ANNUAL REPORT 2019

David Paloušek

INSTITUTE OF MACHINE AND INDUSTRIAL DESIGN
Faculty of Mechanical Engineering
Brno University of Technology

Brno, 29.1.2020

INSTITUTE OF **MACHINE**
AND **INDUSTRIAL DESIGN**

CONTENT

- Human resources and funding
- Projects & Contracts
- Scientific articles
- PR & Events
- Year 2020

HUMAN RESOURCES

People 2019 – 17 + 2 scientists

David Paloušek

Josef Nevrlý

Jan Brandejs

Daniel Koutný

Tomáš Koutecký

Aneta Zatočilová

David Škaroupka

Radek Vrána

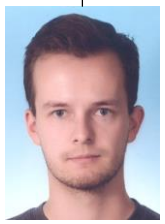
Jakub Hurník

Martin Krčma

Arnošt Vespalec

Jan Suchý

Malý Martin



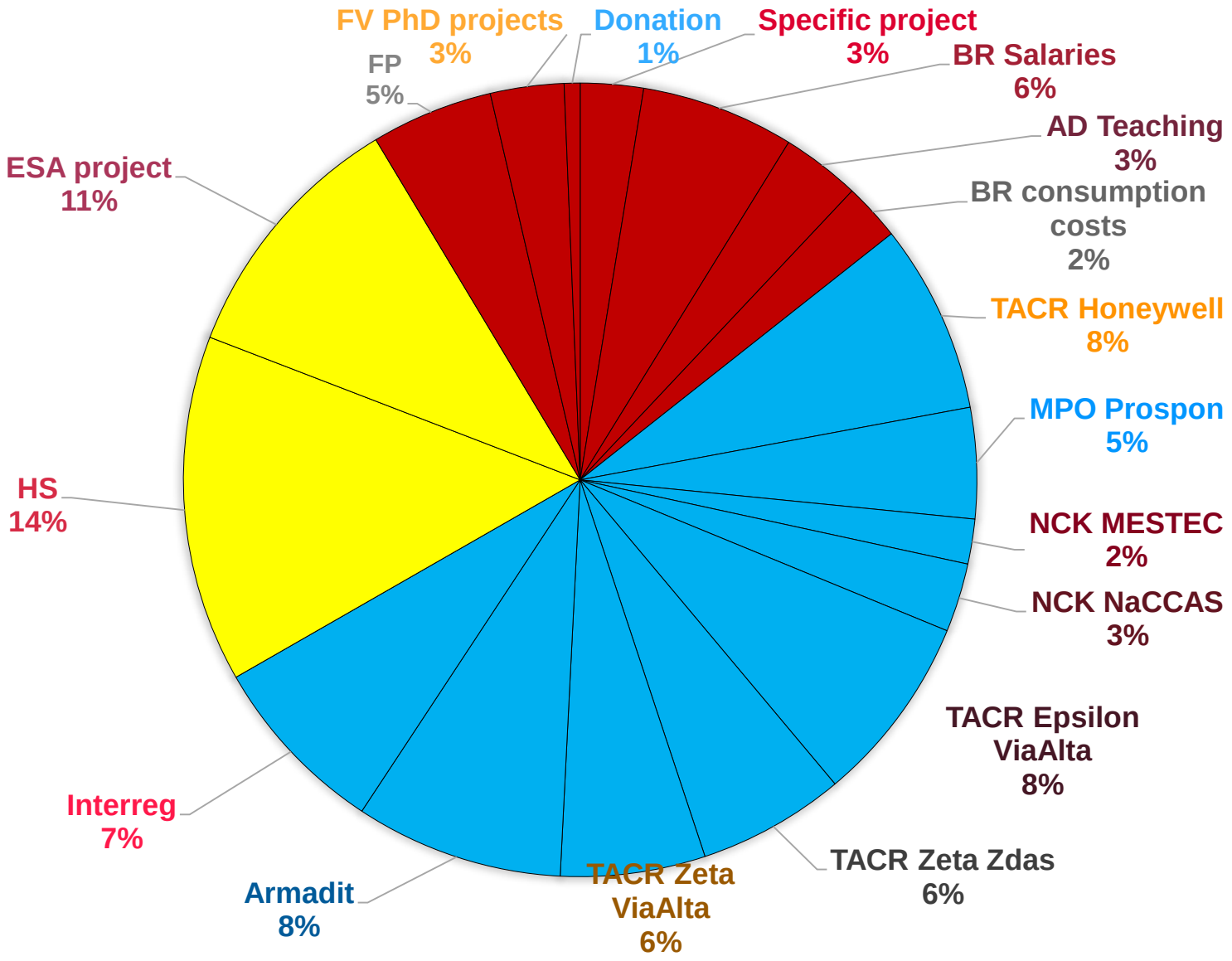
Ondřej Vaverka

Ondřej Červinek

Petr Krejčiřík

Vít Šreibr

FUNDING OF DEPARTMENT



PROJECTS

1. ARMADIT
OP VVV: CZ.02.1.01/0.0/0.0/16_025/0007304
Architectured materials designed for additive manufacturing
2. TACR Epsilon TH03010172
Research and development of 3D printers for use in construction industry
3. TACR Epsilon TH02010514
Development of 3D printing for selected materials and topology optimization of components for aerospace industry
4. TAČR Zeta TJ01000268
Development of optical system for automated measurement of rotary forgings
5. TAČR Zeta TJ01000354
Development of process parameters of additive manufacturing of highly filled waste thermoplastics
6. ESA Contract
Design of Spacecraft Components for Additive Manufacturing
ESA Czech Industry Incentive Scheme AO /1-7397/13/NL/EL
7. MPO TRIO FV20232
Ministry of Industry and Trade
Biodegradable structured implants fabricated by metal 3D printing method
8. NCK MESTEC
National Competence Centre of Mechatronics and Smart Technologies for Mechanical Engineering
9. NCK NaCCAS DOE-SCAM
National Competence Centre for Aeronautics and Space
Design, Optimization and Evaluation of Structural Flight Component Made by Additive Manufacturing
10. FabLabNet
CE283 Interreg: Central European network of innovative and creative labs
Making Central Europe more competitive by unlocking the innovation capacity of Fab Labs within an enhanced innovation ecosystem

EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání

MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY

VIAALTA

Honeywell

ZDAS

GE Aviation

BAUMÜLLER

ProSpon

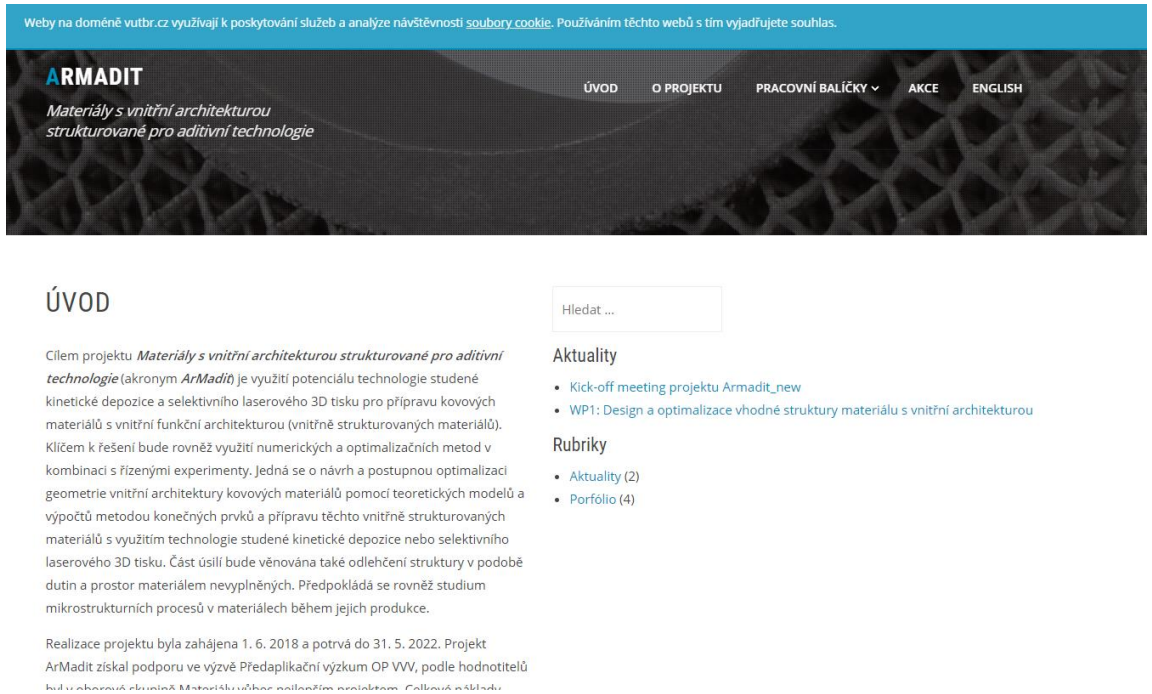
Aero | VODOCHODY

ARMADIT

Architectured materials designed for additive manufacturing

The aim of the proposed project is to utilize the potential of cold kinetic spray deposition technology and selective laser 3D printing for the preparation of metallic materials with internal functional architecture (internally structured materials).

- Institutes: ÚMVI, ÚK, ÚMTMB
- Partner: Institute of Physics of Materials of the Czech Academy of Sciences
- 1. 6. 2018 – 31. 5. 2022 (48 m.)
- Budget BUT Brno: 48 265 069,- Kč
- Cofinancing: 5 %



Objectives:

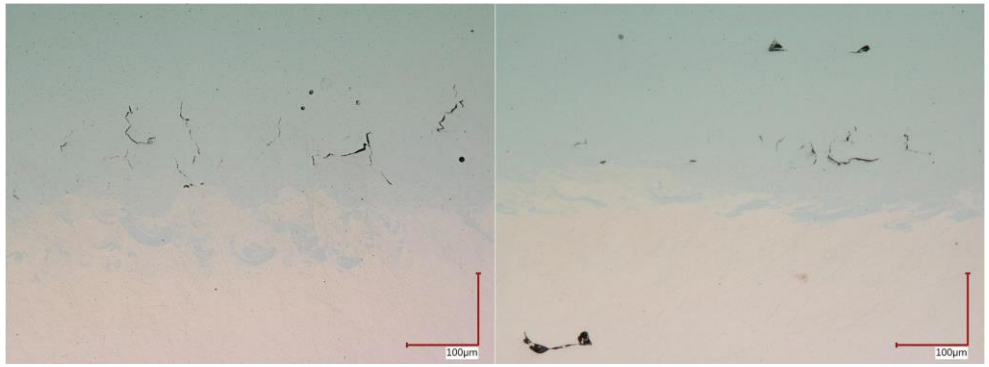
- Microstructure design based on topological optimization.
- Preparation / modification of powder properties.
- Preparation of multi-material structures.
- The characterization of prepared materials.

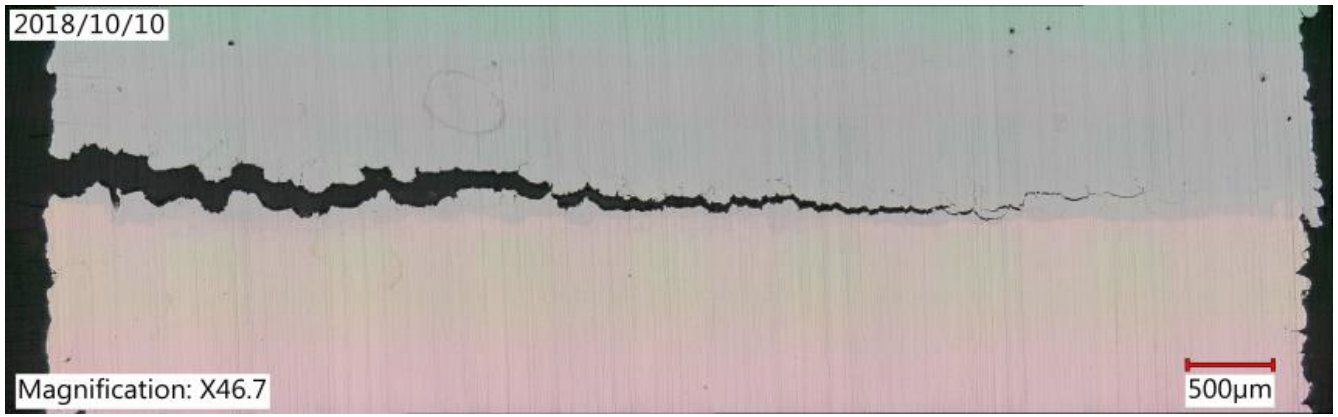
ARMADIT

Architectured materials designed for additive manufacturing

Multimaterial Additive Manufacturing

- Horizontal interface
- Vertical interface
- Cu7.2Ni1.8Si1Cr + Maraging Steel (1.2709)
- Cu7.2Ni1.8Si1Cr + Stainless Steel (316L, 1.4404)
- Stainless Steel 316L + 17-4PH



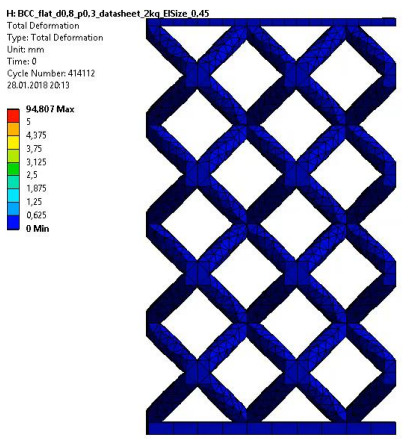


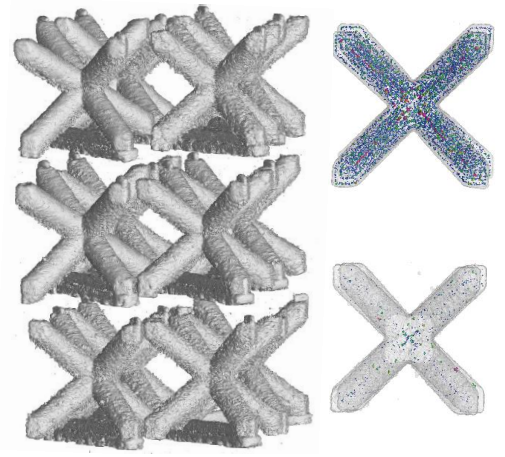
ARMADIT

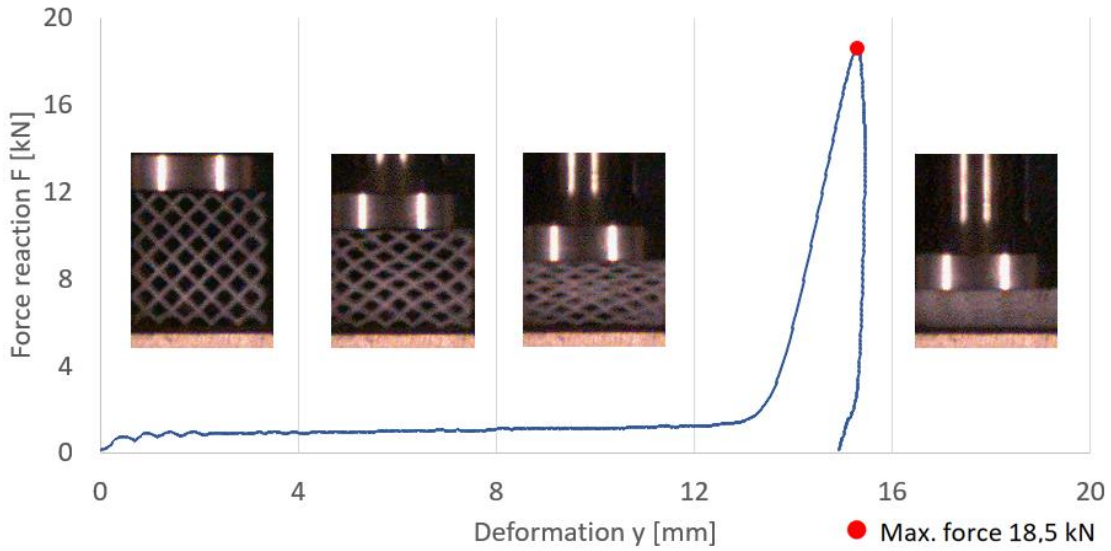
Architectured materials designed for additive manufacturing

Microstructure design

- Optimization of the laser strategy for lattice structure fabrication
- Dependences of the Internal porosity and Surface roughenss vs. SLM process parameters
- Numerical simulation of the energy absorption
- Utilization of numerical and optimization methods
- Computational model of quasi-static lattice compression







TACR Epsilon - Honeywell

Development of 3D printing for selected materials and topology optimization of components for aerospace industry

- Solenoid housing
- Powder reusability F357 (AlSi7Mg0.6)
- Heat treatment F357 (AlSi7Mg0.6)
- Prototype optimization

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TACR EPSILON – ViaAlta + FSI VUT + FS CVUT

Research and development of 3D printers for use in construction industry

- Mechanical design of 3D printer
- 3D printing testing
- Drive and controls
- Manufacturing of the printer

TACR ZETA - Žďas

Development of optical system for automated measurement of rotary forgings

Aim: prototype optical system (G)

Measured parameters :

- Length, diameter, cylindricity/roundness.
- Axis shape.
- Size and position of max. deflection.

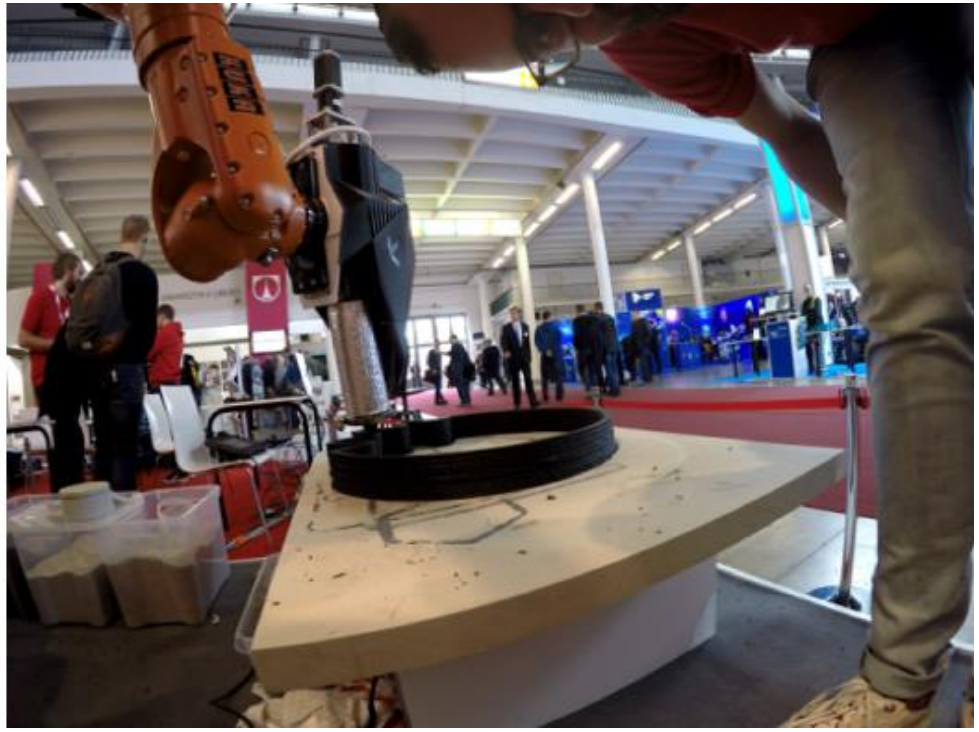
Conditions:

- Temperatures 800 – 1250 ºC
- Forging is held by a manipulator.
- Required accuracy in the order of millimetres.

TACR ZETA - Via Alta + FSI VUT

Development of process parameters of additive manufacturing of highly filled waste thermoplastics

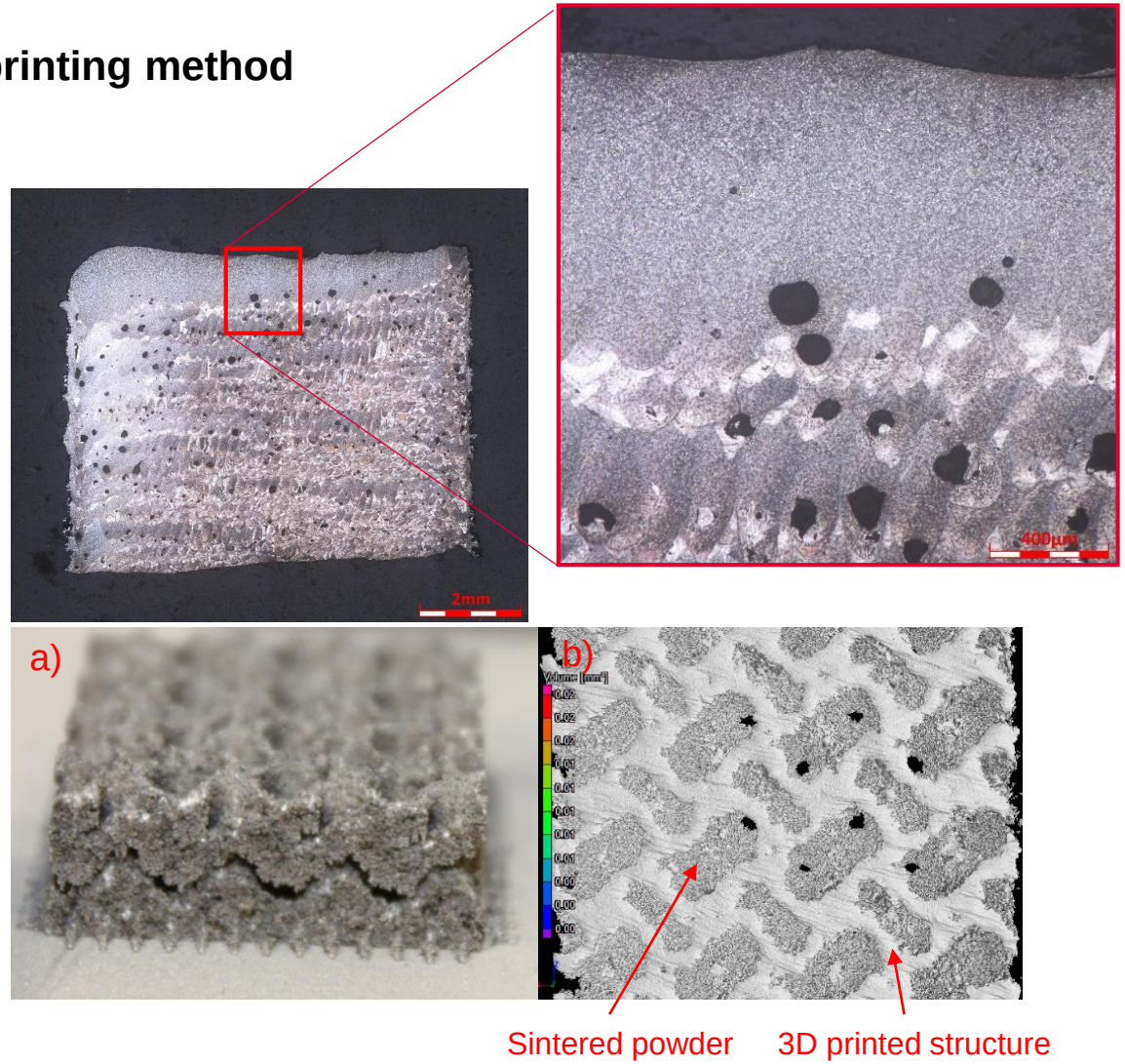
- Mechanical design of 3D printer head.
- 3D printing testing.
- Material testing.
- Manufacturing of testing parts.



MPO TRIO - Prospon + VSCHT + CEITEC + FME

Biodegradable structured implants fabricated by metal 3D printing method

- Stable Mg-alloy manufacturing.
- Layer delay setting.
- Energy density decrease.
- Machine upgrade.
- Minimal porosity 0,47%.



NCK NaCCAS DOE-SCAM – Aero Vodochody

National Competence Centre for Aeronautics and Space

- Design, Optimization and Evaluation of Structural Flight Component Made by Additive Manufacturing
- Aero Vodochody Aerospace, Czech Aerospace Research Center, ČVUT

Air Bracket

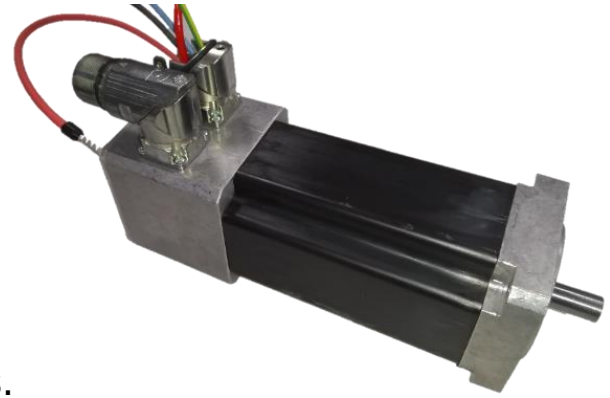
- AM Material qualification.
- Topological optimization of Bracket.
- Fabrication and evaluation of Bracket prototype.

NCK MESTEC – Baumüller

National Competence Centre of Mechatronics and Smart Technologies for Mechanical Engineering

2.1. Structured components for electromagnetic applications

- Synchronous motor with magnets on the surface.
- Cooperation BUT, UFM, Baumuller.



2.5. Implants and materials for bio applications

- Pin-on-plate tribological tests were performed on Ti and CoCr alloys.
- Cooperation of ICT, ProSpon, BUT.

CONTRACTUAL RESEARCH

ESA ADAAC – GE Aviation Czech

Additive Design for Aerospace Applications Capabilities (ADAAC)
AO/1-9018/17/NL/GLC/hh

Objectives:

- Identify aerospace components suitable for AM
- Develop aerospace additive components design procedures
- Verify and validate developed additive design procedures
- Create the AM competency in the Czech Republic

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PBS VB

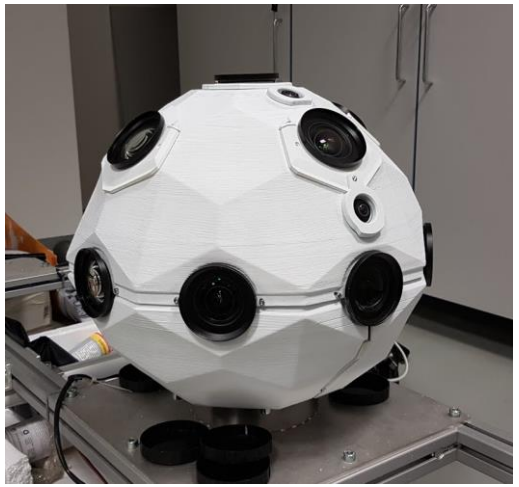
Development and fabrication of stator wheel by selective laser melting

- Machining allowances.
- Additive preprocessing.
- SLM fabrication.
- Dimensional inpection.

CONTRACTUAL RESEARCH

Sunflower Trimmer
Design and development of automatic harvestors

TopGis (ICT Systems)
Robotic Fabrication and development of streetview scanning HEAD



FME RESEARCH FUND

FV 19-14 – ZAT - SIMULATION OF ADDITIVE MANUFACTURING

Ondřej Vaverka

Aim of the project

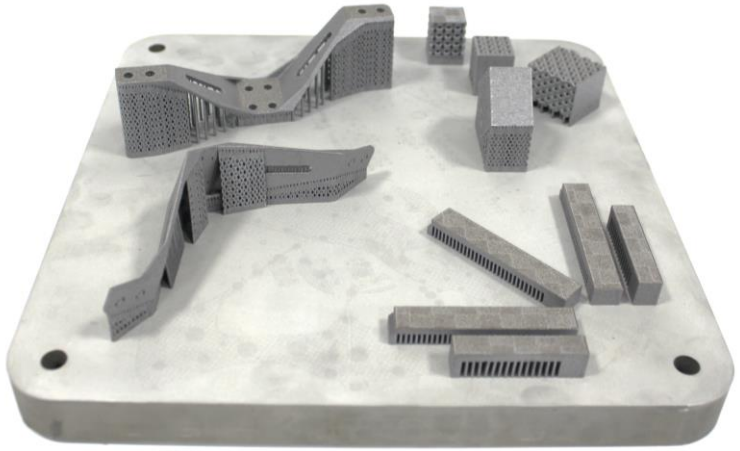
- Create one seminar for students, that will introduce them advantages of simulation of additive manufacturing process

Results

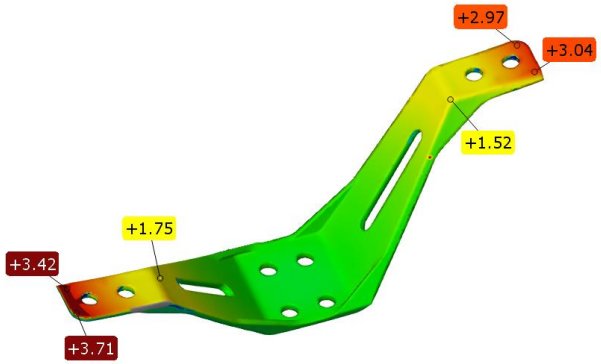
Preparation of real data for exercise:

- material model
- simulations in software and their comparison
- manufacturing and digitalization of real part
- comparison of data

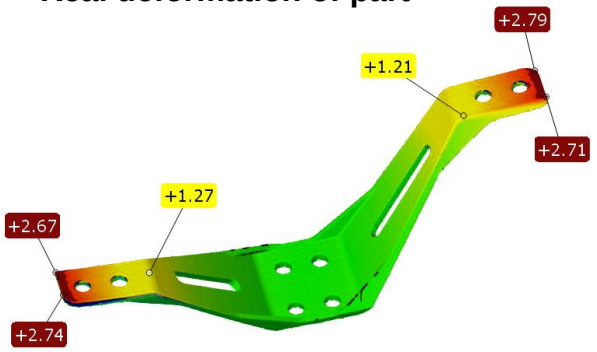
Budget: 80 000 CZK



Simulated deformation of part



Real deformation of part



INSTITUTE OF MACHINE AND INDUSTRIAL DESIGN

FV 19-03 INNOVATION OF YPR – RAPID PROTOTYPING AND 3D DIGITALIZATION BY INTRODUCING GENERATIVE DESIGN TOOLS

Martin Krčma

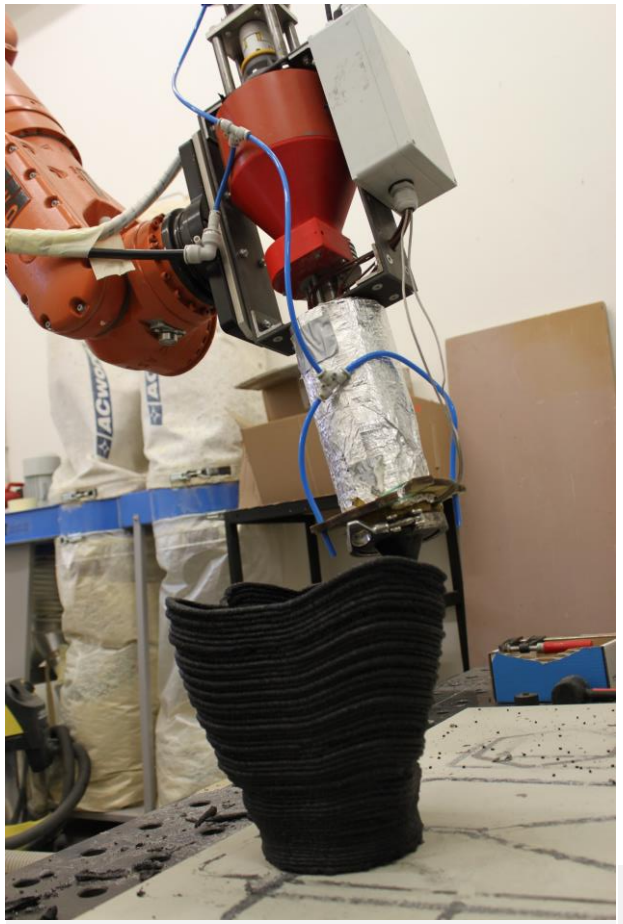
Aim of the project

- Prepare materials for YPR – Rapid prototyping and 3D digitalization.
- The materials will familiarize students with advanced generative design tools.

Results

- A tutorial on how to setup 5-axial 3D print of a vase model on a robotic arm was produced.

Budget: 80 000,- Kč



Print using trajectories generated by presented algorithm

Small arm purchased for demonstration

FV 19-36 - INNOVATION OF PLASTIC PROTOTYPES [ZPP]

Arnošt Vespalec

Aim of the project

Laboratory task with the aim of practically acquainting students with the continuity of production processes.

Laboratory task

Based on the found material characteristics to design a binding hook suitable for additive production in the form of 3D printing (FDM, SLA) and vacuum casting of plastics.

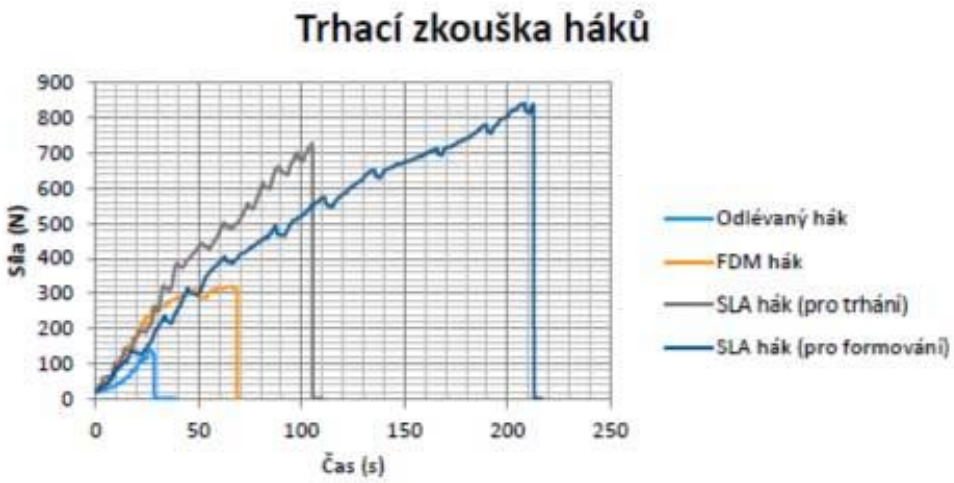
The task was limited by the following criteria:

- maximum dimensions and shape in the form of an outer envelope,
- minimum load capacity Fn = 500N at minimum weight of the sling hook**.**

Project output

Realization of production processes and subsequent practical verification of expected results of the manufactured hooks

Grant finances: 80 000,- CZK



FV19–28 INNOVATION OF ADDITIVE TECHNOLOGIES (ZAT)

Jan Suchý

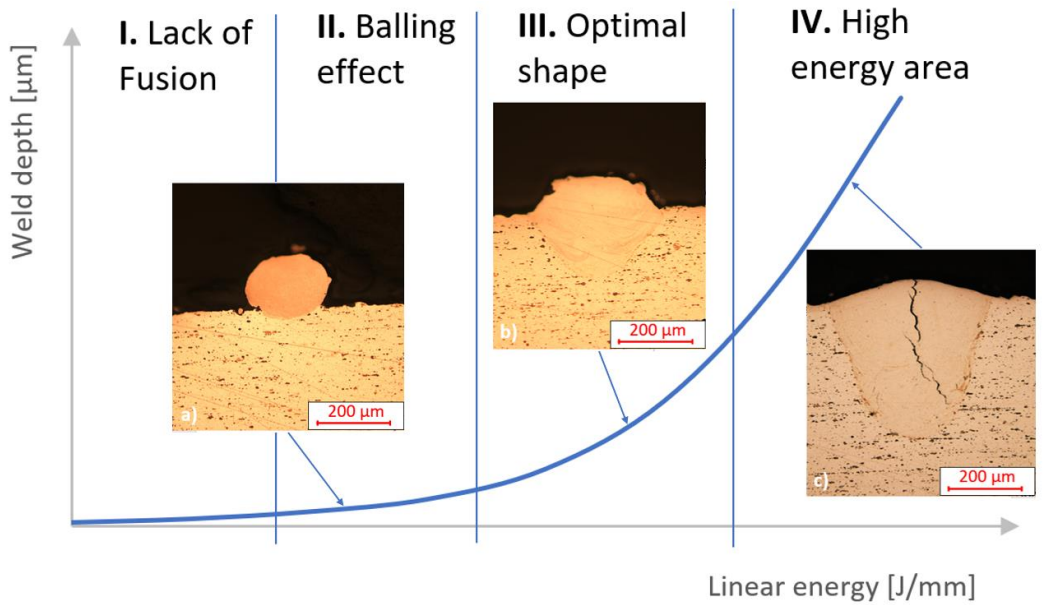
Aim of the project

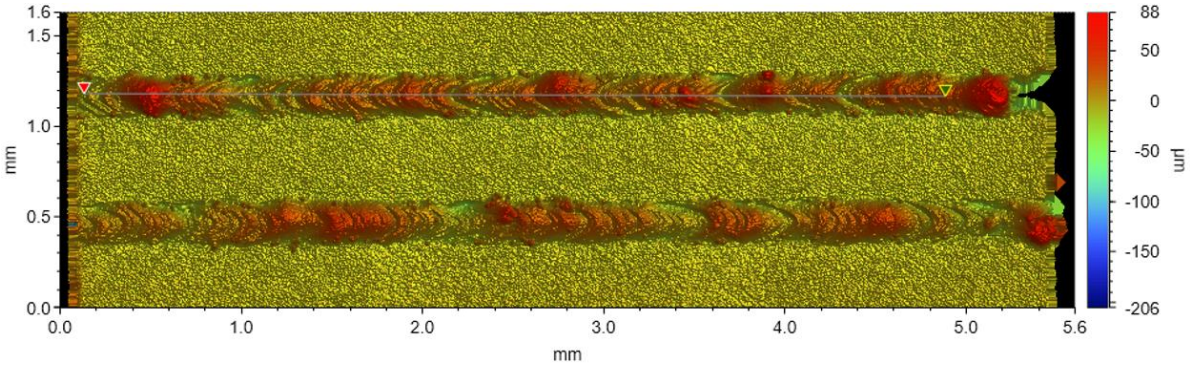
- Identification the stable and unstable manufacturing process.
- Introduce methods to stabilize the process.

Results

- Creation of the methodological instructions and protocols to supporting teaching.
- Preparation of samples series for the practical exercise.

Budget: 80 000,- Kč





FV 2019 - INNOVATION OF ADDITIVE TECHNOLOGIES (ZAT)

Martin Malý

Aim of the project

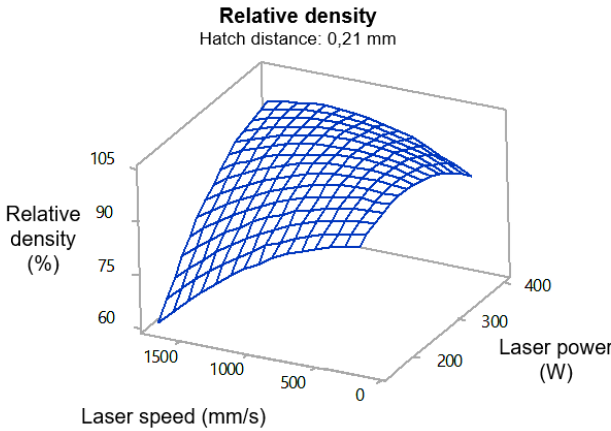
- Demonstration of methods for Design of experiment (DoE) for decrease of samples in SLM technology

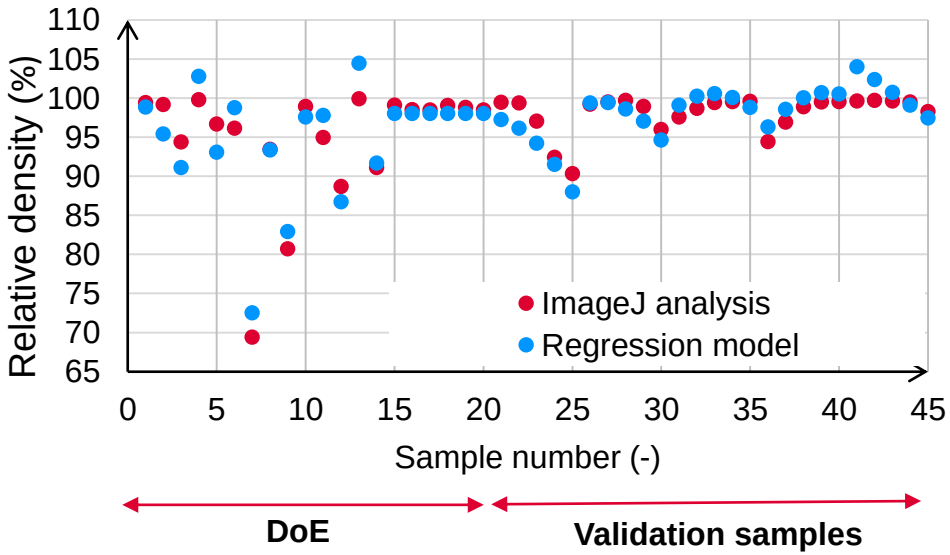
Material and methods

- 45 samples AlSi10Mg (0-20 DoE, 21-45 validation)
- Method: Surface response design
- Variables: power and speed of laser, hatch distance
- Observed values: relative density and hardness

Results

- DoE could be used to decrease the number of samples in SLM process
- Validated regression model for predict relative density and hardness of AlSi10Mg processed by SLM





FV 2019 - ZRI-A INNOVATIONS

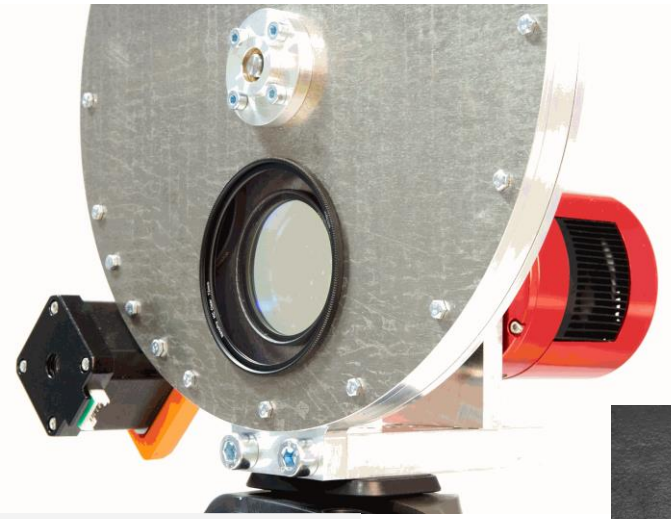
Jakub Hurník

Aim of the project

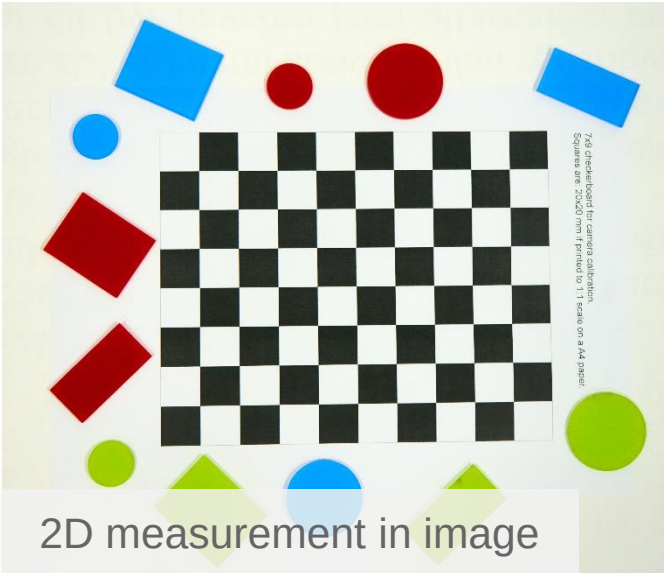
- Deeper explanation of optical instrument principles
- Practical examples on image analysis
- Guidelines and materials for lessons - 3 × 2h

IMPLEMENTATION

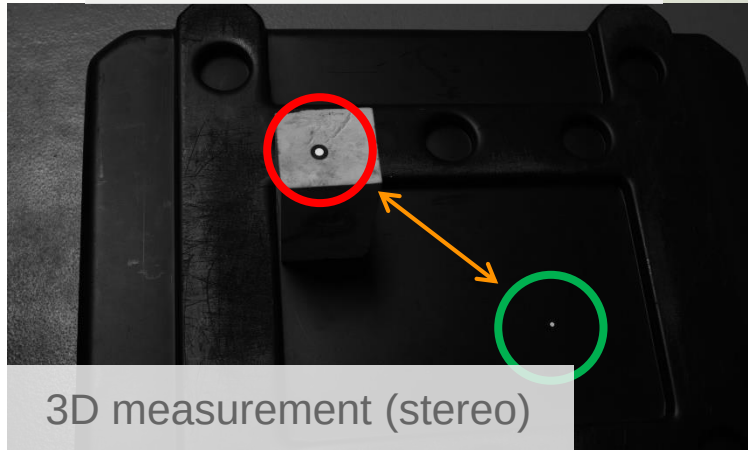
- 2 examples (related to photogrammetry)
  - 2D measurements in image (mono)
  - 3D measurement (stereo camera)
- Outputs: guidelines, materials
- **Implemented in 2019/2020**
- Preparation for future innovations:
  - Colour filter wheel (bachelor thesis)



Colour filter wheel



2D measurement in image



3D measurement (stereo)

FV 2019 - INNOVATION OF STEEL CONSTRUCTIONS AND FEM

Ondřej Červinek

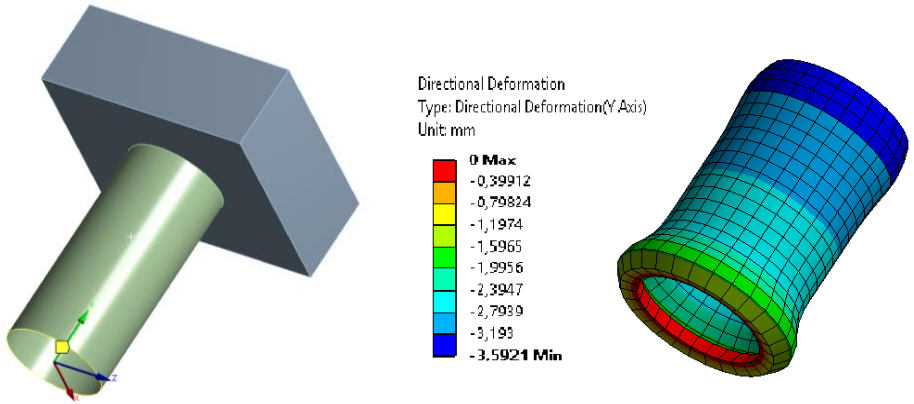
Aim of the project

- Extend the teaching subject with lecture and exercise.
- Simplified explanation of the FE explicit solver principles.
- Show the module usage possibilities.
- Give examples in several different tasks.

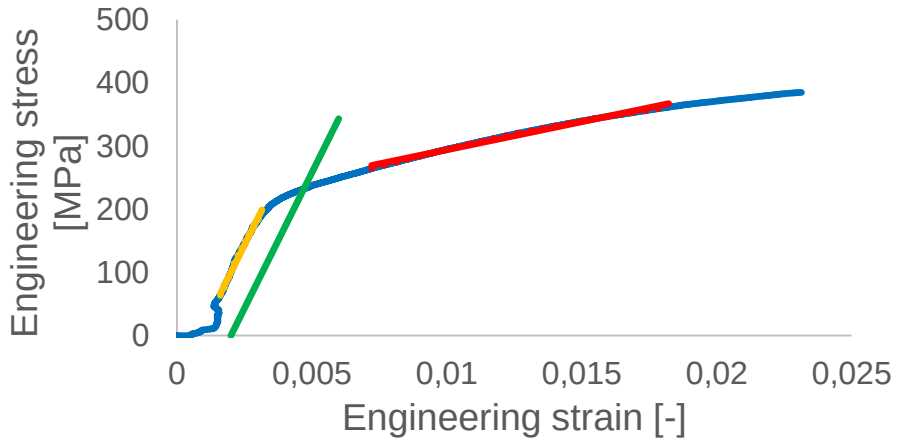
Results

- Evaluation of model of material input parameters.
- Creating of model of geometry with shell elements.
- Setting of BC, analysis data and output parameters.
- Comparing the results.

Budget: 80 000 CZK



Model of geometry of aluminium pipe with punch (left), colour map of deformation of aluminium pipe after impact of punch (right)



Evaluation of material parameters for elastic-plastic model of material

PUBLICATION 2019

Q1

1. Tomáš Zikmund, Jakub Šalplachta, Aneta Zatočilová, Adam Břínek, Libor Pantělejev, Roman Štěpánek, Daniel Koutný, David Paloušek, Jozef Kaiser, Computed tomography based procedure for reproducible porosity measurement of additive manufactured samples, NDT & E International, Vol. 103, 2019, p. 111-118, ISSN 0963-8695.
2. STRECKER, Zbyněk, Michal KUBÍK, Petr VÍTEK, Jakub ROUPEC, David PALOUŠEK a Vít ŠREIBR. Structured magnetic circuit for magnetorheological damper made by selective laser melting technology. Smart Materials and Structures [online]. 2019, 28(5)
3. ZIKMUND, Tomáš, Jakub ŠALPLACHTA, Aneta ZATOČILOVÁ, et al. Computed tomography based procedure for reproducible porosity measurement of additive manufactured samples. NDT & E International [online]. 2019, 103, 111-118

Q2

1. HRUBOŠ, David, Tomáš KOUTECKÝ a David PALOUŠEK. An experimental study for determination of an application method and TiO2 powder to ensure the thinnest matte coating layer for 3D optical scanning. Measurement [online]. 2019, 136(March 2019), 42-49 [cit. 2019-10-25]. DOI: 10.1016/j.measurement.2018.12.058. ISSN 02632241. Dostupné z: https://linkinghub.elsevier.com/retrieve/pii/S026322411831203X
2. VAVERKA, Ondřej, Daniel KOUTNY a David PALOUSEK. Topologically optimized axle carrier for Formula Student produced by selective laser melting. Rapid Prototyping Journal [online]. 2019, 25(9), 1545-1551
3. MALÝ, Martin, Christian HÖLLER, Mateusz SKALON, Benjamin MEIER, Daniel KOUTNÝ, Rudolf PICHLER, Christof SOMMITSCH a David PALOUŠEK. Effect of Process Parameters and High-Temperature Preheating on Residual Stress and Relative Density of Ti6Al4V Processed by Selective Laser Melting. Materials [online]. 2019, 12(6)
4. PALOUSEK, David, Martin KOCICA, Libor PANTELEJEV, Lenka KLAKURKOVA, Ladislav CELKO, Daniel KOUTNY a Jozef KAISER. SLM process parameters development of Cu-alloy Cu7.2Ni1.8Si1Cr. Rapid Prototyping Journal [online]. 2019, 25(2), 266-276
5. HRUBOŠ, David, Tomáš KOUTECKÝ a David PALOUŠEK. An experimental study for determination of an application method and TiO2 powder to ensure the thinnest matte coating layer for 3D optical scanning. Measurement [online]. 2019, 136, 42-49

Q3

1. VRÁBEL, J., P. POŘÍZKA, J. KLUS, D. PROCHAZKA, J. NOVOTNÝ, D. KOUTNÝ, D. PALOUŠEK a J. KAISER. Classification of materials for selective laser melting by laser-induced breakdown spectroscopy. Chemical Papers [online]. 2019, 73(12), 2897-2905

2020

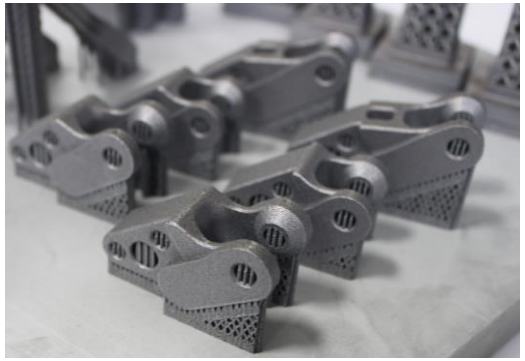
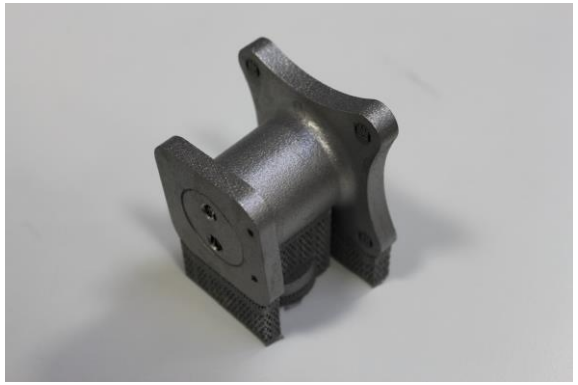
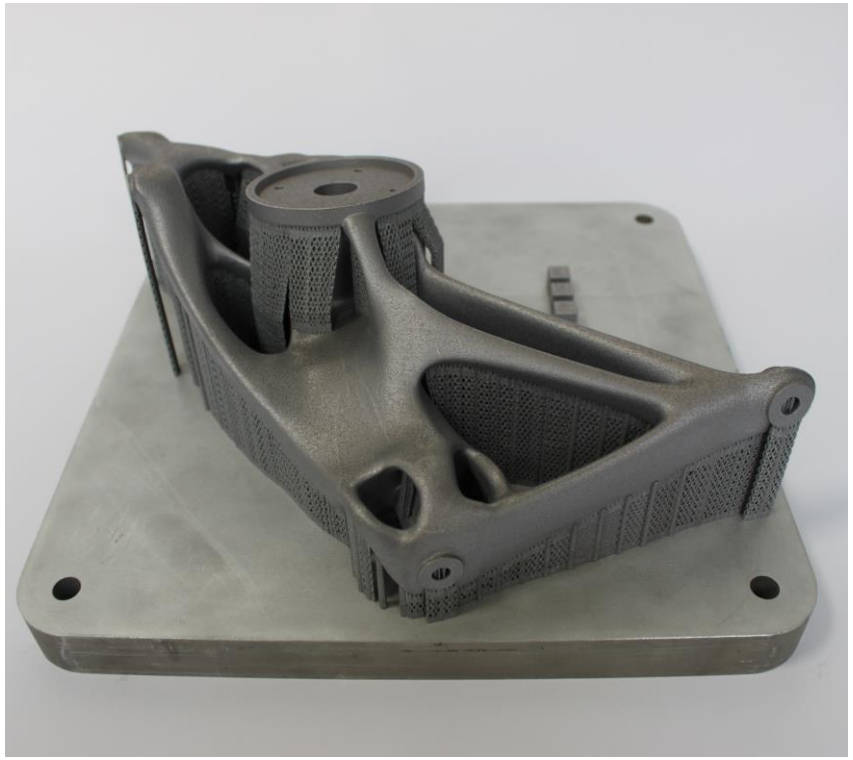
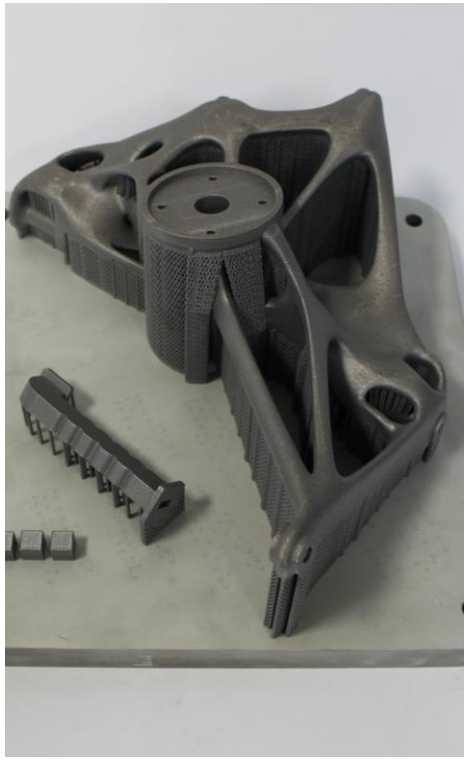
PR 2019

PR activities

- Participation in Scientists' Night.
- Trento (Italy) BIGfest 2019 presentation about strojLAB.
- 120 years of BUT anniversary celebration, scanning of Mayor of Brno, Rector of BUT
- Scanning of materialists conference guests (at the request of the FSI Secretary)
- Open day strojLAB, introduction of new printer DeltiQ XL Custom for 120 000,- CZK, which we obtained from a donation from ŠKODA AUTO a.s.
- MSV 2019, exhibition on fair, live entry to CT24 broadcast https://www.ceskatelevize.cz/…/10101491767-…/219411058331007
- 3DExpo Bratislava – Martin Krčma presentation of robotic additive fabrication
- http://firmy.mmspektrum.com/clanek/ultra-lehke-komponenty-vyrabene-3d-tiskem.html
- Industry 4.0 Konference (http://i40konference.ceitec.cz/program/)

SPONSORING

- Formula student
- Pneumobil


Thanks for your attention

palousek@fme.vutbr.cz

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