11th World Congress on Structural and Multidisciplinary Optimisation
07th -12th, June 2015, Sydney Australia

Filter Based Discrete Material and Thickness Optimization of Laminated Composite Structures

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Abstract

Structural optimization of laminated composite structures consisting of different fiber reinforced materials calls for parameterization methods like the Discrete Material Optimization (DMO) method. In these methods a number of candidate materials are proposed which could be different fiber reinforced polymer (FRP) materials oriented at given chosen angles, and the choice of material and fiber angle is then solved using gradient based optimization techniques where weight factors determine the distribution of the candidate materials over the layered design domain. Increasing penalization is typically introduced in order to push the continuous design variables to 0-1 values. The methods can be used for monolithic FRP laminates and for design of sandwich type structures where FRP materials are combined with soft materials like balsa wood or foam material.

The authors have recently proposed the Discrete Material and Thickness Optimization (DMTO) method for simultaneously determining an optimum thickness variation and material distribution of a laminated composite structure. In this work a DMTO approach based on socalled casting constraints or filters known from traditional topology optimization with isotropic materials is presented. Continuous elementwise thickness design variables are used, and based upon a continuous approximation of a unit step function, the thickness filters are capable of projecting discrete 0/1 values to the underlying layerwise density variables which govern the presence of material in each layer through the thickness of the laminate. Combined with an inplane density filter, the method enables manufacturers to control the length scale of the geometry while obtaining near discrete designs. The DMTO approach using filters will be demonstrated for several optimization examples of laminated composite shell structures, taking different global and local structural criteria into account together with manufacturing constraints.