Abstract

Composite 3D woven components have been used in aerospace components because of their improved through-thickness properties and ability to be woven integrally in near-net shape. The complex stress conditions and long time required to manufacture and test physical specimens means that the relationship between the reinforcement's weaving pattern and the mechanical behaviour of 3D woven composite T-joints is not well understood. With approximately 3.6 million possible combinations of weft yarn configurations alone for a textile with 10 weft layers, an exhaustive search of the design space is not possible. To resolve this, the aim of this project was to apply optimisation algorithms to 3D woven profiled structures such as T-Joints. Previous geometry modelling work in the literature had provided a framework to produce these models but were done by-hand using a manual process.

Initially, flat 3D woven structures were optimised to find the best through-thickness properties using algorithms from MATLAB's optimisation toolbox. Several algorithms were evaluated before determining that the genetic algorithm was the most appropriate based on the time to find an optimum solution and the accuracy. Methods were developed to rule out the large number of spurious weave designs generated by the optimisation algorithm. This resulted in a 94% reduction in run time for function evaluations using periodic boundary conditions when compared to literature values. The reduction in optimisation run time facilitated a novel optimisation of the peak through-thickness load using cohesive zone modelling.

A key outcome was the development of a tool to automatically model T-joint reinforcements using TexGen, the University of Nottingham's 3D woven textile geometry modelling software. Focus was placed on replicating the order in which wefts wrap around each other. This was achieved by determining the ordering of the weft yarn interlacement at the bifurcation region of the 3D weaves. This was then used to facilitate an optimisation of the weft yarn configuration to find the reinforcement weaving pattern that was best able to resist failure under tensile pull-off loading. This resulted with a 3D woven composite T-joint with an 8.8% increase

in the load at initial failure when compared to a T-joint made using an orthogonal weave with no weft yarn crossover or entanglement. An analysis of the results of this optimisation was able to provide information about how weaving features improve the failure behaviour of the joints under tensile loading.

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