Thermal Stress Model for Blended Laminates

MSc. Thesis Proposal

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Introduction

The use of fiber-reinforced composites in the aerospace, automotive and maritime industries has seen a rapid increase over the past decades thanks to their high specific properties. Due to manufacturing cost and design capabilities, the potential of these materials have not been fully utilized.
Laminance is striving to be a game changer in this field by further developing SFVS (Straight-fiber Variable Stiffness) laminates and scaling their manufacturing to an industrial scale. Laminate blending is used to design a variable stiffness laminate that, unlike fiber steering, consists of only straight fibers. By following the relaxed blending guideline the load is effectively redistributed over several regions of the laminate to boost the structural performance.
This is not possible without conducting further research to answer pending questions. This graduation project addresses one of those questions. Laminance is looking forward to setting a research framework with the Technical University of Delft to challenge a MSc. student to solve this problem.

Background

The proposed assignment builds on the work of multiple other MSc thesis projects that have been carried out at the TU Delft. In 2019, as part of a previous MSc. thesis work at TUDelft, a blended laminate demonstrator was manufactured and tested against its conventional counterpart (constant stiffness) in an experimental campaign. The buckling load of the Blended laminate was 80.9% higher than that of its conventional counterpart and the stiffness was 93.75% higher. However, the blended laminates came out from the autoclave oven metastable with three (2 stable and 1 unstable) configurations even though the stacking sequence of each section was balanced and symmetric. The 2 stable configurations were of a saddle shape and the unstable configuration was flat. Since the laminates were tested with knife-edges to simulate simply supported edges, it was not an issue testing the laminates in the desired flat configuration.

Research Objective

The difference in stacking sequence between the regions of the laminate provide increased structural performance but do also introduce thermal stress during the cure. These thermal stresses might result in undesirable stable and unstable deformation after cure. A thorough understanding of how these stresses are introduced and affect the final laminate is needed such that they might be removed or used to further increase the structural performance.

The objective of the proposed thesis work is to develop a tool that predicts thermal stresses in a SFVS laminate and can be used to tailor the stacking sequences which takes into account the following:

1. Material mechanical and thermal properties
2. Autoclave Curing cycle
3. Blended laminate dimensions and the stacking sequences of all segments

Activities

1. Literature study
2. Development of a thermal stress model to predict the stable and unstable modes after cure
3. Validation of thermal stress model with data from previous MSc. thesis work
4. Development of a tool to prevent deformation or tailor the stacking sequences to result in a desired shape

Deliverables

The student is expected to deliver a MSc. thesis to the university in which all activities, analyses and conclusions are described. Furthermore, the student is expected to deliver a working thermal stress model that can be used to predict stable and unstable modes to Laminance. The founders of Laminance, who previously graduated on the topic, will act as daily supervisors. Additionally, a weekly meeting together with the TU Delft supervisor and daily supervisors is organized.