On a Solver of Stiffness Maximization Problems in 3D With Multiple Materials Using Reaction Diffusion Equations

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Abstract: Multi-material design, where more than one material is placed in appropriate configurations, is indispensable to reduce weights of mechanical components while keeping their required performances. Multi-material topology optimization is a promising method for realizing such efficient multi-material designs.

The present authors' group has been developing a multi-material topology optimization method using level set functions and reaction diffusion equations. In this method, multiple level set functions are used to represent the geometrical structure (i.e., shape and topology) and distribution of materials according to the MM-LS (Multi-Material Level Set) model. Then, each level set function is updated using the design sensitivity of the objective functional w.r.t. the level set function and a reaction diffusion equation to obtain the optimal configurations. In this method, one can control complexity of both geometrical structure and distribution of the materials, as one adjusts the coefficients for the diffusion terms in the reaction diffusion equations. The design sensitivities are calculated with the help of the topological derivatives.

In this presentation, we apply the multi-material topology optimization method to three dimensional problems to observe the performances. Specifically, we focus on stiffness maximization problems in 3D. The governing equation is the equilibrium equation for isotropic elastic body in 3D, and we consider a given load condition and boundary settings for the elastic body. The stiffness maximization problems are formulated as mean compliance minimization problems using multiple materials with given volume constraints. We show a new algorithm for calculating the design sensitivity w.r.t. each level set function. Some numerical examples are presented to show the validity and effectiveness of the method.

DOI: 10.32604/icces.2019.05203