

Faculty of Mechanical Engineering  
Brno University of Technology

## Review of Doctoral Thesis

<b>1. PhD candidate</b>
Ing. Radek Vrána / vrana@fme.vutbr.cz
<b>2. Name of PhD programme</b>
Name
<b>3. Title of PhD thesis</b>
Study of Energy Absorption in Micro-Strut Lattice Structure Produced by Selective Laser Melting

<b>4. Principal supervisor</b>
doc. Ing. David Paloušek, Ph.D. / David.Palousek@vut.cz
<b>5. Co-supervisor</b>
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<b>6. Reviewer</b>
Dr Eng. Mateusz Skalon / mateusz.skalon@tugraz.at
Graz University of Technology

<b>7. Overview of the scope of PhD thesis<sup>1</sup></b>
<b>Excellent</b>
The scope of the thesis is focused on delivering the accurate description of energy absorption behaviour of lattice structures manufactured from AlSi10Mg by Selective Laser Melting technique. The scope is very broad however, it circles in an organised manner around one and well defined topic. Both the experimental approach and the research plan are of high quality and leave no space for uncertainties. The influence of the main SLM parameters on the printed single-melt-track properties are investigated. In the next step the influence of both the process parameters and contour strategy on the structure and quality of the struts are investigated. Basing on the received data the numerical model of the lattice deformation is developed. The model is then confronted with a real-life data retrieved from the self-designed test stand. As a result, the Thesis delivers a description of manufacturing process of lattice structures produced from AlSi10Mg along with its behaviour during local impact.

<b>8. Significance of the topic and clarity of problem statement</b>
<b>Very good</b>
The presented topic is well described and the problem properly motivated. Since the lattice structures may be produced only via SLM process the presented topic is of high importance to all further understanding of

<sup>1</sup> Overview of the scope of PhD thesis is a short description of objectives of PhD thesis's research and summary of main findings and scientific achievements.



its failure mechanism, prediction of its behaviour and finally to industrial application. The presented topic is of a great importance due to rapidly growing amount of SLM systems being in use. The problem of the Thesis was stated in a clear manner. The aim of the Thesis was presented thoroughly by listing 7 main tasks. The tasks were designed in order to answer the stated Hypotheses and Scientific Questions. Finally, the Hypotheses are well defined and presented in clear and concise way.

#### **9. Knowledge of existing literature**

##### **Excellent**

The references are properly used, well-structured and properly described. Cited documents refer to relevant and up-to-date documents supporting intentions of the candidate. They are used in a proper and not excessive number. More than 80% of used references cite manuscripts not older than 2012. What is natural some of the references are used both in the Thesis and in the appended manuscripts. As a part of good practices, as a source of knowledge beside the scientific manuscripts also the previous works of the candidate are mentioned and consist coherent background for the thesis. It is worth highlighting that the candidate used diversified sources i.e.: patents, websites and conference papers. The knowledge of the candidate concerning the existing literature is at a very high level.

#### **10. Choice of methods and technical soundness**

##### **Excellent**

The candidate proved to be able to select the experimental methodology in a way to leave no space for uncertainty in respect to obtained results. He is aware of the drawbacks emerging from using each of testing methods therefore the best possible means were harnessed in order to prevent drawbacks or at least to minimise them e.g. Few methods of roughness check and cross-validating of the impactor move or Paper B where the mass check of the lattice was used as a base for checking the printed shape correctness. All values selected for performing experiments and tests are based on thorough preparation and are well justified. Additionally, the Candidate proved to be able to design and build both the testing hardware and software extending his research capabilities. Both the parameters selection algorithm and the constructing the Impact Test Stand coupled with measurement system merits recognition. The FEM simulation were prepared carefully in agreement with the best scientific practice. The Candidate has proved to be fluent in methods' selection and modification and making correct interpretation of results.

#### **11. Quality, originality and significance of the results**

##### **Excellent**

The delivered results are of high quality due to the joint effect of the detailed preparation of each experiment and a high number of tested repetitions. Comprehensive research approach where a broad experimental part is supported with a Finite Element Analysis and a proper explanation of each observed phenomenon further supports the results' quality. Algorithm allowing for design the lattice structures of desired properties is a significant an important step towards an applicative outcome. Static behaviour of the SLM printed lattice structures is already well known. This work however, complements current state-of-art with a detailed explanation of lattices' behaviour and failure mechanism under low-speed impact. The results consist an original piece of work.

#### **12. Quality of attached papers**

##### **Very good**



There are two peer-reviewed papers appended to the Thesis. Both were published in Open Access journal Materials (MDPI) specializing in area of „Materials Science and Multidisciplinary “. The journal is ranked as 111/285 according to JCR and has an assigned Impact Factor of 2.467 (2018) what positions it as a publishing platform for high-impact and high-quality research. Both papers were published in second half of 2018 and already have been cited already three times in total. Both have thoroughly described methodology so the experiments can be easily repeated. Presented results consist pieces of the Thesis. Performed experiments are well designed and conclusions are clear and properly concluded. The first one: „Selective Laser Melting Laser Strategy for Fabrication of Thin Struts Usable in Lattice Structures“ presents the background for the initial part of the Thesis. The second one: „Dynamic Loading of Lattice Structure Made by Selective Laser Melting - Numerical Model with Substitution of Geometrical Imperfections“ supports the second part of the Thesis. The papers are of high quality and present the sound results along with a thorough interpretation.

**13. Overall assessment, strengths and weaknesses (based upon the above evaluation categories 8–12)**

**Excellent**

Clearly, the preparation of the Thesis consumed a lot of time and effort. The Thesis coupled with appended papers reflects the high volume of know-how created along the work. The Thesis is prepared with a great care and with attention on details. There are only few typos in the whole document what reflects that great care about details. The major advantages were: a) versatile approach in order to answer stated questions, b) use of self-designed test stand and algorithm, c) multiple check of each result or obtained data. Another feature deserving recognition is a proper use and interpretation of each method. The candidate proves to understand the technical limits of research tools. The only drawback is that Thesis treats the material as homogeneous entity where pores are the main reason of change in mechanical response of the materials. Therefore, there is a lack of metallographic investigation describing the changes (or lack of changes) in the material microstructure. This, on the other hand, was managed by checking directly the mechanical properties of struts which is also acceptable.

**14. Other comments**

**15. Conclusion**

PhD thesis is an independent scientific work that presents a novel solution to a significant problem in the research area and demonstrates the candidate's ability to conduct independent research.

**YES**

**16. Date and signature**

14/03/2019

*Mateusz Skalm*

Please note



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- A. *Evaluate categories 7 to 13 using the following scale: unacceptable, acceptable, satisfactory, good, very good, excellent. The qualification of 'excellent' should only be given for a PhD Thesis in the top 3% of the research in your field of expertise.*
- B. *E-mail the completed form to: [Klara.Javorceková@vut.cz](mailto:Klara.Javorceková@vut.cz)*