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A Methodology for Material and Thickness Optimization of Laminated Composite Structures

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This work concerns a gradient based topology optimization methodology for minimizing the mass of large-scale laminated composite structures through the determination of an optimum thickness variation and material distribution. This is done while ensuring critical structural performance constraints on criteria such as buckling load factors, eigenfrequencies, and limited displacements. Furthermore, common design guidelines or rules are included explicitly as a series of so-called manufacturing constraints. The simultaneous determination of the material distribution and thickness variation ensures that both the structural performance demands and the manufacturing constraints are satisfied throughout the optimization procedure.

The methodology proposed in this work is a continuation of the work by [1] who presented a novel method for simultaneous determination of material distribution and thickness variation of multilayered, laminated composite structure. The preceding method was demonstrated on monolithic laminated plates with various boundary conditions, where the objective was to minimize compliance subject to a mass/volume constraint, and a series of common manufacturing constraints. Compared to the preceding work, we are now considering multi-material topology optimization where mass is minimized subject to several structural performance constraints as well as the before mentioned manufacturing constraints. Altogether, this constitutes a far more difficult problem due to the presence of design sensitivities with both operational signs. The capabilities of the methodology are demonstrated on several parameterizations of a finite element model of a generic main spar from a wind turbine blade. The different parameterizations of the generic main spar represent different levels of complexity with respect to manufacturability. The results will thus give insight into the relation between weight saving and design complexity.

Keywords: Discrete material and thickness optimization, Manufacturing constraints, Mass minimization, Laminated composite shell structures

References

[1] S. N. Sørensen and E. Lund. Topology and thickness optimization of laminated composites including manufacturing constraints. *Structural and Multidiciplinary Optimization*, 2013. doi: 10.1007/s00158-013-0904-y.