

Review of the Doctoral Thesis

Title of the doctoral thesis:

Fiber reinforced polymer composites: preparation, mechanical properties and thermal analysis

Author:

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I would like to emphasize, at the beginning of this review, that the evaluated doctoral thesis, given by Konstantinos KARVANIS, M. Sc. and submitted within the framework of his graduation of the doctoral study program "Process Engineering (P3909)", has been processed in the field of study "Tools and Processes (3909V013)", at the Faculty of Technology, Tomas Bata University in Zlín.

In this dissertation, the fiber reinforced polymer composites (*with carbon, aramid, carbon/aramid hybrid, glass or basalt fibers as reinforcement phase*) were prepared through various fabrication/technological methods. Their various mechanical properties (*tensile and flexural strength*) were investigated - whereas the special attention was given in the thermal analysis of the these prospective materials, through Dynamic Mechanical Analysis, Thermomechanical Analysis and Thermogravimetric Analysis experiments, as well as Differential Scanning Calorimetry.

I also consider it important to mention the fact that, from a methodological point of view, this is an issue which, on the one hand, is closely related to the research program of the training workplace and at the same time is based on the professional profile of the supervisor.

In terms of "content and form", I evaluate the work as very well elaborated and conceptually balanced, clear and consistent, both in terms of overall arrangement, systematic division, and the chosen structure and logical connections. The work is based on the instrumental, laboratory and personnel background available to the relevant faculty workplace.

In the first part of the experimental section, the GFRP and CFRP composites verified their high quality, as these achieved significant high glassy temperature. In other words, the GFRP composites exhibited temperature T_g depending on the type of fabric/orientation of fibers and as well as on the method followed for the T_g determination. In the second part of the dissertation, the basalt fibers showed excellent thermal resistance, as they were not thermally affected up to the final 900 °C of the TGA experiments, pointing out their highly usefulness in applications where thermal resistance is essential. In the third experimental part, the CFRP, AFRP and ACFRP composites were fabricated, following the VIP process - and, remarkably, both carbon and aramid fiber fabrics demonstrated the same wave, weight and thickness, so the composite properties were compared with accuracy. For these reasons, the chosen topic of the dissertation can be considered very current, which again significantly increases the potential of the results of the results.

In my opinion, there is also necessary to appreciate a thorough search of the current state of knowledge in the field, evidenced with the list of 63 cited works from the literature, which is suitably followed by the author's publishing activity - evidenced with 7 published outputs, as well as 3 projects (internal grants), directly related to the subject area and demonstrating both the application potential of the solved problem and the scientific erudition of the doctoral student.

Furthermore, on the basis of a comparison of the *assignment (or "objectives")* set by the author, i.e. individual partial tasks of the dissertation, as exhaustively listed in the specification on pages 21-22, with the conclusions of the dissertation (especially the "final summary", on pages 111-113), I can say that the author fully met the requirements. In summary, therefore, I can state at this point that: the evaluated doctoral dissertation is beneficial in its research topics as well as with the contribution of new knowledge.

On the occasion of the public debate (*during the scholarly discussion*), I would like to bring the author to think about the questions and suggestions that I have compiled in the following list:

- 1) You present, in the chapter 4.5.5 ("*Mechanical properties of the CFRP and ACFRP composites*"), very interesting results from "3-point bending test". I would like to ask you, according which standard did realized the testing? How were the tested samples broken? Can you explain this or add some figures?
- 2) Why did you use only two samples for TGA measurements, illustrating the weight of the AFRP composites as a function of the temperature, in the air and N₂ atmosphere? Can you support these results with another (literature) research papers?
- 3) What about a content of voids in the composites samples and how these voids generally influence the presented DMA results?
- 4) Can you formulate the advantages and disadvantages of VIP production technology and compare with another manufacturing technology using some level of automatization, respectively?

Final summary:

On the basis of the partial statements set out in this critical review, I can conclude that:

- ◆ the submitted dissertation has the required professional level and brings original knowledge, leading not only to the development of the field, but also to a number of practical applications;
- ◆ with his own solution the author proved his competence for independent scientific work;
- ◆ it is more than obvious that the submitted dissertation meets the conditions in the sense of §47 of the Act on Higher Education Institutions, No. 111/1998 Coll.

Therefore, I can suggest the reviewed work for the public defense in a disputation, with the proviso that in case of its successful result, I am pleased to recommend awarding the "*scientific degree Ph.D.*" to Mr. Konstantinos Karvanis, M. Sc.



In Prague, August 12, 2021

prof. Dr. Ing. Libor Beneš, IWE