Blended Composite Optimization combining Stacking Sequence Tables and a Modified Shepard's Method

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Abstract

Fibre-reinforced composite materials are characterized by their directionally-dependent stiffness properties, which depend on their ply angles and thickness. This 'tailorable' feature offers great potential in the design of efficient structures.

An efficiently designed structure caters to the load distribution by spatially varying its stiffness. In the case of composites, this variation in stiffness is realised by varying the ply angles and/or thickness. Laminate blending is a design technique for composites which allows for such stacking sequence changes over the structure, without compromising its structural integrity or manufacturability.

This article presents a *computationally-efficient* optimization tool for stacking sequence design of *blended composite* structures.

In this tool, blended laminates are designed using a genetic algorithm (GA) for stacking sequence tables (SST) [1]. The SST approach guarantees fully-blended designs, provides a detailed perspective of the transition region between adjacent blended panels and implements industry-standard design guidelines. The GA here is extended to account for load re-distribution due to stiffness change and to handle multiple independently-blended skins.

In order to reduce the number of expensive design analyses required, the successive structural approximation technique [2] is used. A recently-proposed modified Shepard's interpolation [3] improves the quality of the approximation used, by constructing a multi-point approximation using the elite designs of the previous iterations.

The use of direct panel load approximations is presented in this article. Directly approximating panel loads provides the potential of including a wide range of stress-based design criteria in the optimization using in-house design tools.

An analytical multi-panel blended composite problem is presented as an application. The results show that fully blended and feasible stacking sequence designs can be obtained, having its structural performance comparable to the theoretical lamination parameter-based continuous optimum itself, while requiring a reasonably low number of design analyses.

References

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