Univerza v Mariboru

FRAMEWORK PROGRAMME OF EARLY STAGE RESEARCHER TRAINING[1]

1. BASIC DATA

Mentor's name and surname	**Nenad Gubeljak**	Mentor's register number at ARIS (SICRIS)**:**	**10470**
Mentor's e-mail:	nenad.gubeljak@um.si	Mentor's tel. no.:	02 220 7661
Research programme (RP) leader's name and surname:	Nenad Gubeljak	RP leader's register number at ARIS (SICRIS):	10470
Title of research programme:	Numerical and Experimental Analysis of Mechanical Systems	RP's Register number at ARIS (SICRIS):	P2-0137
Research organisation (RO) of University of Maribor, where training shall be conducted:	UM FME	RO Register number at ARIS (SICRIS):	0795
Research field according to ARIS classification:	2.05.02	Research field according to Ortelius classification (EURAXESS)	15.18

2. DEFINITION OF RESEARCH PROBLEM AND GOALS OF DOCTORAL RESEARCH[2]

Starting point of research task of the early stage researcher and its position in the research programme, where the mentor is included, work hypothesis, research goals and foreseen result with emphasis on an original contribution to science:

Within the framework of the program group P2-0137 »Numerical and experimental analysis of nonlinear mechanical systems«, we are engaged in researching the mechanical response of metallic materials to static and dynamic loads in the area of the limit loading state. In the past, models were made for both homogeneous low-strength and high-strength materials to assess the strength behavior and determine the permanent dynamic strength, which

[1] *Term early stage researcher (ESR) is written in male form and used as neutral for women and men.*

[2] *Research and study programme of training have to harmonise with contents of the research programme, where the mentor is a member.*

successfully predict the service life and dynamic load capacity of the components. Already the first researches of materials that are manufactured with additive technologies show that this model cannot be uniquely transferred to components that are manufactured with additive technologies. Although the application of additive technologies for the production of structural components from metallic materials has been expanding rapidly in the last few years, together with the testing of mechanical and fracture-mechanical properties, there is still no universal approach that would allow the determination of the fracture strength of components from these materials. The main reason lies in the fact that manufacturing technologies are constantly being improved in terms of application precision, technological conditions and thermal treatment. All this also affects the results of mechanical and fracture mechanics tests. Which makes testing more and more complex. Namely, when characterizing the fatigue behavior, it is necessary to take into account the distribution and direction of the residual stresses during the application of the layer itself. The thickness and quality of the application depends not only on the technological parameters of production and the orientation of laying the layers, but also on the type of machine and the quality of the input materials. The classical approach based on solid mechanics is therefore difficult to apply directly. The engineering approach is generally simplified and is based on the basic mechanical properties of the material, such as modulus of elasticity, poisson and tensile strength, but it cannot be used in additive technologies, because the structure of the construction of layers and materials has a significantly greater influence on the mechanical behavior than in the case of metallic materials. which are made using classic technologies. Research so far shows that the location of the collapse is influenced by the geometry of the sample and the method of loading (tension, torsion, bending). As part of the proposed doctoral program, the young researcher will carry out extensive non-destructive residual stress measurements as well as surface condition measurements and porosity measurements in the manufactured state and in the state after heat treatment. We will integrate material properties and states into numerical simulations to calibrate and define material parameters for numerical simulations. After determining the mechanical properties, we will carry out extensive fracture-mechanical static testing of materials produced with additive technologies, based on which we will assess the dynamic strength and suitability for various structural components that are exposed to various modes of loading.

The hypothesis we want to confirm is that, due to the specificity of the production of components with additional technologies, it is necessary to modify the models for determining the dynamic strength of structural components, in such a way that the presence of defects is taken into account and their impact is assessed at different levels and methods of dynamic loading. In this case, it is not possible to apply the strength equations for homogeneous materials, but rather it is necessary to determine the influence of the voids, pores in the strength connections in the material due to the defects present.

Research will take place in the field of experimental testing of materials and load-bearing components, and in the field of numerical modeling with peridynamic tools, which, unlike the differential (classical) approach, is based on an integration approach.

In the first year, in addition to performing regular study obligations, the young researcher will get to know measuring equipment and the technique of

experimental work, as well as the technique of making samples with additional technologies.
In the second year of the project at UM, we plan to make samples for AM from metallic materials and characterize the material's microstructural parameters and mechanical properties as key parameters for numerical simulations. We also plan to determine the change of these parameters according to the manufacturing technology parameter. We would produce a set of tensile test specimens with different manufacturing parameters, a set of bending lomnomechanical test specimens, which in the support part are structurally adapted to AM production in order to obtain the smallest possible deformation during production, and in the third part, we would produce structural components loaded with bending, which would verify the numerical results.
In the third year, we plan to produce structural components with additive technologies and to statically test them on a uniaxial and biaxial test bed, thereby simulating the fracture behavior of structural components with a crack in the most critical part.
In the fourth year, the results would be analyzed and contributions would be prepared, which would be presented at conferences and published in international journals, and he would conclude my studies with the defense of my doctorate.
The main objectives of the proposed research are to determine:
- criteria for determining mechanical properties and fracture toughness;
- strategies for determining mechanical resistance depending on different manufacturing conditions;
- methods for quantitative characterization of microstructure and defects;
- criteria for the construction of a damage-resistant component.

3. STUDY PROGRAMME

Foreseen study programme, to which early stage researcher shall be enrolled in academic year 2024/2025:

Study programme doctoral school of the Faculty of Mechanical Engineering Maribor.

4. DESCRIPTION OF WORK AND TASKS

Implementing projects of scientific research.
Taking part in the design of research programmes.
Cooperating with research sponsors.
Drawing up research and other reports.
Monitoring and coordinating research work according to the grant agreement.
Ensuring safety and health at work.
Organising and instructing employees and students on using personal safety equipment and other safety measures.
Performing other tasks at the behest of the superiors.
Participating in ad-hoc and permanent committees of university or faculty bodies.

Acting on behalf of colleagues and superiors during their absence (upon authorisation).
Participating in annual and other inventories.
Performing other related tasks delegated by superiors.

5. REQUESTED LEVEL OF EDUCATION

VII/2. tariff group

6. REQUESTED FIELD OF EDUCATION

Technical, Natural sciences

7. KLASIUS SRV

Seventh level: Second cycle of higher and similar education/Second cycle of higher and similar education

8. KLASIUS P

145 – Education of teachers of individual subjects
4 - Natural science, mathematics and computing
5 - Engineering, manufacturing and construction

9. REQUESTED KNOWLEDGE

Computer skills: MS Windows, Word, Excel, Internet, e-mail, e-commerce

10. REQUESTED SPECIAL REQUIREMENTS

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11. REQUESTED LANGUAGES

Active knowledge of one world language

12. REQUESTED WORK EXPERIENCE

/

13. FORESEEN POSTDOCTORAL TRAINING

Kliknite ali tapnite tukaj, če želite vnesti besedilo.

Mentor's signature:

Nenad Gubeljak
Digitalno podpisal Nenad Gubeljak
Datum: 2024.02.23 15:14:44 +01'00'

Research programme leader's signature:

Nenad Gubeljak
Digitalno podpisal Nenad Gubeljak
Datum: 2024.02.23 15:15:02 +01'00'

Name and surname of Dean or authorised person[3]:
red. prof. dr. Matej Vesenjak

Signature of dean or authorised person:

Digitally signed by Matej Vesenjak
Date: 2024.02.23 17:07:43 +01'00'

Place and date:

Maribor, 23. 02. 2024

Stamp:

[3] The training program is signed by the dean of the member where the ESR's employment and training will take place.