Shape and Topology Optimization Method for Designing a Shell Structure with Multi-materials

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Abstract

Weight reduction is strictly required in the structural design, especially for vehicles with shell structures. Usage of multi-materials and their optimal combination is expected to become one of the solutions to the requirement. In this paper, we propose a simultaneous shape and topology optimization method for designing a multi-material shell structures. By implementing topology optimization in the variable design domain which is optimized by shape optimization at every iteration, the optimal topology and shape can be simultaneously determined [1]. The GSIMP method [2] and the free-form optimization method for shells [3] are used as topology and shape optimization method, respectively. Compliance is used as the objective functional. The volumes of two materials and the surface area of the shell are used as the constraint functionals for topology and shape optimization, respectively. The fictitious density and the out-of-plane shape variation are employed as the design variables. The optimum design problem is formulated as a distributed-parameter optimization problem based on the variational method, and the sensitivity functions for density and shape variations are theoretically derived. Both the optimal density distribution and the optimal shape variation are determined by using the H^1 gradient method [1][3], where the sensitivity functions are applied as the Robin condition to vary the shape and density. With the proposed method, the compliance is minimized while maintaining the smoothness of the surface shape and the density distribution. Fig. 1 shows a calculated example of a torsion plate. (a) shows the initial shape and the boundary conditions. The obtained designs are shown from (b) to (e) for various material ratios of materials 1 and 2. The results show we can obtain the optimal shapes and topologies of a shell structure with two materials according to the ratios of two materials. With the proposed method, lighter and stiffer shell structures can be designed without design parameterization and numerical instabilities.

Keywords: **Shape and topology optimization, Multi-materials, Shell structure**

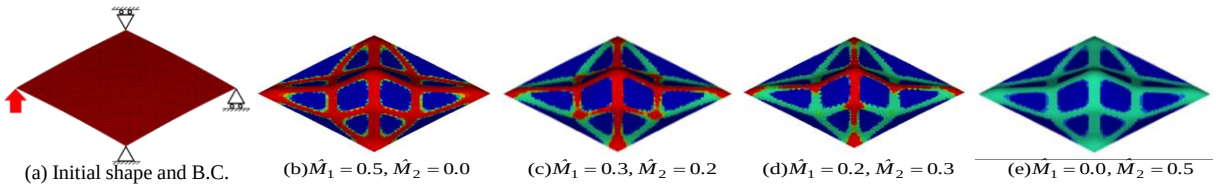

Figure 1. Calculated results of square shell for various material ratios

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