

Review of the Doctoral Thesis

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

by Konstantinos Karvanis

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The work directs attention towards a highly actual topic of fiber-reinforced polymer composites finding applications in several industrial areas. It is expected that their importance will even increase, particularly when some hindering issues, e.g. utilization of a low-cost reinforcement phase with excellent compatibility with a polymeric matrix reaching in total the required properties, etc. are improved. In this view, the presented Doctoral Thesis focuses on: (i) Study on dynamic mechanical analysis of glass or carbon fiber/epoxy composites, (ii) Study on preparation, thermal analysis and mechanical properties of basalt fiber/epoxy composites, and (iii) Preparation, thermal analysis and various mechanical properties of post-cured carbon, aramid or carbon/aramid hybrid fiber epoxy matrix composites. The Author's results presented in the enclosed papers (in all of these publications is Mr. Karvanis the first author), which have been already published in scientific journal after passing demanding review process, prove that the progress in the mentioned points has been realized.

The Doctoral Thesis is written as a monograph and consists of about 135 pages, referring to 64 sources mainly from the last decade. The Doctoral Thesis consists of following chapters: *Czech and English summaries; Acknowledgement; Introduction to theoretical background; Experimental part* divided into above mentioned three points; *Conclusions of the dissertation; Relating the scientific results with practical applications; References; List of Figures, Tables and Symbols and Acronyms; List of Author's publications and Professional Curriculum vitae* of the Author. What could be confusing is stressing some sub-chapters (e.g. *1.5 Literature review* or *3.6.1 Analytical theoretical model for the prediction of the BFRP composites tensile strength*), which are out of context of the Doctoral Thesis, while, on the other hand, some sub-

chapters, such as principles of thermomechanical analysis or description of production method for polymer matrix composites using an autoclave, could be added into relevant parts.

This Doctoral Thesis extends the long-term research devoted to composite materials of the group of the supervisor (S. Rusnakova), the appropriate discussion of the results obtained so far would be of a great interest to a reader. Instead only a descriptive text of obtained results is presented without getting these into relevant consequences between the materials composition and structure, and mechanical and thermal properties. It also seems that the author ran out of breath from chapter 4.5.2 *Tg of the CFRP and ACFRP composites*, where even the descriptive character is missing and only non-committal figures are given.

The thesis is written in appropriate English, however with a number of misprints or incorrectness; there are also points demanding formal revision, e.g. symbols should be in italic; missing references to some figures (although these are parts of Author's publications); better designation to the main experimental point mentioned above in sub-sections titles instead of e.g. *1.6.1 First experimental part*; to improve the visual presentation of prepared fiber-reinforced polymer composites; to present decimal point accordingly instead of using "comma" in graphs taken directly from the software with Czech setting (preparing a new graph from raw data or digitalization the data could help); to remove some useless figures (2.1, 2.3, 2.4, 3,5, 4.4, 4.8, 4.13, 4.20, 4.46, 4.48, "Appendices" and some others); missing scale bars in visual pictures; etc. On the other hand, there come also positive things to the reader when reading the Doctoral Thesis, e.g. the Author has extensive experience with the preparation of fiber-reinforced polymer composites by the lay-up compression molding method, where the obtained experimental results are even better in comparison with the standard preparation of the same composite by the autoclave method.

During the Doctoral Thesis defence, Mr. Konstantinos Karvanis could reflect following points:

1. Considering that the fiber-reinforced polymer composites are used in aircraft industry, why did the Author perform the measurements in temperature range of 30–180 °C and at 1, 5 or 10 Hz?
2. What is the most sensitive technique from thermal analyses to evaluate glass transition temperature and why? How did the Author evaluate the glass transition temperature from the peak of the loss modulus and $\tan\delta$ curves? The glass transition temperature is

presented at two decimal points in the Doctoral Thesis and simple lowering the line from the peak to the temperature axis is not correct in this case.

3. Did the Author measure linear viscoelastic region (LVR) in sub-chapter 2.4 *Experimental details* and did LVR change with different orientation of fibres or frequency applied?
4. Could the Author comment on a peak value before dropping the storage modulus in Fig. 2.7, Fig. 2.8 and Fig. 4.15 for Gf-UD-L-39%, CF-W-0°-38% and “10 Hz” samples, respectively?
5. Why was the cyclic long-term loading occurring in practical application in aircraft industry not applied to the samples? The structural evaluation after such a test or after exposition to elevated temperature in DMA could bring interesting results.
6. Why did the displacement amplitude for “3N 25 °C” in Fig. 3.12 and “1N 50 °C” in Fig. 3.13, i.e. the middle conditions applied, reach the highest displacement amplitude at high temperatures compared with other conditions applied?
7. Could the Author comment on two maxima observed in TGA curve in air atmosphere in Fig. 3.19?
8. Why did the glass transition temperature decrease too much for “1 Hz” and “5 Hz” and not as significantly for “10 Hz” compared to the original epoxy matrix (93 °C) for AFRP composites as highlighted in Tab 4.5?
9. Did the Author dry the aramid fibres before their use?
10. Why did the Author evaluate peaks! using a function “glass transition” at high temperatures ignoring the number of heating scan in Figs. 4.28, 4.33, 4.34

In summary, the submitted Doctoral Thesis of M.Sc. Karvanis meets the standard quality of PhD thesis. I am pleased to recommend, without reservation, this Doctoral Thesis for public defense in a disputation and, after that, to award to M.Sc. Karvanis the degree Doctor philosophiae.



In Linz, July 27, 2021

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