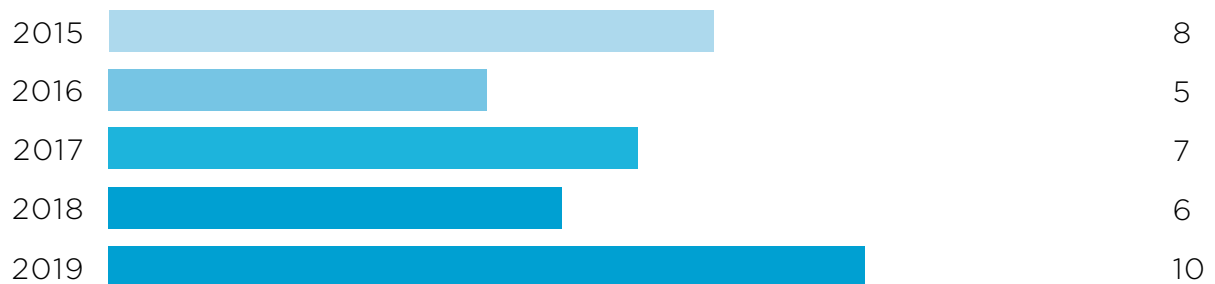
## NUMBER OF MARKET-ORIENTED PROJECTS WITH THE INDUSTRY



## NUMBER OF ORIGINAL SCIENTIFIC ARTICLE



## NUMBER OF PATENTS



# PUBLISHING AND JOURNALS

## PUBLISHING

The publishing department of the Faculty of Mechanical Engineering is publishing study materials and other non-periodicals. The department is following the rules, set out by the Senate of the faculty, which define the main framework of its activities. The publishing department publishes 25 publications per year with an international standard book number (ISBN) and CIP, the acronym for the cataloguing in publication. The publishing department began using the ISBN system in 1986; since then it published almost 340 works with the ISBN number. These are course books, proceedings of domestic and international conferences, organised by chairs and laboratories of the faculty, printed editions of doctoral works, and scientific monographs. In the recent years the publications are also available in electronic form on CDs and USB sticks; free course books are available at the faculty website and the Repository of the University of Ljubljana.

With the introduction of digital printing technology the process for printing publications is significantly shorter and also much cheaper. Digital printing technology provides quality and relatively low cost printing also for limited editions. Due to this new technology the policy of the publishing department is to sell the entire edition of a textbook in three years; after this it gets reprinted with any possible revisions and updates. The editions for the first year programmes have up to 400 copies; and up to 150 copies for higher year programmes and the second cycle. The publishing department tries to offer the textbooks at an affordable price for students; around €10 for the first year textbooks, and around €15 for higher years. In order for the textbooks to be available at the student friendly prices, the authors usually charge no fees for the first editions. Only after a reprint, when there is no cost of reviews, proofreading, and design, the authors get some compensation.

# JOURNALS

## **Strojniški vestnik – Journal of Mechanical Engineering**

The scientific international journal publishes original and (mini)review articles covering the concepts of materials science, mechanics, kinematics, thermodynamics, energy and environment, mechatronics and robotics, fluid mechanics, tribology, cybernetics, industrial engineering and structural analysis. The journal follows new trends and progress proven practice



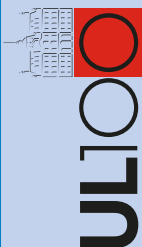
## **Strojniški vestnik**

---

## **Journal of Mechanical Engineering**



University of Ljubljana  
Faculty of Mechanical Engineering



no. **11-12**  
year **2019**  
volume **65**

in the mechanical engineering and also in the closely related sciences as are electrical, civil and process engineering, medicine, microbiology, ecology, agriculture, transport systems, aviation, and others, thus creating a unique forum for interdisciplinary or multidisciplinary dialogue. The international conferences selected papers are welcome for publishing as a special issue of SV-JME with invited co-editor(s). The Journal is indexed in the WoS Thomson and Scopus databases where is positioned in the second quarter. The growth of the Journal is evident in the constant increase in the number of citations in WoS.

The SV-JME has been published since 1955; the publishers are the Faculty of Mechanical Engineering of the University of Ljubljana, the Faculty of Mechanical Engineering of the University of Maribor, the Association of Mechanical Engineers of Slovenia, and the Chamber of Commerce and Industry of Slovenia.

Centenary of the University of Ljubljana and the study of mechanical engineering in Slovenian language were celebrated in the issue of SV-JME no. 11-12 in 2019. In 1919 was the beginning of a great age for the small Slovenian nation and our hearth of science and (technical) culture was born. A particular nation's culture is based in its entirety on the nuance of the ebb and flow of life.

The Journal is freely available at <https://www.sv-jme.eu/issues/volume-65-2019/>

## **Ventil**

The scientific and professional journal Ventil publishes articles, dealing with the development and research work at universities, institutes and companies from the field of fluid technics, automatisisation and mechatronics. Its aim is to familiarise with the achievements of Slovene companies, their products, and events, which are connected with the development and production in the relevant fields. It creates new connections between the Slovene industry and the research and development sphere, and among the Slovene and world production, developmental and expert community. It also encourages popularity of fluid technics, automatisisation, and mechatronics, especially among the young people, while it also cultivates the scientific terminology in these fields.

The publishers are the University of Ljubljana, the Faculty of Mechanical Engineering with co-founders GZS-ZKI-FT (Chamber of Commerce and Industry of Slovenia, Chemical Industries Association) and SDFT (Slovene Fluid Technics Association). It has 6 issues per volume in single issues at 1,500 copies each. The technical quality conforms to the international standards, valid in Slovenia. It is also included in the COBBIS, INSPEC and university and library databases (RWTH Aachen - IFAS, TU - Wien, University in Hannover and The British Library). Under its present title Ventil the journal has been published since 1995.

The magazine is freely available at <http://www.revija-ventil.si>.



REVIJA ZA FLUIDNO TEHNIKO, AVTOMATIZACIJO IN MEHATRONIKO

# VENTIL

ISSN 1318 - 7279

Letnik 25 / 2019 / 6 / December

Tribološki testi  
s hidravličnimi  
črpalkami

Razvoj  
servohidravličnega  
pogona

Hidravlika  
skozi čas

Ekologija -  
trajnostni razvoj

## PPTcommerce d.o.o.

### HIDRAVLIKA IN PROCESNA TEHNIKA

PRODAJA • PROJEKTIRANJE • SERVIS

[www.ppt-commerce.si](http://www.ppt-commerce.si)

**FISHER**

**EMERSON**  
Process Management

**ELMatic**

Dantorque

**HYTORK**

Shafer

**BETTIS**

Field



Univerza v Ljubljani  
Fakulteta za strojništvo



**FESTO**

**POCLAIN**  
Hydraulics

**OPL**

**S3C**  
pneumatika | hidravlika

**Parker**

**IMI**  
Precision Engineering

**MIEL** OMRON  
[www.miel.si](http://www.miel.si)



**ppt commerce**

# STUDY PROGRAMMES

The Faculty of Mechanical Engineering of the University of Ljubljana offers study programmes for all three levels since 1960, which testifies to the strong foundations of its study programmes in Slovenia. Through the years the programmes were adapted to various requirements, changed in accordance with legislation and regulations, and were recently thoroughly renewed in accordance with the Bologna Declaration.



Today, the Faculty of Mechanical Engineering offers the following study programmes:

## 1<sup>ST</sup> CYCLE

### Professional Study Programme in Mechanical Engineering – Project and Applicative Programme

lasts 3 years and is practice oriented; in the 2nd year it is separated into 5 basic study directions, and in the 3rd year into sub-directions. The graduates acquire the degree of Bachelor of Applied Science in Mechanical Engineering (graduate’s professional degree).

1 <sup>st</sup> year	2 <sup>nd</sup> year – directions	3 <sup>rd</sup> year – sub-directions
Common curriculum	<b>Power, Process and Environmental Engineering - EPO</b>	Power Engineering, Household and Sanitary technology, Process Engineering
	<b>Engineering Design, Machine Operation and Maintenance - SOV</b>	Material Handling and Self-propelled Machines, Vehicle Engineering, Maintenance Management
	<b>Production Engineering - PRS</b>	Production Technologies, Production Management, Welding Technologies
	<b>Mechatronics - MEH</b>	Mechatronics
	<b>Aviation - LET</b>	Airplane pilot/Helicopter pilot, Aircraft Design and Maintenance

### Academic Study Programme in Mechanical Engineering – Research and Development Program

lasts 3 years and has no directions. Students acquire theoretical knowledge for continuation of the studies in the 2nd Cycle. Graduates acquire the degree of Bachelor of Science in Mechanical Engineering.

## 2<sup>ND</sup> CYCLE

**Master's Study Programme in Mechanical Engineering – Development Research Program** last 2 years and is divided into 4 basic and 7 interdisciplinary directions. Graduates acquire the degree of Master of Engineering.

Basic directions	Interdisciplinary directions
<b>Machine Design and Mechanics:</b> Mechanics of Materials, Systems and Processes, Engineering Design and Product Development	Traffic Safety Systems, Engineering rheology, Environmental Engineering, Welding, Terotechnology, Engineering pedagogy, Engineering Safety
<b>Power and Process Engineering:</b> Thermal and Process Engineering, Power Engineering	
<b>Production Engineering:</b> Production Technologies and Systems Industrial Engineering	
<b>Mechatronics and Laser Technology</b>	

**TRIBOS – Joint Master's Programme in Tribology of Surfaces and Interfaces** lasts 2 years and is carried out by four partner European universities. Graduates acquire the degree of Master of Tribology of Surfaces and Interfaces.

## 3<sup>RD</sup> CYCLE

**Doctoral Study Programme in Mechanical Engineering** lasts 4 years and is divided into three basic fields of study. Graduates acquire the degree of Doctor of Science.

Fields
<b>Machine Design and Mechanics Engineering Science</b>
<b>Power and Process Engineering Science</b>
<b>Production Engineering Sciences, Cybernetics and Mechatronics</b>

**Interdisciplinary Doctoral Programme in Environmental Protection (coordinated at the level of the University of Ljubljana)** lasts 4 years and combines the scientific fields of 13 faculties. Graduates acquire the degree of Doctor of Science.

**Interdisciplinary Doctoral Study Programme Biosciences** lasts 4 years and is carried out by four members of the University of Ljubljana. Graduates acquire the degree of Doctor of Science.

# RESEARCH

The Faculty of Mechanical Engineering of the University of Ljubljana is carrying out its social agenda in the scientific research and applicative developmental fields in order to provide high level of excellence, and to transfer new research findings into the industrial environment.

## **Research and development activities at the Faculty of Mechanical Engineering include:**

- Power and process engineering,
- Design,
- Engine mechanics and maintenance,
- Production engineering,
- Mechatronics,
- Micromechanical systems,
- Automatisatation.

The research activities are carried out within the laboratories. The faculty is closely linked with institutes, domestic and foreign companies, and with other organisations from the field of medicine, electrical engineering, chemistry, informational technology and civil engineering. It is venturing outside the boundaries of classic research engineering, since it is reaching into new research fields, which bring higher added value to the society.

## **Research work is the basis for modern and quality teaching**

Our researchers strongly believe that research work is the basis for progressive and quality teaching, therefore taking part in national basic and applicative projects and international projects is a regular practice at the faculty.

## **Development of young and promising researchers**

The faculty pays special attention to the education and development of young and promising students, who are deciding on the career in research through the programme of the Slovenian Research Agency.

## The Infrastructure centre for modern engineering

Within the Network of infrastructure centres of the University of Ljubljana (MRIC UL) the faculty has the Infrastructure centre for modern engineering, which offers quality operations, infrastructural support, know-how and cooperation between research groups within research institutions, the Slovene industry and the wider international arena. The Centre uses high-end equipment, which requires highly qualified and specialised staff for its operation and maintenance. The Centre is divided into four sub-units:

- Centre for macromechanical assessments of materials and structures
- Centre for video-diagnostic analysis in process engineering
- Centre for surface diagnostics and lubricants in machine structures
- Centre for informational technologies and support

Highly trained staff, wide networks of researchers and interdisciplinary approach make the Faculty of Mechanical Engineering the largest scientific research institution in mechanical engineering in Slovenia.

## Program groups

Within the Slovene Research Agency there are programme groups, which represent research fields established for a longer time period, and are important for Slovenia. The researchers from the Faculty of Mechanical Engineering are involved in the following 14 programme groups:

1. Synergetics of complex systems and processes
2. Mechanics in Engineering
3. Sustainable Polymer Materials and Technologies
4. Engineering design
5. Tribology
6. Development evaluation
7. Modelling in technics and medicine
8. Production systems, laser technologies and materials welding - PLAS
9. Innovative production systems and processes
10. Advanced Manufacturing Technologies for High Quality and Sustainable Production
11. Energy Engineering
12. Heat and Mass Transfer
13. Transient two-phase flows
14. Optodynamics

# PRESENTATION OF PROGRAMME GROUPS AND ACTIVITIES OF LABORATORIES



# 01

## MODELLING IN TECHNICS AND MEDICINE

The Modelling in Engineering Sciences and Medicine programme group is based on an interdisciplinary approach and consists of researchers from the Faculty of Mechanical Engineering and the Faculty of Medicine (both University of Ljubljana).

The group's main research activity is modelling of systems related to traffic which involve modelling of mechanical and anatomical structures for investigating systems response to different kinds of excitation. Integrated into commercial software packages and expandable, these developed material and mechanical models are used for predicting the initiation and growth behaviour of damage to metallic and non-metallic materials at diverse monotonic and dynamic loads.

This enables modelling of various types of mechanical and biomechanical systems (human body, vehicles, traffic devices). The group also investigates and updates data and their relationships in traffic databases and develops geoinformation systems designed to determine exposure to traffic accident risk on specific sections of the road network.





## Laboratory for Modelling Machine Elements and Structures **LAMEK**

### RESEARCH AREAS

Mechanical engineering • Special constructions know-how • Large size bearings • Rolling rotational connections • Combustion processes in internal combustion engines • Vehicles • Traffic accidents

- Machine design • Mechanics of structures and machines • Geometric dimensioning and tolerancing • Expert systems • Tolerance analysis
- Transportation research • Biomechanics • Vehicle engineering
- Measurement in traffic • Traffic accident analysis

**DEPARTMENT HEAD** Assist. Prof. Samo Zupan, PhD

**DEPARTMENT MEMBERS** Assoc. Prof. Robert Kunc, PhD, Assist. Prof. Miha Ambrož, PhD, Assist. Prof. Jovan Trajkovski, PhD, Assist. Prof. Andrej Žerovnik, PhD, Assist. Simon Krašna, PhD, Assist. Ana Trajkovski, PhD, Assist. Matej Žvokelj, PhD, Assist. Matej Kranjec, Assist. Aleksander Novak, Slobodanka Ivanjić Kostrešević, Jernej Korinšek, Silva Brenčič

### ORIGINAL SCIENTIFIC ARTICLE

AMBROŽ, Miha, HUDOMALJ, Uroš, MARINŠEK, Alexander, KAMNIK, Roman. Raspberry Pi-based low-cost connected device for assessing road surface friction. *Electronics*, Mar. 2019, vol. 8, iss. 3.

KRAŠNA, Simon, ČOH, Milan, PREBIL, Ivan, MAĆKAŁA, Krzysztof. Comparative analysis of golf clubhead motion at impact. *Facta Universitatis. Series, Physical education and sport*, 2019, vol. 17, no. 3, p. 437-452.



BLAŽ, Janez, ZUPAN, Samo, AMBROŽ, Miha. Study on the eligibility of introducing hybrid-drive buses into the public passenger transport. *Strojniški vestnik*, 2019, vol. 65, no. 1, p. 12-20.

BLAŽ, Janez, ZAJC, Klemen, ZUPAN, Samo, AMBROŽ, Miha. Evaluation system for the implementation of public passenger transport as a public service obligation. *Sustainability*, vol. 11, iss. 12.

### **DOCTORAL DISSERTATIONS**

BIČEK, Matej. Modelling and optimization of in-wheel motor mechanical design. Mentor: Zupan, Samo.

### **PROJECTS**

Company DARS - Testing the deceleration of a passenger car. Robert Kunc. 3.7.2019 – 3.7.2020

EDA - Hybrid Drive Trains. Samo Zupan. 13.12.2019 – 12.12.2020

Horizon 2020 - VIRTUAL - Open access virtual testing protocols for enhanced road users safety. Simon Krašna. 01.06.2018 – 31.05.2022

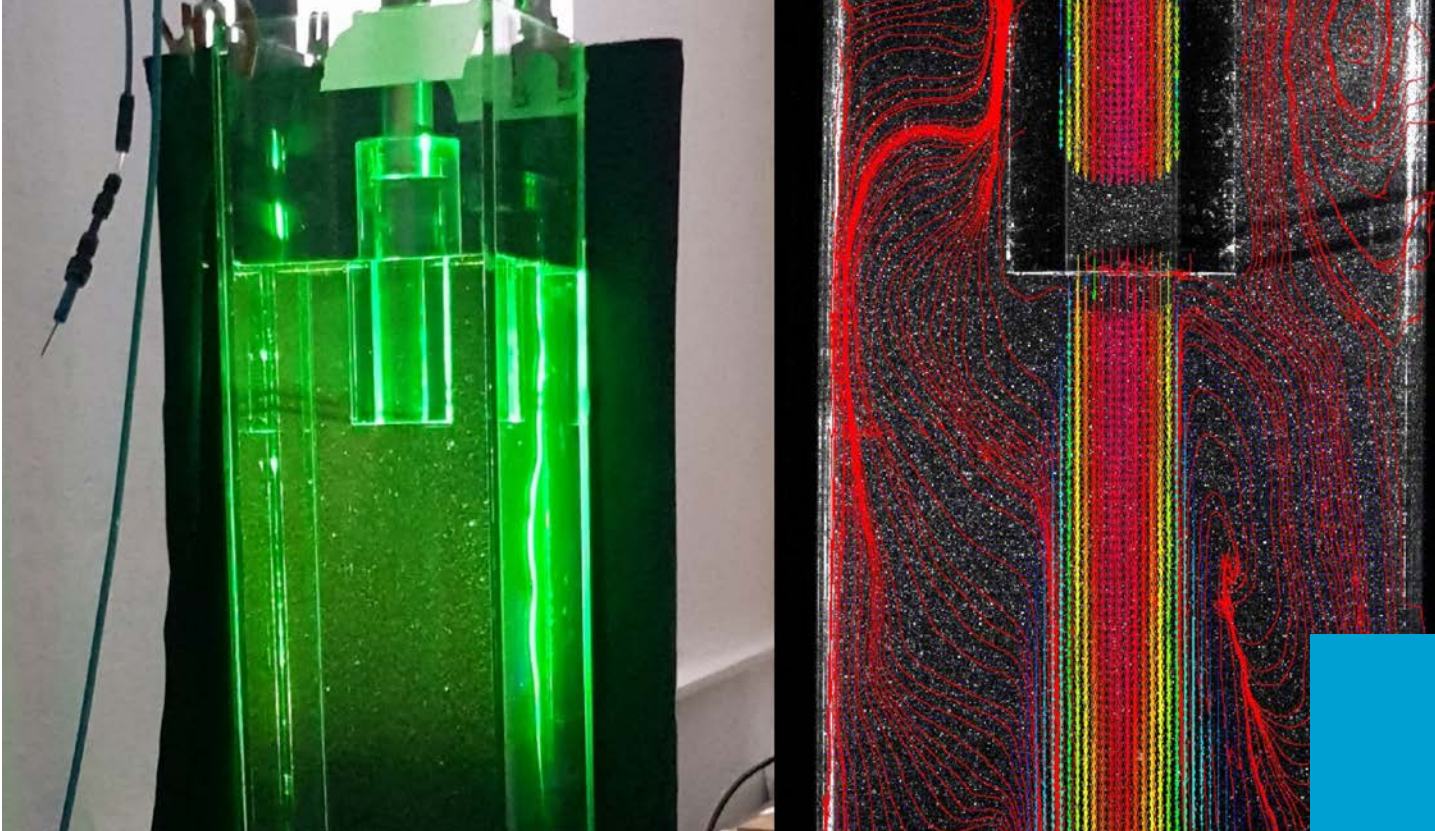
Company SMM – Research work. Robert Kunc. Ongoing since 1.1.2016

# 02

## TRANSIENT TWO-PHASE FLOWS

Key long-term research activities of the programme group Transient two-phase flows are focussed on the following areas:

1. Two-phase flows (gas-liquid, solid-gas) where we want to include also more complex systems with different types of boundaries, moving surfaces (such as stirred vessels, trickle bed reactors and fluidization of solid particles in Wurster chamber) which are frequently used in industry.
2. Investigation of unsteady friction effects on the magnitude and timing of pressure pulses during column separation events in industrial applications.
3. Medical modelling and simulation in fluid-structure interaction studies, for example, for analysing partial upper airway collapse or air stream coupling with soft tissue vibration. The only reasonable methodology leading to a successful scientific development involves a coherent and tight integration of theory, modelling and simulation (TMS) with experiment (E) and the data obtained.
4. Validation of CFD codes where the specific problems are going to be chosen in searching for generic principles of complex fluid dynamics simulation with the aim to range commercial codes of applicability to selected industrial problems.



## Laboratory for Fluid Dynamics and Thermodynamics **LFD**T

### RESEARCH AREAS

- Two-phase flow • Microfluidics • Solidification • Meshless methods
- Multiscale and multiphysics • Modelling of materials and processes
- Intelligent systems

**DEPARTMENT HEAD** Prof. Božidar Šarler, PhD

**DEPARTMENT MEMBERS** Assoc. Prof. Anton Bergant, PhD, Assist. Prof. Andrej Bombač, PhD, Assist. Prof. Matjaž Perpar, PhD, Assist. Boštjan Mavrič, PhD, Assist. Jurij Gregorc, PhD, Assist. Zahoor Rizwan, PhD, Assist. Vanja Hatić, PhD, Zlatko Rek, PhD, Assist. Umut Hanoglu, PhD, Katarina Mramor, PhD, Miha Kovačič, PhD, Robert Vertnik, PhD, Qingguo Liu, PhD, Belšak Grega, Matic Cotič, Rana Khush Bakhat, Gašper Vuga, Zdenka Rupič

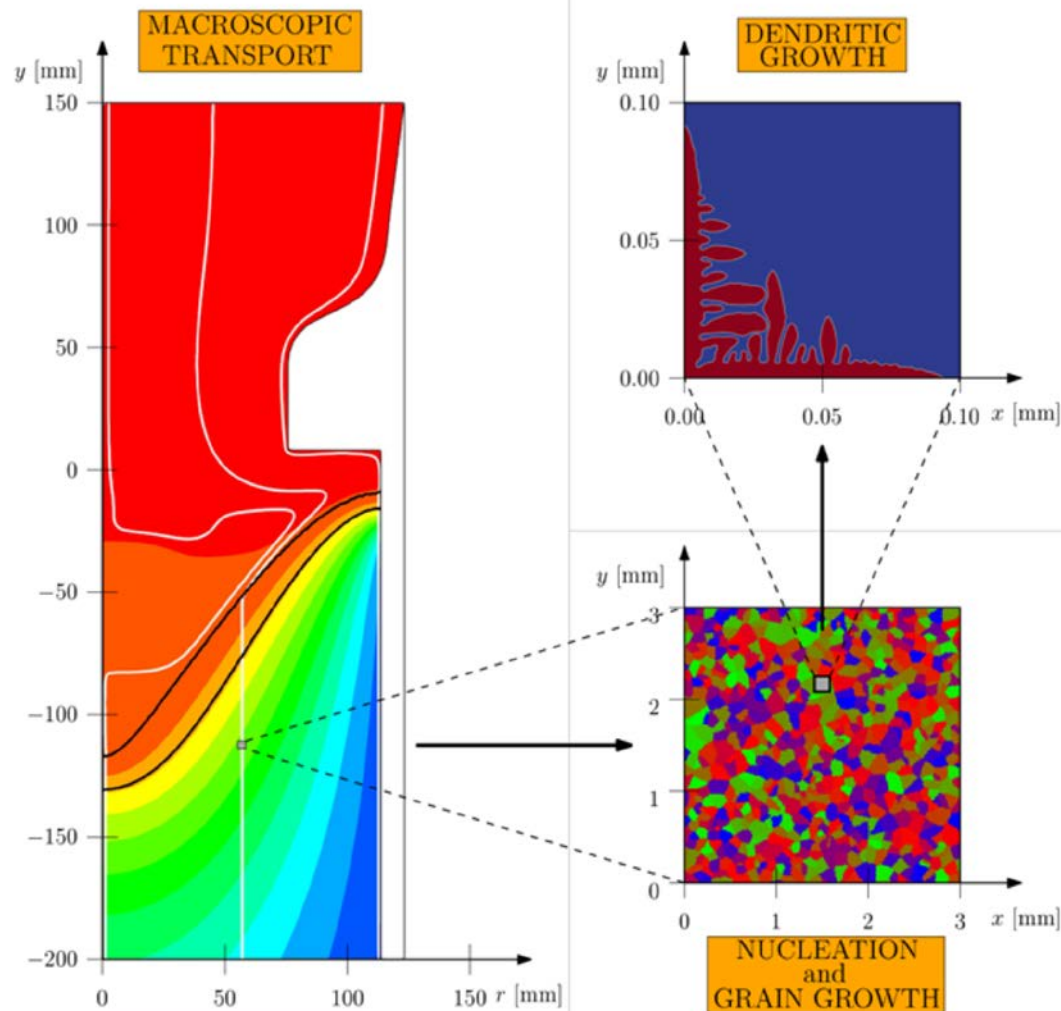
### ORIGINAL SCIENTIFIC ARTICLE

BOMBAČ, Andrej, REK, Zlatko, LEVEC, Janez. Void fraction distribution in a bisectonal bubble column reactor. *AIChE journal*, Apr. 2019, vol. 65, iss. 4, p. 1186-1197.

BOMBAČ, Andrej, PIRNAR, Jernej. Numerical and experimental analyses of a stirred vessel for a large volumetric flow rate of sparged air. *Chinese journal of chemical engineering*, 2019, vol. 27, iss. 10, p. 2304-2312.

KOVAČIČ, Miha, STOPAR, Klemen, VERTNIK, Robert, ŠARLER, Božidar. Comprehensive electric arc furnace electric energy consumption modeling: a pilot study. *Energies*, ISSN 1996-1073, Jun. 2019, vol. 12, iss. 11.

## MULTISCALE SOLIDIFICATION



FAN, Chia-Ming, CHU, Chi-Nan, ŠARLER, Božidar, LI, Tsung-Han. Numerical solutions of waves-current interactions by generalized finite difference method. *Engineering analysis with boundary elements*, ISSN 0955-7997. [Print ed.], 2019, vol. 100, p. 150-163.

VERTNIK, Robert, MRAMOR, Katarina, ŠARLER, Božidar. Solution of three-dimensional temperature and turbulent velocity field in continuously cast steel billets with electromagnetic stirring by a meshless method. *Engineering analysis with boundary elements*, Jul. 2019, vol. 104, p. 347-363.

LIU, Qingguo, ŠARLER, Božidar. Method of fundamental solutions without fictitious boundary for three dimensional elasticity problems based on force-balance desingularization. *Engineering analysis with boundary elements*, Nov. 2019, vol. 108, p. 244-253.

REK, Zlatko. Using a dynamic and constant mesh in numerical simulation of the free-rising bubble. *Fluids*, ISSN 2311-5521, Feb. 2019, vol. 4, iss. 1.

HATIĆ, Vanja, CISTERNAS FERNÁNDEZ, Martín, MAVRIČ, Boštjan, ZALOŽNIK, Miha, COMBEAU, Hervé, ŠARLER, Božidar. Simulation of a macrosegregation benchmark in a cylindrical coordinate system with a meshless method. *International journal of thermal sciences*, Aug. 2019, vol. 142, p. 121-133.

ZAMOLO, Riccardo, NOBILE, Enrico, ŠARLER, Božidar. Novel multilevel techniques for convergence acceleration in the solution of systems of equations arising from RBF-FD meshless discretizations. *Journal of computational physics*, vol. 392, p. 311-334.

KOVAČIČ, Miha, MIHEVC, Andrej, TERČELJ, Milan. Roll wear modeling using genetic programming - industry case study = Modeliranje obrabe valjev z genetskim programiranjem - primer iz industrije. *Materiali in tehnologije*, 2019, y. 53, no. 3, p. 319-325.

HANOGLU, Umut, ŠARLER, Božidar. Hot rolling simulation system for steel based on advanced meshless solution. *Metals*, Jul. 2019, vol. 9, iss. 7.

ZAHOOR, Rizwan, REGVAR, Rok, BAJT, Saša, ŠARLER, Božidar. A numerical study on the influence of liquid properties on gas-focused micro-jets. *Progress in computational fluid dynamics*, 2019, p. 1-13.

KARADŽIĆ, Uroš, BERGANT, Anton, STARINAC, Danica, BOŽOVIĆ, Boško. Water hammer investigation of shut-down of high-head hydropower plant at very high Reynolds number flows. *Strojniški vestnik*, Jul./Avg. 2019, vol. 65, no. 7/8, p. 430-440.

ŠARLER, Božidar, DOBRAVEC, Tadej, GLAVAN, Gašper, HATIĆ, Vanja, MAVRIČ, Boštjan, VERTNIK, Robert, CVAHTE, Peter, GREGOR, Filip, JELEN, Marina, PETROVIČ, Marko. Multi-physics and multi-scale meshless simulation system for direct-chill casting of aluminium alloys. *Strojniški vestnik*, Nov./Dec. 2019, vol. 65, no. 11/12, p. 658-670.

BOMBAČ, Andrej. Experimental study of the void fraction distribution in a bisectional bubble-column reactor. *Ventil: revija za fluidno tehniko in avtomatizacijo*, Avg. 2019, y. 25, no. 4, p. 286-291.

#### **UNIVERSITY, HIGER EDUCATION OR SHORT-TERM HIGER EDUCATION TEXTBOOK WITH REVIEW**

BOMBAČ, Andrej. Zbirka nalog iz mehanske procesne tehnike. 1. izd. Ljubljana: Fakulteta za strojništvo, 2019.

#### **DOCTORAL DISSERTATIONS**

HATIĆ, Vanja. Modelling of macrosegregation of a low-frequency electromagnetic direct chill casting by a meshless method. Mentor: Šarler, Božidar.

#### **PROJECT**

Slovenian Research Agency - Multiphysics and multiscale numerical modelling for competitive continuous casting. Božidar Šarler. 1.7.2018 - 30.6.2021

Slovenian Research Agency. Modelling of trapped air pockets in hydraulic piping systems. Božidar Šarler. 1.7.2019 - 30.6.2022

Slovenian Research Agency. Advanced meshless modelling and simulation of multiphase systems. Božidar Šarler 1.7.2019 - 30.6.2022

Company DESY - Innovative methods for imaging with the use of x-ray Free Electron Laser and synchrotron sources. Božidar Šarler. 13.4.2018 - 12.4.2022

# 03

## ENERGY ENGINEERING

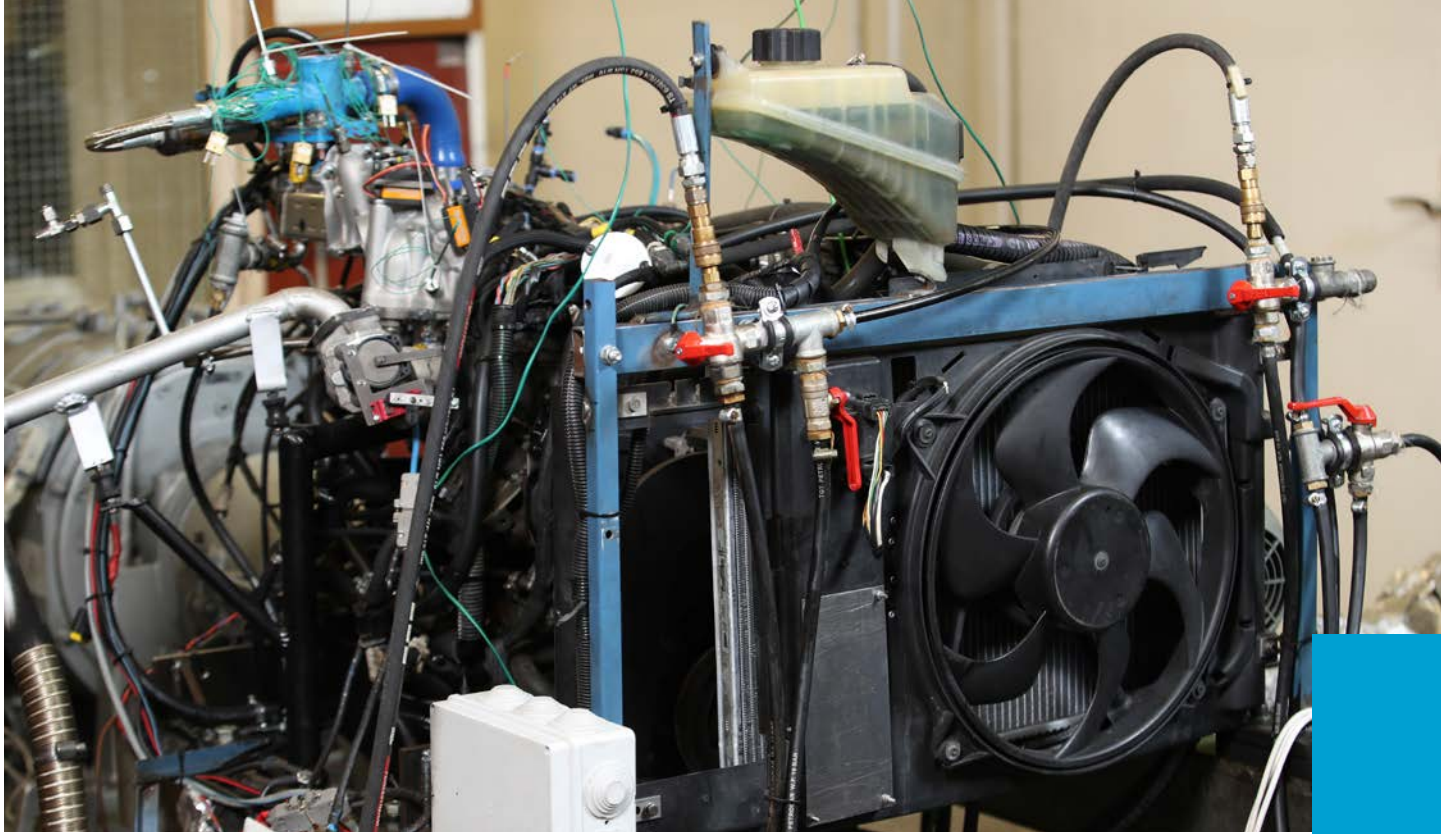
The Energy Engineering research programme is engaged in a wide range of activities:

In the field of internal combustion engines we research advanced designs of engine control and scavenging optimisation. We take part in designing future hybrid, electric and conventional powertrain systems.

In the field of fuel cells and batteries we have been developing next-generation electrochemical models containing nanomaterials.

To achieve high efficiency, durability, economic and environmental sustainability of the use of alternative fuels for, among other things, the research into stationary energy systems, we optimise the performance of systems for cogeneration of heat and electricity.

The research work in the field of turbine machines is concerned with the development of high efficiency and low noise systems. We develop cavitation erosion models. We also study the biological effects of cavitation for medical use and for wastewater treatment.



## Laboratory for Internal Combustion Engines and Electromobility **LICeM**

### RESEARCH AREAS

Internal combustion engines • Alternative fuels • Exhaust emission  
• Hybrid powertrain systems • Electric vehicles • Fuel cells • Batteries  
• Numerical modelling of systems and components

**DEPARTMENT HEAD** Prof. Tomaž Katrašnik, PhD

**DEPARTMENT MEMBERS** Assist. Prof. Tine Seljak, PhD, Assist. Ambrož Kregar, PhD, Assist. Samuel Rodman Oprešnik, PhD, Assist. Gregor Tavčar, PhD, Assist. Rok Vihar, PhD, Assist. Anton Žnidarčič, PhD, Chowdhury Haque Amer Amor, PhD, Assist. Klemen Zelič PhD, Assist. Urban Žvar Baškovič, Igor Mele, Andraž Kravos, Ivo Pačnik, Davor Rašić, Žiga Rosec, Tibaut Tilen, Darja Jeločnik

### ORIGINAL SCIENTIFIC ARTICLE

GUTEŠA Božo, M., VIGUERAS-ZUNIGA, M. O., BUFFI, Marco, SELJAK, Tine, VALERA-MEDINA, Augustin. Fuel rich ammonia-hydrogen injection for humidified gas turbines. Applied energy, Oct. 2019, vol. 251, p. 1-12.

JURIĆ, Filip, PETRANOVIĆ, Zvonimir, VUJANOVIĆ, Milan, KATRAŠNIK, Tomaž, VIHAR, Rok, WANG, Xuebin, DUIĆ, Neven. Experimental and numerical investigation of injection timing and rail pressure impact on combustion characteristics of a diesel engine. Energy conversion and management, Apr. 2019, vol. 185, p. 730-739.

SELJAK, Tine, KATRAŠNIK, Tomaž. Emission reduction through highly oxygenated viscous biofuels: use of glycerol in a micro gas turbine. Energy, Feb. 2019, vol. 169, p. 1000-1011.



ZELIČ, Klemen, KATRAŠNIK, Tomaž. Thermodynamically consistent and computationally efficient OD lithium intercalation model of a phase separating cathode particle. Journal of the Electrochemical Society, ISSN 1945-7111, vol. 166, iss. 14.

KREGAR, Ambrož, KATRAŠNIK, Tomaž. Theoretical analysis of particle size re-distribution due to Ostwald ripening in the fuel cell catalyst layer. Open Physics, ISSN 2391-5471, Jan. 2019, vol. 17, iss. 1.

ZELIČ, Klemen, KATRAŠNIK, Tomaž. Thermodynamically consistent derivation of chemical potential of a battery solid particle from the regular solution theory applied to LiFePO<sub>4</sub>. Scientific reports, Feb. 2019, vol. 9.

ZELIČ, Klemen, MELE, Igor, PAČNIK, Ivo, MOŠKON, Jože, GABERŠČEK, Miran, KATRAŠNIK, Tomaž. Revealing the thermodynamic background of the memory effect in phase separating cathode materials. Strojniški vestnik, Nov./Dec. 2019, vol. 65, no. 11/12, p. 690-700.

### DOCTORAL DISSERTATIONS

ŽVAR BAŠKOVIČ, Urban. Advanced combustion concepts with innovative waste derived fuels. Mentor: Katrašnik, Tomaž.

### PROJECT

AVL List GmbH - Li-ion battery, fuel cell and ICE model development. Tomaž Katrašnik. 1.1.2019 - 31.12.2019

COMET K2 Funding Program - K2 Digital Mobility - Context-Embedded Vehicle Technologies. Tomaž Katrašnik. 01.01.2018 - 31.12.2021

ERDF (Smart Specialization) MOZTART - More efficient electric motors with the development of an EXPERT system and new technologies. Tomaž Katrašnik. 1.10.2018 - 30.9.2021

ERDF (Smart Specialization) - NMP - Exploring biomass potential for development of advanced materials and bio-based products. Tomaž Katrašnik. 01.09.2016 - 30.06.2020

ERDF - European regional development fond SPS - Exploring biomass potential for development of advanced materials and bio-based products (AMP). Tomaž Katrašnik. 1.10.2019 - 30.6.2020

ERDF (Smart Specialization) - EVA4green - Environmentally Safe Green Mobility Car. Tomaž Katrašnik. 01.09.2016 - 28.02.2019

FFG (Austria) - CD Labor - CD Laboratory for Innovative Control and Monitoring of Automotive Powertrain Systems. Tomaž Katrašnik. 01.06.2018 - 31.01.2024

FFG (Austria) - SOH4PEM - State of Health Überwachung für PEM Brennstoffzellenstapel. Tomaž Katrašnik. 01.10.2016 - 30.09.2019

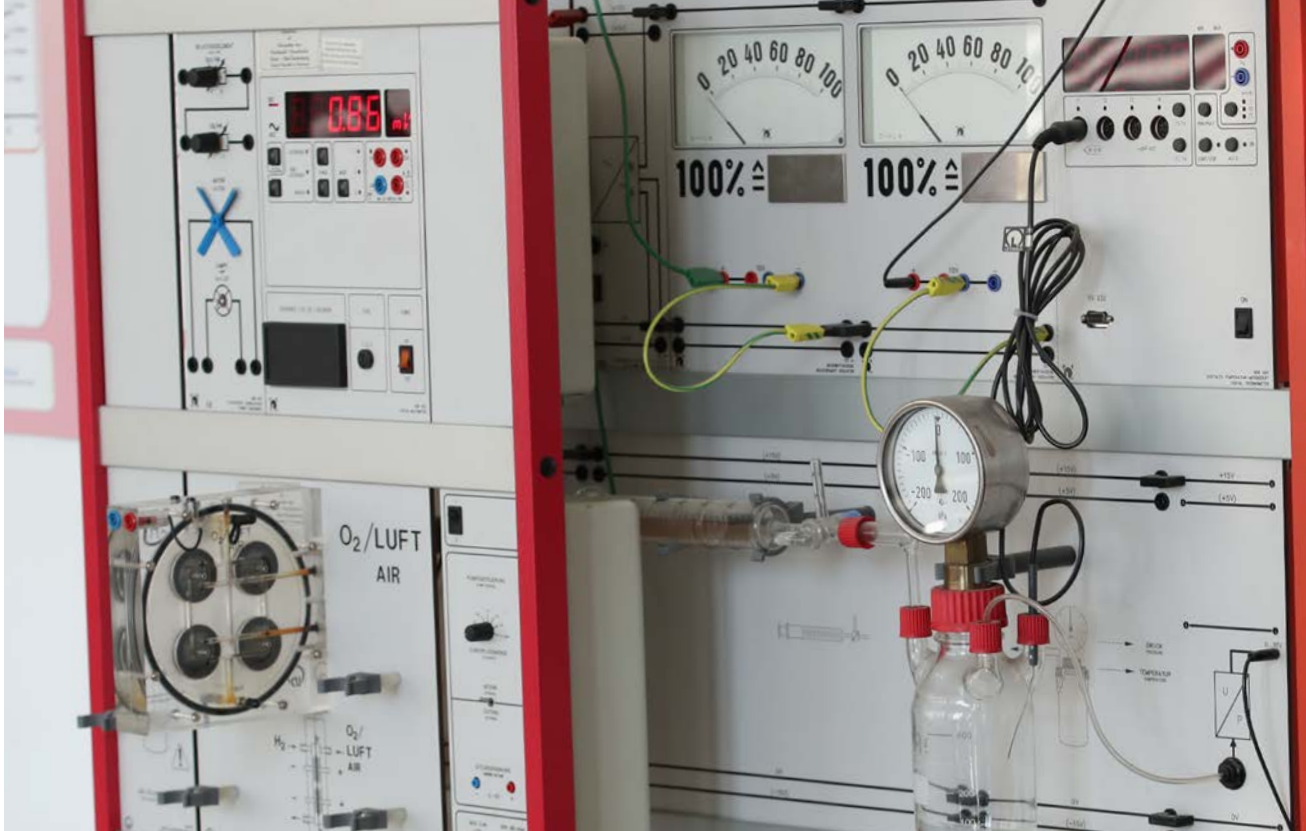
Horizon 2020 - OBELICS - Optimization of scalaBle rEaltime modeLs and functlional testing for e-drive ConceptS. Tomaž Katrašnik. 01.10.2017 - 30.09.2020

Slovenian Research Agency - Next-generation electrochemical LiFePO<sub>4</sub> battery model. Tomaž Katrašnik. 1. 5. 2017 - 30. 4. 2020

Slovenian Research Agency. Zero-footprint combustion for green power generation. Tine Seljak. 1. 7. 2019 - 30. 6. 2021

### AWARDS AND ACHIEVEMENTS

Klemen Zelič received an award of the Faculty of Mechanical Engineering for high quality publications.



## Laboratory for Heat and Power **LTE**

### RESEARCH AREAS

Energy systems • Heat generators • Combustion • Hydrogen technologies • Smart Grids • Life Cycle Assessment • Environmental impacts of energy conversion

**DEPARTMENT HEAD** Prof. Mihael Sekavčnik, PhD

**DEPARTMENT MEMBERS** Assoc. Prof. Andrej Senegačnik, PhD, Assist. Prof. Boštjan Drobnič, PhD, Assist. Prof. Mitja Mori, PhD, Igor Kuštrin, PhD, Assist. Andrej Lotrič, PhD, Assist. Rok Stropnik, Darja Jeločnik

### ORIGINAL SCIENTIFIC ARTICLE

MORI, Mitja, STROPNIK, Rok. Comparing environmental impacts of three typical Slovenian electricity providers with hydroelectricity. *Elektrotehniški vestnik*, 2019, vol. 83, no. 6, p. 97-104.

STROPNIK, Rok, LOTRIČ, Andrej, MONTENEGRO, Alfonso Bernad, SEKAVČNIK, Mihael, MORI, Mitja. Critical materials in PEMFC systems and a LCA analysis for the potential reduction of environmental impacts with EoL strategies. *Energy science & engineering*, Dec. 2019, vol. 7, iss. 6, p. 2519-2539.

MLAKAR, Urška, STROPNIK, Rok, KOŽELJ, Rok, MEDVED, Sašo, STRITIH, Uroš. Experimental and numerical analysis of seasonal solar-energy storage in buildings. *International journal of energy research*, ISSN 0363-907X, 2019, vol. 43, iss. 12, p. 6409-6418.

FÉRRIZ, Ana María, BERNAD, Alfonso, MORI, Mitja, FIOROT, Sabina. End-of-life of fuel cell and hydrogen products: a state of the art. *International journal of hydrogen energy*, 2019, vol. 44, iss. 25, p. 12872-12879.



STROPNIK, Rok, KOŽELJ, Rok, ZAVRL, Eva, STRITIH, Uroš. Improved thermal energy storage for nearly zero energy buildings with PCM integration. *Solar energy*, Sep. 2019, vol. 190, p. 420-426.

KUŠTRIN, Igor, JURJEVČIČ, Boštjan, SENEGAČNIK, Andrej. An electrostatic measuring technique for monitoring particle size in dilute pneumatic transport. *Thermal science*, 2019, p. 1-14.

MELE, Jernej, SENEGAČNIK, Andrej. Design of a fast internal circulating fluidized-bed gasifier with a conical bed angle. *Thermal science*, ISSN 0354-9836, 2019, vol. 23, iss. 1, p. 33-45.

## PROJECTS

COST - CA COST Action CA16235 - Performance and Reliability of Photovoltaic Systems: Evaluations of Large-Scale Monitoring Data. Mitja Mori. 05.10.2017 - 04.10.2021

Horizon 2020 - HYTECHCYCLING - New technologies and strategies for fuel cells and hydrogen technologies in the phase of recycling and dismantling. Mihael Sekavčnik. 01.05.2016 - 30.04.2019

LIFE SUSTAINHUTS - Sustainable Mountain huts in Europe. Mihael Sekavčnik. 01.07.2016 - 30.06.2020

Slovenian Research Agency. Optimization based control of P2G converter connected to hydro power plant. Mihael Sekavčnik. 1.7.2019 - 30.6.2022

Šoštanj Thermal Power Plant - Technical support for the operation of TPP. Mihael Sekavčnik. 1.3.2018 - 28.2.2022



## Laboratory for Hydraulic Machines **LVTS**

### RESEARCH AREAS

Fluid mechanics • Turbine machines • Computer aided visualisation

**DEPARTMENT HEAD** Prof. Marko Hočevar, PhD

**DEPARTMENT MEMBERS** Prof. Matevž Dular, PhD, Prof. Branko Širok, PhD, Assist. Prof. Benjamin Bizjan, PhD, Assist. Prof. Martin Petkovšek, PhD, Assist. Lovrenc Novak, PhD, Assist. Darjan Podbevšek, PhD, Assist. Janez Vrtovšek, PhD, Assist. Mojca Zupanc, PhD, Assist. Jurij Gostiša, Assist. Jure Zevnik, MSc Tone Godeša, Gregor Kozmus, Aleš Malneršič, Matej Sečnik, Peter Pipp, Žiga Pandur, Pero Gatarič, Darja Jeločnik

### ORIGINAL SCIENTIFIC ARTICLE

HOČEVAR, Marko, NOVAK, Lovrenc, RAK, Gašper. Future needs for energy storage in the alpine region = Prihodnje potrebe po shranjevanju energije v alpskem prostoru. Acta hydrotechnica, 2019, y. 32, no. 56, p. 35-43.

NOVAK, Lovrenc, GATARIČ, Pero, ŠIROK, Brane. Influence of drum inlet air conditions on drying process in a domestic tumble dryer. Drying technology, 2019, vol. 37, no. 6, p. 781-792.

GATARIČ, Pero, ŠIROK, Brane, HOČEVAR, Marko, NOVAK, Lovrenc. Modeling of heat pump tumble dryer energy consumption and drying time. Drying technology, 2019, vol. 37, no. 11, p. 1396-1404.

CHEN, Jinpeng, MRVAR, Primož, ŠIROK, Brane, BIZJAN, Benjamin. Melt film adhesion dynamics on spinning wheels. European journal of glass science and technology. Part A, Glass technology, Feb. 2019, vol. 60, no. 1, p. 1-8.

IMAMOVIĆ, Aida, BIZJAN, Benjamin, SEFEROVIĆ, Raif, MRVAR, Primož, BOMBAČ, David. Mechanical properties of mineral stone wool fibers based on mixture of blast furnace slag and diabase. *International journal of advanced research*, 2019, vol. 7, no. 4.

BERK, Peter, BELŠAK, Aleš, STAJNKO, Denis, LAKOTA, Miran, MUŠKINJA, Nenad, HOČEVAR, Marko, RAKUN, Jurij. Intelligent automated system based on a fuzzy logic system for plant protection product control in orchards. *International journal of agricultural and biological engineering*, 2019, vol. 12, no. 3, p. 92-102.

BILUŠ, Ignacij, HOČEVAR, Marko, DULAR, Matevž, LEŠNIK, Luka. Numerical prediction of various cavitation erosion mechanisms. *Journal of fluids engineering: Transactions of the ASME*, Published Online: Oct. 1, 2019.

PODNAR, Andrej, DULAR, Matevž, ŠIROK, Brane, HOČEVAR, Marko. Experimental analysis of cavitation phenomena on kaplan turbine blades using flow visualization. *Journal of fluids engineering: Transactions of the ASME*, Jul. 2019, vol. 141, iss. 7, p. 1-13.

RAK, Gašper, HOČEVAR, Marko, STEINMAN, Franci. Water surface topology of supercritical junction flow. *Journal of Hydrology and Hydromechanics*, 2019, y. 67, no. 2, p. 1-8.

HADŽIĆ, Vedran, ŠIROK, Brane, MALNERŠIČ, Aleš, ČOH, Milan. Can infrared thermography be used to monitor fatigue during exercise?: a case study. *Journal of Sport and Health Science*, 2019, vol. 8, iss. 1, p.

ZEVNIK, Jure, KRAMAR FIJAVŽ, Marjeta, KOZELJ, Daniel. Generalized normalized cut and spanning trees for water distribution network partitioning. *Journal of water resources planning and management*,... 2019, y. 145, no. 10, p. 1-12.

KOSEL, Janez, ŠINKOVEC, Andrej, DULAR, Matevž. Rotacijski generator hidrodinamske kavitacije za fibrilacijo dolgih vlaken iglavcev = Rotational cavitation generator for the fibrillation of conifer fibres. *Papir: revija Društva inženirjev in tehnikov papirništva*, Nov. 2019, y. 47, no. 22, p. 48-51.

BERK, Peter, STAJNKO, Denis, HOČEVAR, Marko, MALNERŠIČ, Aleš, JEJČIČ, Viktor, BELŠAK, Aleš. Plant protection product dose rate estimation in apple orchards using a fuzzy logic system. *PloS one*, ISSN 1932-6203, Apr. 2019, vol. 14, no. 4.

LUO, Kaikai, WANG, Yong, LIU, Houlin, DULAR, Matevž, CHEN, Jie, ZHANG, Zilong. Effect of coating thickness on a solid-liquid two-phase flow centrifugal pump under water medium. *Strojniški vestnik*, Apr. 2019, vol. 65, no. 4, p. 251-261.

SEŽUN, Mija, KOSEL, Janez, ZUPANC, Mojca, HOČEVAR, Marko, VRTOVŠEK, Janez, PETKOVŠEK, Martin, DULAR, Matevž. Cavitation as a potential technology for wastewater management: an example of enhanced nutrient release from secondary pulp and paper mill sludge. *Strojniški vestnik*, Nov./Dec. 2019, vol. 65, no. 11/12, p. 641-649.

KOSEL, Janez, ŠINKOVEC, Andrej, DULAR, Matevž. A novel rotation generator of hydrodynamic cavitation for the fibrillation of long conifer fibers in paper production. *Ultrasonics Sonochemistry*, Dec. 2019, p. 1-9.

STEPIŠNIK PERDIH, Tadej, ZUPANC, Mojca, DULAR, Matevž. Revision of the mechanisms behind oil-water (O/W) emulsion preparation by ultrasound and cavitation. *Ultrasonics Sonochemistry*, Mar. 2019, vol. 51, p. 298-304.

PETKOVŠEK, Martin, DULAR, Matevž. Cavitation dynamics in water at elevated temperatures and in liquid nitrogen at an ultrasonic horn tip. *Ultrasonics Sonochemistry*, Nov. 2019, vol. 58, p. 1-9.

DULAR, Matevž, POŽAR, Tomaž, ZEVNIK, Jure, PETKOVŠEK, Rok. High speed observation of damage created by a collapse of a single cavitation bubble. *Wear*, Jan. 2019, vol. 418/419, p. 13-23.

## **PATENT**

ŠIROK, Brane, DULAR, Matevž, PETKOVŠEK, Martin. Cavitation device for treatment of water by cavitation: United States patent US10202288 B2, 2019-02-12. [S.I.]: Unated States Patent and Trademark Office, 2019.

## **PROJECTS**

EIP - Introduction of new mechanical and autonomous automated technologies for the sustainable production of grapes. Marko Hočevar. 23.11.2019 – 22.11.2022

EIT InnoEnergy CTPProfiler - Cooling Tower Profiler – Performance Evaluation of Cooling Towers. Marko Hočevar. 01.04.2017 – 30.09.2019

ERDF (Smart Specialization) - IQ Home - Intelligent home of the new generation designed on smart appliances and wood. Marko Hočevar. 01.09.2016 – 28.02.2019

ERDF (Smart Specialization) - NMP - Exploring biomass potential for development of advanced materials and bio-based products. Marko Hočevar. 01.09.2016 – 30.06.2020

Horizon 2020 - ERC- CABUM - An investigation of the mechanisms at the interaction between cavitation bubbles and contaminants. Matevž Dular. 01.07.2018 – 30.06.2023

Gorenje d.d. - Development of a fan and independent control of fan and drum of a tumble dryer with heat pump. Marko Hočevar. 1.12.2018 – 31.5.2020

Slovenian Research Agency. Improved treatment and monitoring of Water Framework Directive priority pollutants. Marko Hočevar. 1.3.2016 – 28.2.2019

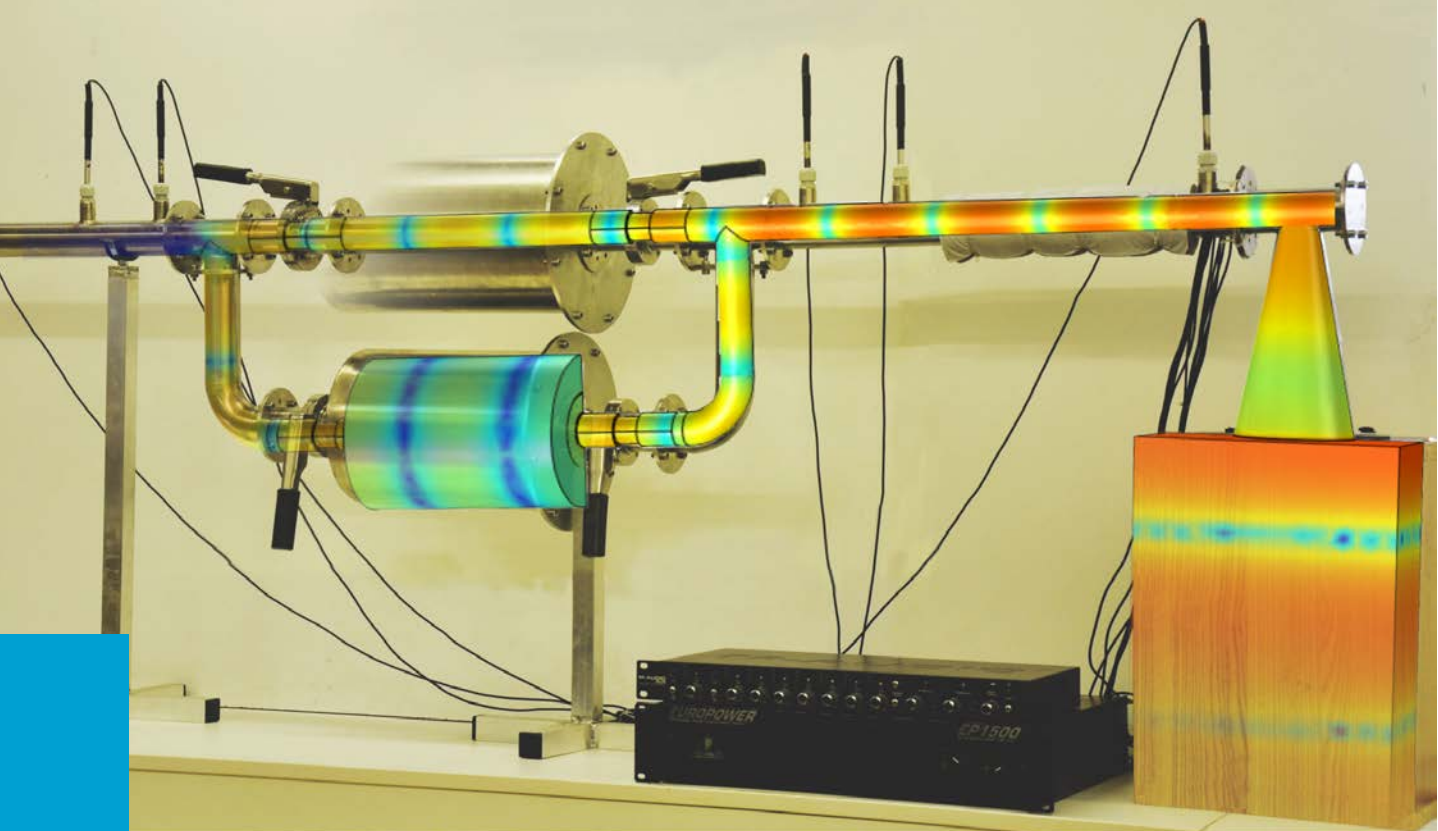
Slovenian Research Agency. Development of new, environment-friendly approaches for plant and human virus inactivation in waters. Matevž Dular. 1.7.2018 – 30.6.2021

Slovenian Research Agency. Scale effects in acoustic cavitation in various liquids with dimensionless number definition. Martin Petkovšek. 1.5.2017 – 30.4.2019

Slovenian Research Agency. Cavitation - a solution for microplastics degradation? Martin Petkovšek. 1.7.2019 – 30.6.2022

## **AWARDS AND ACHIEVEMENTS**

Matevž Dular received the Zois Award for important contribution to understanding the phenomenon of cavitation.



## Laboratory for Pumps, Compressors and Technical Acoustics **LEDSTA**

### RESEARCH AREAS

Noise measurement and analysis • Environmental noise • Noise reduction • Identification and parametrisation of sound sources • Prediction and modelling of noise propagation • Use of noise as a source of information • Psychoacoustics • Pumps • Ventilators • Compressors • Cavitation

**DEPARTMENT HEAD** Assoc. Prof. Jurij Prezelj, PhD

**DEPARTMENT MEMBERS** Assist. Luka Čurović, Jure Murovec, Tadej Novaković, Zdenka Rupič

### ORIGINAL SCIENTIFIC ARTICLE

MUROVEC, Jure, KUŠAR, Janez, BERLEC, Tomaž. Methodology for searching representative elements. Applied sciences, 2019, vol. 9, iss. 7.

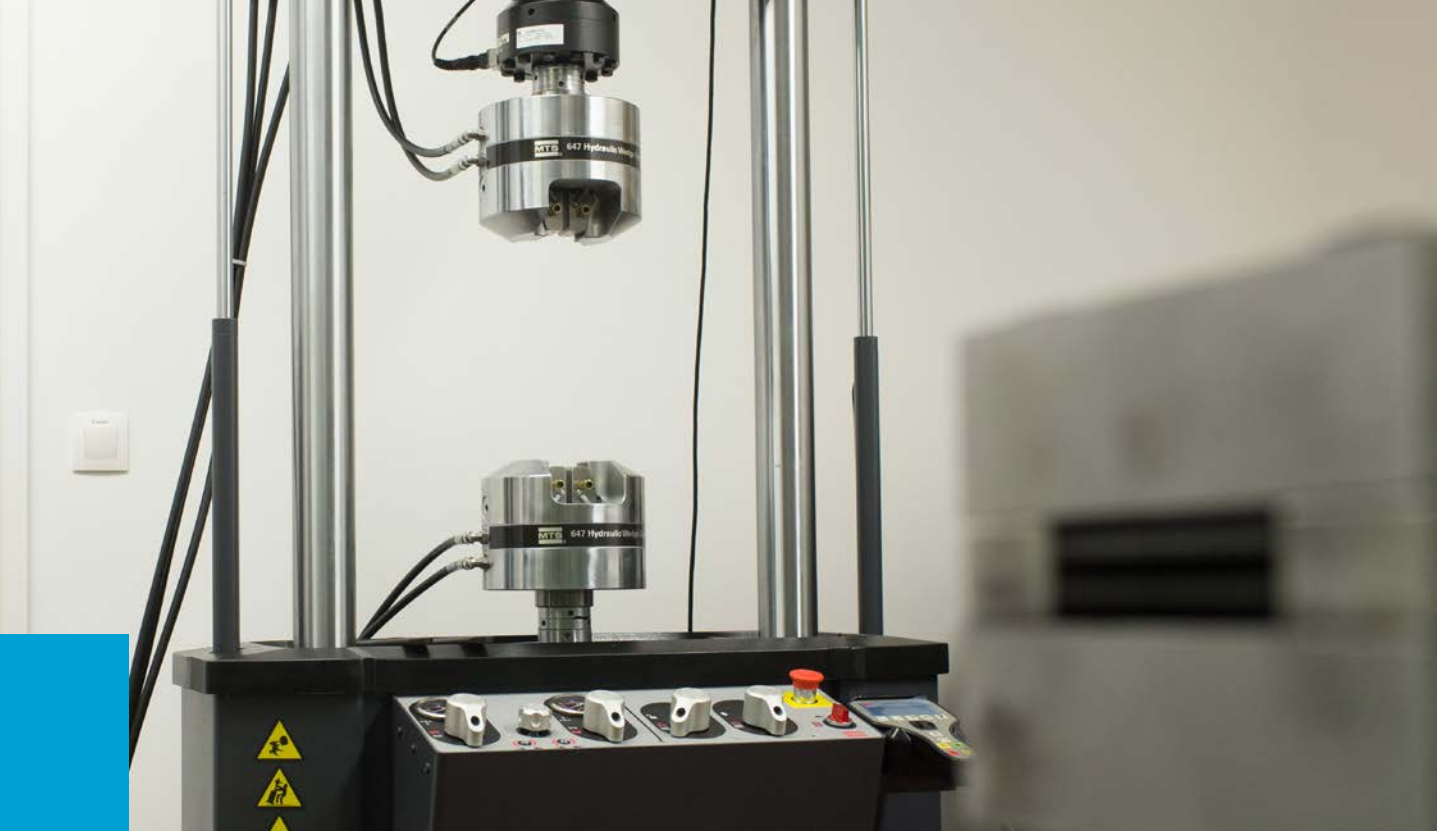
# 04 DEVELOPMENT EVALUATION

In the Development evaluation programme group, we are improving upon the rebmix algorithm for finite mixture parameter estimation and the Dirlik method for fatigue life prediction in the frequency-domain.

We will model the stress-strain states of rubber and rubber composites and their fatigue life. We will improve the energy based method for the durability prediction of thermomechanically loaded components. We will research the lithium-ion batteries. We will improve the models of durability showing a significant break-point in the durability curve. We will research the modelling of the fatigue life of casted parts with inhomogeneities and of parts with a hybrid metal-nonmetal load-carrying structure.

Prediction of the behaviour of structures that are loaded with mechanical loads causing high strain rates in the material will be improved. For wood products, the influence of the probability distribution of occurrence and location of inhomogeneities on the material properties of wood will be determined. The damage initiation and damage propagation periods during fatigue of wood and wood-based composites and hybrids will be investigated.





## Laboratory for Machine Elements **LASEM**

### RESEARCH AREAS

Machine element • Operational strength • Development evaluations

**DEPARTMENT HEAD** Prof. Marko Nagode, PhD

**DEPARTMENT MEMBERS** Assist. Prof. Simon Oman PhD, Assist. Aleš Gosar, PhD, Assist. Ivan Okorn, PhD, Assist. Tadej Kocjan, Assist. Branislav Panić, Assist. Urša Šolinc, Miran Nerat, Boris Šrklec, Silva Brenčič

### ORIGINAL SCIENTIFIC ARTICLE

NAGODE, Marko, GOSAR, Aleš, SWEENEY, Caoimhe A., JAGUEMONT, Joris, MIERLO, Joeri Van, ŠERUGA, Domen. Mechanistic modelling of cyclic voltage-capacity response for lithium-ion batteries. *Energy*, Nov. 2019, vol. 186, p. 1-12.

YE, X. W., XI, P. S., NAGODE, Marko. Extension of REBMIX algorithm to von Mises parametric family for modeling joint distribution of wind speed and direction. *Engineering structures*, Mar. 2019, vol. 183, p. 1134-1145.

GOSAR, Aleš, NAGODE, Marko, OMAN, Simon. Continuous fatigue damage prediction of a rubber fibre composite structure using multiaxial energy-based approach. *Fatigue & fracture of engineering materials & structures*, Jan. 2019, vol. 42, iss. 1, p. 307-320.

ŠOLINC, Urša, KLEMENC, Jernej, NAGODE, Marko, ŠERUGA, Domen. A direct approach to modelling the complex response of magnesium AZ31 alloy sheets to variable strain amplitude loading using Prandtl-Ishlinskii operators. *International journal of fatigue*, ISSN 0142-1123, Oct. 2019, vol. 127, p. 291-304.



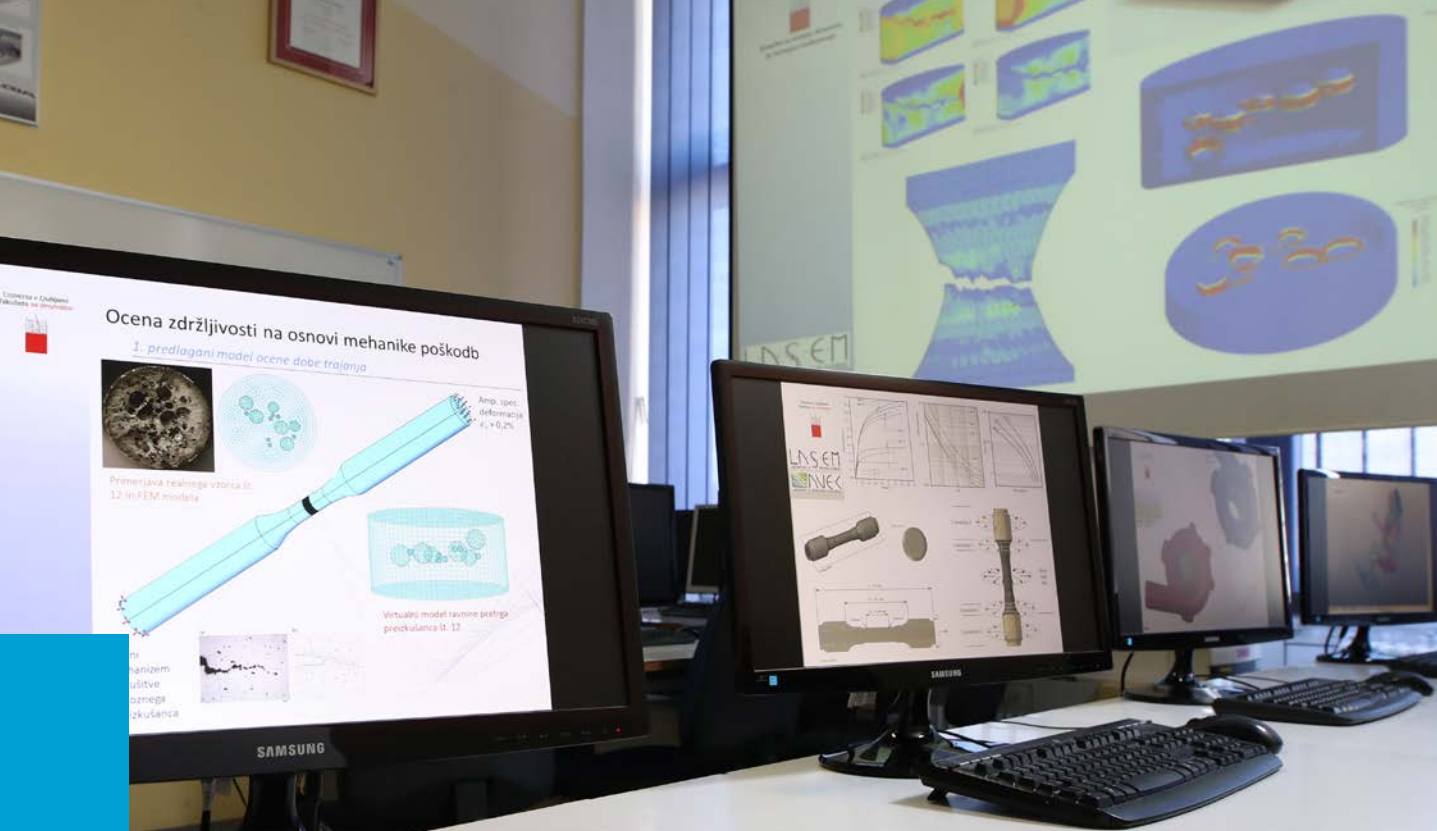
PEČNIK, Matija, NAGODE, Marko, ŠERUGA, Domen. Influence of geometry and safety factor on fatigue damage predictions of a cantilever beam. Structural engineering and mechanics, Apr. 2019, vol. 70, no. 1, p. 33-41.

#### **PROJECTS**

ERDF (Smart Specialization) - EVA4green - Ecological Safe Vehicle for green mobility. Marko Nagode. 01.09.2016 - 28.02.2019

Slovenian Research Agency. Development of multifunctional auxetic cellular structures. Marko Nagode. 1.5.2017 - 30.4.2020

Texas Institute of Science - Variable displacement modular Axial Piston Pump Including Separator. Marko Nagode. 17.6.2019-31.12.2019



## Laboratory for Structure Evaluation **LAVEK**

### RESEARCH AREAS

Development • Evaluation • Reliability • Maintainability • Supportability  
• Availability • Dependability • Durability • Prediction

**DEPARTMENT HEAD** Prof. Jernej Klemenc, PhD

**DEPARTMENT MEMBERS** Assist. Prof. Domen Šeruga, PhD, Assist. Andrej Škrlec, PhD, Assist. Dejan Tomažinčič, Assist. Peter Zobec, MSc Tomaž Bešter, Silva Brenčič

### ORIGINAL SCIENTIFIC ARTICLE

BEŠTER, Tomaž, OMAN, Simon, NAGODE, Marko. Determining influential factors for an air spring fatigue life. *Fatigue & fracture of engineering materials & structures*, ISSN 1460-2695, Jan. 2019, vol. 42, iss. 1.

TOMAŽINČIČ, Dejan, NEČEMER, Branko, VESENJAK, Matej, KLEMENC, Jernej. Low-cycle fatigue life of thin-plate auxetic cellular structures made from aluminium alloy 7075-T651. *Fatigue & fracture of engineering materials & structures*, ISSN 8756-758X, May 2019, vol. 42, iss. 5, p. 1022-1036.

ŠERUGA, Domen, NAGODE, Marko. A new approach to finite element modelling of cyclic thermomechanical stress-strain responses. *International journal of mechanical sciences*, Dec. 2019, vol. 164, p. 1-14.

KLEMENC, Jernej, ŠERUGA, Domen, NAGODE, Aleš, NAGODE, Marko. Comprehensive modelling of the hysteresis loops and strain-energy density for low-cycle fatigue-life predictions of the AZ31 magnesium alloy. *Materials*, Nov. 2019, vol. 12, iss. 22.



ŠERUGA, Domen, NAGODE, Marko, KLEMENC, Jernej. Eliminating friction between flat specimens and an antibuckling support during cyclic tests using a simple sensor. *Measurement science & technology*, 2019, vol. 30, no. 9, p. 1-15.

KLEMENC, Jernej, ŠERUGA, Domen, NAGODE, Marko. A durability prediction for the magnesium alloy AZ31 based on plastic and total energy. *Metals*, Sep. 2019, vol. 9, iss. 9.

ŠERUGA, Domen, NAGODE, Marko. Comparative analysis of optimisation methods for linking material parameters of exponential and power models: an application to cyclic stress-strain curves of ferritic stainless steel. *Proceedings of the Institution of Mechanical Engineers, Proceedings part L, Journal of materials - design and applications*, 2019, vol. 233, iss. 9, p. 1802-1813.

KLEMENC, Jernej, PODGORNIK, Bojan. An improved model for predicting the scattered S-N curves. *Strojniški vestnik*, May 2019, vol. 65, no. 5, p. 265-275.

ŠERUGA, Domen, NAGODE, Marko, KLEMENC, Jernej. Stress-strain response determination during incremental step tests and variable loadings on flat specimens. *Technologies*, 2019, vol. 7, iss. 3.

#### **UNIVERSITY, HIGHER EDUCATION OR SHORT-TERM HIGHER EDUCATION TEXTBOOK WITH REVIEW**

KLEMENC, Jernej. *Dinamika vozil*. 1. elektronska izd. Ljubljana: Fakulteta za strojništvo, 2019.

#### **PROJECTS**

ERDF (Smart Specialization) - EVA4green - Ecological Safe Vehicle for green mobility. Jernej Klemenc. 01.09.2016 – 28.02.2019

Texas Institute of Science - Variable displacement modular Axial Piston Pump Including Separator. Jernej Klemenc. 17.6.2019 – 31.12.2019

Slovenian Research Agency - Analysis of failures that were detected at technical inspection procedures by using conventional statistical methods and data mining methods. Jernej Klemenc. 1.11.2019 – 31.10.2022

Slovenian Research Agency. Development of multifunctional auxetic cellular structures. Jernej Klemenc. 1.5.2017 – 30.4.2020

# 05

## HEAT AND MASS TRANSFER

We conduct research and development of systems for the supply and use of energy for heating, cooling, air-conditioning and process engineering with emphasis on renewable energy sources and efficient use of energy.

We are engaged in advanced mechanisms of heat transfer and heat transport, a part of which includes boiling research in microstructures. We are involved in exergoeconomic optimisation of the entire energy supply chain. We research and develop alternative magnetocaloric and electrocaloric cooling technologies for real applications in the domain of conventional refrigerators with inclusion of thermal diodes and switches.

We conduct research of thermal response of cities with natural building elements and integration into buildings' envelope. We study the impact of cooling loads of buildings on electricity consumption and thermal comfort in buildings with inclusion of thermal storage. Research results are verified with measurements conducted in laboratories and on real systems for which innovative measuring methods and meters are being developed.



## Laboratory for Measurements in Process Engineering **LMPS**

### RESEARCH AREAS

- Metrology • Measurements of temperature, pressure and fluid flow rate
- Development of measuring equipment and measurement methods
  - Calibration

**DEPARTMENT HEAD** Assoc. Prof. Jože Kutin, PhD

**DEPARTMENT MEMBERS** Assist. Prof. Gregor Bobovnik, PhD, Assist. Andrej Svete, PhD, Assist. Metka Štefe, Marjan Pohl, Peter Sambol, Zdenka Rupič

### ORIGINAL SCIENTIFIC ARTICLE

BOBOVNIK, Gregor, KUTIN, Jože. Experimental identification and correction of the leakage flow effects in a clearance-sealed piston prover. *Metrologia*, 2019, vol. 56, no. 1, p. 1-9.

### AWARDS AND ACHIEVEMENTS

Laboratory LMPS successfully renewed its accreditation according to SIST EN ISO/IEC 17025:2017 in the field of pressure, gas flow rate and temperature (Slovenian Accreditation, LK-015).



## Laboratory for Heating Technology **LTT**

### RESEARCH AREAS

Heat and mass transfer • Thermal engineering • Applied thermodynamics • Process engineering • Biotechnology • Environmental protection technologies

**DEPARTMENT HEAD** Prof. Iztok Golobič, PhD

**DEPARTMENT MEMBERS** Assist. Prof. Matevž Zupančič, PhD, Assist. Anže Sitar, PhD, Assist. Ivan Sedmak, PhD, Assist. Jure Voglar, PhD, Assist. Matic Može, Zdenka Rupič

### ORIGINAL SCIENTIFIC ARTICLE

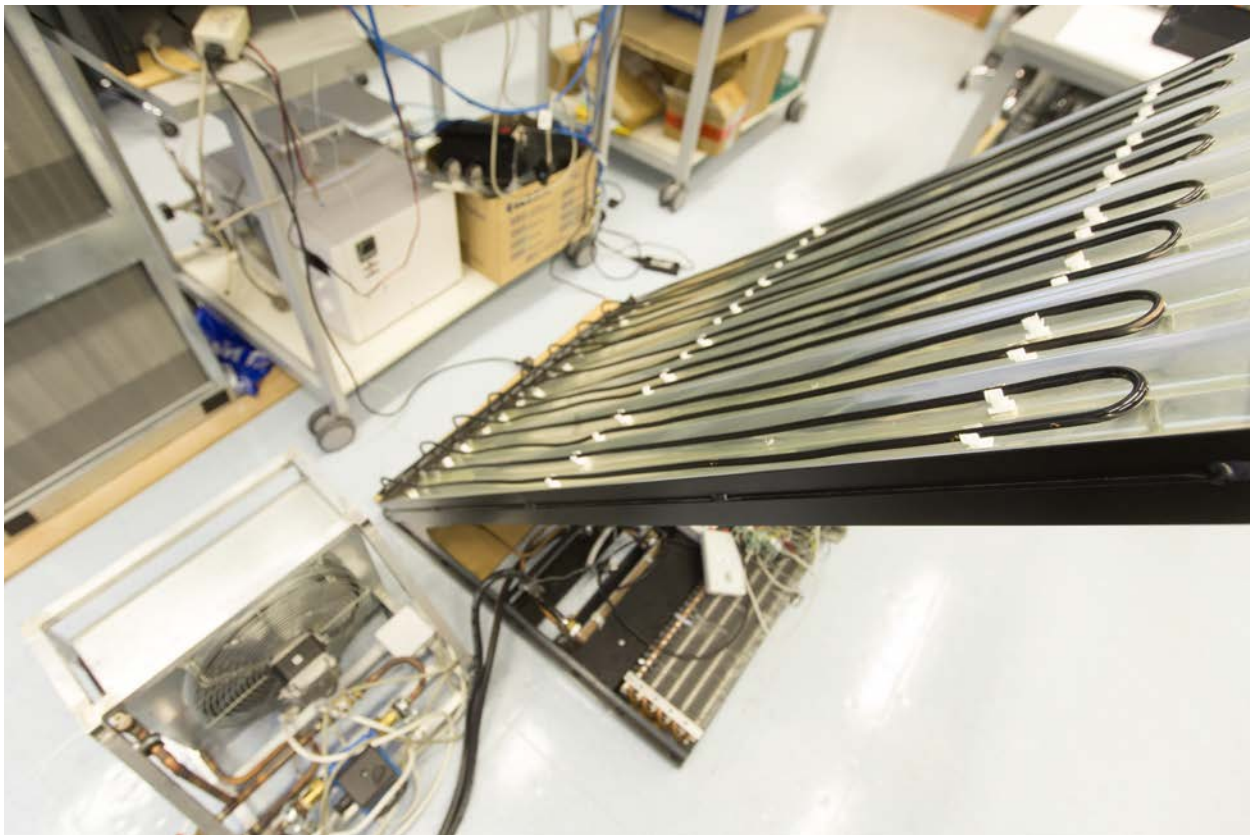
MOŽE, Matic, ZUPANČIČ, Matevž, HOČEVAR, Matej, GOLOBIČ, Iztok, GREGORČIČ, Peter. Surface chemistry and morphology transition induced by critical heat flux incipience on laser-textured copper surfaces. Applied Surface Science, Oct. 2019, vol. 490, p. 220-230.

VOGLAR, Jure, ZUPANČIČ, Matevž, PEPERKO, Aljoša, BIRBARAH, Patrick, MILJKOVIC, Nenad, GOLOBIČ, Iztok. Analysis of heater-wall temperature distributions during the saturated pool boiling of water. Experimental thermal and fluid science, Apr. 2019, vol. 102, p. 205-214.

### DOCTORAL DISSERTATIONS

SEDMAK, Ivan. Submicron detection of temperature fields in transient heat transfer. Mentor: Golobič, Iztok.

VOGLAR, Jure. Characteristics of boiling process on biphilic surfaces. Mentor: Golobič, Iztok.



## **PROJECTS**

ESA - MAP Project - "Microgravity Applications Program (MAP) project AO-2004-111 (Convective boiling and condensation)". Iztok Golobič. 01.01.2016 - 30.06.2019

Company Melamin - Making of the study on the development of a membrane process system for nano-filtration of PAE resins. Iztok Golobič. 17.2.2017 - 17.2.2018

Company Melamin - Execution of an ultrafiltration system for the preparation of process water for filling up the cooling system. Iztok Golobič. 27.11.2018 - 27.5.2019

## **AWARDS AND ACHIEVEMENTS**

Matic Može received a ceremonial certificate of the University of Ljubljana for an outstanding academic achievement.

Iztok Golobič received the Golden Plaque of the University of Ljubljana.





## Laboratory for Refrigeration and District Energy LAHDE

### RESEARCH AREAS

Heat and Mass Transfer • Refrigeration • Caloric energy conversion  
• Heat pumps • Thermal control devices • District energy

**DEPARTMENT HEAD** Prof. Andrej Kitanovski, PhD

**DEPARTMENT MEMBERS** Assist. Prof. Jure Mencinger, PhD, Assist. Prof. Jaka Tušek, PhD, Assist. Dall'Olio Stefan, PhD, Assist. Primož Poredoš, PhD, Assist. Urban Tomc, PhD, Assist. Boris Vidrih, PhD, Assist. Uroš Plaznik, PhD, Parham Kabirifar, PhD, Assist. Žiga Ahčin, Assist. Katja Klinar, Assist. Luka Lorbek, Assist. Nada Petelin, Assist. Luka Porenta, MSc Miha Bobič, Simon Bogič, Jan Cerar, Simon Nosan, Darja Jeločnik

### ORIGINAL SCIENTIFIC ARTICLE

KLINAR, Katja, TOMC, Urban, JELENC, Blaž, NOSAN, Simon, KITANOVSKI, Andrej. New frontiers in magnetic refrigeration with high oscillation energy-efficient electromagnets. *Applied energy*, Feb. 2019, vol. 236, p. 1062-1077.

MAIORINO, Angelo, DEL DUCA, Manuel Gesù, TUŠEK, Jaka, TOMC, Urban, KITANOVSKI, Andrej, APREA, Ciro. Evaluating magnetocaloric effect in magnetocaloric materials: a novel approach based on indirect measurements using artificial neural networks. *Energies*, May 2019, vol. 12, iss. 10.

POREDOŠ, Primož, KITANOVSKI, Andrej, POREDOŠ, Alojz. Exergy analyses of low-temperature district heating systems with different sanitary hot-water boosters. *Entropy*, Apr. 2019, vol. 21, iss. 4.

ŠADL, Matej, TOMC, Urban, PRAH, Uroš, URŠIČ NEMEVŠEK, Hana. Protective alumina coatings prepared by aerosol deposition on magnetocaloric gadolinium elements. *Informacije MIDEM: časopis za mikroelektroniko, elektronske sestavne dele in materiale*, 2019, vol. 49, no. 3, p. 177-182.

PLAZNIK, Uroš, VRABELJ, Marko, KUTNJAK, Zdravko, MALIČ, Barbara, ROŽIČ, Brigita, POREDOŠ, Alojz, KITANOVSKI, Andrej. Numerical modelling and experimental validation of a regenerative electrocaloric cooler. *International journal of refrigeration*, Feb. 2019, vol. 98, p. 139-149.

KABIRIFAR, Parham, ŽEROVNIK, Andrej, AHČIN, Žiga, PORENTA, Luka, BROJAN, Miha, TUŠEK, Jaka. Elastocaloric cooling: state-of-the-art and future challenges in designing regenerative elastocaloric devices. *Journal of Mechanical Engineering/Strojniški vestnik*, ISSN 0039-2480, Nov./Dec. 2019, vol. 65, no. 11/12, p. 615-630.

## PROJECTS

ERDF (Smart Specialization) - IQ Home - Intelligent home of the new generation designed on smart appliances and wood. Andrej Kitanovski. 01.09.2016 - 28.02.2019

Gorenje d.d. - Gorenje d.d. - Development of methods for self-adaptive control and management of heat flows in household appliances. Andrej Kitanovski. 1.3.2019 - 31.7.2020

Gorenje d.d. - Gorenje d.d. - Development of thermal processes in household appliances. Andrej Kitanovski. 22.2.2017-21.2.2020

Horizon 2020 - ERC SUPERCOOL - Superelastic Porous Structures for Efficient Elastocaloric Cooling. Jaka Tušek. 01.01.2019 - 31.12.2023

Slovenian Research Agency. Multicaloric cooling. Andrej Kitanovski. 1.7.2018 - 30.6.2021

Slovenian Research Agency. Advanced electrocaloric energy conversion. Andrej Kitanovski. 1.3.2016 - 28.2.2019

Slovenian Research Agency. Digital microfluidics in magnetocaloric refrigeration. Urban Tomc. 1.7.2018 - 30.6.2020

## AWARDS AND ACHIEVEMENTS

Team LAHDE from the Faculty of Mechanical Engineering and their colleagues from the JSI have created the world's first electro-caloric demonstration cooling device. For this achievement they received the Slovenian Research Agency Award for Excellence in Science.

Katja Klinar received an award of the Faculty of Mechanical Engineering for high quality publications.



## Laboratory for Heating, Sanitary, Solar and Air Conditioning Engineering **LOSK**

### RESEARCH AREAS

Heat and mass transfer in buildings and building installations • Indoor environment • Ventilation • Air conditioning • Efficient use of energy • Environment protection (air) • Sanitary engineering • Alternative systems • Modelling

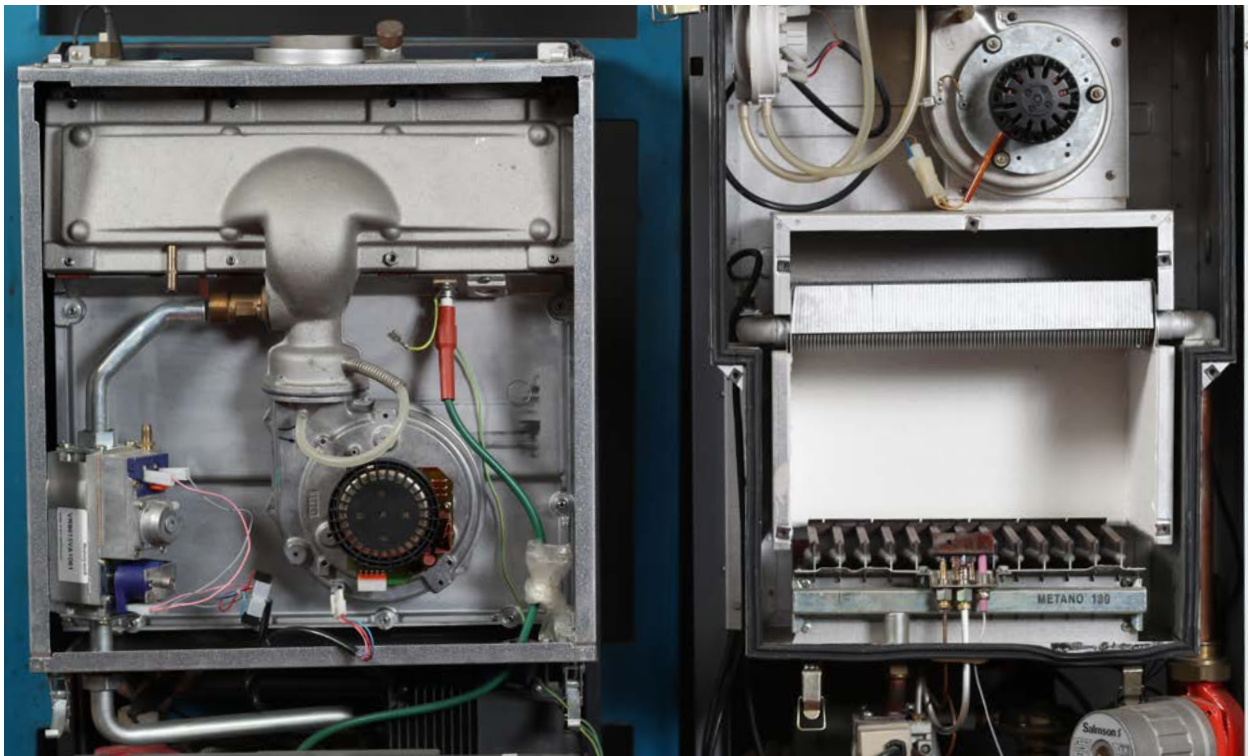
**DEPARTMENT HEAD** Assoc. Prof. Uroš Stritih, PhD

**DEPARTMENT MEMBERS** Assist. Prof. Matjaž Prek, PhD, Assist. Eneja Osterman, PhD, Assist. Rok Koželj, Žiga Lampret, Eva Zavrl, Darja Jeločnik

### ORIGINAL SCIENTIFIC ARTICLE

STRITIH, Uroš, ZAVRL, Eva, PAKSOY, Halime. Energy analysis and carbon saving potential of a complex heating system with solar assisted heat pump and phase change material (PCM) thermal storage in different climatic conditions. European journal of sustainable development research, 2019, vol. 3, iss. 1.

LAMPRET, Žiga, KRESE, Gorazd, PREK, Matjaž. The effect of population aging on heating energy demand on national level: a case study of Slovenia. Strojniški vestnik, Nov./Dec. 2019, vol. 65, no. 11/12, p. 701-708.



## PROJECTS

Horizon 2020 - HEART - Holistic Energy and Architectural Retrofit Toolkit. Uroš Stritih.  
01.10.2017 - 30.09.2021

Slovenian Research Agency. Advanced heat storage materials for integrated storage solutions.  
Uroš Stritih. 1.3.2016 - 28.2.2019



## Laboratory for Sustainable Technologies in Buildings **LOTZ**

### RESEARCH AREAS

Engineering sciences • Energy engineering • Renewable sources and technologies

**DEPARTMENT HEAD** Prof. Sašo Medved, PhD

**DEPARTMENT MEMBERS** Assoc. Prof. Ciril Arkar, PhD, Assist. Tomaž Šuklje, PhD, Assist. MSc Suzana Domjan, Assist. Žiga Begelj, Darja Jeločnik

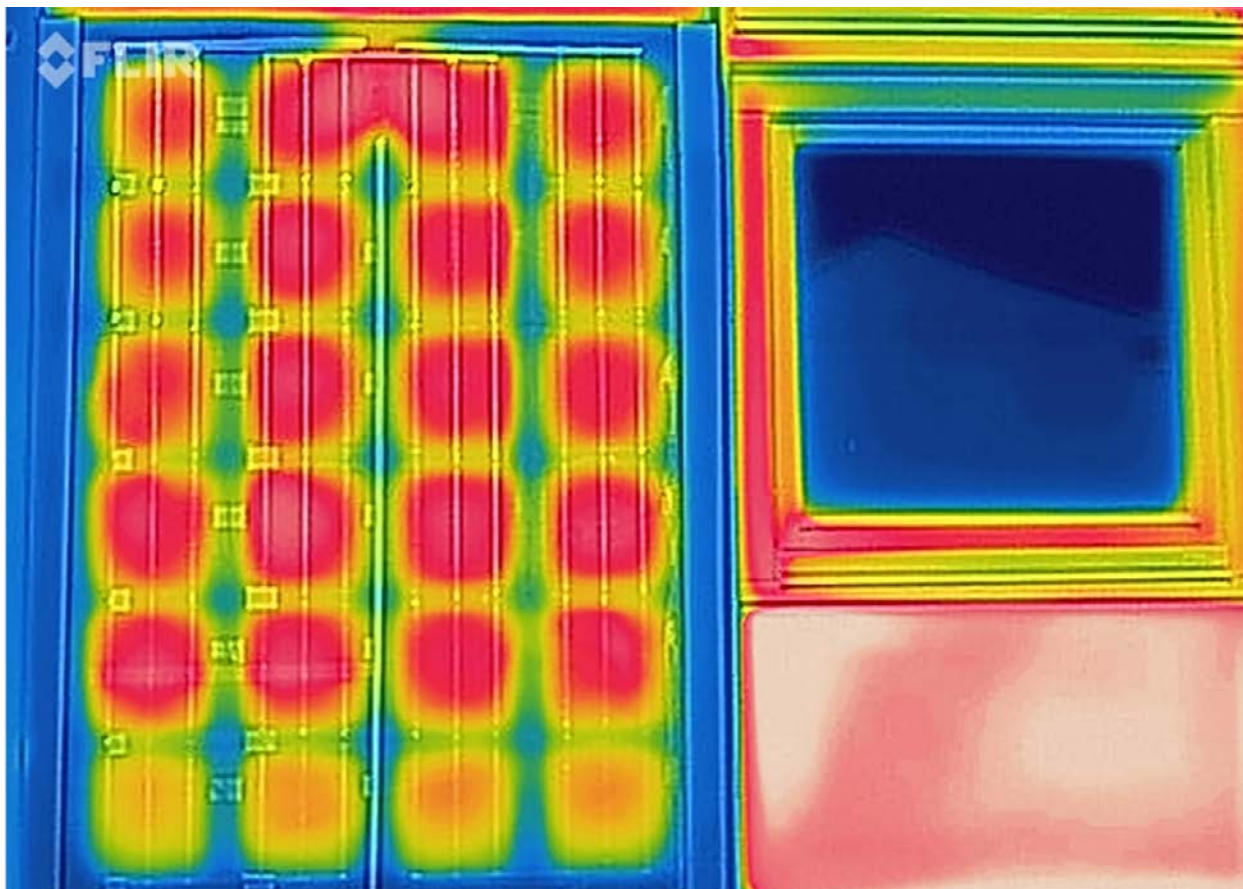
### ORIGINAL SCIENTIFIC ARTICLE

ŠUKLJE, Tomaž, HAMDY, Mohamed, ARKAR, Ciril, HENSEN, Jan, MEDVED, Sašo. An inverse modeling approach for the thermal response modeling of green façades. *Applied energy*, Feb. 2019, vol. 235, p. 1447-1456.

DOMJAN, Suzana, ARKAR, Ciril, BEGELJ, Žiga, MEDVED, Sašo. Evolution of all-glass nearly zero energy buildings with respect to the local climate and free-cooling techniques. *Building and environment*, 2019, vol. 160, p. 1-15.

DOMJAN, Suzana, MEDVED, Sašo, ČERNE, Boštjan, ARKAR, Ciril. Fast modelling of nZEB metrics of office buildings built with advanced glass and BIPV facade structures. *Energies*, Aug. 2019, vol. 12, iss. 16.

MEDVED, Sašo, BEGELJ, Žiga, DOMJAN, Suzana, ŠUKLJE, Tomaž, ČERNE, Boštjan, ARKAR, Ciril. The dynamic thermal response model and energy performance of multi-layer glass and BIPV facade structures. *Energy and buildings*, Apr. 2019, vol. 188/189, p. 239-251.



## PROJECTS

ERDF (Smart Specialization) - TIGR4smart - ERDF - European regional development fund  
SPS - Sustainable and innovative construction of smart buildings (TIGR4smart). Sašo Medved.  
01.09.2016 - 31.03.2019

Slovenian Research Agency. Development of the prognostic model of exposure to indoor air  
pollutants in schools and preparation of evidence based measures for planning of efficient  
natural ventilation of the classrooms. Sašo Medved. 1.11.2019 - 31.10.2021

# 06 TRIBOLOGY

The Tribology programme group is interdisciplinary and includes 15-20 member from different disciplines: mechanical engineering, physics, chemistry, materials and nanotechnologies.

The group is developing an energy-efficient, sustainable and at the same time more environment-friendly “green” operation of mechanical systems. Linking understanding of tribological and surface processes from nano- to macroscale with the aim of solving industrial problems is the group’s basic goal. The central closely-related areas of work are: contact engineering and surface mechanics, wear-resistant mechanical systems, protective surface coatings, lubrication and surface films, nanotribology, wetting, tribochemistry and adhesion processes, and power-control hydraulic design.

The group is also actively engaged in topography and real contact area models, advanced polymer, electrical and mechatronic contacts tribology, tribology in production processes, polymer gears and automotive applications, and water hydraulics.



## Laboratory for tribology and interface nanotechnology **TINT**

### RESEARCH AREAS

Wear • Lubrication • Friction • Surface engineering • Nanotribology  
• Interface nanotechnology • Maintenance

**DEPARTMENT HEAD** Prof. Mitjan Kalin, PhD

**DEPARTMENT MEMBERS** Assist. Prof. Marko Polajnar, PhD, Assist. Prof. Janez Kogovšek, PhD, Assist. Boris Kržan, PhD, Assist. Akbari Somayeh PhD, Assist. Arshad Muhammad Shahid, PhD, Assist. Blaž Brodnik Žugelj, PhD, Assist. Sharma Sandan Kumar, PhD, Assist. Lucija Čoga, PhD, Assist. Jure Jerina, PhD, Assist. Marko Soderžnik, PhD, Assist. Maja Kus, PhD, Assist. Vadivel Hari Shankar, Assist. Urban Klanjšček, Sebastjan Matkovič, Hamouda Karim, Siddiqui Muhammad Shoab Naseem, Franc Kopač, Petra Jan, Jožica Sterle

### ORIGINAL SCIENTIFIC ARTICLE

KUS, Maja, KALIN, Mitjan. Influence of additives and their molecular structure on the static and dynamic wetting of oil on steel at room temperature. *Applied Surface Science*, Oct. 2019, vol. 490, p. 420-429.

ČOGA, Lucija, SIMIČ, Rok, GEUE, Thomas M., KALIN, Mitjan. Additive adsorption on DLC coatings in static and tribological conditions using neutron reflectometry. *Frontiers in mechanical engineering*, Mar. 2019, vol. 5.

SODERŽNIK, Marko, LI, J., LI, Lihua, SEPEHRI-AMIN, H., OHKUBO, T., SAKUMA, N., SHOJI, T., SCHREFFL, T., HONO, K., et al. Magnetization reversal process of anisotropic hot-deformed magnets observed by magneto-optical Kerr effect microscopy. *Journal of alloys and compounds*, 2019, vol. 771, p. 51-59.





PEJAKOVIĆ, Vladimir, TOTOLIN, Vladimir, RISTIC, Andjelka, GABLER, Christoph, KALIN, Mitjan, DÖRR, Nicole. Tribological performance and degradation of 1-n-butyl-1-methylpyrrolidinium methylsulfate ionic liquid in glycerol as lubricant for steel-steel sliding contacts. *Lubrication science*, 2019, vol. 31, iss. 4, p. 137-149.

XU, X. D., SEPEHRI-AMIN, H., SASAKI, T., SODERŽNIK, Marko, TANG, X., OHKUBO, T., HONO, K. Comparison of coercivity and squareness in hot-deformed and sintered magnets produced from a Nd-Fe-B-Cu-Ga alloy. *Scripta materialia*, 2019, vol. 160, p. 9-14.

KALIN, Mitjan, POLAJNAR, Marko, KUS, Maja, MAJDIČ, Franc. Green tribology for the sustainable engineering of the future. *Strojniški vestnik*, Nov./Dec. 2019, vol. 65, no. 11/12, p. 709-727.

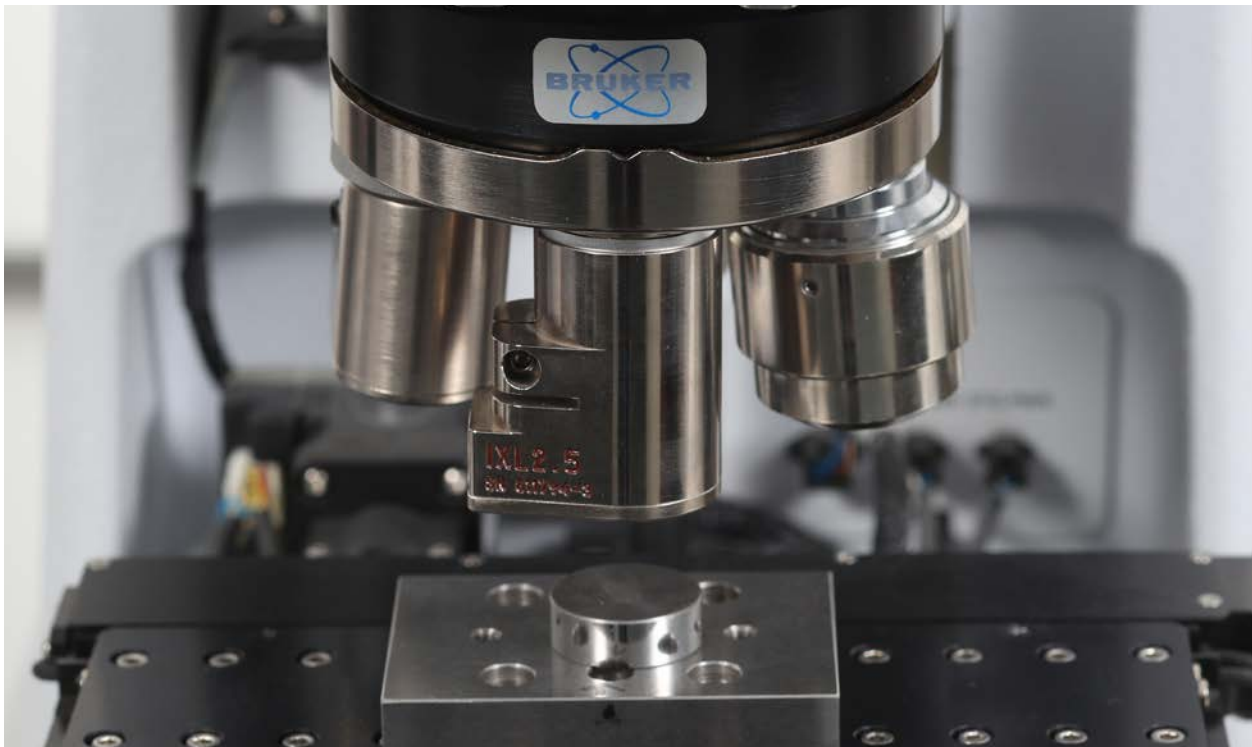
TOMALA, Agnieszka Maria, RODRÍGUEZ RIPOLL, Manel, KOGOVSĚK, Janez, KALIN, Mitjan, BEDNARSKA, A., MICHALCZEWSKI, R., SZCZEREK, M. Synergisms and antagonisms between MoS<sub>2</sub> nanotubes and representative oil additives under various contact conditions. *Tribology international*, Jan. 2019, vol. 129, p. 137-150.

KOGOVSĚK, Janez, KALIN, Mitjan. Lubrication performance of graphene-containing oil on steel and DLC-coated surfaces. *Tribology international*, Oct. 2019, vol. 138, p. 59-67.

POLJANEC, Dejan, KALIN, Mitjan. Effect of polarity and various contact pairing combinations of electrographite, polymer-bonded graphite and copper on the performance of sliding electrical contacts. *Wear*, Apr. 2019, vol. 426/427, part B, p. 1163-1175.

#### **DOCTORAL DISSERTATIONS**

KUS, Maja. Influence of dynamic wetting on friction. Mentor: Kalin, Mitjan.



## PROJECTS

COMET - Competence Centers for Excellent Technologies - XTribology Excellence Center of Tribology. Mitjan Kalin. 01.04.2015 - 31.03.2020

Erasmus + (Erasmus Mundus) - TRIBOS+ - Joint European Master on Tribology of Surfaces and Interfaces. Mitjan Kalin. 01.09.2018 - 31.08.2024

LLP (Erasmus Mundus) - Joint European Master on Tribology of Surfaces and Interfaces (TRIBOS). Mitjan Kalin. 01.08.2013 - 31.07.2019

ERDF (Smart Specialization) - EVA4green - Ecological Safe Vehicle for green mobility. Mitjan Kalin. 01.09.2016 - 28.02.2019

M-era.Net - GreenCOAT - Green high-performance and low-friction interfaces tailored by the reactivity of novel DLC coatings and ionic liquids. Mitjan Kalin. 01.08.2017 - 31.07.2020

Slovenian Research Agency. E-maintenance of electro-mechanical drives: prognostics and health management solutions under non-stationary operating conditions. Mitjan Kalin. 1.3.2016 - 28.2.2019

Slovenian Research Agency. Nano-engineered Green lubrication technology for sustainable high-performance stamping. Mitjan Kalin. 1.7.2018 - 30.6.2021

Slovenian Research Agency. Novel design of EHL contacts by employing solid-liquid interface phenomena. Marko Polajnar. 1.7.2019 - 30.6.2021



## Laboratory for Fluid Power and Controls **LFT**

### RESEARCH AREAS

Fluid power • Oil and water hydraulics • Numerical simulations  
• Hydraulic components and systems • Control • Component and system development • Durability tests • Diagnostics in hydraulics

**DEPARTMENT HEAD** Assist. Prof. Franc Majdič, PhD

**DEPARTMENT MEMBERS** Assist. Ervin Strmčnik, Rok Jelovčan, Nejc Novak, Jožica Sterle

### ORIGINAL SCIENTIFIC ARTICLE

STRMČNIK, Ervin, MAJDIČ, Franc, KALIN, Mitjan. Influence of a diamond-like carbon-coated mechanical part on the operation of an orbital hydraulic motor in water. *Metals*, Apr. 2019, vol. 9, iss. 4.

STRMČNIK, Ervin, MAJDIČ, Franc, KALIN, Mitjan. Water-lubricated behaviour of AISI 440C stainless steel and a DLC coating for an orbital hydraulic motor application. *Tribology international*, Mar. 2019, vol. 131, p. 128-136.

BOBNAR, Blaž, ČELIK, Anže, MAJDIČ, Franc. Eksperimentalno preverjanje tokovnih sil v hidravličnih ventilih. *Ventil: revija za fluidno tehniko in avtomatizacijo*, Apr. 2019, y. 25, no. 2, p. 124-131.

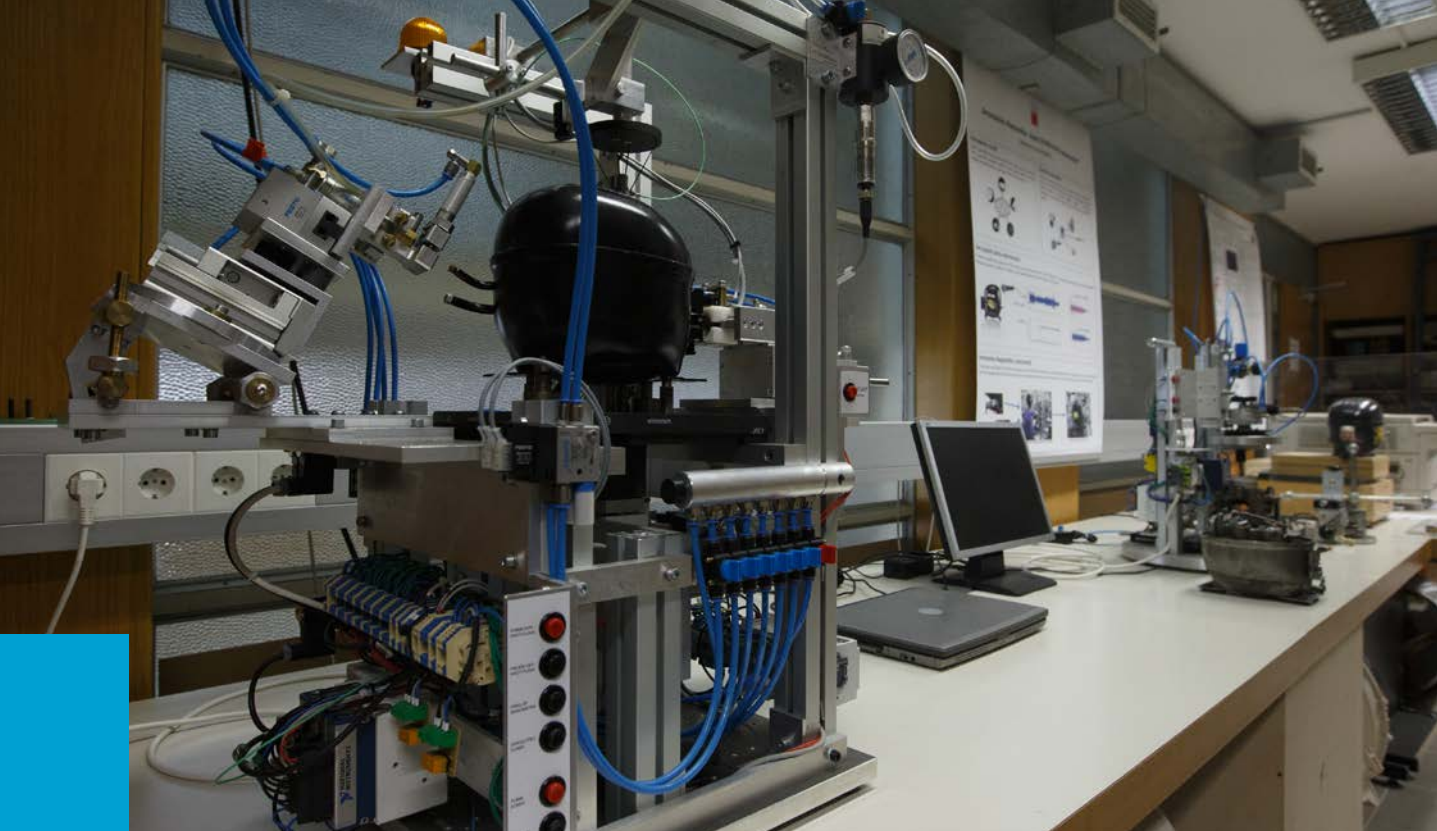
NOVAK, Nejc, MAJDIČ, Franc. Srednji čas do okvare hidravličnih ventilov. *Ventil: revija za fluidno tehniko in avtomatizacijo*, 2019, y. 25, no. 3, p. 214-219.

# 07

## SYNERGETICS OF COMPLEX SYSTEMS AND PROCESSES

Development of new as well as optimisation of existing technologies, systems and processes with complex and time-varying properties requires an understanding of the mutual nonlinear interactions which can often lead to instabilities and even chaos, and are reflected in the corresponding temporal spatial structures.

The main aim of the research programme is to contribute to world science with regards to description and understanding of complex technological systems and processes. Methods of research are based on synergetic approach to complex systems which includes use of advanced methods of probability and statistics, information theory, chaotic dynamics, soft computing, data mining, adaptive empirical modelling, machine learning, methods of optimisation and predictive control. Within the context of the programme, research is conducted in the field of additive technologies using direct laser deposition of materials, in the field of adaptive information systems for automated monitoring, optimisation and control of complex technological systems and processes, and in the field of non-destructive diagnostics of loaded materials and products.



## Laboratory for Synergetics **LASIN**

### RESEARCH AREAS

- Synergetics • Technology driven physics • Additive manufacturing
- Direct laser deposition • Empirical modelling and industrial diagnostics
  - Optimisation and predictive control

**DEPARTMENT HEAD** Prof. Edvard Govekar, PhD

**DEPARTMENT MEMBERS** Assist. Prof. Primož Potočnik, PhD, Assist. Andrej Jeromen, PhD, Assist. Blaž Krese, Assist. Ragunanth Venkatesh, Matjaž Kotar, Jaka Peternel, Ana Vidergar, Marta Ilešič / Teja Pirnat

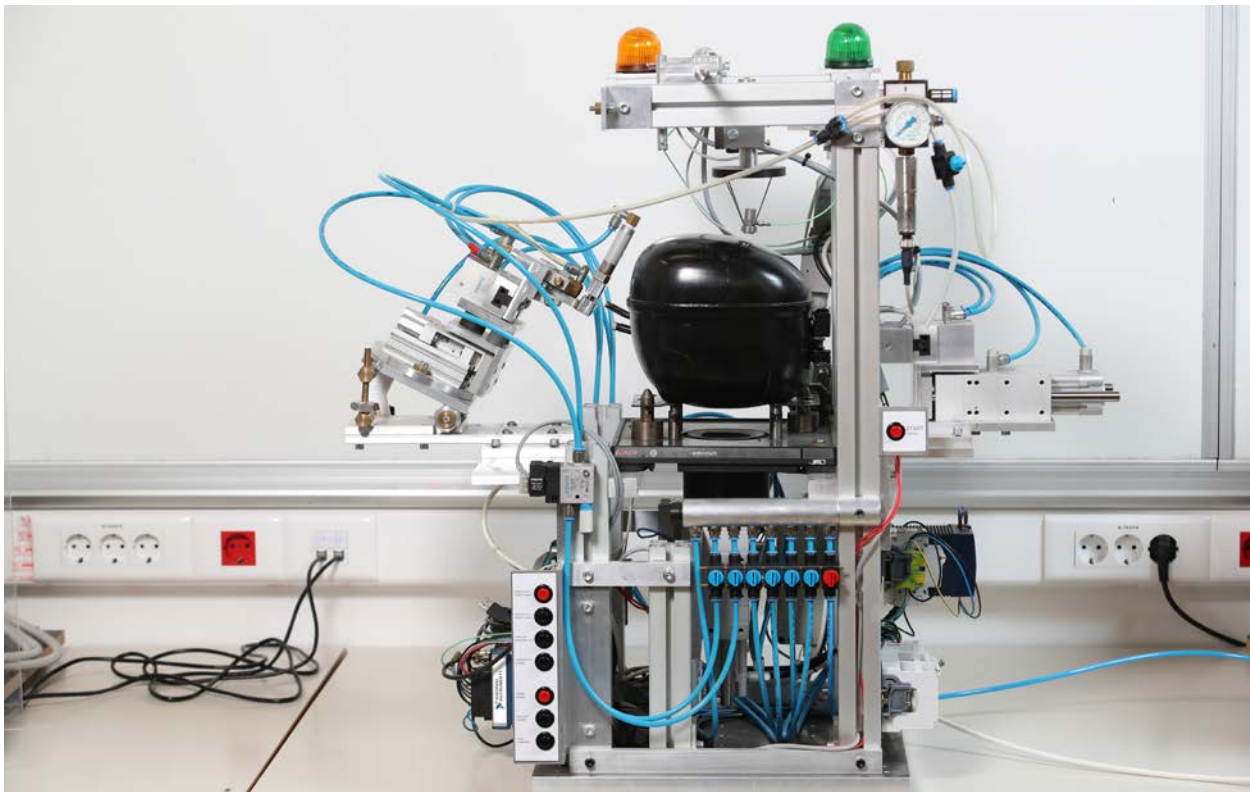
### ORIGINAL SCIENTIFIC ARTICLE

KOTAR, Matjaž, FUJISHIMA, Makoto, LEVY, Gideon N., GOVEKAR, Edvard. Initial transient phase and stability of annular laser beam direct wire deposition. *CIRP annals*, 2019, vol. 68, iss. 1, p. 233-236.

POTOČNIK, Primož, GOVEKAR, Edvard. Adaptive optimization of heating curves in buildings heated by a weather-compensated heat pump. *Science and technology for the built environment*, 2019, vol. 25, no. 10, p. 1380-1393.

JEROMEN, Andrej, GOVEKAR, Edvard. Nonlinear dynamic force balance mass-spring-damper model of laser droplet generation from a metal wire. *Strojniški vestnik*, Apr. 2019, vol. 65, no. 4, p. 201-211.

POTOČNIK, Primož, VIDRIH, Boris, KITANOVSKI, Andrej, GOVEKAR, Edvard. Neural network, ARX, and extreme learning machine models for the short-term prediction of temperature in buildings. *Building simulation*, 2019, vol. 12, iss. 6, p. 1077-1093



## **PATENT**

FUJISHIMA, Makoto, MEZAWA, Yuhei, GOVEKAR, Edvard, LEVY, Gideon N., JEROMEN, Andrej, KUZNETSOV, Alexander. Additive-processing head and processing machinery: JP6535821 (B2), 2019-06-26. [Osaka: Fukami Patent Office], 2019.

FUJISHIMA, Makoto, GOVEKAR, Edvard, LEVY, Gideon N.. Additive-manufacturing head, manufacturing machine, and manufacturing method: JP6529610 (B2), 2019-06-12. [Osaka]: Fukami Patent Office, 2019.

## **PROJECTS**

Company DMGMORI RING project phase IV - RING universal 2.5 kW deposition head development and wire process optimization. Edvard Govekar, 01.01.2019 – 31.12.2019

ERDF (Smart Specialization) - IQ Home - Intelligent home of the new generation designed on smart appliances and wood. Edvard Govekar. 01.09.2016 – 28.02.2019

## **AWARDS AND ACHIEVEMENTS**

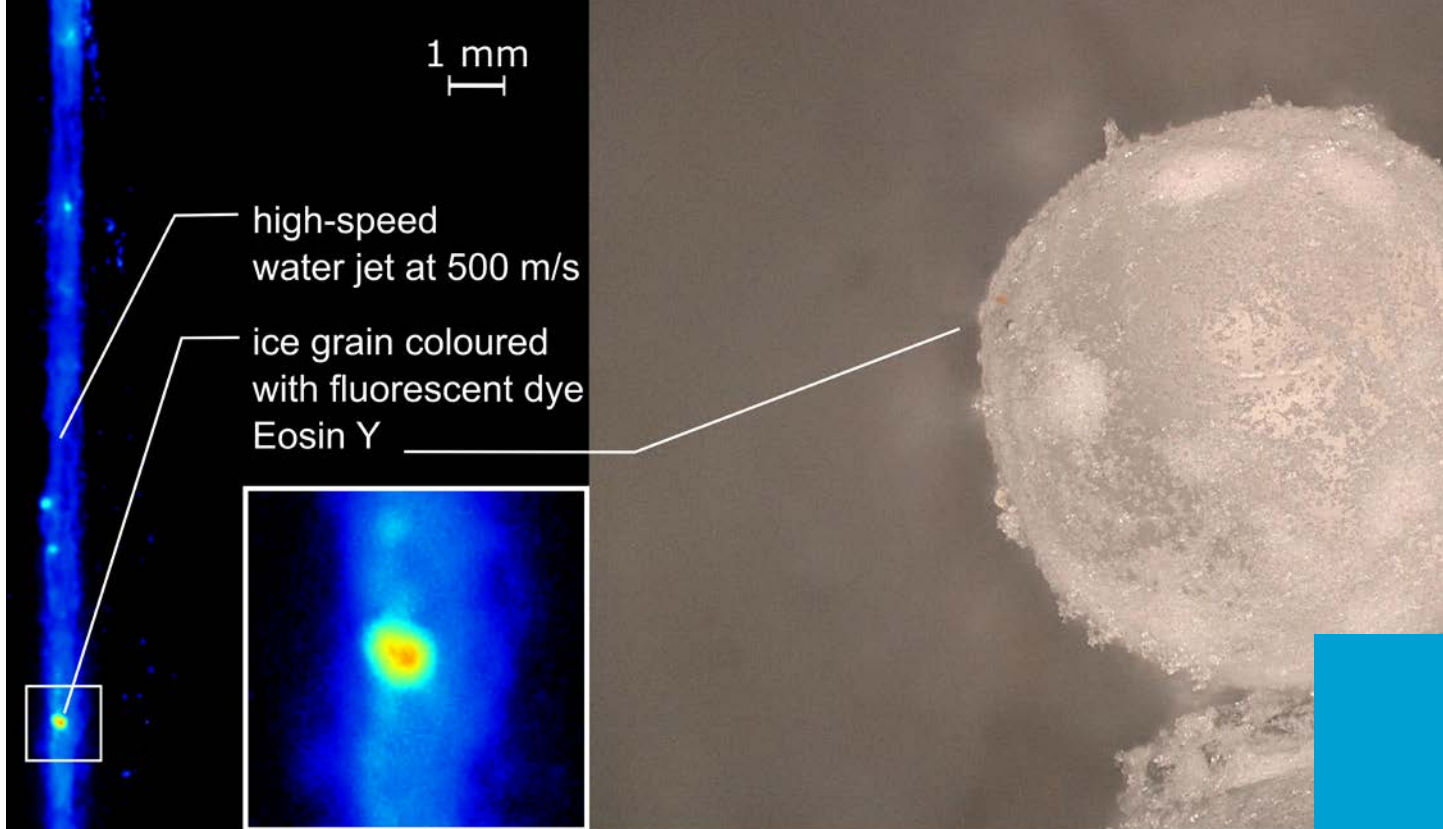
Andrej Jeromen received an award of the Faculty of Mechanical Engineering for excellence in teaching.

# 08 INNOVATIVE PRODUCTION SYSTEMS AND PROCESSES

The programme group Innovative manufacturing systems is continuing the research work from previous years with its main focus on the Smart factories concept.

The aim is to increase the efficiency and flexibility of manufacturing systems and processes (MSP), based on the principles of the Digital Factory, LEAN, AGILE and TQM and aligned with the Industry 4.0 guidelines. In constructing self-adjusting mechanisms of MSP with defined roles we are focusing on the development of an intelligent algorithm that would automatically suggest optimization steps and solutions. We will apply the above mentioned technologies, related to the Smart Factories concepts, also in the fields of smart forming tools, IceJet cutting, high-dynamic hydraulic positioning axes, intelligent MSP in the domain of assembly and packaging of the consumer products, etc.

In this way we are keeping pace with the evolution and the prospect of manufacturing systems and processes, which extends from the current state of the so-called LEAN manufacturing, through the paradigm of Manufuture to smart factories and further on to the concept of Remote factory.



## Laboratory for Alternative Technologies **LAT**

### RESEARCH AREAS

Unconventional machining processes • Additive technologies • Forming and machining of plastic materials and composites • Metrology • Microtechnologies

**DEPARTMENT HEAD** Assoc. Prof. Joško Valentinčič, PhD

**DEPARTMENT MEMBERS** Assist. Prof. Andrej Lebar, PhD, Assist. Prof. Henri Orbanić, PhD, Assist. Izidor Sabotin, PhD, Assist. Marko Jerman, PhD, Miha Prijatelj, Suzana Vinetič, Pavel Drešar, Tanja Plestenjak

### PATENT

ORBANIĆ, Henri, ŽILNIK, Marko, MAZEJ, Stanislav, POGAČAR, Toni. Schneidscheibe = Cutting disc = Disque de coupe: Europäische Patentschrift EP 3 053 713 B1, 2019-04-03. München: Europäisches Patentamt, 2019.





## Forming Laboratory LAP

### RESEARCH AREAS

Theory of plasticity • Forming properties of materials • Forming processes  
 • Biomimetics in forming • Tribology in forming, CARP, CAE, MKE

**DEPARTMENT HEAD** Assoc. Prof. Tomaž Pepelnjak, PhD

**DEPARTMENT MEMBERS** Assist. Luka Sevšek, Matjaž Rot, Tanja Plestenjak

### ORIGINAL SCIENTIFIC ARTICLE

PEPELNJAK, Tomaž, KAYHAN, Erdem, KAFTANOĞLU, B. Analysis of non-isothermal warm deep drawing of dual-phase DP600 steel. International journal of material forming, Mar. 2019, vol. 12, iss.2, p. 223-240.

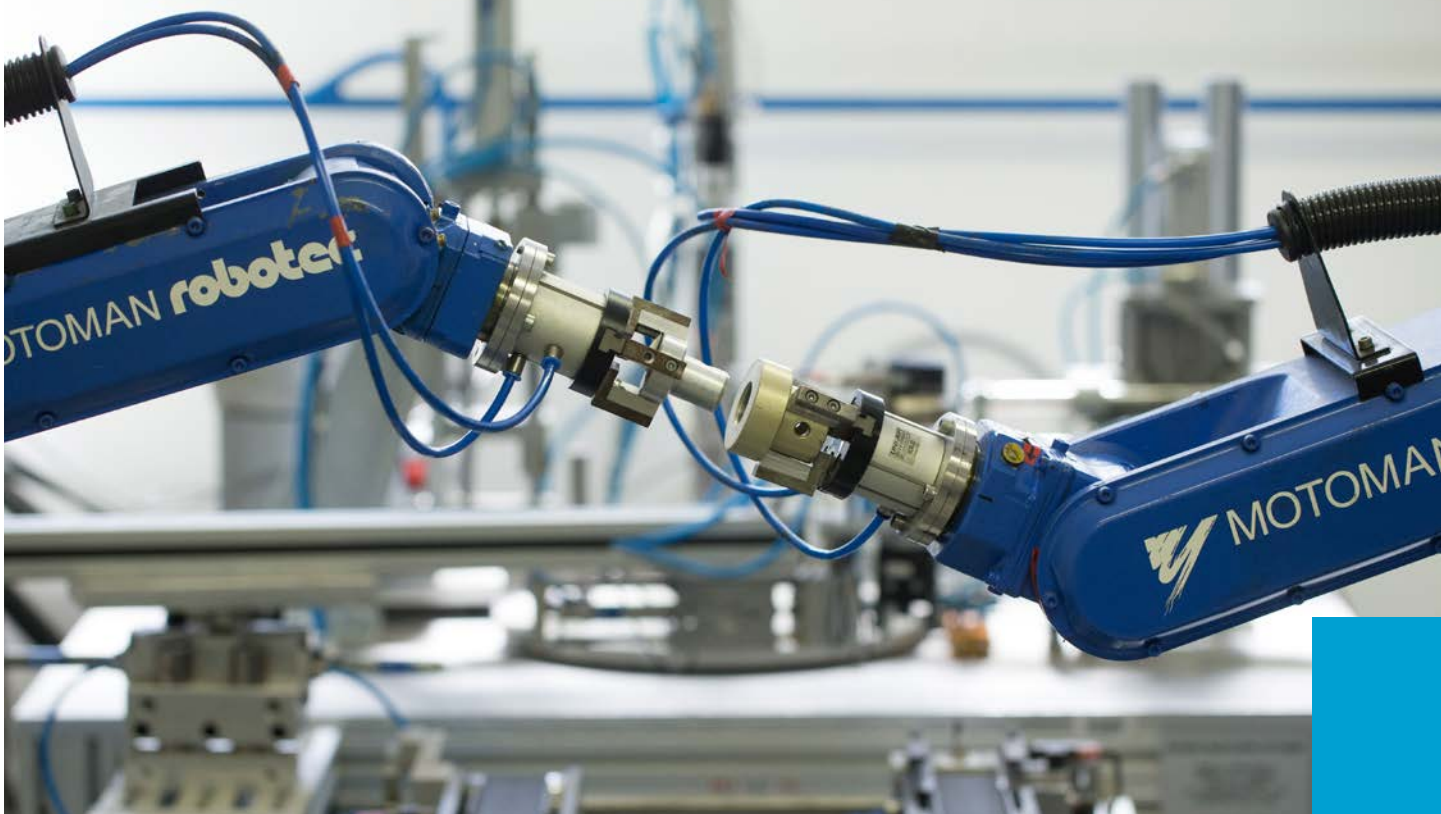
BORIĆ, Andrej, KALEDOVÁ, Alena, URBANEK, Michal, PEPELNJAK, Tomaž. Characterisation of polyamide (PA)12 nanocomposites with montmorillonite (MMT) filler clay used for the incremental forming of sheets. Polymers, ISSN 2073-4360, Jul. 2019, vol. 11, iss. 8.

SATOŠEK, Roman, VALEŠ, Michal, PEPELNJAK, Tomaž. Study of influential parameters of the sphere indentation used for the control function of material properties in forming operations. Strojniški vestnik, 2019, vol. 65, no. 10, p. 585-598.

### PROJECTS

COST - CA COST Action CA15216 - European Network of Bioadhesion Expertise: Fundamental Knowledge to Inspire Advanced Bonding Technologies. Tomaž Pepelnjak. 26.02.2016 - 20.10.2020

Ceepus Network CII-HR-0108 Concurrent Product and Technology Development - Teaching, Research and Implementation of Joint Programs Oriented in Production and Industrial Engineering. Tomaž Pepelnjak. Ongoing since 2005



## Laboratory for Handling, Assembly and Pneumatics **LASIM**

### RESEARCH AREAS

Handling and assembly • Industry 4.0, smart factories • Discrete simulation • Production logistics • Production resources • Fluid power • Hydraulic and pneumatic control systems and components • Piezo engineering

**DEPARTMENT HEAD** Prof. Niko Herakovič, PhD

**DEPARTMENT MEMBERS** Assist. Prof. Marko Šimic, PhD, Assist. Mihael Debevec, PhD, Assist. Miha Pipan, PhD, Assist. Hugo Zupan, PhD, Peter Metlikovič, PhD, Jernej Protner, Assist. Matevž Resman, Edo Adrovič, Denis Jankovič, Jernej Protner, Maja Turk, Rok Živec, Tanja Plestenjak

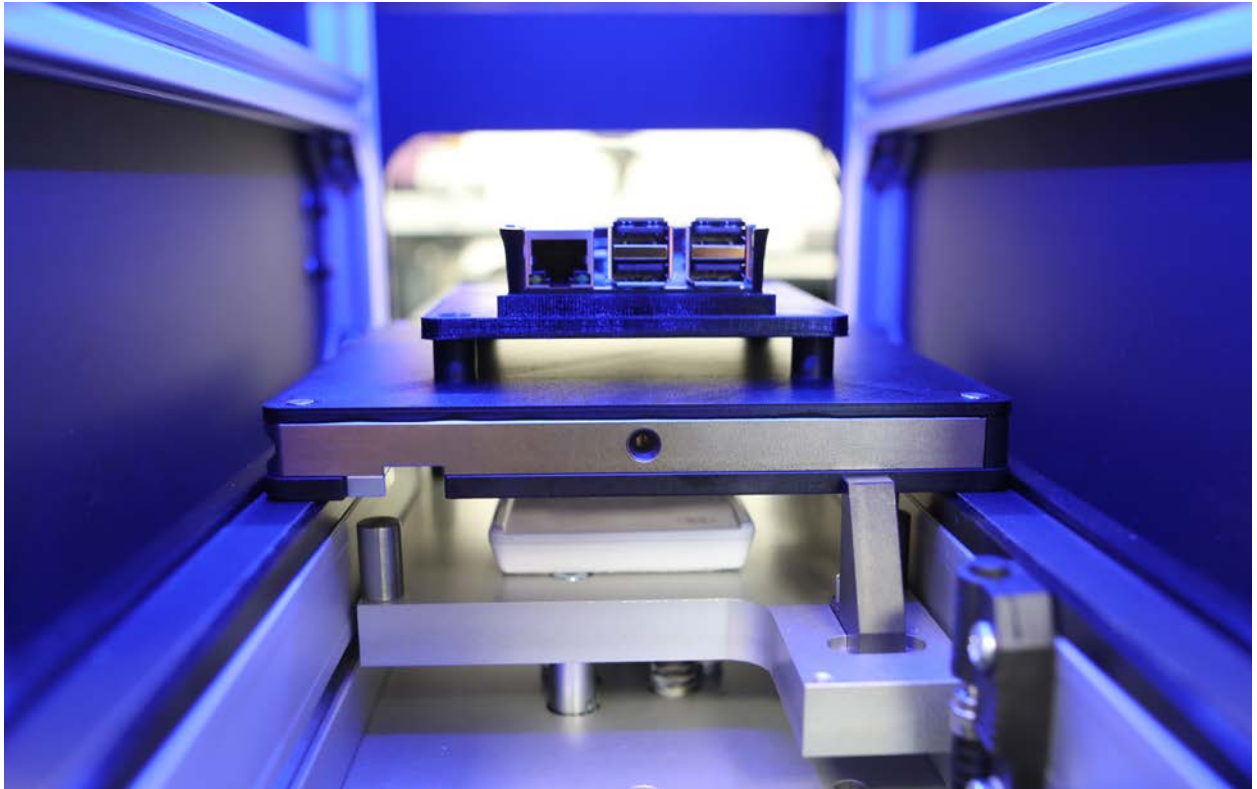
### ORIGINAL SCIENTIFIC ARTICLE

RESMAN, Matevž, PIPAN, Miha, ŠIMIC, Marko, HERAKOVIČ, Niko. A new architecture model for smart manufacturing: a performance analysis and comparison with the RAMI 4.0 reference model. *Advances in production engineering & management*, Jun. 2019, vol. 14, no. 2, p. 153-165.

HERAKOVIČ, Niko, ZUPAN, Hugo, PIPAN, Miha, PROTNER, Jernej, ŠIMIC, Marko. Distributed manufacturing systems with digital agents. *Strojniški vestnik*, Nov./Dec. 2019, vol. 65, no. 11/12, p. 650-657.

### DOCTORAL DISSERTATIONS

ZUPAN, Hugo. Intelligent algorithm for the optimization of assembly and handling systems and processes for in-line production. Mentor: Herakovič, Niko.



## PROJECTS

Company Kolektor - sofinanciranje programa SPS - Niko Herakovič

ERDF - European regional development fond SPS – Building Blocks, Tools and Systems for Factories of the Future (GOSTOP). Niko Herakovič. 01.11.2016 – 30.04.2020

## AWARDS AND ACHIEVEMENTS

Niko Herakovič, Matija Jezeršek (Faculty of Mechanical Engineering) and Hubert Kosler, Erih Arko, Damjan Širaj (Yaskawa company) received the Puh Prize as a group. They received the prize for outstanding achievements in the field of industrial robotic technology.

# 09

## ENGINEERING DESIGN

The Engineering design programme group develops basic and applied knowledge needed for the development of new products: design models and methods of innovation, in-depth application of CFX methods, PDM/PLM methods for comprehensive management of information flows in companies, physical/mathematical modelling of polymer gears, and hybrid numerical methods with code development in the field of fusion (ITER) and wider (plasma simulation).

The research was carried out in four basic directions, providing knowledge in the field of design necessary for the innovative development of new products and their implementation. The group has established supercomputing structures in the Slovenian academic environment and is integrated into projects of the supercomputer association PRACE.

Together with domestic and foreign companies (Germany, Japan, China) the group participates in projects in the fields of fusion research (ITER, MSU-USA), auxiliary heart pump (TU Eindhoven and UT Houston) and development of polymer gears and gear trains. The group also implements the model of laboratories, linked to companies.



## Laboratory for Engineering Design **LECAD**

### RESEARCH AREAS

Engineering design • Computer-aided design • Technical information system • Kansei engineering • Polymer gears research • High-Performance Computing • Big data analysis • Computer-intensive methods and applications • Mathematical optimisation • Plasma sheath transition research • Fusion process simulation • Integrated modelling of fusion

**DEPARTMENT HEAD** Prof. Roman Žavbi, PhD / Assoc. Prof. Janez Povh, PhD

**DEPARTMENT MEMBERS** Jože Tavčar, PhD, Assist. Prof. Janez Benedičič, PhD, Assist. Prof. Leon Kos, PhD, Assist. Prof. Nikola Vukašinović, PhD, Assist. Vanja Čok, PhD, Assist. Ivan Demšar, PhD, Assist. Tomaž Finkšt, PhD, Assist. Janez Rihtaršič, PhD, Assoc. Prof. Aleksander Grm, PhD., Assist. Borut Černe, Assist. Pavel Tomšič, PhD, Assist. Damijan Zorko, PhD, Assist. Primož Drešar, Assist. Timotej Hrga, Assist. Dejan Penko, MSc Janez Krek, Mateja Maffi, Luka Sedej, Matjaž Šubelj, Assist. Ivona Vasileska, Assist. Uroš Urbas, Assist. Matic Brank, Daria Vlah, Alenka Maffi, Gregor Simič, Silva Brenčič

### ORIGINAL SCIENTIFIC ARTICLE

BENEDIČIČ, Janez, BERNIK, Rajko. Vpliv pretoka zraka na sušenje krme na sušilnih napravah. Acta agriculturae Slovenica, 2019, y. 114, no. 1, p. 5-11.

DICKINSON, Peter J. C., POVH, Janez. A new approximation hierarchy for polynomial conic optimization. Computational optimization and applications, 2019, vol. 73, iss. 1, p. 37-67.

KOS, Leon, PITTS, Richard, SIMIČ, Gregor, BRANK, Matic, ANAND, H., ARTER, W. SMITER: a field-line tracing environment for ITER. *Fusion engineering and design*, Sep. 2019, vol. 146, pt. B, p. 1796-1800.

ANAND, H., PITTS, Richard, VRIES, P. C. de, SNIPES, J. A., NESPOLI, F., LABIT, B., GALPERTI, C., CODA, S., BRANK, Matic, KOS, Leon. Experimental implementation of a real-time power flux estimator for the ITER first wall on the TCV tokamak. *Fusion engineering and design*, Oct. 2019, vol. 147, p. 1-7.

TAVČAR, Jože, HORVÁTH, Imre. A Review of the principles of designing smart cyber-physical systems for run-time adaptation: learned lessons and open issues. *IEEE transactions on systems, man, and cybernetics, Systems*, Jan. 2019, vol. 49, iss. 1, p. 145-158.

TAVČAR, Jože, BENEDIČIČ, Janez, ŽAVBI, Roman. Knowledge management support in the engineering change process in small and medium-sized companies. *International journal of agile systems and management*, 2019, vol. 12, no. 4, p. 354 - 381.

ČERNE, Borut, DUHOVNIK, Jože, TAVČAR, Jože. Semi-analytical flash temperature model for thermoplastic polymer spur gears with consideration of linear thermo-mechanical material characteristics. *Journal of computational design and engineering*, Oct. 2019, vol. 6, iss. 4, p. 617-628.

TAVČAR, Jože, DUHOVNIK, Jože, HORVÁTH, Imre. From validation of medical devices towards validation of adaptive cyber-physical systems. *Journal of integrated design & process science*, Jul. 2019, vol. 23, no. 1, p. 37-59.

DREŠAR, Primož, DUHOVNIK, Jože. A hybrid RANS-LES computational fluid dynamics simulation of an FDA medical device benchmark. *Mechanika*, ISSN 1392-1207, 2019, vol. 25, no. 4, p. 291-298.

ZORKO, Damijan, KULOVEC, Simon, DUHOVNIK, Jože, TAVČAR, Jože. Durability and design parameters of a Steel/PEEK gear pair. *Mechanism and machine theory*, Oct. 2019, vol. 140, p. 825-846.

MALOD-DOGNIN, Noël, PETSCHNIGG, Julia, WINDELS, Sam F. L., POVH, Janez, HEMMINGWAY, Harry, KETTELER, Robin, PRŽULJ, Nataša. Towards a data-integrated cell. *Nature communications*, Feb. 2019, [Vol.] 10.

## PROJECTS

COST - MI-NET COST Action TD1409 - Mathematics for industry network (MI-NET). Janez Povh. 05.05.2015 - 04.05.2019

ERDF (Smart Specialization) - EVA4green - Ecological Safe Vehicle for green mobility. Roman Žavbi. 01.09.2016 - 28.02.2019

ERDF (Interreg Danube) - INNOHPC - High-performance Computing for Effective Innovation in the Danube Region. Roman Žavbi. 01.01.2017 - 30.06.2019

ERDF (Smart Specialization) - MAPgears - Advanced materials, methodologies and technologies for the development of lightweight power transmission components for drives technology. Jože Tavčar. 01.09.2018 - 31.12.2021

Erasmus + ELPID - E-learning Platform for Innovative Product Development. Nikola Vukašinič. 01.09.2018 - 31.08.2021

Erasmus + CASProD - Capitals of Smart Product Development. Nikola Vukašinič. 01.09.2017 - 31.08.2020

Horizon 2020 - EXDCI-2 - European eXtreme Data and Computing Initiative - 2. Roman Žavbi. 01.03.2018 - 31.08.2020



Horizon 2020 – EURATOM – EUROfusion - Implementation of activities described in the Roadmap to Fusion during Horizon. 2020 through a Joint programme of the members of the EUROfusion consortium. Roman Žavbi. 01.01.2014 – 31.12.2020

Horizon 2020 - PRACE-6IP - PRACE 6th Implementation Phase Project. Janez Povh. 01.05.2019 – 31.12.2021

Horizon 2020 - PRACE-5IP - PRACE 5th Implementation Phase Project. Janez Povh. 01.01.2017 – 30.04.2019

Slovenian Research Agency. Extending first and second order algorithms for nested classes of optimization problems to solve computationally challenging industrial questions. Janez Povh. 1.11.2017 – 31.10.2020

Slovenian Research Agency. High-Performance Solver for Binary Quadratic Problems. Janez Povh. 1.1.2017 – 31.12.2019

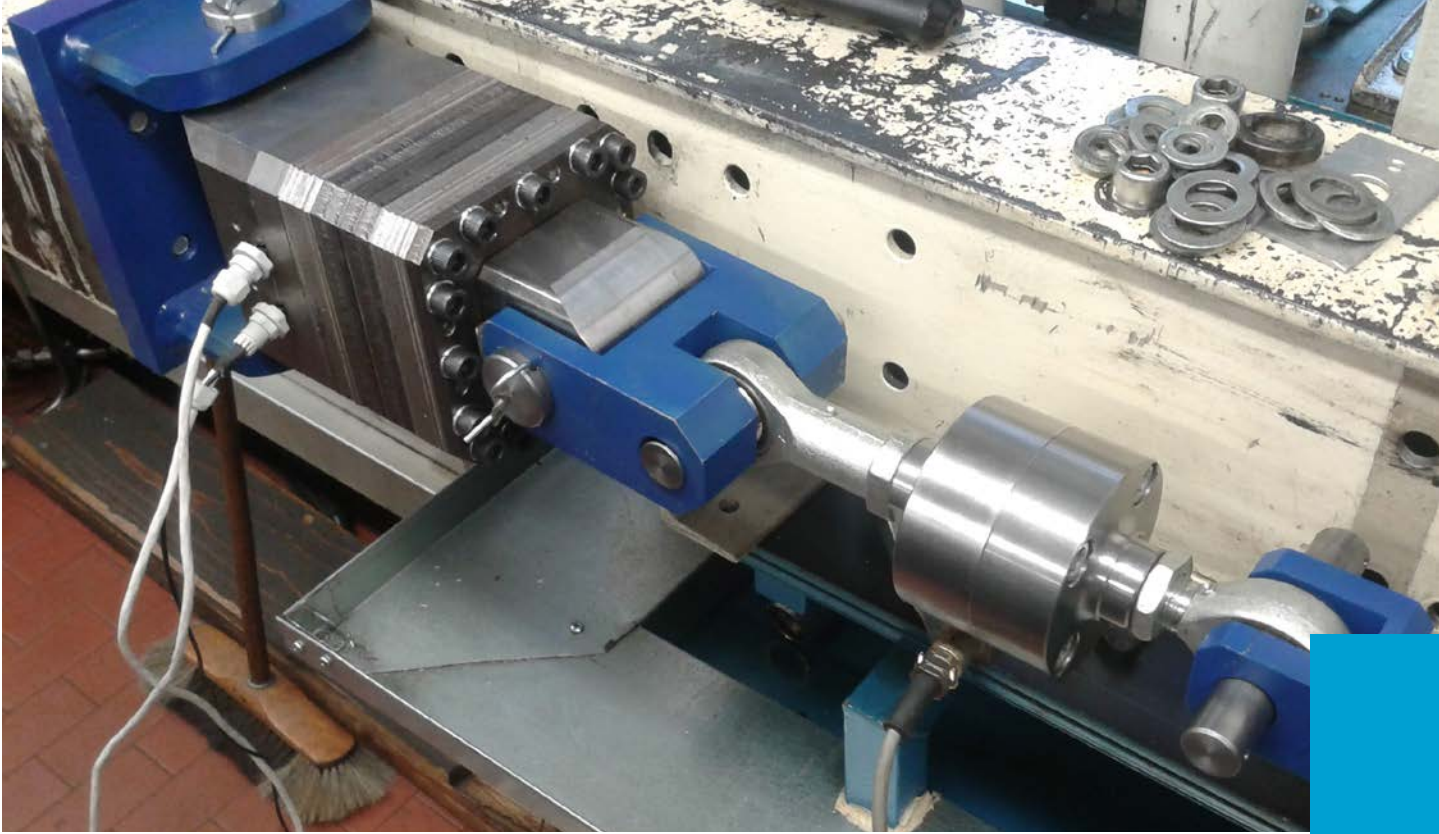
Slovenian Research Agency. Technological solutions for high – quality hay production. Janez Benedičič. 1.10.2016 – 30.9.2019

Slovenian Research Agency. Biomedical data fusion by nonnegative matrix tri-factorization. Janez Povh. 01.05.2017-30.04.2020

### **DOCTORAL DISSERTATIONS**

ZORKO, Damijan. Engineering design of polymer gears with S form of teeth. Mentor: Duhovnik, Jožef.

TOMŠIČ, Pavel. Topology optimization of steel lattice structures using a evolutionary algorithm. Mentor: Duhovnik, Jožef.



## Laboratory for Material Handling and Machine Structures **LASOK**

### RESEARCH AREAS

Load-bearing structures • Welded structures • Pressure vessels and pipelines • Lifting and transport devices • Development • Optimisation • Evaluation

**DEPARTMENT HEAD** Assist. Prof. Boris Jerman, PhD

**DEPARTMENT MEMBERS** Assist. Jurij Hladnik, PhD, MSc Franc Resman, Luka Bizjak, Silva Brenčič

### ORIGINAL SCIENTIFIC ARTICLE

HLADNIK, Jurij, SUPEJ, Matej, VODIČAR, Janez, JERMAN, Boris. The influence of boot longitudinal flexural stiffness on external mechanical work and running economy during skate roller-skiing: a case study. Proceedings of the Institution of Mechanical Engineers. Part P, Journal of sports engineering and technology (Print), 2019, vol. 233, iss. 4, p. 548-558.

### PATENT

UMEK, Anton, JERMAN, Boris, GLIHA, Mitja, KOS, Anton, ŠPAN, Iztok. Za dinamično tehtanje bremena prirejena pritrđilna enota prijemala na roko hidravličnega dvigala: patent SI 25473 A, 2019-01-31. Ljubljana: Urad RS za intelektualno lastnino, 2019.



# 10

## MECHANICS IN ENGINEERING

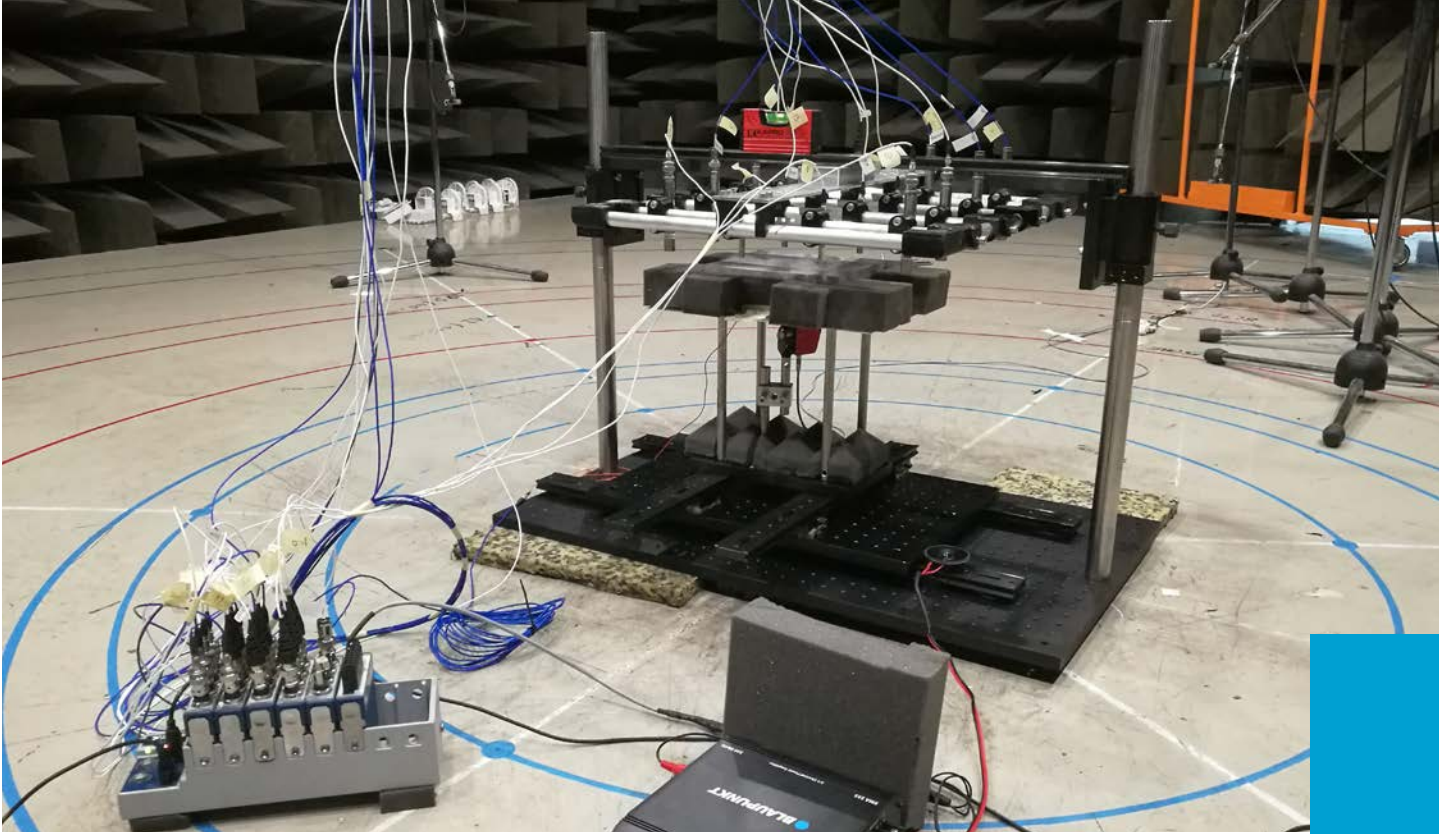
The Mechanics in engineering programme group consists of four laboratories: The Laboratory for Dynamics of Machines and Structures (LADISK), the Laboratory for Numerical Modelling and Simulation (LNMS), the Laboratory for Non-Linear Mechanics (LANEM) and the Laboratory for aeronautics (AEROL).

**LADISK:** Within the context of flexible multibody system dynamics, the research is focussed on advanced methods of valid nonlinear dynamics modelling of rigid-flexible multibody systems with unilateral contacts or large displacements/deformations. In the field of structural dynamics, the group is focussed on management of vibration fatigue and product noise. Here, the main emphasis is on research into valid models. Research activities are also geared toward smart structures with sensing function and the development of advanced optical methods for identifying dynamic parameters of structures.

**LNMS:** Long-term research activities are related to the constitutive modelling of the metallic materials response and the development of numerical methods in this field, whereby the numerical aspect of an effective integration of developed algorithms into the FEM programs is crucial. The more complex constitutive models also require the development of algorithms for inverse identification of model parameters.

**LANEM:** The theory of elasticity and thermoelasticity, geometric and material nonlinearities, stability, fluid mechanics, inelastic deformation, materials with shape memory, characterization of mechanical properties of materials, biomechanics.

**AEROL:** Development of unmanned aerial vehicles and systems, research into the possibility of controlling unmanned aerial vehicles using cameras and ground landmarks in areas without the GPS signal, aircraft calculation, calculation and measurement of resistance, lift and torque of aerodynamic bodies, measurement of aerodynamic properties and airflow around bodies in the wind tunnel, construction and testing components related to firearms, modelling and mold making for the manufacture of composite parts of unmanned aerial vehicles.



## Laboratory for Dynamics of Machines and Structures **LADISK**

### RESEARCH AREAS

Mechanics • Dynamics • Dynamics of machines and structures  
 • Structural dynamics • Vibration fatigue • Mechanical vibrations  
 • Nonlinear vibrations • Dynamics of rigid and flexible multibody systems • Structure-borne noise • Signal processing (CWT, HOS) • Rotor dynamics • Automatic fault detection in mechanical systems • Dynamics of moving continua • Digital image correlation methods

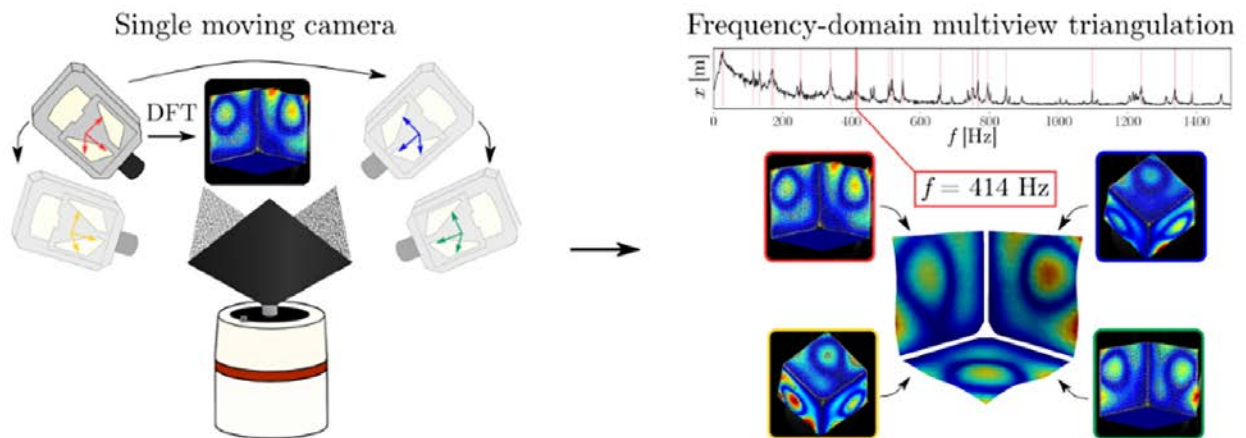
**DEPARTMENT HEAD** Prof. Miha Boltežar, PhD

**DEPARTMENT MEMBERS** Prof. Janko Slavič, PhD, Assoc. Prof. Gregor Čepon, PhD, Assist. Martin Česnik, PhD, Assist. Luka Knez, PhD, Assist. Matej Razpotnik, PhD, Assist. Blaž Starc, PhD, Vitoslav Bratuš, PhD, Aleš Mihelič, PhD, Assist. Tibor Barši Palmić, Assist. Matej Bogataj, Assist. Miha Kodrič, Assist. Miha Pogačar, Assist. Domen Gorjup, Assist. Klemen Zaletelj, Martin Furlan, PhD, Primož Ogrinec, Matic Arh, Luka Kenk, Marta Ilešič / Teja Pirnat

### ORIGINAL SCIENTIFIC ARTICLE

OGRINEC, Primož, SLAVIČ, Janko, ČESNIK, Martin, BOLTEŽAR, Miha. Vibration fatigue at half-sine impulse excitation in the time and frequency domains. *International journal of fatigue*, Jun. 2019, vol. 123, p. 308-317.

SUHADOLNIK, Luka, POHAR, Andrej, NOVAK, Uroš, LIKOZAR, Blaž, MIHELIČ, Aleš, ČEH, Miran. Continuous photocatalytic, electrocatalytic and photo-electrocatalytic degradation of a reactive textile dye for wastewater-treatment processes: batch, microreactor and scaled-up operation. *Journal of industrial and engineering chemistry*, 2019, vol. 72, p. 178-188.



BREGAR, Tomaž, HOLEČEK, Nikola, ČEPON, Gregor, RIXEN, Daniel J., BOLTEŽAR, Miha. Including directly measured rotations in the virtual point transformation. *Mechanical systems and signal processing*, ISSN 0888-3270, 2019, p. 1-21.

GORJUP, Domen, SLAVIČ, Janko, BOLTEŽAR, Miha. Frequency domain triangulation for full-field 3D operating-deflection-shape identification. *Mechanical systems and signal processing*, Nov. 2019, vol. 133, p. 1-13.

MAURIZI, Marco, SLAVIČ, Janko, CIANETTI, Filippo, JERMAN, Marko, VALENTINČIČ, Joško, LEBAR, Andrej, BOLTEŽAR, Miha. Dynamic measurements using FDM 3D-printed embedded strain sensors. *Sensors*, 2019, vol. 19, iss. 12.

LUZARN, Janez, SLAVIČ, Janko, BOLTEŽAR, Miha. Structure-borne noise at PWM excitation using an extended field reconstruction method and modal decomposition. *Strojniški vestnik*, Sep. 2019, vol. 65, no. 9, p. 471-481.

OGRINEC, Primož, SLAVIČ, Janko, BOLTEŽAR, Miha. Harmonic equivalence of the impulse loads in vibration fatigue. *Strojniški vestnik*, Nov./Dec. 2019, vol. 65, no. 11/12, p. 631-640.

VIVOD, Vera, NERAL, Branko, MIHELIČ, Aleš, KOKOL, Vanja. Highly efficient film-like nanocellulosebased adsorbents for the removal of loose reactive dye during textile laundering. *Textile research journal*, 2019, vol. 89, iss. 6, p. 975-988.

#### PATENT

GREŠOVNIK, Marijan, MIHELIČ, Aleš, ŠTIMULAK, Mitja. Postopek upravljanja aparatov, vključenih v pametno omrežje: patent SI 25632 A, 2019-10-30. Ljubljana: Urad RS za intelektualno lastnino, 2019.

MIHELIČ, Aleš, ŠTIMULAK, Mitja, MAČKOVŠEK, Roman. Pralni stroj s tipalom: patent SI 25517 A, 2019-03-29. Ljubljana: Urad RS za intelektualno lastnino, 2019.

ČEPON, Gregor, BOLTEŽAR, Miha, MAČKOVŠEK, Roman, MIHELIČ, Aleš, POGOREVC, Robi, PEČNIK, Marko. Tesnilni element pri pralnem stroju: patent SI25516 A, 2019-03-29. Ljubljana: Urad Republike Slovenije za intelektualno lastnino, 2019.

#### DOCTORAL DISSERTATIONS

RAZPOTNIK, Matej. The dynamic characterisation of rolling-element bearings. Mentor: Boltežar, Miha.

LUZARN, Janez. Vibro-acoustic characterization of electronically commutated motors. Mentor: Boltežar, Miha.

## PROJECTS

Company ISD Strugarstvo - Turbine Hause - development of polymer connection bend of oil separator. Miha Boltežar. 21.5.2018 - 15.4.2019

Company Gorenje - Research development cooperation and lease of capacities for numerical analyses and performance of measurements and tests. Miha Boltežar. 7.11.2018 - 6.11.2021

Company Gorenje - Static and dynamic numerical analyses and optimization of parameters. Miha Boltežar. 27.6.2017 - 26.6.2019

ERDF (Smart Specialization) MOZTART - More efficient electric motors with the development of an EXPERT system and new technologies. Miha Boltežar. 1.10.2018 - 30.9.2021

ERDF (Smart Specialization) - EVA4green - Ecological Safe Vehicle for green mobility. Miha Boltežar. 01.09.2016 - 28.02.2019.

ERDF (Smart Specialization) - IQ Home - Intelligent home of the new generation designed on smart appliances and wood. Miha Boltežar. 01.09.2016 - 28.02.2019

Slovenian Research Agency. Hybrid Dynamic Substructuring in the Industry of Home Appliances. Miha Boltežar. 1.7.2019 - 30.6.2022

Slovenian Research Agency. High-speed-camera based high-spatial-density sensing of 3D vibrations with applications in digital-twins and remote sensing. Janko Slavič. 1.7.2019 - 30.6.2022



## Laboratory for Non-Linear Mechanics **LANEM**

### RESEARCH AREAS

Nonlinear mechanics • Stability • Mechanics of materials • Materials with shape memory

**DEPARTMENT HEAD** Assist. Prof. Miha Brojan, PhD

**DEPARTMENT MEMBERS** Assist. Prof. Viktor Šajn, PhD, Assist. Prof. Tomaž Videnič, PhD, Assist. Matjaž Čebtron, PhD, Assist. Matej Bogataj, Assist. Jan Zavodnik, Damjan Lolić, Jonas Trojer, Marta Ilešič / Teja Pirnat

### ORIGINAL SCIENTIFIC ARTICLE

VELDIN, Tomo, BRANK, Boštjan, BROJAN, Miha. Computational finite element model for surface wrinkling of shells on soft substrates. Communications in Nonlinear Science & Numerical Simulation, May 2019, y. XX, p. 1-29.

ŠAJN, Viktor. Semi-analytical multidimensional algorithm for aircraft design optimisation: student design build fly (DBF) competition. Strojniški vestnik, Nov./Dec. 2019, vol. 65, no. 11/12, p. 728-740.

### PROJECTS

Slovenian Research Agency. Crystallography of wrinkled elastic surfaces. Miha Brojan. 1.7.2018 - 30.6.2021



## Laboratory for Numerical Modelling and Simulation **LNMS**

### RESEARCH AREAS

Mechanics • Numerical methods • Computer simulations of technological processes • Modelling of thermomechanical processes  
• Optimisation of products and processes • Nuclear engineering  
• Constitutive modelling • Electromagnetism • Finite element method and boundary element method

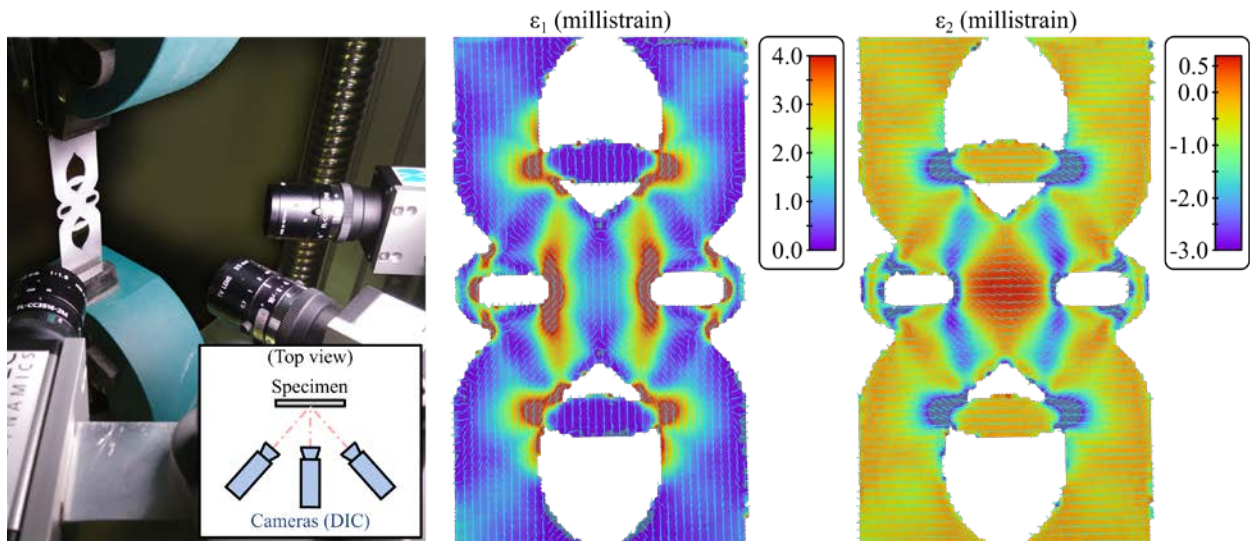
**DEPARTMENT HEAD** Assist. Prof. Miroslav Halilovič, PhD

**DEPARTMENT MEMBERS** Assoc. Prof. Nikolaj Mole, PhD, Assist. Prof. Pino Koc, PhD, Assist. Kristjan Kregelj, PhD, Assist. Primož Rus, PhD, Assist. Bojan Starman, PhD, Assist. Janez Urevc, PhD, MSc Andrej Kotar, Assist. Štefan Obid, Assist. Tomaž Kastelic, Assist. Andraž Maček, Matija Nabergoj, Marta Ilešič / Teja Pirnat

### ORIGINAL SCIENTIFIC ARTICLE

HALILOVIČ, Miroslav, UREVC, Janez, KOC, Pino. Prediction of recirculation flow rate for icing prevention in water intake supply systems of nuclear power plants. Cold regions science and technology, May 2019, vol. 161, p. 63-70.

KREBELJ, Kristjan, HALILOVIČ, Miroslav, MOLE, Nikolaj. The cooling rate dependence of the specific volume in amorphous plastic injection molding. International journal of advanced manufacturing technology, 2019, vol. 103, iss. 1/4, p. 1175-1184.



STARMAN, Bojan, VRH, Marko, KOC, Pino, HALILOVIČ, Miroslav. Shear test-based identification of hardening behaviour of stainless steel sheet after onset of necking. *Journal of materials processing technology*, Aug. 2019, vol. 270, p. 335-344.

KOC, Pino. An exacting wall-penetration pipe analysis. *Strojniški vestnik*, Mar. 2019, vol. 65, no. 3, p. 189-197.

### DOCTORAL DISSERTATIONS

KREBELJ, Kristjan. Numerical prediction of injection molded product's shape after complex ejection. Mentor: Štok, Boris.

### PROJECTS

EIT KIC RawMaterials - SPL-CYCLE - Closing the loop of the Spent Pot-line (SPL) in Al smelting process. Mirko Halilović 01.02.2018 – 31.03.2021

ERDF (Smart Specialization) - TIGR4smart - ERDF - European regional development fond SPS - Sustainable and innovative construction of smart buildings (TIGR4smart). Miroslav Halilović. 01.09.2016 – 31.03.2019

ERDF (Smart Specialization) MOZTART - More efficient electric motors with the development of an EXPERT system and new technologies. Nikolaj Mole. 1.10.2018 – 30.9.2021

### AWARDS AND ACHIEVEMENTS

Miroslav Halilović received an award of the Faculty of Mechanical Engineering for excellence in teaching.



## Laboratory for aeronautics **AEROL**

### RESEARCH AREAS

Construction mechanics • Special development know-how • Special constructions know-how

**DEPARTMENT HEAD** Assoc. Prof. Tadej Kosel, PhD

**DEPARTMENT MEMBERS** Assist. Igor Petrović, PhD, Marta Ilešič / Teja Pirnat



# 11

## SUSTAINABLE POLYMER MATERIALS AND TECHNOLOGIES

The Sustainable polymer materials and technologies programme group covers basic research on non-linear time-dependent behaviour of polymers and their composites which are regarded as dissipative systems. The programme is divided into three complementary research spheres:

**SPHERE 1:** Study of the structure-property relationship in polymeric materials (without changing their chemical composition) and the means of controlling their inherent topological structure. This allows us to control their physical properties and, consequently, to fit properties of polymeric materials to a particular application.

**SPHERE 2:** Development of experimental methods for analyzing dissipative time-dependent behaviour of materials that will allow characterisation and prediction of the durability of products made of polymeric materials.

**SPHERE 3:** Development of theoretical models and numerical tools which, together with new experimental methods, can be used to predict the mechanical behaviour of polymers and their nano-, micro-, and macrocomposites over a longer period of time.



## Laboratory for Experimental Mechanics **LEM**

### RESEARCH AREAS

Polymers • Composites • Nanomaterials • Time-dependent behaviour of materials • Experimental mechanics • Modelling of mechanical properties of materials • Technology of polymer processing • Material structure formation

**DEPARTMENT HEAD** Assist. Prof. Lidija Slemenik Perše, PhD

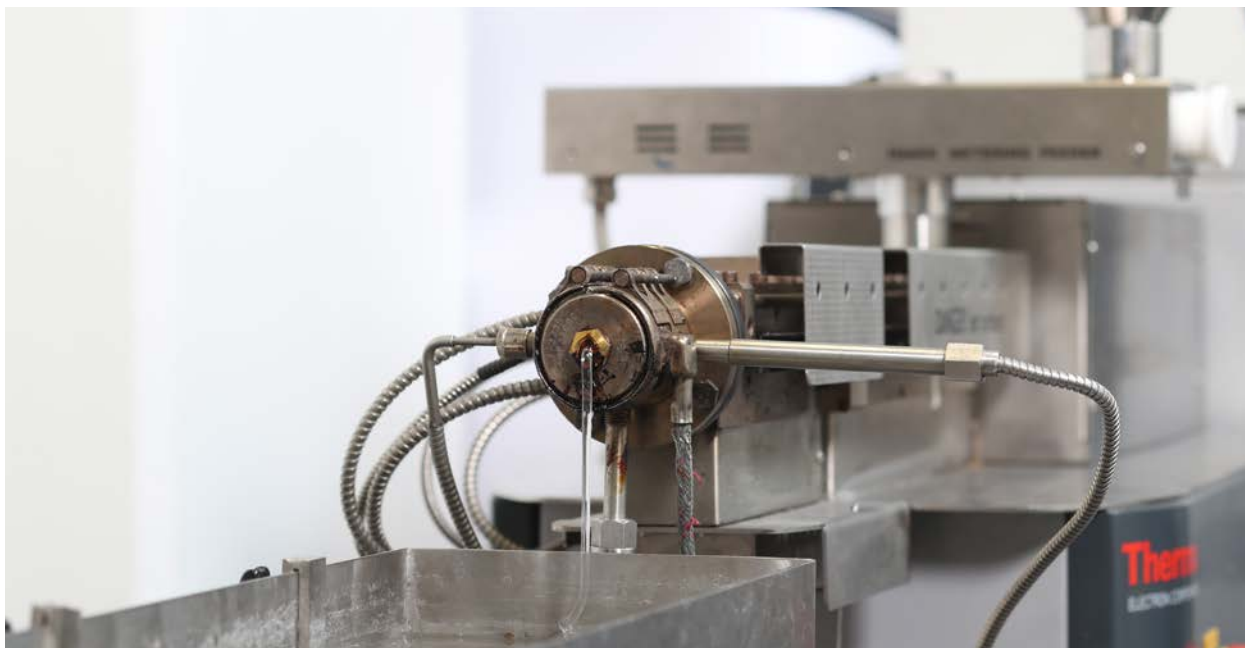
**DEPARTMENT MEMBERS** Assist. Alexandra Aulova, PhD, Assist. Ted Prodan, PhD, Assist. Marko Bek, PhD, Mohor Mihelčič, PhD, Assist. Alen Oseli, Król Elžbieta, Alenka Rogelj Ritonja

### ORIGINAL SCIENTIFIC ARTICLE

MIHELČIČ, Mohor, GABERŠČEK, Miran, DI CARLO, Gabriella, GIULIANI, Chiara, SALZANO DE LUNA, Martina, LAVORGNA, Marino, SURCA, Angelja Kjara. Influence of silsesquioxane addition on polyurethane-based protective coatings for bronze surfaces. *Applied Surface Science*, 15 Feb. 2019, vol. 467/468, p. 912-925.

ŠTULAR, Danaja, ŠOBAK, Matic, MIHELČIČ, Mohor, ŠEST, Ervin, GERMAN ILIĆ, Ilija, JERMAN, Ivan, SIMONČIČ, Barbara, TOMŠIČ, Brigita. Proactive release of antimicrobial essential oil from a “Smart” cotton fabric. *Coatings*, 10 April 2019, vol. 9, iss. 4, p. 1-18.

MIHELČIČ, Mohor, GABERŠČEK, Miran, SALZANO DE LUNA, Martina, LAVORGNA, Marino, GIULIANI, Chiara, DI CARLO, Gabriella, SURCA, Angelja Kjara. Effect of silsesquioxane addition on the protective performance of fluoropolymer coatings for bronze surfaces. *Materials & design*, Sep. 2019, vol. 178, 107860, p. 1-13.



ŠULIGOJ, Andraž, PLIEKHOVA, Olena, VODIŠEK, Nives, MIHELČIČ, Mohor, SURCA, Angelja Kjara, KUNIČ, Roman, ŠUBIC, Barbara, STARMAN, Jernej, UGOVŠEK, Aleš, LAVRENČIČ ŠTANGAR, Urška. Field test of self-cleaning Zr-modified-TiO<sub>2</sub>-SiO<sub>2</sub>TiO<sub>2</sub>-SiO<sub>2</sub> films on glass with a demonstration of their anti-fogging effect. *Materials*, Jul. 2019, vol. 12, iss. 13, p. 1-14.

SURCA, Angelja Kjara, DRAŽIČ, Goran, MIHELČIČ, Mohor. Low-temperature V-oxide film for a flexible electrochromic device: comparison of its electrochromic, IR and Raman properties to those of a crystalline V<sub>2</sub>O<sub>5</sub>V<sub>2</sub>O<sub>5</sub> film. *Solar energy materials and solar cells*, 1 Jul. 2019, vol. 196, p. 185-199.

NIKLAUS, Lukas, SCHOTT, Marco, MIHELČIČ, Mohor, JERMAN, Ivan, POSSET, Uwe, SEXTL, Gerhard. Metallopolymers and non-stoichiometric nickel oxide: towards neutral tint large-area electrochromic devices. *Solar energy materials and solar cells*, 15 Sep. 2019, vol. 200, p. 110002-1-110002-9.

## PROJECTS

Development of complex shape multicomponent permanent magnets with the use of advanced 3D printing technology. Spomenka Kobe. 1.7.2019 – 30.6.2022

Slovenian Research Agency. Rheological behavior and mechanical properties for processing of highly filled powder – polymer systems. Lidija Slemenik Perše. 1.11.2018 – 31.10.2021

Slovenian Research Agency. Electrospun nanofibrous materials for solid state drug delivery system. Igor Emri. 1.3.2016 – 28.2.2019

Slovenian Research Agency. Neural networks for determination of polymer creep response at different temperatures. Alexandra Aulova. 1.7.2019 – 30.6.2021

# 12

## ADVANCED MANUFACTURING TECHNOLOGIES FOR HIGH QUALITY AND SUSTAINABLE PRODUCTION

Slovenian industry has a significant impact on the development of economy, employment, innovations and export. A large part of the economy depends on the competitiveness of the manufacturing industry. Thus, the concept of rapid production, innovative machining technologies, manufacturing technology management and the idea of sustainable development are becoming key research areas for increasing the competitiveness of the Slovenian processing industry.

Long-term research content focuses on the development, transfer and research support of high-performance machining technologies (cutting, 3D printing, etc.), including the implementation of sustainable development considerations in manufacturing technologies in response to environmental, social and economic challenges. The focus is not limited to innovations in technology, but also on providing integrated development solutions.

The research domains of the programme group are complementary, and to a certain extent interdisciplinary, comprised of:

- advanced machining processes;
- technology and resource efficiency;
- quality engineering for manufacturing;
- human-centered manufacturing.



## Laboratory for Cutting **LABOD**

### RESEARCH AREAS

Technology and product planning • Sustainable development of machining processes • Research of machining processes • Development of new machining processes (cryogenic machining, the novel dry machining) • Characterisation of material machinability • High-speed hard milling for the tool industry • Machine tools • Machining process sensors • Reverse engineering • 3D prototype printing • Characterisation of machining surface quality • Product precision and accuracy

**DEPARTMENT HEAD** Assoc. Prof. Franci Pušavec, PhD

**DEPARTMENT MEMBERS** Prof. Janez Kopač, PhD, Assoc. Prof. Peter Krajnik, PhD, Radovan Dražumerič, PhD, Assist. David Homar, PhD, Assist. Awais Ikram, PhD, Assist. Jani Kenda, PhD, Assist. Damir Grguraš, PhD, Assist. Jaka Dugar, Assist. Matjaž Kern, David Muženič, Vinko Rotar, Luka Sterle, Marija Jeretina

### ORIGINAL SCIENTIFIC ARTICLE

GRGURAŠ, Damir, KERN, M., PUŠAVEC, Franci. Cutting performance of solid ceramic and carbide end milling tools in machining of nickel based alloy Inconel 718 and stainless steel 316L. *Advances in production engineering & management*, ISSN 1854-6250, Mar. 2019, vol. 14, no. 1, p. 27-38.

PUŠAVEC, Franci, GRGURAŠ, Damir, KOCH, Matthias, KRAJNIK, Peter. Cooling capability of liquid nitrogen and carbon dioxide in cryogenic milling. *CIRP annals*, vol. 68, iss. 1, p. 73-76.

GRGURAŠ, Damir, STERLE, Luka, KRAJNIK, Peter, PUŠAVEC, Franci. A novel cryogenic machining concept based on a lubricated liquid carbon dioxide. *International journal of machine tools & manufacture: Design, research and application*, Oct. 2019, vol. 145, p. 1-6.

IKRAM, Awais, MEHMOOD, Muhammad Farhan, PODLOGAR, Matejka, ELDOSOUKY, Anas, MAČEK, Marjeta, TOMŠE, Tomaž, KOBÉ, Spomenka, ŠTURM, Sašo, ŽUŽEK ROŽMAN, Kristina, et al. The sintering mechanism of fully dense and highly coercive Nd-Fe-B magnets from the recycled HDDR powders reprocessed by spark plasma sintering. *Journal of alloys and compounds*, 2019, vol. 774, p. 1195-1206.

DAVID, Elena, KOPAČ, Janez. Upgrading the characteristics of the bio-oil obtained from rapeseed oil cake pyrolysis through the catalytic treatment of its vapors. *Journal of analytical and applied pyrolysis*, ISSN 0165-2370. [Print ed.], 2019, vol. 141, p. 1-11.

DAVID, Elena, KOPAČ, Janez. Functional carbon structures derived from unburned coal contained in fly ash. *Materials today: proceedings*, ISSN 2214-7853, 2019, vol. 7, part 3, p. 817-827.

STERLE, Luka, GRGURAŠ, Damir, KERN, Matjaž, PUŠAVEC, Franci. Sustainability assessment of advanced machining technologies. *Strojniški vestnik*, Nov./Dec. 2019, vol. 65, no. 11/12, p. 671-679.

HOIER, Philipp, MALAKIZADI, Amir, KLEMENT, Uta, KRAJNIK, Peter. Characterization of abrasion- and dissolution-induced tool wear in machining. *Wear*, 2019, vol. 426/427, part B, p. 1548-1562.

HOIER, Philipp, MALAKIZADI, Amir, FRIEBE, Sven, KLEMENT, Uta, KRAJNIK, Peter. Microstructural variations in 316L austenitic stainless steel and their influence on tool wear in machining. *Wear*, 2019, vol. 428/429, p. 315-327.

MUŽENIČ, David, DUGAR, Jaka, KRAMAR, Davorin, JEZERŠEK, Matija, PUŠAVEC, Franci. Improvements in machinability of zinc oxide ceramics by laser-assisted milling. *Strojniški vestnik*, Oct. 2019, vol. 65, no. 10, p. 539-546.

## PROJECTS

Erasmus + REACH - Palestinian higher education institutions-PHEIs. Franci Pušavec. 15.11.2019 - 14.11.2022

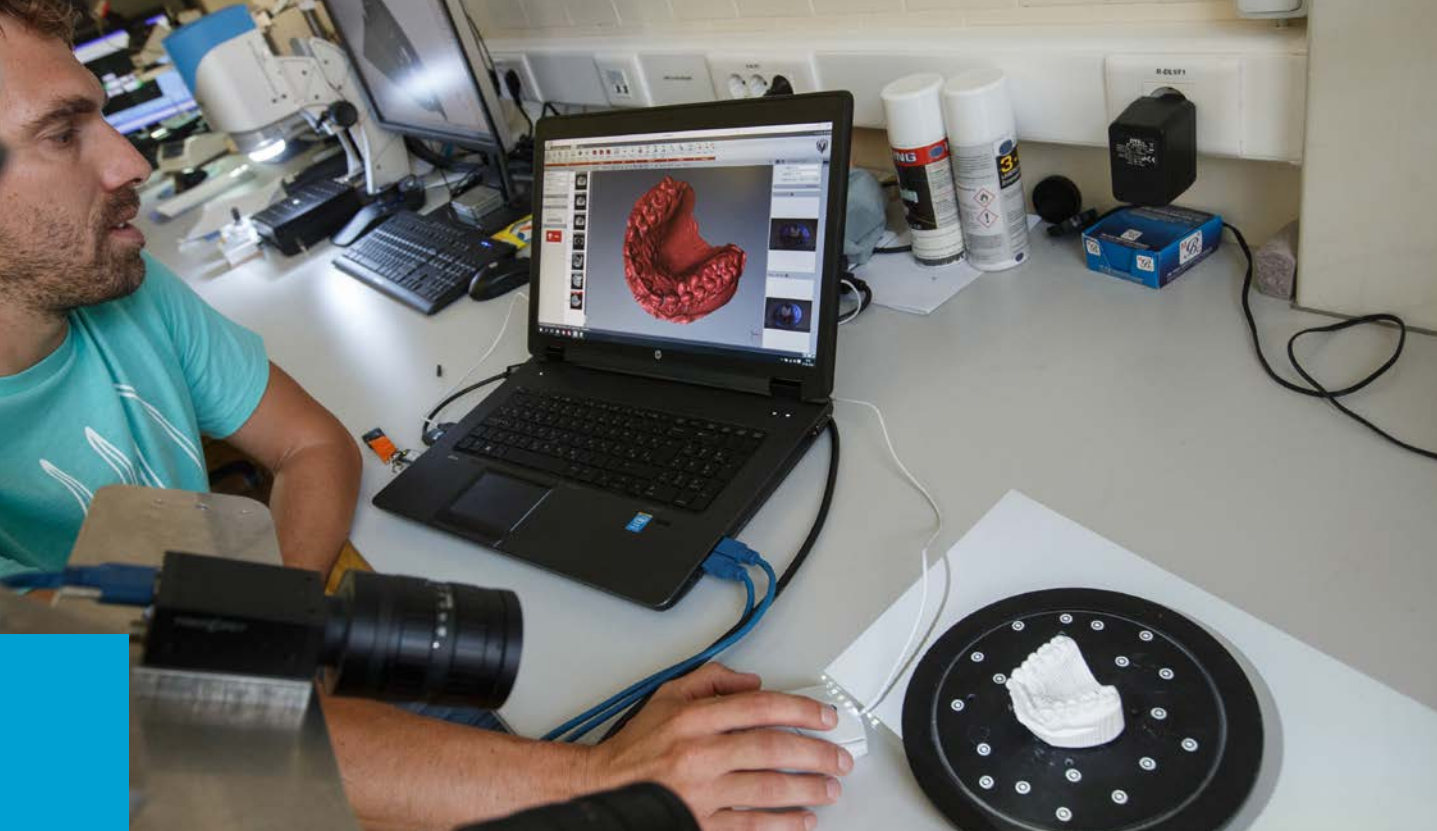
Slovenian Research Agency. Development and implementation of cryogenic machining into serial production industry for increasing productivity of drilling and milling processes. Franci Pušavec. 1.5.2017 - 30.4.2020

Slovenian Research Agency. Development and implementation of innovative machining technology for machining ZnO based ceramics with defined cutting geometry, in serial production, to increase the quality of varistors as final products. Franci Pušavec. 1.7.2019 - 30.6.2022

## AWARDS AND ACHIEVEMENTS

Jaka Dugar received an award of the Faculty of Mechanical Engineering for excellence in teaching.

Damir Grguraš received an award of the Faculty of Mechanical Engineering for high quality publications.



## Laboratory for Quality Assurance **LAZAK**

### RESEARCH AREAS

Quality planning and control • Quality assurance of processes, products and services • Technology and innovation management • 3D digitisation and reverse engineering • Machine tools precision and accuracy measurement

**DEPARTMENT HEAD** Assoc. Prof. Davorin Kramar, PhD

**DEPARTMENT MEMBERS** Assist. Luka Čerče, PhD, Luka Kastelic, David Muženič, Marija Jeretina

### ORIGINAL SCIENTIFIC ARTICLE

CICA, Djordje, KRAMAR, Davorin. Multi-objective optimization of high-pressure jet-assisted turning of Inconel 718. International journal of advanced manufacturing technology, ISSN 0268-3768, Dec. 2019, vol. 105, iss. 11, p. 4731-4745.

MUŽENIČ, David, DUGAR, Jaka, KRAMAR, Davorin, JEZERŠEK, Matija, PUŠAVEC, Franci. Improvements in machinability of zinc oxide ceramics by laser-assisted milling. Strojniški vestnik, Oct. 2019, vol. 65, no. 10, p. 539-546.

# 13

## PRODUCTION SYSTEMS, LASER TECHNOLOGIES AND MATERIALS WELDING - PLAS

The research programme Production systems, laser technologies and materials welding integrates four research fields which are of key importance for the development of modern manufacturing.

The Production systems field focuses on:

- concepts of distributed manufacturing systems, including their structuring and control;
- concurrent product development concepts;
- principles of product-service systems, on-line monitoring and remote control;
- development of mechatronics and cyber-physical systems applications.

The research in the Laser systems field is aimed at:

- Fiber and hybrid laser sources, and pulsed laser sources;
- laser measuring systems for simultaneous 3D shape and color measurement of bodies in real time;
- adaptive control of laser systems based on identification, monitoring and adaptive process control;
- opto-mechatronic systems based on optical elements with free surfaces, electrically focus-tunable lenses and microlens arrays.



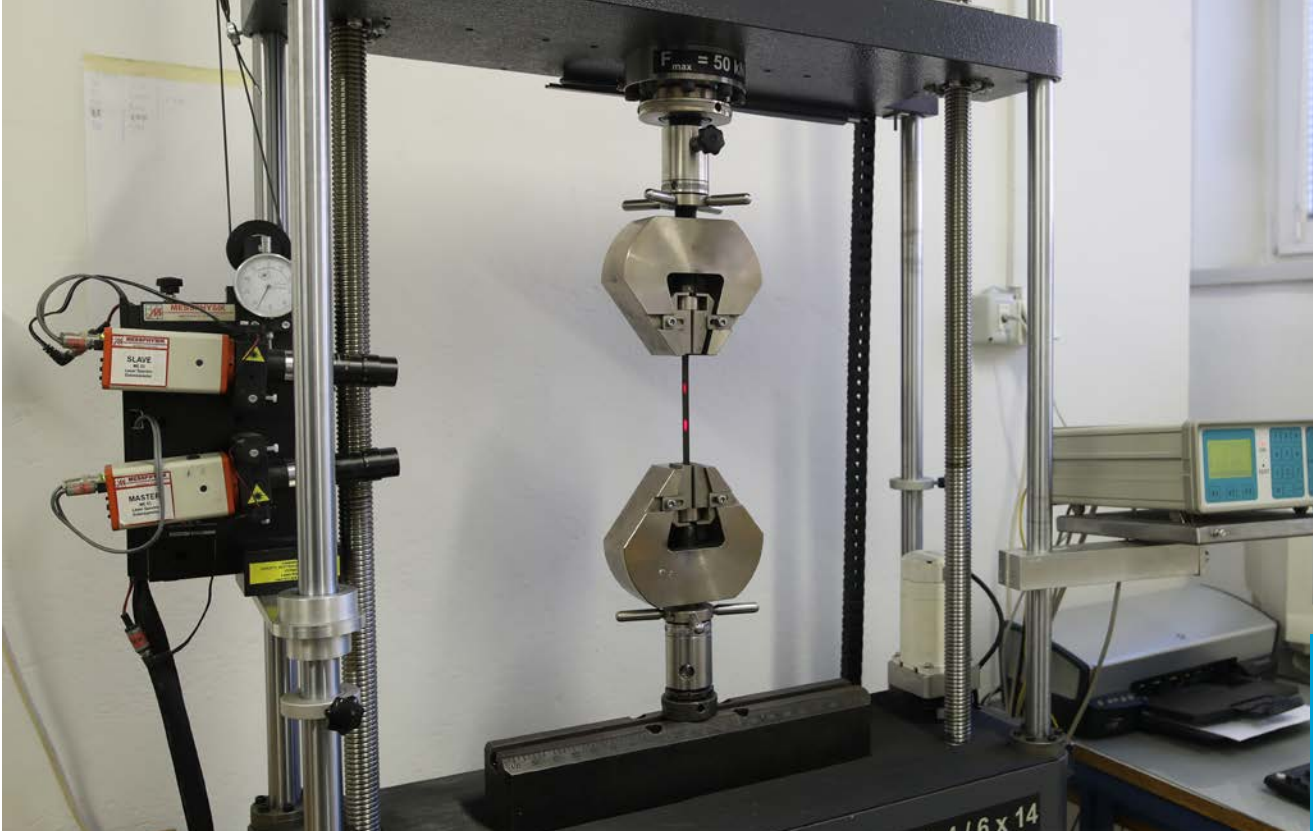
Research in the field of Laser machining processes, surface modification and non-destructive testing is geared towards:

- development of new laser machining processes for surface finishing and improvement of mechanical properties;
- optimisation of various laser processes in terms of surface integrity;
- development of a method for non-destructive testing based on monitoring of die-casting process of reinforced polymeric materials using acoustic emission signals;
- testing of glued joints by means of ultrasound.

The Joining of materials section performs the following research:

- analysis of the chemical composition of joining accelerators;
- optimisation of welding parameters and mutual weldability of dissimilar materials;
- repair-welding of tools for extending the in-service tool life, filler materials;
- development of design welding, friction stir welding and other joining technologies;
- applying different materials with high-energy arc procedures.

These topics are highly relevant for advances of manufacturing science as well as for the economic and social development of Slovenia. The research is conducted in a close cooperation with the industry.



## Laboratory for Heat Treatment and Materials Testing **LATOP**

### RESEARCH AREAS

Heat treatment • Laser surface hardening • Shot peening of surfaces  
• Surface integrity • Measurement of residual stresses • Determination of microstructures • Modelling of casting processes • Determination of tool life

**DEPARTMENT HEAD** Prof. Roman Šturm, PhD

**DEPARTMENT MEMBERS** Assist. Prof. Zoran Bergant, PhD, Assist. Prof. Tomaž Kek, PhD, Assist. Prof. Uroš Trdan, PhD, Assist. Janez Sušnik, PhD, Assist. Sebastjan Žagar, PhD, Assist. Bor Mojšker, PhD, Assist. Boštjan Pečnik, PhD, Assist. Dunja Ravnikar, PhD, Assist. Matjaž Žnidaršič, PhD, Vane Kralj, Rok Markežič, Anja Vrhovec, Dušanka Grubor Železnik

### ORIGINAL SCIENTIFIC ARTICLE

MARKEŽIČ, Rok, NAGLIČ, Iztok, MOLE, Nikolaj, ŠTURM, Roman. Experimental and numerical analysis of failures on a die insert for high pressure die casting. Engineering failure analysis, Jan. 2019, vol. 95, p. 171-180.

MOJŠKERC, Bor, GRUM, Janez, KEK, Tomaž. Acoustic emission characterisation of specimen surface-area-to-volume ratio during immersion quenching. Insight, 2019, vol. 61, no. 5, p. 257-263.



STEINER PETROVIČ, Darja, ŠTURM, Roman, PEPELNJAK, Tomaž. Characterization of macroscopic mechanical anisotropy of magnetocaloric gadolinium cylinders. *JOM: The journal of minerals, metals and materials society*, 2019, vol. 71, no. 9, p. 3151-3158.

MOJŠKERC, Bor, KEK, Tomaž, GRUM, Janez. Experimental characterization of quenching bath contamination using acoustic emission. *Journal of nondestructive evaluation*, Sep. 2019, vol. 38, no. 69, p. 1-13.

PETAN, Luca, GRUM, Janez, PORRO, Juan Antonio, OCAÑA, José Luis, ŠTURM, Roman. Fatigue properties of maraging steel after laser peening. *Metals*, Nov. 2019, vol. 9, iss. 12.

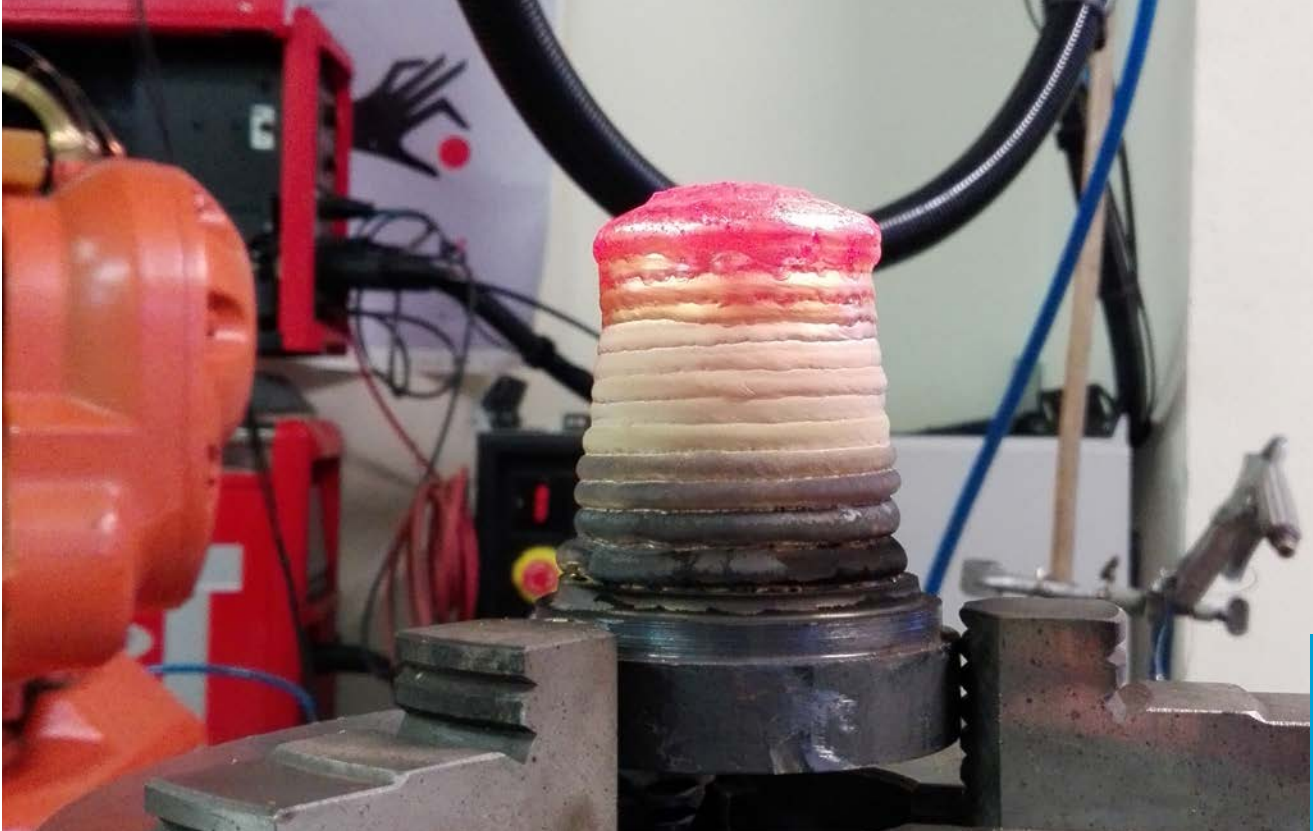
ŽAGAR, Sebastjan, ŠTURM, Roman. Influence of grinding on the residual stress measurements of shot peened aluminum alloy AA7075. *Strojniški vestnik*, Jul./Avg. 2019, vol. 65, no. 7/8, p. 401-409.

#### **DOCTORAL DISSERTATIONS**

MOJŠKERC, Bor. Prediction of mechanical properties of steel during the quenching process, based on acoustic emission. Mentor: Grum, Janez.

#### **PROJECTS**

COST - CERTBOND CA18120 - Reliable roadmap for certification of bonded primary structures. Uroš Trdan. 04.04.2019 - 03.04.2023



## Laboratory for Welding **LAVAR**

### RESEARCH AREAS

Technologies of material joining and assembly (arc welding, laser welding, friction stir welding, resistance welding, ultrasonic welding)

- Technologies of thermal cutting
- Wire arc additive manufacturing
- Materials science
- Production technologies
- Weldability of metallic materials and polymers
- Welding machines and devices
- Additive and auxiliary welding materials
- Chemical and metallurgical processes in welding

**DEPARTMENT HEAD** Assist. Prof. Damjan Klobčar, PhD

**DEPARTMENT MEMBERS** Matej Pleterski, PhD, Assist. Maja Lindič, Peter Kolar, Andraž Logar, Aljaž Ščetinec, Dušanka Grubor Železnik

### ORIGINAL SCIENTIFIC ARTICLE

KOSEC, Tadeja, LEGAT, Andraž, KOVAČ, Janez, KLOBČAR, Damjan. Influence of laser colour marking on the corrosion properties of low alloyed Ti. *Coatings*, Jun. 2019, vol. 9, iss. 6, p. 1-14.

BALOŠ, Sebastian, DRAMIČANIN, Miroslav D., JANJATOVIC, Petar, ZABUNOV, Ivan, KLOBČAR, Damjan, BUŠIĆ, Matija, GRILLI, Maria Luisa. Metal oxide nanoparticle-based coating as a catalyzer for A-TIG welding: critical raw material perspective. *Metals*, ISSN 2075-4701, 2019, vol. 9, iss. 5.



## PROJECTS

COST - CERTBOND CA18120 - Reliable roadmap for certification of bonded primary structures. Damjan Klobčar. 04.04.2019 - 03.04.2023

COST - CA COST Action CA15102; CRM-EXTREME - Solutions for Critical Raw Materials Under Extreme Conditions. Damjan Klobčar. 10.03.2016 - 09.03.2020

COST - Action MP1407; e-MINDS - Electrochemical processing methodologies and corrosion protection for device and systems miniaturization. Damjan Klobčar. 23.04.2015 - 22.04.2019

ERDF (Smart Specialization) - MARTINA - MateRiali in Tehnologije za Nove Aplikacije. Damjan Klobčar. 01.08.2016 - 31.07.2019

Erasmus + APTIME - Additive Process Technology Integration with Management and Entrepreneurship. Damjan Klobčar. 04.10.2019 - 03.10.2022

Slovenian Research Agency. Selective plasma oxidation of FeCrAl alloys for extended-lifetime of glow plugs for diesel engines. Damjan Klobčar. 1.5.2017 - 30.4.2020



## Laboratory for Digital Systems and Electrical Engineering **LDSE**

### RESEARCH AREAS

Modelling • Simulation • Automation • Hardware • Software

**DEPARTMENT HEAD** Prof. Janez Diaci, PhD

**DEPARTMENT MEMBERS** Assist. Prof. Marjan Jenko, PhD, Assist. Marko Corn, PhD, Assist. Tomaž Požrl, PhD, Anja Juriševič, Rožman Nejc, Alenka Rogelj Ritonja

### ORIGINAL SCIENTIFIC ARTICLE

HRIBAR, Melita, TRONTELJ, Jurij, BERGLEZ, Sandra, BEVC, Alenka, KUŠČER, Lovro, DIACI, Janez, LEGEN, Igor. Design of an innovative advanced gastric simulator. Dissolution technologies, 2019, vol. 26, iss. 4, p. 20-29.

### PROJECTS

ERDF - European regional development fond SPS - Building Blocks, Tools and Systems for Factories of the Future (GOSTOP). Janez Diaci. 01.11.2016 - 30.04.2020



## Laboratory for Process Automation **LPA**

### RESEARCH AREAS

Analysis of control systems • Design of control systems • Optimal control laws • Energy devices and processes

**DEPARTMENT HEAD** Assoc. Prof. Primož Podržaj, PhD

**DEPARTMENT MEMBERS** Assist. Prof. Samo Simončič, PhD, Miha Finžgar, Matic Kelvišar, Igor Reznichenko, Alenka Rogelj Ritonja

### ORIGINAL SCIENTIFIC ARTICLE

DOI, Shunsuke, IMAI, Yoshiro, KAGAWA, Koji, OHNO, Asako, PODRŽAJ, Primož, HATTORI, Tetsuo. Proposal and development of web-based programming educational system with error analysis and visualization. Denki gakkai ronbunshi = : IEEJ transactions on electronics, information and systems. C, Denshi joho shisutemu bumonshi, 2019, vol. 139, no. 11.

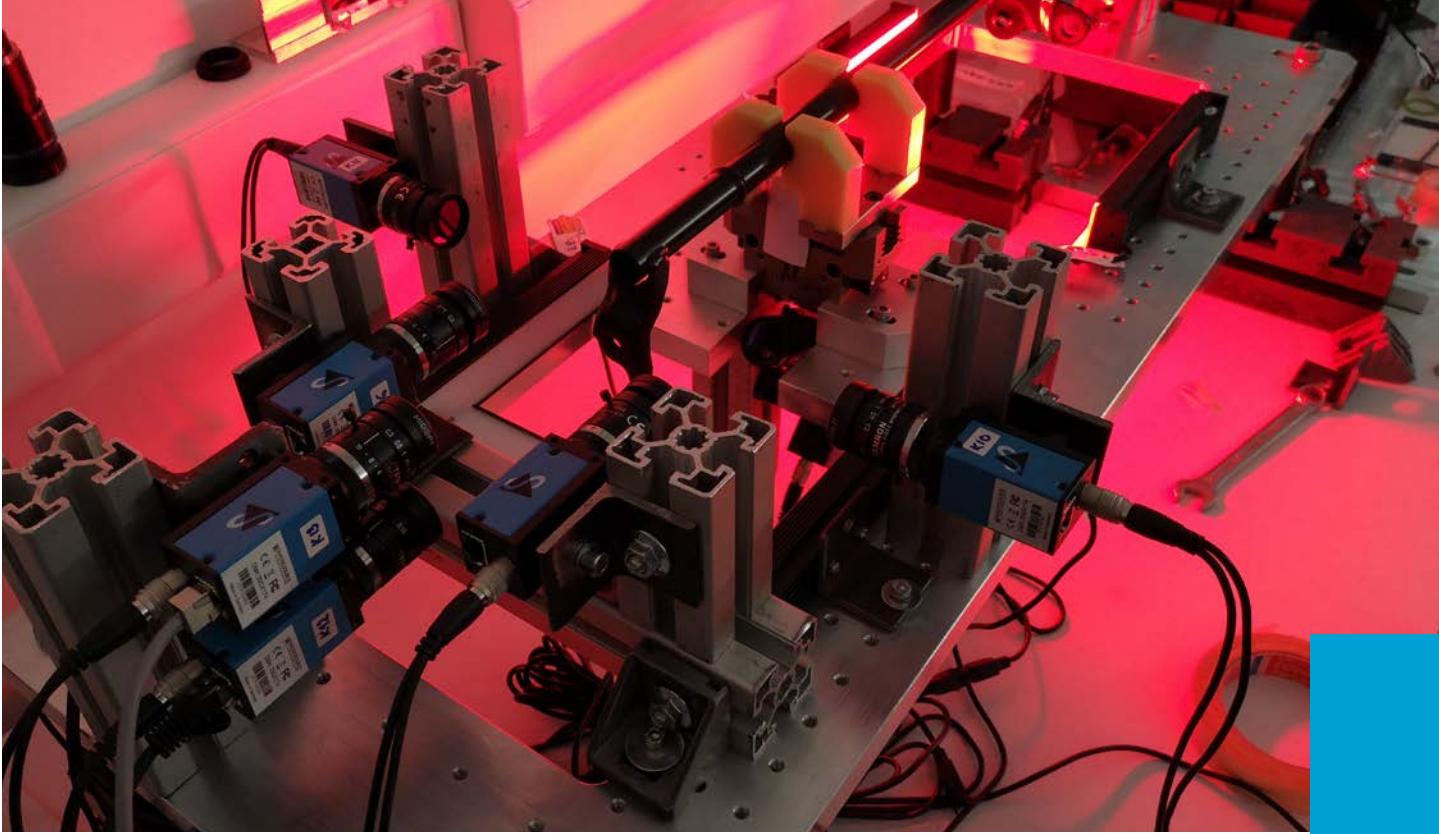
PODRŽAJ, Primož. Neural network programming in Python. International journal of innovative technology and exploring engineering, 2019, vol. 8, no. 6S4, p. 373-377.

PODRŽAJ, Primož. An overview of arc welding control systems. Progress of electrical and electronic engineering, 2019, no. 4, vol. 1.

### PROJECTS

Erasmus + MAESTRO - Manufacturing Education for a Sustainable fourth Industrial Revolution. Primož Podržaj. 01.09.2019 – 31.08.2022

Erasmus + ICCT - Interactive course for Control Theory. Primož Podržaj. 01.09.2018 – 31.08.2021



## Laboratory for Manufacturing Cybernetics and Experimentation **MCE**

### RESEARCH AREAS

Quality • Computer integrated manufacturing • Adaptive control  
• Machine vision • Internet of Things • Mechatronics • Biologically inspired robotics

**DEPARTMENT HEAD** Assist. Prof. Drago Bračun, PhD

**DEPARTMENT MEMBERS** Assist. Luka Selak, PhD, Assist. Gašper Škulj, PhD, Nejc Kozamernik, Alenka Rogelj Ritonja

### ORIGINAL SCIENTIFIC ARTICLE

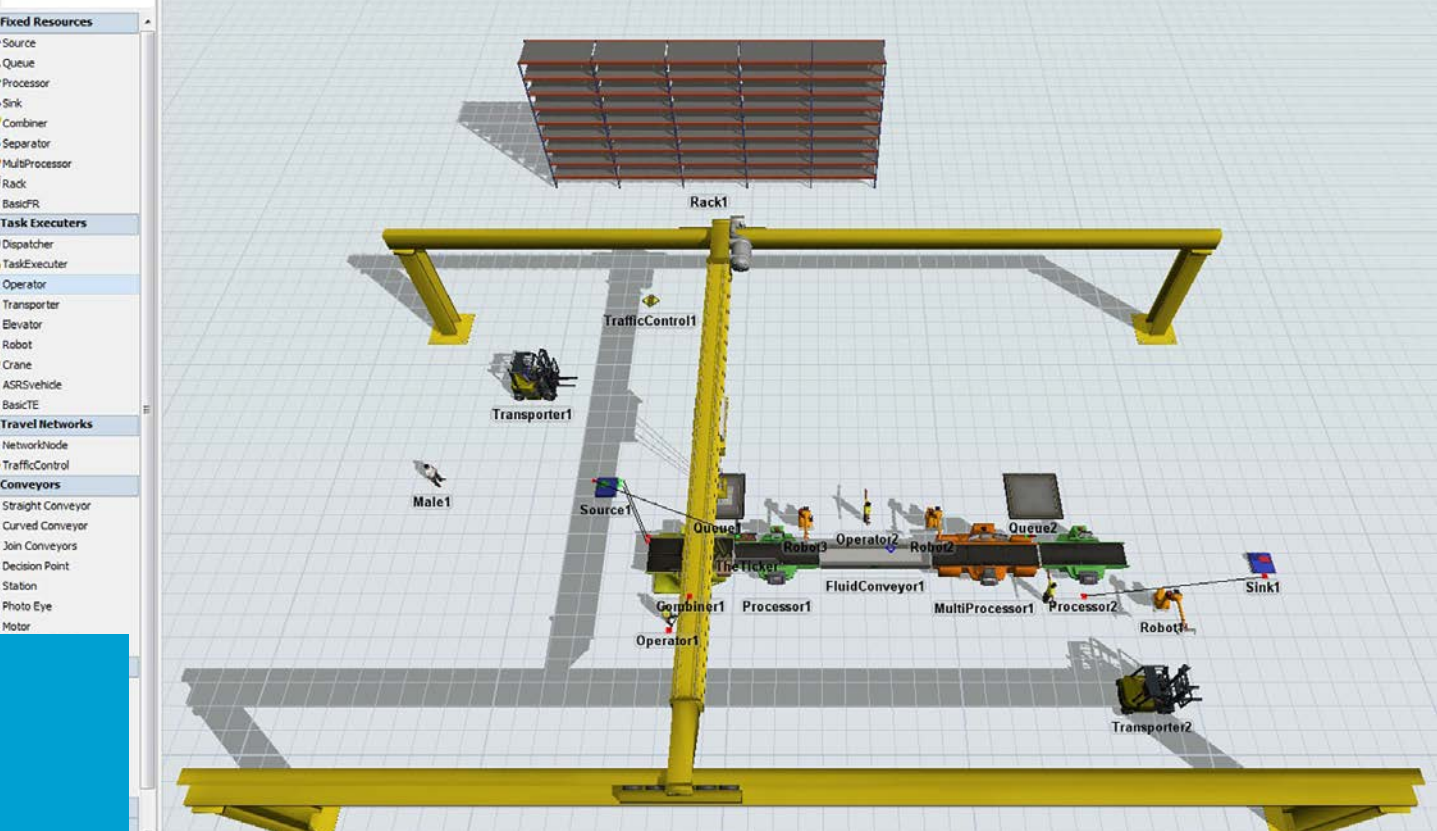
ŠKULJ, Gašper, SLUGA, Alojzij, BRAČUN, Drago, BUTALA, Peter, VRABIČ, Rok. Energy efficient communication based on self-organisation of IoT devices for material flow tracking. CIRP annals, 2019, vol. 68, iss. 1, p. 495-498.

BRAČUN, Drago, SELAK, Luka. Optical probing for CNC machining of large parts made from fiber-reinforced polymer composite materials. International journal of advanced manufacturing technology, 2019, vol. 100, iss. 5/8, p. 1855-1865.

### PROJECT

Erasmus + UniGov - Improving Governance Practices at Palestinian Higher Education Institutions-PHEIs. Drago Bračun. 15.10.2016 - 14.10.2019





# Laboratory for Manufacturing Systems and Production Process Planning **LAPS**

## RESEARCH AREAS

Production systems • Production planning and control • Logistics of material and information flows • Work and time studies • Project management • Concurrent engineering • Operational research

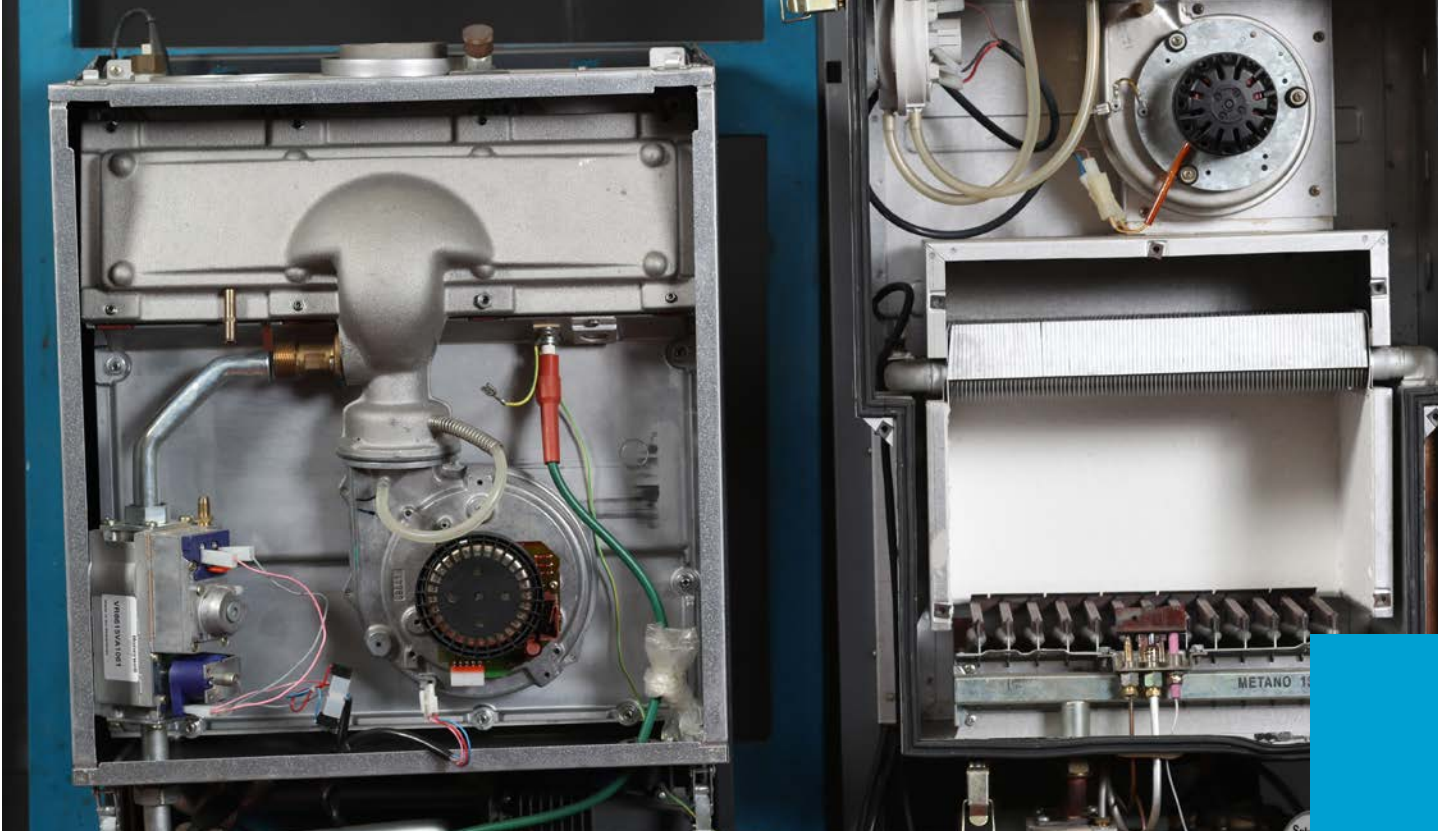
**DEPARTMENT HEAD** Assoc. Prof. Janez Kušar, PhD

**DEPARTMENT MEMBERS** Assist. Prof. Tomaž Berlec, PhD, Assist. Lidija Rihar, PhD, Tadeja Kavčič, Tena Žužek, Alenka Rogelj Ritonja

## ORIGINAL SCIENTIFIC ARTICLE

JORDAN, Eva, KUŠAR, Janez, RIHAR, Lidija, BERLEC, Tomaž. Portfolio analysis of a lean six sigma production process. Central European Journal of Operations Research, 2019, vol. 27, iss. 3, p. 797-813.

ŽUŽEK, Tena, PEPPERKO, Aljoša, KUŠAR, Janez. A max-plus algebra approach for generating a non-delay schedule. Croatian operational research review: CRORR, 2019, vol. 10, no. 1, p. 35-44.



## Laboratory for control and manufacturing systems **LAKOS**

### RESEARCH AREAS

Mechatronics • Robotics • Flexible manufacturing systems  
• Computer-integrated manufacturing • Distributed control  
• Multi-agent systems • Reinforcement learning • Engineering informatics • Manufacturing data analytics

**DEPARTMENT HEAD** Assist. Prof. Rok Vrabič, PhD

**DEPARTMENT MEMBERS** Assist. Dominik Kozjek, PhD, Assist. Andreja Malus, Dominik Rupert, Alenka Rogelj Ritonja

### DOCTORAL DISSERTATIONS

KOZJEK, Dominik. Information support framework for processes in manufacturing systems based on big data. Mentor: Butala, Peter.

### CONFERENCE

Organization of the 52nd CIRP Conference on Manufacturing Systems in Ljubljana, from 12 to 14 June.



## PROJECTS

Erasmus + REACH - Reinforcing access to cross border employment at Palestinian higher education institutions-PHEIs. Rok Vrabič. 15.11.2019 - 14.11.2022

Erasmus + UniGov - Improving Governance Practices at Palestinian Higher Education Institutions-PHEIs. Rok Vrabič. 15.10.2016 - 14.10.2019

ERDF - European regional development fond SPS - Building Blocks, Tools and Systems for Factories of the Future (GOSTOP). Rok Vrabič. 01.11.2016 - 30.04.2020

# 14

## OPTODYNAMICS

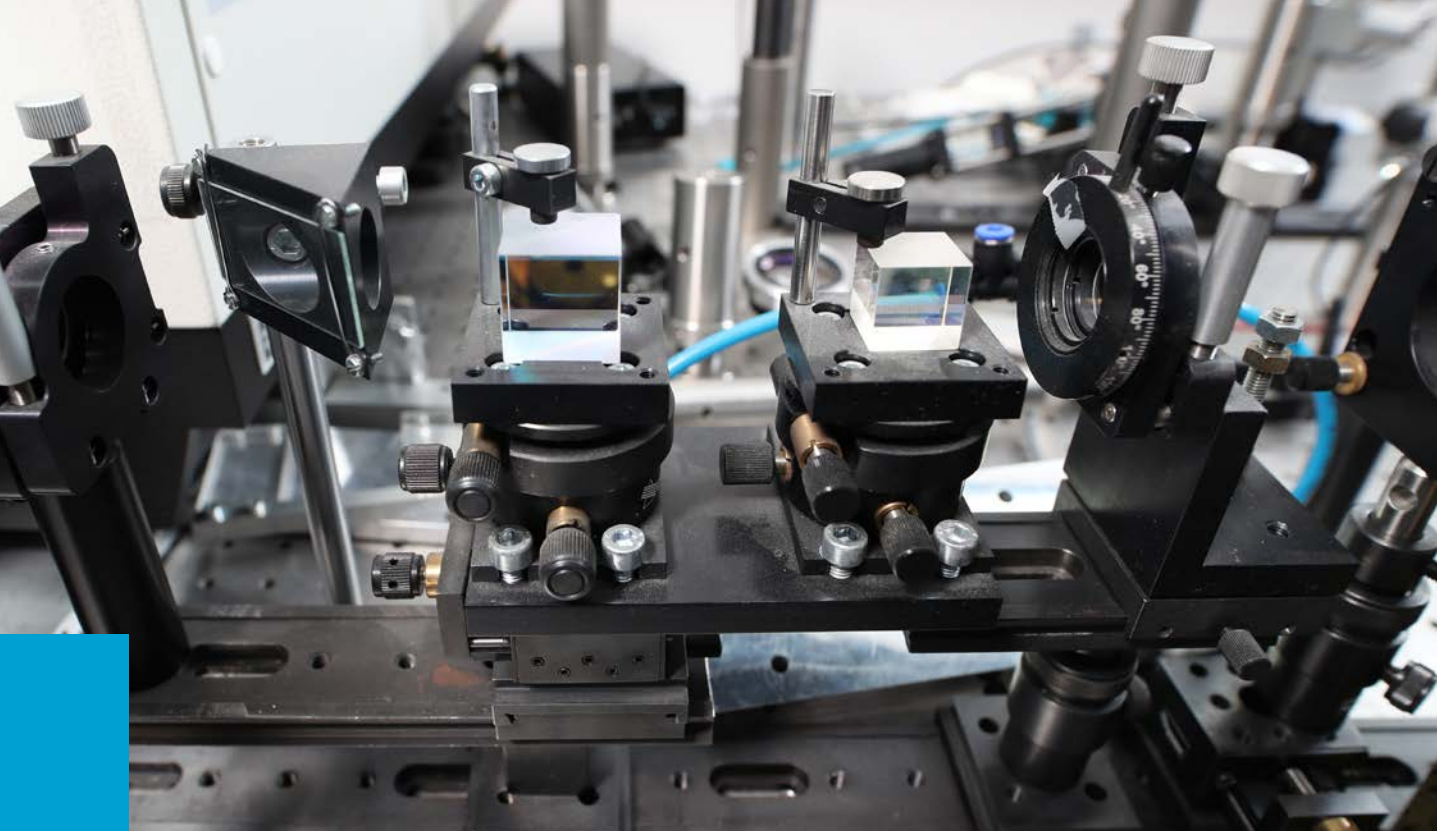
Optodynamics explores the dynamic aspects of light-to-substance interaction, which are the basis of most laser machining processes and laser-based medical interventions. Since optodynamic responses are an important source of information on the interaction between light and matter, their simultaneous detection and analysis can provide effective control over all laser processes.

The recent discovery of the programme group's researchers on characteristics of mechanical waves induced due to reflection of light is the basis for an important progress in resolving the dilemmas regarding the momentum of light in transparent media. Basic research into optodynamics leads to new applied research.

The programme also enables the development of new approaches in research on:

- laser-induced mass transfer;
- manipulation of nanoparticles;
- microfluidics;
- laser micro- and nanoprocessing;
- laser-based non-destructive testing and its transfer into practice.

The program is also oriented towards the further development and optimisation of new, more efficient and safer medical laser systems. The results of the programme are closely related to the Master's and Doctoral education programs at Faculty of Mechanical Engineering.



## Laboratory for Laser Techniques **LASTEH**

### RESEARCH AREAS

Laser measuring methods • Laser triangulation • Fiber-optic sensors  
• Fast photography • Interferometry • Laser machining processes  
• Laser microstructuring • Adaptive control of laser processes • Medical laser procedures • Optodynamics

**DEPARTMENT HEAD** Assoc. Prof. Matija Jezeršek, PhD

**DEPARTMENT MEMBERS** Assist. Prof. Peter Gregorčič, PhD, Assist. Aleš Babnik, PhD, Assist. Urban Pavlovčič, PhD, Assist. Jernej Laloš, PhD, Assist. Ladislav Grad, PhD, Nejc Lukač, PhD, Assist. Luka Hribar, Daniele Vella, PhD, Assist. Jure Košir, Assist. Matjaž Kos, Assist. Matej Senegačnik, Teja Jereb, Alenka Rogelj Ritonja

### ORIGINAL SCIENTIFIC ARTICLE

VERZHBITSKIY, Ivan, VELLA, Daniele, WATANABE, Kenji, TANIGUCHI, Takashi, EDA, Goki. Suppressed out-of-plane polarizability of free excitons in monolayer WSe [sub] 2. ACS nano, Feb. 2019, [Vol.] 13, [no.] 3, p. 3218-3224.

AUKSZTOL, Filip, VELLA, Daniele, VERZHBITSKIY, Ivan, NG, Kian Fong, HO, Yi Wei, GRIEVE, James A., VIANA-GOMES, José, EDA, Goki, LING, Alexander. Elastomeric waveguide on-chip coupling of an encapsulated MoS [sub] 2 monolayer. ACS photonics, Feb. 2019, [Vol.] 6.

ROGELJ, Luka, PAVLOVČIČ, Urban, STERGAR, Jošt, JEZERŠEK, Matija, SIMONČIČ, Urban, MILANIČ, Matija. Curvature and height corrections of hyperspectral images using built-in 3D laser profilometry. Applied optics, 2019, vol. 58, no. 32, p. 9002-9012.

HOPPIUS, Jan S., MARAGKAKI, Stella, KANITZ, Alexander, GREGORČIČ, Peter, GUREVICH, Evgeny L. Optimization of femtosecond laser processing in liquids. *Applied Surface Science*, Feb. 2019, vol. 467/468, p. 255-260.

CONRADI, Marjetka, SEVER, Tina, GREGORČIČ, Peter, KOCIJAN, Aleksandra. Short- and long-term wettability evolution and corrosion resistance of uncoated and polymer-coated laser-textured steel surface. *Coatings*, Sep. 2019, vol. 9, iss. 9.

KOS, Matjaž, ARKO, Erih, KOSLER, Hubert, JEZERŠEK, Matija. Remote laser welding with in-line adaptive 3D seam tracking. *International journal of advanced manufacturing technology*, Aug. 2019, vol. 103, iss. 9/12, p. 4577-4586.

IVANUSIC, Tomaz, LUKAČ, Matjaž, LUKAČ, Nejc, JEZERŠEK, Matija. SSP/SWEEPS Endodontics with the SkyPulse Er:YAG Dental Laser. *LAHA: journal of the Laser and Health Academy*, 2019, vol. 2019, no. 1, p. 1-10.

MILANIČ, Matija, TAŠIČ MUC, Blaž, LUKAČ, Nejc, LUKAČ, Matjaž. Numerical study of hyperthermic laser lipolysis with 1,064 nm Nd:YAG laser in human subjects. *Lasers in surgery and medicine*, 2019, vol. 51, iss. 10, p. 897-909.

POGAČAR, Marko, JEZERŠEK, Matija. Laser-based magnetic micro-inscription: surface heating versus deep penetration regime. *Optics and laser technology*, Jun. 2019, vol. 114, p. 164-170.

JEZERŠEK, Matija, JEREB, Teja, LUKAČ, Nejc, TENYI, Ana, LUKAČ, Matjaž, FIDLER, Aleš. Evaluation of apical extrusion during novel Er:YAG laser-activated irrigation modality. *Photobiomodulation, photomedicine, and laser surgery*, Sep. 2019, vol. 37, iss. 9.

VIŠIĆ, Bojana, YADGAROV, Lena, POGNA, Eva Arianna Aurelia, DAL CONTE, Stefano, VEGA MAYORAL, Victor, VELLA, Daniele, TENNE, Reshef, CERULLO, Giulio, GADERMAIER, Christoph. Ultrafast nonequilibrium dynamics of strongly coupled resonances in the intrinsic cavity of WS<sub>2</sub>WS<sub>2</sub> nanotubes. *Physical review research*, 2019, vol. 1, no. 3, p. 033046-1-033046-7.

WILD, Stefan, LLORET, Vicent, VEGA MAYORAL, Victor, VELLA, Daniele, NUIN, Edurne, SIEBERT, Martin, KOLEŠNIK-GRAY, Maria, LÖFFLER, Mario, et al. Monolayer black phosphorus by sequential wet-chemical surface oxidation. *RSC advances*, 2019, vol. 9, iss. 7.

## PATENT

LUKAČ, Nejc, LUKAČ, Matjaž, JEZERŠEK, Matija, GREGORČIČ, Peter. Cleaning system: European patent specification EP3127502 B1, 2019-03-20. München: Europäisches Patentamt, 2019.

## PROJECTS

Company Yaskawa Slovenija - Razvojne aktivnosti laserske triangulacije v robotiki. Matija Jezeršek. 21.3.2017 - 31.3.2019

Company Fotona - Research and development of laser medical systems. Matija Jezeršek. 1.9.2018 - 1.9.2021

ERDF - European regional development fond SPS - Building Blocks, Tools and Systems for Factories of the Future (GOSTOP). Matija Jezeršek. 01.11.2016 - 30.04.2020

Fotona - Raziskave in razvoj laserskega medicinskega robota za dermatološke in estetske terapije. Matija Jezeršek. 26.7.2017 - 31.12.2019

Slovenian Research Agency. Laser-induced subsurface microdestruction of tissue (LasDes). Matija Jezeršek. 1.7.2019 - 30.6.2022



Slovenian Research Agency. Optodynamic optimization of laser root canal irrigation. Matija Jezeršek. 1.3.2016 – 28.2.2019

Slovenian Research Agency. Combined multispectral and thermographic imaging for screening and monitoring of small joint arthritis. Matija Jezeršek. 1.5.2017 – 30.4.2020

Slovenian Research Agency. Laser micro and nano structuring for development of biomimetic metallic surfaces with unique properties (LaMiNaS). Peter Gregorčič. 1.7.2019 – 30.6.2022

Slovenian Research Agency. New Conventional and Additive Manufactured Biodegradable Fe-Mn alloy with Tailored Biodegradability. Peter Gregorčič. 1.7.2019 – 30.6.2022

### **AWARDS AND ACHIEVEMENTS**

Matija Jezeršek, Niko Herakovič (Faculty of Mechanical Engineering) and Hubert Kosler, Erih Arko, Damjan Širaj (Yaskawa company) received the Puh Prize as a group. They received the prize for outstanding achievements in the field of industrial robotic technology.



## Laboratory for photonics and laser systems **FOLAS**

### RESEARCH AREAS

Laser sources • Fiber and hybrid lasers • Photonics • Optical fiber processing • Laser transfer printing • Laser micro- and nano-processing • Laser treatment and diagnostic in medicine • Rapid photography • Laser interferometric methods • Optodynamics

**DEPARTMENT HEAD** Assoc. Prof. Rok Petkovšek, PhD

**DEPARTMENT MEMBERS** Assist. Prof. Vid Agrež, PhD, Assist. Prof. Tomaž Požar, PhD, Assist. Darja Horvat, PhD, Assist. Žiga Lokar, PhD, Assist. Jaka Mur, PhD, Assist. Jaka Petelin, PhD, Uroš Orthaber, PhD, Marko Šajn, PhD, Vid Novak, PhD, Assist. Luka Černe, Assist. Jernej Jan Kočica, Assist. Peter Šušnjar, Alenka Rogelj Ritonja

### ORIGINAL SCIENTIFIC ARTICLE

MUR, Jaka, PETKOVŠEK, Rok. Near-THz bursts of pulses: governing surface ablation mechanisms for laser material processing. *Applied Surface Science*, Jun. 2019, vol. 478, p. 355-360.

MUR, Jaka, PETELIN, Jaka, SCHILLE, Jörg, LOESCHNER, Udo, PETKOVŠEK, Rok. Ultra-fast laser-based surface engineering of conductive thin films. *Applied Surface Science*, Apr. 2020, vol. 509, p. 1-7.

POŽAR, Tomaž, HORVAT, Darja, STARMAN, Bojan, HALILOVIČ, Miroslav, PETKOVŠEK, Rok. Pressure wave propagation effects in the eye after photoablation. *Journal of applied physics*, ISSN 0021-8979, May 2019, vol. 125, iss. 20, p. 1-9.





ČERNE, Luka, NOVAK, Jure, AGREŽ, Vid, PETKOVŠEK, Rok. Optimization of a supercontinuum source based on tapered ordinary fibers. *Laser physics*, Jan. 2019, vol. 29, no. 2, p. 1-6.

AGREŽ, Vid, PETKOVŠEK, Rok. Highly adaptable gain-switched fiber laser with improved efficiency. *Optics express*, 2019, vol. 27, no. 9, p. 12100-12109.

LOKAR, Žiga, LIPOVŠEK, Benjamin, RAZZAQ, Arsalan, DEPAUW, Valérie, GORDON, Ivan, POORTMANS, Jef, KRČ, Janez, TOPIČ, Marko, 35737. Coupled modelling approach for optimization of bifacial silicon heterojunction solar cells with multi-scale interface textures. *Optics express*, 30 Sep. 2019, vol. 27, no. 20, p. A1554-A1568.

PETKOVŠEK, Rok, AGREŽ, Vid, PETELIN, Jaka, ČERNE, Luka, BÜNTING, Udo, PODOBNIK, Boštjan. Pulses on demand in fibre and hybrid lasers. *Strojniški vestnik*, Nov./Dec. 2019, vol. 65, no. 11/12, p. 680-689.

### DOCTORAL DISSERTATIONS

LOKAR, Žiga. Optical modelling and optimization of solar cells with nano- and microphotonic structures based on rigorous coupled wave. Mentor: Krč, Janez.

### PROJECTS

ERDF - European regional development fond SPS – Building Blocks, Tools and Systems for Factories of the Future (GOSTOP). Rok Petkovšek. 01.11.2016 – 30.04.2020

LPKF - Mikroobdelovalni laserski procesi. Rok Petkovšek. 1.7.2017 – 30.6.2020

Slovenian Research Agency. Ultrashort pulses on demand. Rok Petkovšek. 1.7.2018 – 30.6.2021

Slovenian Research Agency – Spatial and temporal shaping of laser light for minimally invasive ophthalmic procedures. Tomaž Požar. 1.7.2018 – 30.6.2021

Slovenian Research Agency. High power highly adaptable fiber lasers for the industrial applications. Vid Agrež. 1.5.2017 – 30.4.2020



## UNIT FOR SUPPLEMENTARY DIVISION EDZ

The Faculty of Mechanical Engineering also hosts the Unit for Supplementary Division, which is not part of research groups, but operates independently as an organisational unit. The Unit for Supplementary Division covers the areas of mathematics and sports as the key supplementary factors contributing to the teaching process.



Photo: Matej Pušnik

## Unit for supplementary division **EDZ**

**MEMBERS** Bratuž Jože, Bratuž Žiga

### ACTIVITIES OF COMPLEMENTARY KNOWLEDGE UNIT IN 2019

- Organization of indoor sports activities for students (basketball, volleyball, futsal, fitness, boxing, swimming, dancing...)
- Alpine skiing course for students in Kranjska Gora
- Hiking trips for students
- One day alpine skiing trips for students
- Cooper's physical fitness testing for students
- Physical education chart fitness testing for students
- Participation in various competitions of University of Ljubljana or Slovenian university sports association (basketball league, volleyball league, futsal league, triathlon, fencing, swimming, squash, orienteering, pool, shooting, weightlifting)

### TOP RESULTS IN 2019 COMPETITION

1st place	Orienteering	Peter Tušar
1st place	Weightlifting (under 81kg)	Tim Mušič
1st place	Pool	Aljoša Roškar
2nd place	Badminton	Matic Lindič
2nd place	Orienteering	Simon Stanonik
2nd place	Volleyball	Team
2nd place	Weightlifting (under 109kg)	Janez Kalan
3rd place	Orienteering	Gregor Hvala
3rd place	Orienteering (employees category)	Vid Agrež
3rd place	Rifle	Domen Jarni
3rd place	Pistol	David Rožman



## Mathematics Research Team **RSMAT**

**DEPARTMENT HEAD** Prof. Janez Žerovnik, PhD

**DEPARTMENT MEMBERS** Assist. Prof. Aljoša Peperko, PhD, Assist. Prof. Boštjan Gabrovšek, PhD, Assist. Tina Novak, PhD, Assist. Darja Rupnik Poklukar, PhD, Assist. Helena Zakrajšek, PhD, Marta Ilešič / Teja Pirnat

### ORIGINAL SCIENTIFIC ARTICLE

SHAO, Zehui, LI, Zepeng, PEPERKO, Aljoša, WAN, Jiafu, ŽEROVNIK, Janez. Independent rainbow domination of graphs. *Bulletin of the Malaysian Mathematical Sciences Society*, Mar. 2019, vol. 42, iss. 2, p. 417-435.

SHAO, Zehui, JIANG, Huiqin, WU, Pu, WANG, Shaohui, ŽEROVNIK, Janez, ZHANG, Xiaosong, LIU, Jia-Bao. On 2-rainbow domination of generalized Petersen graphs. *Discrete applied mathematics*, Mar. 2019, vol. 257, p. 370-384.

RUPNIK POKLUKAR, Darja, ŽEROVNIK, Janez. Networks with extremal closeness. *Fundamenta informaticae*, 2019, vol. 167, no. 3, p. 219-234.

HORVAT, Eva, GABROVŠEK, Boštjan. The Alexander polynomial of links in lens spaces. *Journal of knot theory and its ramifications*, ISSN 0218-2165, Jul. 2019, vol. 28, no. 8, p. 1-28.

VIZINGER, Tea, ŽEROVNIK, Janez. A stochastic model for better planning of product flow in retail supply chains. *The Journal of the Operational Research Society*, 2019, vol. 70, iss. 11, p. 1900-1914.

ROSENMANN, Amnon, LEHNER, Franz, PEPERKO, Aljoša. Polynomial convolutions in max-plus algebra. *Linear Algebra and its Applications*, Oct. 2018, vol. 578, p. 370-401.

PEPERKO, Aljoša. Inequalities on the spectral radius, operator norm and numerical radius of the Hadamard weighted geometric mean of positive kernel operators. *Linear and Multilinear Algebra*, 2019, vol. 67, iss. 8, p. 1637-1652.

PEPERKO, Aljoša. Inequalities on the joint and generalized spectral and essential spectral radius of the Hadamard geometric mean of bounded sets of positive kernel operators. *Linear and Multilinear Algebra*, 2019, vol. 67, iss. 11, p. 2159-2172.

YE, Ansheng, MIAO, Fang, SHAO, Zehui, LIU, Jia-Bao, ŽEROVNIK, Janez, REPOLUSK, Polona. More results on the domination number of Cartesian product of two directed cycles. *Mathematics*, 2019, vol. 7, no. 2, p. 1-9.

SHAO, Zehui, LI, Zepeng, ERVEŠ, Rija, ŽEROVNIK, Janez. The 2-rainbow domination numbers of  $C_4 \square C_n$  and  $C_8 \square C_n$ . *National Academy Science Letters*, 2019, vol. 42, iss. 5, p. 411-418.

SUN, Jijiang, LI, Lin, CENCELJ, Matija, GABROVŠEK, Boštjan. Infinitely many sign-changing solutions for Kirchhoff type problems in  $\mathbb{R}^3$ . *Nonlinear Analysis, Theory, Methods and Applications*, Sep. 2019, vol. 186, p. 33-54.

DENG, Fei, JIANG, Huiqin, LIU, Jia-Bao, RUPNIK POKLUKAR, Darja, SHAO, Zehui, WU, Pu, ŽEROVNIK, Janez. The Sanskruti index of trees and unicyclic graphs. *Open chemistry*, Jan. 2019, vol. 17, iss. 1.

PEPERKO, Aljoša. Logarithmic convexity of fixed points of stochastic kernel operators. *Positivity*, Apr. 2019, vol. 23, iss. 2, p. 367-377.

#### **UNIVERSITY, HIGHER EDUCATION OR SHORT-TERM HIGHER EDUCATION TEXTBOOK WITH REVIEW**

NOVAK, Tina, PEPERKO, Aljoša, RUPNIK POKLUKAR, Darja, ZAKRAJŠEK, Helena. *Tehniška matematika 2: naloge in postopki reševanja*. 2. dopolnjena izd. Ljubljana: Fakulteta za strojništvo, 2019.

#### **PROJECTS**

COST CA18232 - Mathematical models for interacting dynamics on networks. Aljoša Peperko. 04.10.2019 - 03.10.2023

# PROMOTION OF MECHANICAL ENGINEERING

Mechanical engineering offers many possibilities for engagement and provides opportunities for designing creative solutions which have a practical value and are interesting for man and the environment in which he lives. Mechanical engineers have the mission to transform ideas into products that co-create the modern reality. The Faculty of Mechanical Engineering of the University of Ljubljana actively follows modern trends, promotes mechanical engineering in all its forms, organises events and conferences, runs workshops and published periodicals. With its active engagement, the Faculty helps to popularise mechanical engineering among the public and spread the awareness of the importance of engineering in everyday life.

## **MECHANICAL ENGINEERING DAYS**

The Mechanical engineering days event takes place every year in September in collaboration with the Technical museum of Slovenia in Bistra near Vrhnika where visitors are offered a glimpse into the appealing world of engineering design which is the result of collaboration between the students and researchers at the Faculty of Mechanical Engineering.



## **MECHANICAL ENGINEERING SUMMER CAMP**

As a part of engineering, mechanical engineering is a creative endeavour and for this reason, we want to excite primary school pupils in grade 8h and 9 and secondary school students from year 1 to 4 about the technical science by organising Mechanical engineering summer camp in August every year. The participants are divided into smaller groups within thematic workshops, such as a mobile robot, 3D printing, water hydraulic press and construction of a remote control airplane where they learn about and make products. Participant take the finished products home at the end of the summer camp.



## **INFORMATIVA**

Informativa is an all-Slovenian educational and career fair which takes place at the Ljubljana Exhibition and Convention Center Gospodarsko razstavišče every year at the end of January. The one-stop shop offers an overview of educational programs available in Slovenia and abroad - from secondary schools to higher education and postgraduate programs, additional education and training, language courses and lifelong learning. Every year the Faculty of Mechanical Engineering participates in Informativa fair as a part of the University of Ljubljana university city.



## **PROMOTION OF MECHANICAL ENGINEERING IN SECONDARY SCHOOLS AND GYMNASIA**

The Faculty of Mechanical Engineering pays special attention to the promotion of mechanical engineering in secondary schools and gymnasias with intent of raising awareness in young people about the importance of the engineering profession. Every year, mechanical engineering is presented to students at more than 20 secondary schools and gymnasias. By joining the Let's Be Engineers! project we further excite young people about engineering, technology and innovation.



## **STUDENT CONFERENCE ON ENGINEERING - ŠTeKam**

The Faculty of Mechanical Engineering offers successful students the first step into the scientific world by presenting their contributions at the ŠTeKam Student conference on Engineering in September each year. At the conference, students from other faculties can also participate, thus widening the horizons and connecting with other research areas. Students can claim their attendance at the conference as an exceptional achievement, which is a prerequisite for obtaining a scholarship. All contributions are published in a comprehensive conference proceedings and are entered into the Cobiss system.





## THEMATIC CONFERENCES

Within the framework of chairs and laboratories, thematic conferences are organized throughout the year, bringing together domestic and foreign researchers. Some conferences are held traditionally every year as a linking element between researchers in the same field.



## ALUMNI CLUB

In 2019, the Faculty Mechanical Engineering's Alumni Club organized lectures in which interesting stories by engineers from business and research were presented. Attending the lectures proved to be a great way to stay in touch with fellow students and an opportunity to gain a thorough insight into the past and future of mechanical engineering. At the same time, the lectures stimulated many professional debates and pointed out the importance of mechanical engineering in Slovenian society, its achievements and the ways and anomalies that hinder the development of mechanical engineering and thus the entire society.



## University of Ljubljana,

Faculty of Mechanical Engineering

Aškerčeva cesta 6, 1000 Ljubljana, Slovenia

Telephone: [+386 1 4771 200](tel:+38614771200)

Fax: [+386 1 2518 567](tel:+38612518567)

E-mail: [dekanat@fs.uni-lj.si](mailto:dekanat@fs.uni-lj.si)

Splet: <http://www.fs.uni-lj.si/>

Issued by: University of Ljubljana, Faculty of Mechanical Engineering

Collected and edited by: Katja Pustovrh

Responsible editor: Prof. Mitjan Kalin, PhD

Design by: Toaster studio d.o.o.

Photography by: Archives of the Faculty of Mechanical Engineering

Printed by: Camera d.o.o.

Circulation: 70

Ljubljana, 2020

ISSN 1580-1411

Not for sale