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Review

of a doctoral dissertation of M.Sc. Ramesh Kumpati

"Optimization method for ultralight aerial composite structures".

Formal basis for developing a review:

The review of the dissertation of M.Sc. Ramesh Kumpati was prepared in accordance with the resolution of the Council of the Discipline of Mechanical Engineering of the Silesian University of Technology dated 23 October 2024.

1. Comments on the choice of subject matter for the dissertation

Composite materials are increasingly used in a variety of industries. The increasing proportion of components made from such materials in modern machines is noteworthy; multilayer composite profiles are of great interest to designers. This is particularly true for aeronautical structures, where lightness and strength are important and production costs are not a decisive criterion.

Ecology, with its demands on reducing greenhouse gas emissions and the need for high energy efficiency, necessitates the design of ultralight robust structures that guarantee reliability and operational safety. It is of paramount importance to shape components aimed at minimising stress concentrations that initiate fatigue processes.

Given the above, I believe that the subject matter of the thesis is timely and that research into the optimisation of lightweight composite structures for the construction of unmanned aerial vehicles is of utilitarian and scientific interest.

2. Dissertation characteristics

The dissertation submitted for assessment runs to 173 pages. The main body contains 140 pages of text including figures and tables. The remainder consists of a 160-item bibliography, title page, table of contents, list of acronyms and symbols, list of figures, list of tables, and abstracts in English and Polish.

In the first chapter entitled 'Introduction', the author presents the applications of composite materials, the purpose and scope of the dissertation, and his own scientific publications related to the topic of the dissertation.

Chapter two, based on a literature review, contains information on optimisation methods, buckling phenomena, the importance of structural and material parameters for the mechanical properties of composites, and elements of the theory of the multilayer laminate plate.

In the third chapter, the Candidate presented a proposal for the modelling of multilayer laminates and elements of an optimisation methodology for composite structures; this chapter is crucial for the dissertation. The considerations were used to select optimal solutions for three types of example composite structures - as described in the next two chapters.

The manufacturing of natural fibre composites and the problem of experimental verification of mechanical properties for optimised structures is dealt with in Chapter Six. I consider specimen preparation and testing using a testing machine to be an essential part of the dissertation.

The title 'Results and Discussion' reflects the content of chapter seven. Among other things, the results of finite element calculations and microscopic images of the surfaces of specimens damaged during strength tests are presented. Several different variants of composite structures, including those with a photovoltaic layer, were considered during the calculations. Examples of element buckling and an element optimisation strategy are discussed.

The author presented a summary of the results obtained and prospects for further research in the final eighth chapter.

3. Evaluation of dissertation

The presented literature review reflects the current state of knowledge and refers to previous research related to the dissertation issues conducted in foreign and domestic centres. Despite a number of editing and editorial errors, I consider the selection of literature presented by the Author to be accurate, and the manner of citation to be generally correct, demonstrating the ability to use bibliographic material. The author's own publication output related to the dissertation issues should be emphasised, which includes 5 co-authored articles in recognised scientific journals and 5 chapters in monographs.

The author identified as the aim of the dissertation 'the optimisation of composite structures for increased load carrying capacity and stability, particularly in the construction of unmanned aerial vehicles'. Achieving such a formulated objective required the development of a strategy adequate for the optimisation of lightweight composite structures. The Candidate analysed selected aspects of the optimisation processes, taking into account the modelling of the mechanical properties of laminated plates with synthetic and natural reinforcements with different fibre orientations, and on this basis proposed a procedure using multi-criteria genetic algorithms.

The considerations were illustrated with examples of composite structure elements designed according to the developed strategy, the design of which was optimised using finite element calculations. An interesting aspect of the activities carried out as part of the verification of the correctness of the methodology was the fabrication of samples of natural and hybrid composite materials, the mechanical properties of which were tested using a testing machine.

The paper concludes with a correct summary and indication of development directions; the usefulness of the developed methodology for shaping the properties of the material layers and the overall structure is emphasised.

The aim of the dissertation has been realised and the methodology developed is of utilitarian importance, contributing to the discipline of mechanical engineering.

I assess the activities presented in the dissertation positively in terms of content and methodology. The author has presented an interesting approach to the problem of constructing structures from composite materials, and the achieved

results should improve the solution of specific engineering tasks related to the design of ultralight aircraft.

4. Specific criticisms

The following questions and comments arise when reading the dissertation:

- How does the Candidate understand the concept of optimisation? Why has the presentation of an example (illustrating the title methodology of the dissertation) of a task performed according to the diagrams in Figures 8b and 27 been abandoned?
- What and how have multi-criteria genetic algorithms (MOGAs) been used for? What is an example of using such an algorithm to solve an optimisation task?
- What properties of the analysed structures are illustrated by the strain-time curves (Figure 52)? What is the relevance of these graphs to the analyses?
- Is the value of the modulus E_2 (4.44 GPa, page 77) correct, or was there a calculation error?
- The ungainly editorial form of the dissertation is a source of factual errors: in Tables 5, 6, 7, the values of the dimensionless Poisson's number are expressed in units of stress (GPa); the same units apply to the numerical values given in the 'weight' row (Table 5).
- What is the stratified structure optimisation methodology illustrated in Figure 50?
- Little attention was paid by the author to issues of maintaining measurement consistency during laboratory testing. How has good practice been implemented in this area?
- Why was uncertainty estimation of experimental results abandoned? Is measurement uncertainty relevant for the verification of simulation solutions?

5. Notes on the editorial side of the dissertation

From an editorial point of view, the dissertation has not been prepared very carefully and numerous editorial errors are noticeable. There was a cursory integration of previously prepared fragments - resulting in incomplete consistency in the numbering

of formulas, references in the text to incorrect figure or table numbers and to some literature items. The small font size severely hinders the interpretation of some of the figures, and the usefulness of the list of acronyms and symbols is poor due to the incompleteness of the list.

Here are some examples of mistakes not eliminated during the editorial work.

- Table of contents, page 3 - title of chapter 7 different from page 99;
- List of figures, page 6 - incorrect page numbering for figures 35-42;
- Table of tables page 9 - incorrect numbering of tables 14, 15, 16; two tables identically numbered 17 (in the text on pages 95 and 102) were not highlighted;
- Page 40, last paragraph - the deciphered symbols do not coincide with the symbols used in the dependencies;
- Page 65 - the description in the text of figure 23b does not correspond to this figure;
- Page 67, second line from top - wrongly referenced Figure 17;
- Pages 71-73 - mistakes in numbers of figures referenced and bibliographical references;
- Page 76 - incorrect citation of Table 3 as source of data for calculations;
- Unintelligible reference to Table 2 (page 92), incorrect reference to Table 16 (page 94), Figure 42 (page 95), Figure 43 (page 96).

6. Final conclusions

The critical remarks I have mentioned do not lower the positive overall assessment of the thesis. I believe that the dissertation presented for review is valuable in terms of cognitive and utilitarian aspects, and contains an innovative view on the selection of composite structures for the construction of light unmanned aerial vehicles.

Ramesh Kumpati, M.Sc., has demonstrated the ability to formulate and independently solve the scientific problem of developing a proposal to optimise the structure and shape of composite coatings for a lightweight unmanned aerial vehicle. He properly planned a series of simulation studies supported by experimentation on real samples, and used the results obtained to correctly formulate conclusions. The

Candidate has demonstrated that he has sufficient theoretical knowledge and practical skills in the discipline of mechanical engineering.

Considering the above, I conclude that the reviewed doctoral thesis of M.Sc. Ramesh Kumpati "Optimization method for ultralight aerial composite structures" meets the requirements for doctoral theses by the Act of 20 July 2018. Law on Higher Education and Science (Journal of Laws 2018, item 1668, as amended) and may be admitted to public defence.