

Review of Doctoral Thesis

1. PhD candidate
Ing. Jan Suchý / Jan.Suchy1@vut.cz
2. Name of PhD programme
Design and Process Engineering (Mechanical Engineering Design)
3. Title of PhD thesis
Processing of magnesium alloys by selective laser melting method
4. Principal supervisor
doc. Ing. David Paloušek, Ph.D. / david.palousek@one3d.cz
5. Co-supervisor
doc. Ing. Libor Pantělejev, Ph.D. / pantelejev@fme.vutbr.cz
6. Reviewer
Dr.techn. Fernando Gustavo Warchomicka/ fernando.warchomicka@tugraz.at
Graz University of Technology
7. Overview of the scope of PhD thesis¹
Very good
The candidate focuses the goals of the thesis on two main scientific questions, after a detailed analysis of the literature and the formulation of the hypotheses. During the research activities, he is finding the best parameters for printing, reducing defects, improving surface quality, and trying to control the vaporization and oxidation of Mg during the processing. These findings help to characterize also the material by metallography and mechanical properties. In section 7, the candidate describes precisely the finding for process parameters, the preparation of the machine for safety use, and different microstructural features. In the case of mechanical testing, the obtained results are not bringing any new findings.
8. Significance of the topic and clarity of problem statement
Excellent
The investigated topic is very challenging since the processing of magnesium alloys at elevated temperatures can provoke burning or flame ignition. The use of rare-earth to retard this effect does not reduce completely this problem. For that, the investigation of proper parameters in an almost inert atmosphere seeks to build high-performance components. In this context, the thesis aims to determine the optimal parameters and reduce the typical defects observed during additive processing. The candidate

¹ 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.

identifies the problems described in the literature (section 3.3) and uses them as starting point to improve the technique.

9. Knowledge of existing literature

Very good

The candidate prepared a very good summary of the existing literature related to the additive manufacturing of magnesium alloys (section 2.2) and the consequence of oxidation on the processing of magnesium (section 2.3). It is a very challenging topic of investigation since there is a lack of information in the literature, having two main consequences: a good preparation of scientific questions to be answered during the study, the possibility to determine the main problems of processing, and the difficulty to find comparable results to validate/confirm the obtained one. Although the corrosion behaviour of the material is not the main topic of investigation, the state of the art (section 2.4) in this field is limited only to some examples in additive manufactured material. It could have helped with a summary of cast conditions of the same material in different environments.

10. Choice of methods and technical soundness

Good

The experimental method selected for this thesis was correct, but there were some techniques not enough exploited and insufficient details in the description of the methodology. Some methods are poor described or unclear, which makes the reproduction of the method difficult for obtaining similar results. The first part to identify the best parameters and improvement of the atmosphere circuit is good explained, and it influences the quality of the results. The microstructural analysis would be right, but the results shown focused mainly on the defects, without a good analysis of the microstructural features and their relationship with the mechanical properties. The selection of the compression test is not well justified, and the results for extruded material are missing in the section of results. Furthermore, there is some inconsistency in the curves shown for the compression test without any explanation.

11. Quality, originality and significance of the results

Very good

Although WE43 is one of the most studied magnesium alloys in the field of additive manufacturing, the thesis attempts to be original by determining open scientific questions from the literature. The preparation of state-of-the-art, the formulation of the hypotheses and the questions led to obtaining research with good quality due to the originality of the investigation. In this case, the thesis presents new insights into the field of manufacturing. The analysis of different parameters affecting the surface quality and the defects (pores, cracks, delamination, lack of fusion, etc.) brings new information to optimize the process for future components and improve the quality of the surface. The modifications carried out in the atmosphere circuit will have a positive impact on further studies, giving an overview of possible problems to be found during the printing of the material (mainly oxygen contamination). In general, the quality of the work is good, with highlights in the technological aspects but with a barely metallographic and mechanical characterization of the material. The candidate did not exploit the possibility to understand the microstructure -mechanical properties relationship and compare in a better way with different processes (casting, extrusion, forming)

12. Quality of attached papers

Very good

The current version of the thesis does not have the original articles annexed. The candidate mentions the articles in the different sections and invites the readers to read the works to understand better the description of his thesis. From this Thesis, at least six articles were submitted and accepted, finding the latest publication online available in March 2022. From these six articles, three bring substantial information and new insights in the studied field. During the review process, I did not have access to article D. Article A focuses on the influence of the process parameter on the weld tracks, with a very good characterization of the surface quality and defects found after the weld track. Article B summarizes, technologically, the relationship between some process parameters, defects formation and mechanical properties, without scientific details. Article C is previous to A and with a different process's technique (it uses a pre-heated plate) shows only a microstructure characterization and the influence of Oxygen on the defects. Article E is well prepared, focusing on the corrosion resistance of a material with low porosity. Interpretation and discussion of the results are clear and bring an interesting conclusion of the post-surface treatment surface of the material to reduce the degradation rate.

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

Very good

In general, the overall performance shown in the thesis is very good. He clearly prepared the problem statement and the scientific questions to determine the major findings through the chosen methodology. The strengths of this work are the conceptual formulation mentioned before and the analysis and interpretation of the results obtained to optimize the process, comparing and correlating with existing literature. The weakest of this work are the presentation of the results in section 6 for the results and the superficial characterization of the as built material by metallography and mechanical testing.

14. Questions and comments

Comments: 1) Some typo mistakes and text formatting were found during the reading. 2) The structure of the result (Section 6) is complicated to follow. I am finding that each sub-section has a mix of results, like process parameters, microstructure characterization, different compression tests, and some bending tests, among other experimental techniques. I would recommend in the future to separate processing optimization (including roughness, porosity, and microstructure of build material) from the property's characterization (corrosion, mechanical testing and metallographic characterization of the best parameter set). 3) One suggestion to be considered in the future is the author's contribution (Autorovo přispění) to the accepted publications, given in Section 4.3. The candidate does not describe his activities in each article and he uses the results in his Thesis, especially those where he meant his contribution was only 20% (printing samples?). Questions: a) Metallography: What is the main goal of only one EBSD measurement in the work? b) Mechanical testing: Are you using average curves? How is the reproducibility of the results? Why tensile and/or Impact test were not included? c) Immersion Test: Why the corrosion rate was not estimated by weight loss? d) Immersion Test: Why the immersion test was not with constant pH?

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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	
21/06/2022	

Please note

- 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.Javorcekova@vut.cz