Skoltech
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Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Milad Jafarypouria

PhD Program: Mathematics and Mechanics

Title of Thesis: NUMERICAL SIMULATIONS OF STRESS-STRAIN STATE IN FIBROUS UNIDIRECTIONAL POLYMER COMPOSITES BASED ON 3D GEOMETRY WITH VARIABLE MICROSTRUCTURE AT DIFFERENT STAGES OF CURING AND POST-CURING

Supervisor: Dr. Sergey Abaimov, Skoltech
Co-supervisor: Professor Stepan Lomov, KU Leuven

Name of the Reviewer:

I confirm the absence of any conflict of interest 	**Date: 10-10-2024**

The purpose of this report is to obtain an independent review from the members of PhD defense Jury before the thesis defense. The members of PhD defense Jury are asked to submit signed copy of the report at least 30 days prior the thesis defense. The Reviewers are asked to bring a copy of the completed report to the thesis defense and to discuss the contents of each report with each other before the thesis defense.

If the reviewers have any queries about the thesis which they wish to raise in advance, please contact the Chair of the Jury.

Reviewer's Report

Reviewers report should contain the following items:

- Brief evaluation of the thesis quality and overall structure of the dissertation.
- The relevance of the topic of dissertation work to its actual content
- The relevance of the methods used in the dissertation
- The scientific significance of the results obtained and their compliance with the international level and current state of the art
- The relevance of the obtained results to applications (if applicable)
- The quality of publications

The summary of issues to be addressed before/during the thesis defense

This thesis has investigated the effects of curing temperature and time on the cure degree and mechanical properties of epoxy resin, which demonstrate the possibility monitoring curing state by using single-walled CNTs sensor. Based on 3D fiber break model, the thesis performed comprehensive finite element modelling studies to investigate the effects of constituent properties and microstructural parameters, such as the fiber type, matrix elastic/plastic deformation, fiber diameter distribution, fiber/matrix interfacial debonding and fiber misalignment, on the stress concentrations around fiber break and ineffective fiber length, which is expected to advance the prediction accuracy of fiber bundle model on longitudinal tensile strength.

The author has published multiple journal publications, conference papers and patents, and I think these good publications has demonstrated the scientific importance of this thesis. Other comments on this thesis are listed as follows:

(1) The subfigures/figure captions of many figures are in different pages, for example, Figure 1.1, figure 1.3, figure 2.6, figure 2.7, etc. It is better to keep the subfigures/figure captions of a figure on the same page. A similar problem also exists for Tables, Table 3.3, Table 4.1 for example.

(2) The values of electrical resistance in Table 2.2 seem to be inconsistent with those shown in Fig. 2.3. Please check whether there is a mistake.

(3) On Page 60, it is indicated that '…while shear modulus ratio rise.' How the shear modulus ratio is defined. The description is inconsistent with figure 2.17, where the variation of the shear modulus with time is not monotonical.

(4) In Table 2.7, the hardening modulus of epoxy resin should be given.

(5) As for the finite element modeling in Chapters 2 to 5, a strain of 2.0% is chosen to represent the effects of matrix plasticity. Why this value is chosen? Are the results of SCFs and ineffective fiber lengths are significantly different if other strain corresponding to different plastic stage is chosen? Considering CF and GF have significantly different failure strain, would a different external strain should be chosen for the two types of composites. Please give some comments for the choice of external strain.

(6) On Page 71, a mistake exists for the citation format, [9][19].

(7) In Table 3.4, L(not-debonded) is given as $20\times D$, but it is mentioned that the debonded length is dependent on fiber volume fraction on Page 73. Please check it.

(8) On Page 76, it is mentioned that 'the maximum principal stress in the matrix around the fiber break is 409 MPa and 294 MPa, respectively'. It is more reasonable to give the Mises stress for examining the existence of plastic deformation.

(9) On Page 81, it is mentioned that 'The results of FCD calculations correspond well to the ones presented in [6,17,20]'. I think this conclusion is drawn based on the comparisons in Figure 3.5. If it is true, this conclusion should be not placed in section 3.5.

(10) On Pages 84 and 85, the effects of the standard deviation of fiber diameter on SCFs are different CF and GF composites, can the difference be interpreted more physically?

(11) On Page 146, the author gives the introduction about EE-CZM and comparisons between direct and EE-CZM modeling results in Fig. 5.2. But it is mentioned that only the interfacial debonding of the

broken fiber is modelled using cohesive contact on Page 145. So it is confusing which modelling methodology is used in the following modelling studies.

(12) On page 151, the figure 5.3(b) shows a non-monotonical stress distribution along the fiber axial direction on NNF. Is it possible that the cross-section with fiber break is not most dangerous cross-section on which the SCF is maximal? If this is case, does it mean the SCF results should be given on several cross-sections, but not only on the fiber-break cross-section?

(13) This thesis demonstrates that the choice of fiber and matrix, the interfacial properties, fiber diameter, fiber misalignment, even external strain have significant effects on the SCFs and ineffective length. The various affecting factors mean that huge datasets would be transported to the model predicting the longitudinal tensile strength of UD composites. Does this prevent the application of the present modeling results? Maybe some comments would be given in the chapter of 'conclusion'.

Provisional Recommendation

☒ *I recommend that the candidate should defend the thesis by means of a formal thesis defense*

☐ *I recommend that the candidate should defend the thesis by means of a formal thesis defense only after appropriate changes would be introduced in candidate's thesis according to the recommendations of the present report*

☐ *The thesis is not acceptable and I recommend that the candidate be exempt from the formal thesis defense*