A novel method for designing blended laminate composite structures

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To reduce the weight of aerospace structures, the stiffness of composite laminate shells can be tailored by varying laminate thickness and ply fibre orientations. The process of designing each panel to fit harmoniously into the wing as a whole is known as blending, and is challenging because of two reasons. Firstly, there is a large number of discrete design variables to deal with, i.e. fibre orientations and ply drop positions. Secondly, the design of individual panels is constrained by many guidelines that ensure global geometric continuity, strength requirements and ease of manufacture.

Current optimisation techniques for blending have several drawbacks. For instance, their tendency to convergence towards local sub-optimal designs and their speed, or lack thereof, especially for thick panels with many plies.

Principles of the novel blending technique

Blending methodology

Guide-based blending: panels with the same thickness designed identically

Greater-than-or-equal rule: all plies in a panel continue in adjacent thicker panels

Optimisation procedure

1) Generation of an initial ply drop layout
2) Ply orientation optimisation
3) Repair of the multi-panel designs

Best multi-panel design

Main novelties

A novel procedure to create laminate layouts with ply drops almost uniformly distributed through the laminate thickness at panel boundaries, for minimal ply-drop interference.

A deterministic optimisation of the ply orientations with a beam search using novel heuristic cost functions for fast and controlled exploration of the laminate design space

Results

Retrieval of the design for a structure with 6 symmetric panels of 60 / 56 / 52 / 48 / 44 / 40 plies

Design obtained in less than a minute with the following guidelines considered: symmetry, balance, contiguity, disorientation, 10% rule, ply-drop spacing rule and ply-drop stacking rule

Lamination parameter results: average error 3.6% and worst error around 15%

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