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OPTIMIZING TOPOLOGY AND STACKING SEQUENCE IN LAMINATED COMPOSITE STRUCTURES

Abstract

Fiber-reinforced composite materials have become increasingly important for aerospace and aeronautical applications due to their high strength- and stiffness- to-weight ratios, outstanding fatigue properties and corrosion resistance. A common goal in design of structural laminates is to determine the fiber orientation of each laminate sheet within a stack (the stacking sequence) and across the structural domain. To simplify fabrication and assembly, the choice of fiber orientations that can be placed in the design is often limited to a discrete set of candidate angles, such as -45 / 0 / +45 / 90 degrees, with selection governed by design guidelines and engineer experience. Discrete material optimization (DMO) has proven an effective alternative, enabling optimization of the orientation of laminated composite panels across a structural design domain to maximize structural properties, as predicted by finite element methods. The DMO expresses the elemental material constitutive tensor as a combination of the constitutive tensors corresponding to candidate orientations, and local constraints on each element are used to ensure that only one candidate orientation be chosen at a location. However, optimizing orientation at the finite element level can lead to rapidly varying orientation distributions that are quite challenging, or even impossible, to manufacture in practice. Recent literature has introduced filtering schemes from classical density-based topology optimization into the DMO approach in order to influence the manufacturability of solutions. In this talk we take this idea one step further and integrate the Heaviside Projection Method to topology optimization within DMO, thereby providing rigorous control over the minimum length scale of structural features, holes, and laminate patches of constant orientation. The design problem is posed as a continuous optimization problem, penalized using traditional SIMP formulations, and solved using gradient-based optimization with sensitivities computed using the adjoint method. The proposed approach is demonstrated on maximum stiffness design problems and compared with results from literature (where appropriate) in terms of structural properties and manufacturability. Numerical results suggest that the proposed projection-based approach can play an important role in tailoring the manufacturability of laminated composites optimized for stiffness and strength.