**Examination for the Degree of PhD - First Submission**

**Joint Report Form**

|  |
| --- |
| **School/Dept:** Engineering Research |
| **Candidate’s name:** George Hugo Spackman [14305363] |
| **Title of thesis:**  Optimisation of 3D Profiled Woven Composite Structures |
| **Programme of Study:** PhD Materials Engineering and Materials Design |
| **Name of External Examiner:** Dr Xiaogang Chen |
| **Name of Internal Examiner:** Professor Ian Ashcroft |

*A brief report on the thesis examination should be included below.*

*If the examiners are recommending re-submission for PhD**but have concerns that it may not be possible for the candidate to achieve that standard in the re-submission period, they may inform the candidate that it is advisable to re-submit for MPhil, and if this is done this should be clearly stated here.*

*If the examiners require the candidate to incorporate revisions contained in their Independent Reports when completing corrections or submitting a thesis for re-examination this should be explicitly stated.*

**Report on the thesis examination:**

The examiners reported on the thesis in their individual reports. In general there was agreement in their opinions of the thesis, a summary of which is given below.

The thesis concerns the development of a method of optimising weave patterns for 3D woven profiled structures. In particular, the method is demonstrated for a T-joint, of the type used in aerospace applications as stiffeners. The work is presented in the following parts: (i) experimental – manufacture, characterisation and mechanical testing of two types of T-joint; (ii) formulation of optimisation problem and comparison of three optimisation algorithms; (iii) creatin of geometric model; (iv) meshing geometric model for FEA; and (v) optimisation of weave pattern for a T-joint. The work is beneficial to the engineering design of T-joint composites with optimal structures offering resistance to inter-yarn delamination and for reduced CPU time and efficiency.

While the quantity of work is sufficient required for a PhD, there are rooms for improvement in terms of logic, consistency, strategy and methodology and research findings. There are a number of issues with the thesis that need to be addressed, including abstract lacking key results and conclusions, no clear overall methodology, some poor figures, some repetition and inclusion of unnecessary literature in results chapters, no clear differentiation between summary, discussion, conclusions and further work, lack of high-level discussion of novelty and significance of work in context of industrial applications and literature etc. Details to key literature with critical comments and to research background should be properly introduced. Each chapter should be written logically and compressively to tell the “academic story”. The thesis referred to appendices, but they were not attached to the thesis. This needs to be addressed.

**Date of *viva voce* examination: 10 August 2022**

**Report on the *viva voce* examination:**

The candidate participated in the oral examination with competence and demonstrated confidence in the research presented in the thesis. He understood the questions put to him and responded satisfactorily in most of the cases. He was able to further explain principles, mechanisms and the research process including challenging questions such as the research rationale, strategy and result interpretation. The candidate performed actively in discussions and in defending the research, and he was also patient in responding to the comments and recommendations made on inaccurate descriptions and lack on information. The viva was carried out pleasantly, candidly, and constructively.

The examiners were satisfied that the work presented was at a standard suitable for the award of Phd and that the candidate performed satisfactorily in the viva. However, from both the initial examination of the thesis and from the viva it was apparent that the thesis was not at the required standard. The recommendation is, therefore, a referral to enable the candidate to make the required improvements to the thesis to enable the award. The required corrections are listed below. (note that the external examiner has also returned his copy of the thesis with further comments and corrections that should also be considered in revising the thesis.)

**General Corrections**

* Abstract is lacking key results and conclusions
* The disadvantages as well as advantages of woven composites need to be discussed, together with a more comprehensive comparison with current practice and alternatives. Current penetration of woven composites in the market and challenges to further adoption needs a better discussion – particularly for the aerospace T-joint application.
* The overall aim of the research is not clear and needs to be better articulated
* The current state-of-the-art of in the field of research needs to be defined more clearly. The literature review requires a more critical analysis and clearer identification of gaps in current state of the art.
* The research strategy adopted for the research needs to be described and justified.
* Indicate the coherence among the different objectives and explain how the objectives will ensure the fulfilment of the research aim.
* Give a general description of the T-joints involved in this research from the textile point of view.
* The results chapters need to have introductions that introduce the aims and structure and indicate how these fit into the bigger picture of the thesis – linking to the previous chapters. The elements of literature review in these introductions need to be moved to the literature review.
* What is to be optimised when optimising the woven weaves (fabrics)?
* What are the key structural parameters for automatically generating the T-joint models?
* Separate discussion and conclusions & further work chapters needed.
* All figures need to be referenced and discussed in the text. Many figures need to be improved as they are not of publishable quality. The use of annotations and schematics would help to clarify important features in many of the figures.
* Appendices referenced in the text are not part of the submitted thesis. These need to be added in the revision.

**Specific Corrections**

Chapter 1

* This chapter needs a better defined aim and objectives for the work
* P4-5: Use references for important statements.
* P6 Figure 1-1: This figure was not referred to.
* P7 L1-2 from bottom: “… geometries where the …” Clarify this. An illustration may be a good idea.
* P8 Figure 1-3: Not referred to.
* P8 Para 1 L2: “…sheds (shedding) attached” Word “sheds” should be replaced by “heald frames (or heald wires in the case of jacquard weaving)”.
* P8 Figure 1-4: Indicate the warp (straight and binding) and weft yarns.
* P11 Para 2 L1 from bottom: “… Weaves.” Strictly speaking, a weave means the way the warp and weft yarns interlace to for fabrics. Therefore, suggest the use of "fabrics" instead of "weaves". Please make changes throughout the thesis.

Chapter 2

* P18 Para 3 L6: You used junction region, noodle region and bifurcation region. Clarify and unify.
* General comments:

(1) For important research literature, you should give detailed introductions to demonstrate your understanding to let the readers into the situation;

(2) Your critical comments are expected on the papers reviewed; and

(3) highlight the research gaps for the research area identified for your research.

Chapter 3

* This chapter (or the introduction) needs an overall methodology to illustrate the approach taken to achieving the objectives and justifying the decisions made.
* The role of this chapter in the overall thesis is not clear.
* The choice and justification of T-joints used in experiments not clear.
* P31-33 Figures 3-1, 3-2 and 3-2: The illustrations are not clear enough to indicate the structural features of the two specimens provided by SigmaTex, nor are the coupled descriptions.
* P32 Para 2: Yarns in +45 and -45 degrees need to be indicated crystal clear. Structures of the two specimens must introduced clearly.
* P36 -figure reference missing
* P37 Figure 3-6: the use of this tool to form a J-joint composite is not clear. Clarify.
* P38: The thesis does not introduce important factors such the fibre volume fraction, thickness and other dimensions and the composite quality (C-Scan, micro-CT results) of the two composite specimens, which are vitally important for mechanical properties.
* P39 the tubes in the background of fig 3-7 are distracting.
* P40 This is an example of a poorly presented figure, which seems to be based on Excel defaults. Labels can’t be read, key is poor, grey lines hard to see, unnecessary outer box etc. Figs 3-10 and 3-11 similarly poor.You should select a professional and effective style for your x-y plots, then use this for all figures in the thesis.
* P41 Figure 3-9: Indicate pictures for coupons 1 and 2.
* P41 the features discussed in text can’t be clearly seen in Figure 3-9. A better figure and annotation would help.
* P43 Section 3.5.3: What is the common ground for comparing the two specimens?
* P44 Section 3.7: What is the significance of the testing results? How would the outcome benefit this research?

Chapter 4

* Chapter starts with literature review material that would be better in the actual literature review. The literature review appeared to have important elements missing, which were then found scattered through other chapters. This needs remedying throughout the thesis.
* Fig 4.3 is referenced in the text before figure 4-1. The should be referenced in order.
* The optimisation problem needs a better mathematical definition and justification.
* A reason needs to be given why these specific optimisation methods investigated, rather than the more efficient gradient based method, for example.
* P46 Figure 4-1: Explain the necessity.
* Figure 4-1 is poor quality and poorly explained
* P47 Figure 4-2: The structures in the web and flanges are different. What are the considerations?
* P47 Figure 4-3: Yarn crossing the T-joint should have been introduced before this point, as structure affects the failure mode.
* Figure 4-7 is an example of the quality of figure and annotation expected in a thesis.
* P49 Section 4.2: (1) Please highlight the objective (function) of the optimisation. (2) Use a flow chart to accompany the description of the optimisation process.
* P52 Table 4-1: What is a X yarn? How were the parameter values decided?
* P52 Para 1: You do not have Appendices.
* P53 Table 4-2: (1) What is the benchmark used to decide the mesh size? Experimental data? (2) This table needs be analysed and discussed.
* P54 Section 4.3.3: T-joint direction MUST be clarified to avoid confusions in this Section.
* P55 End of page: How are the rules established?
* P57 Constraint 2: What is x?
* P57 Para 3 L6: “…with three binder yarns in the unit cell.” Why three? Number of binders is determined by the binding weave.
* P59 Section 3.3.1: Apart from compare CPU time, calculating accuracy must be compared. (Figure 4-7)
* P59 -incorrect section numbering
* P61 L3-5 from bottom: describe the optimisation process to achieve this.
* P66 the reason for selection of GA is not convincing -is computation time more important than optimality. No indication how universal the results in the table are to this type of problem.
* P69 Equation (5): Explain.
* P71 Figures 4-17 & 4-18: Geometrical discontinuity will seriously affect the mechanical properties.
* P72 Figure 4-19: Experimental validation needed.

Chapter 5

* The first paragraph is unnecessary repetition. As indicated previously, results chapter introductions need to be re-written to provide a better understanding of how the chapter fits with the overall aims and methodology of the thesis as a whole.
* P77 Para 1 L5: What is a “direct” load?
* P77 Para 2 L7-8: “… difficult to predict the effect … relying on experience…” There must be ways to predict/estimate the effect of the fabric structure on properties.
* P78 Figure 5-2: There are many ways for weft yarn separation. Which one you are targeting and why.
* P80 Figure 5-3: Notation confusion and mistake.
* P83 Figure 5-6: What principle is followed when considering yarn cross-sectional deformation?

Chapter 6

* General comment: Describe your own research activities, methodology, results and analysis and findings with clarity. As this builds on previous work/existing software. The novel additions (and the significance of these) need to be clearly defined. It would also be useful to have a more comprehensive description of the capabilities of TexGen before and after this work.
* P93 – you mention shear locking – but I don’t think this is what you mean.
* P95 Show model with boundary conditions. Are these realistic ? discuss Also need some examples of meshes.
* P97 If loading quasi-static, why use explicit analysis ? Did you attempt implicit ?
* P101 very poor figure, cannot understand the meshing exercise as can’t read legends and not explained properly. Need to justify choice of convergence criteria in mesh study – should be related to what model is being used for.
* Why no experimental validation of FEA ? As optimisation based on failure, we need confidence that the method of predicting failure is correct

Chapter 7

* Optimisation problem needs defining properly.
* Should show results illustrating the performance of the optimisation method.
* P109 L12: the string – Are you optimising the crossing of the weft yarns for reduced simulation time? What about the other parameters, such as the binding weave, yarn thickness, yarn cross-section, warp and weft density and so on?
* P112 Para 3 L5: “The optimisation converged …”. What is the objective of the optimisation?
* P113 Figure 7-2: There are interferences. How did you carry out FE simulation?
* P113 Section 7.4.1: This is the only subsection under Section 7.4. Suggest breaking this section into a number of sections.
* P117 Figure 7-6: Has the model validated? These are subjective comparisons. Show the comparison in an objective fashion.
* The chapter is lacking experimental validation of the optimised results. It is accepted tat this can be attributed to lack of laboratory access during lockdown but it should at least be discussed.

Chapter 8

* This isn’t really a conclusions chapter; it is more of a summary. You should add a discussion chapter in which you bring together the various elements of the thesis, discuss achievements in context of aim and objectives, discuss novelty and significance of work in context of published literature and industry needs, discuss how the work could be used and what next steps should be etc. The conclusion chapter should then be a concise set of points take from the discussion.
* General comment: what were the aim and objectives?
* What were the strategy and methodology adopted?
* What are the key findings?

SA/24/08/2022 contd..../

|  |
| --- |
| Candidate’s Name: **George Hugo Spackman [14305363]** |

**Summary of Examiners' Recommendations**

Please tick the appropriate box (s)

|  |
| --- |
| **Award of PhD**  ¨ without conditions  ¨ subject to correction of typographical errors within 1 month1  ¨ subject to minor amendments2 to be completed within 3 months3 |
| **Referral**, with  ***EITHER***  a) resubmission of the thesis within 12 months for PhD:  ¨ *viva voce* required  ⧫ *viva voce* not required  Please Complete this section if ‘a’ is selected:  If resubmission for PhD is recommended but the student is unable to re-submit:  ¨ MPhil to be awarded now  ⧫ MPhil to be awarded now subject to minor amendments2 to be completed within 3 months3  ¨ Thesis not currently at MPhil level  ***OR***  b) another *viva voce* examination although thesis is accepted  ¨ without conditions  ¨ subject to minor amendments2 to be completed within 3 months3 |
| **Failure** at PhD standard  ¨ No higher degree to be awarded at all4 |
| 1 This option should be selected only in instances when the candidate is required to make minor corrections to the text, e.g. typographical errors, which are so minor as to be completed in one month. It is the responsibility of the Internal Examiner to verify that the corrections have been made to his/her satisfaction.  2 Minor amendments are amendments to the thesis not requiring external academic re-assessment, e.g. extensive typographical errors, minor re-organisation of material, addition of supplementary material to clarify the content of the thesis, or removal of extraneous text and may include minor re-writing of material. Minor amendments are in excess of minor corrections but are not, in the opinion of the examiners, sufficient to require the student to be referred and to resubmit. It is the responsibility of the Internal Examiner to verify that amendments have been made to his/her satisfaction.  3 Exceptionally, where a student has been previously registered as a part-time student and it has been demonstrated that circumstances exist such that it would be in the best interests of that student, the examiners may recommend that the degree be awarded subject to minor amendments being completed within six months. Where this option is chosen, please indicate by deleting ‘3’ and replacing with ‘6’.  4 The University recommends that, other than in exceptional circumstances, Examiners should not normally choose this option on a student’s first examination. |
| It is confirmed that the *viva voce* examination has been conducted and that the student has been given informal feedback on the outcome of the examination.  Name of External Examiner: **Dr Xiaogang Chen**  Date . 11 August 2022.. . .Signature  Name of Internal Examiner: **Professor Ian Ashcroft**  Date . . . . . . . . . . . . .19/8/22 . . . . . . . . . . . . . . .Signature  I confirm that the examination process has been completed according to University regulations and procedures[[1]](#footnote-2). I endorse the Examiners’ recommendations.  Signature of Head of School/Dept: Date .24/08/2022 . . . . .Signature |

Recommended Modification List

1. For joint/dual awards it is confirmed that the Partner Institution(s) regulations have been satisfied. [↑](#footnote-ref-2)