OPPONENT'S REVIEW OF A DOCTORAL DISSERTATION

Opponent:	doc. Ing. Marek PAGÁČ, Ph.D.
Thesis Topic:	Advanced Technology of 3D Printing of Metal Parts and Their Machining
Author of Thesis:	Ing. Martin Malý
Supervisor:	doc. Ing. Jan Zouhar, Ph.D.

This review was prepared based on a request for an opponent's assessment of the doctoral dissertation of Ing. Martin Malý, dated 14 November 2025. In accordance with the guidelines for preparing the review, I comment on the following aspects:

- Evaluation of the significance of the dissertation for the field;
- Assessment of the approach to the addressed problem, the methods used, and the fulfilment of the defined objectives;
- Evaluation of the results of the dissertation and the originality of the author's contribution;
- Assessment of the structure, clarity, formal layout, and language quality of the dissertation;
- Evaluation of the doctoral candidate's publication activity;
- Recommendation or non-recommendation of the dissertation for defence pursuant to Act No. 111/1998 Coll., Section 47.

Relevance of the Chosen Dissertation Topic

The topic of the submitted doctoral dissertation is highly relevant, and its professional focus corresponds well with the studied doctoral programme. The scientific and research-oriented nature of the work provides both theoretical conclusions for the field and findings applicable in practice. The topic is very appropriately aligned with current trends in nanomaterials research, particularly in the area of additive manufacturing technologies.

The focus on material extrusion (MEX) of metal parts made of H13 tool steel represents an area that is:

- still relatively underexplored compared to PBF technologies,
- industrially attractive in terms of cost, safety, and accessibility,
- highly relevant for tooling applications and the production of functional components.

Definition and Fulfilment of the Dissertation Objectives

The objectives of the dissertation were formulated clearly, comprehensibly, and in direct connection with the conducted literature review and the identified research gap in the field of additive manufacturing of metal parts using material extrusion.

The main objective was to comprehensively assess the influence of printing parameters, subsequent heat treatment, HIP, and machining on the microstructure, porosity, mechanical properties, and machinability of H13 tool steel. These objectives were fulfilled through systematically designed experiments and their thorough analysis.
Based on the results obtained, it can be stated that the defined objectives were fully achieved, and the dissertation provides original and practically applicable findings.

Achieved Results and Evaluation of the Dissertation in Terms of Contribution to New Knowledge

The dissertation presents a comprehensive set of experimental results documenting the effects of material extrusion technology, subsequent heat treatment, HIP, and machining on the properties of H13 tool steel. It was demonstrated that the combination of HIP and heat treatment significantly reduces porosity and leads to a substantial improvement in mechanical properties, thereby bringing the properties of additively manufactured parts closer to those of conventionally produced material.
A significant contribution of the dissertation is also the detailed analysis of the machinability of MEX parts and the influence of print orientation on cutting forces, tool wear, and surface quality. From both scientific and application-oriented perspectives, the dissertation can be evaluated as highly beneficial, as it expands existing knowledge in the field of additive manufacturing of tool steels and provides valuable data applicable in industrial practice.

Methods Used in the Dissertation

The dissertation was prepared using standard as well as advanced experimental and analytical methods corresponding to the current state of the art in metal additive manufacturing. The author combined methods of materials engineering, mechanical testing, metallographic and microstructural analyses with experiments focused on machining and machinability evaluation.
The chosen methodological approach is systematic, clear, and enables reliable interpretation of the achieved results as well as their comparison with findings published in scientific literature. I agree with the selected methods and the overall approach used to solve the research problem addressed in the dissertation.

Formal Layout and Language Quality

From a formal perspective, the dissertation is of an appropriate standard, free of significant errors or typographical mistakes, and all borrowed material is properly cited. The formal layout is of a very good quality and meets the standards of a technical doctoral dissertation.
The language (English) is clear and professional; in some places it is slightly descriptive or stylistically repetitive, which, however, does not diminish the scientific value of the work.

Significance for Practice and for the Development of the Scientific Field

The dissertation makes a significant contribution both to industrial practice and to the further development of the scientific field of metal additive manufacturing. It provides comprehensive and

experimentally verified knowledge regarding the use of material extrusion technology to produce parts made from H13 tool steel, including the effects of subsequent heat treatment, HIP, and machining on their properties.

From a practical standpoint, the dissertation offers a basis for designing technological procedures and for decision-making regarding the suitability of this technology for tooling applications. From a scientific perspective, it expands existing knowledge of the relationships between process parameters, microstructure, mechanical properties, and machinability of MEX parts, thereby contributing to the further development of the field of additive manufacturing of metallic materials.

Publication Activity

I positively evaluate the quality publication activity of the doctoral candidate. At the time of preparing this review, I identified four publications indexed in the Scopus database in Q1 and Q3 journals. The candidate has an H-index of 2, with 21 citations, 17 of which are without self-citations. Similar results are recorded in the Web of Science database. I also positively evaluate the inclusion of information on outputs, conferences, and symposia.

Comments on the Dissertation

I have no comments.

Questions for the Defence

1. What are the main technological limitations of the material extrusion method in the production of H13 tool steel, and how can these limitations be further minimized in terms of porosity and structural homogeneity?
2. What is the mechanism behind the improvement of mechanical properties after the combination of HIP and heat treatment, and to what extent does the modified MEX material approach the properties of conventionally manufactured H13 steel?
3. What effect does print orientation have on the machinability of MEX parts, and how would these findings influence the design of geometry and technological procedures for real industrial applications?
4. What are your future prospects after the successful defence of your doctoral dissertation?

Conclusion

The objectives set out in the submitted dissertation were successfully achieved. The results obtained may contribute both to the further development of the scientific discipline and to practical applications. The submitted doctoral dissertation is of an appropriate formal and professional standard, and its results are correct and applicable.

Through the submitted dissertation, Ing. Martin Malý has demonstrated his ability to conduct creative scientific research, to apply scientific and experimental methods, and to possess solid theoretical knowledge for further research and development activities in the given field.

Based on the submitted materials, the dissertation, and the above-mentioned facts, I therefore

R E C O M M E N D

the doctoral dissertation for defence and, upon its successful completion, the award of the academic degree Ph.D.

Ostrava, 19 Janury 2026.

Ing. Marek Pagáč

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doc. Ing. Marek Pagáč, Ph.D.
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Opponent of the Doctoral Dissertation