Incorporating strength constraints in a simultaneous material anisotropy and topology optimization of composite laminate structures

Soutenance de thèse de Lander VERTONGHEN qui aura lieu le vendredi 28 avril 2023 à 14h en salle CONTENSOU ONERA Châtillon

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Abstract

This research funded by Airbus Atlantic focuses on merging material and structural design further. A density-based framework for topology optimization is adopted, in which material anisotropic stiffness is incorporated as additional design variables. Material stiffness is characterized by means of the polar parameters, an invariant-based representation of the elasticity tensor. The considered design space of the polar parameters is described by the thermodynamic bounds for the general case of 2D orthotropic materials, or by the geometric bounds to restrict the scope to composite laminates. In the optimizations, either domain of existence is enforced through a remapping as optimization bounds. A gradient-based optimization strategy is formulated based on the Method of Moving Asymptotes, in which density and anisotropy variables are optimized in parallel. The method is validated against optimality criteria optimizations for compliance minimization. Thereafter, strength constraints are incorporated for topology and unidirectional fiber steering optimizations using a lower KS aggregation method. Elliptic stress criteria, such as the Tsai-Wu failure criterion, are considered to define material failure. As these criteria are expressed in the material reference frame, the rotation effect of the fiber is taken into account for the computation of both the optimization constraint and its gradient. Finally, to extend strength considerations to the more general case of laminates, a conservative strain envelope is employed. This envelope represents the maximal allowed deformation for any possible ply orientation. The corresponding optimization constraint is formulated based on the strains in the global frame. To this end, a strain-based topology framework is proposed and validated against stress-based optimizations with isotropic material. Finally, the method is applied to show the influence of material anisotropy, both for stiffness and strength, on the optimized solutions.

Key words: DISTRIBUTED ANISOTROPY; SIMP; POLAR PARAMETERS; STRESS; STRAIN; ELLIPTIC FAILURE CRITERION