Structural Efficiency of Multi-scale Topology Optimization of cellular materials using Bi-directional Evolutionary Structural Optimization

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ABSTRACT

Topology Optimization is a very active field of research and development with a large number of industrial applications. One important application is the development of new materials at the microstructure. Due to the heterogeneous medium present in many engineering materials, an analysis of the microstructure features is necessary to improve the design of high-performance structures. In this paper, it is proposed to apply the Evolutionary technique to design new cellular materials using Topology Optimization in the periodic micro-scale domain. In cellular materials, the microstructure has only one material (and voids). The structural efficiency of multi-scale problems can be defined as the objective functions ratio for the optimized micro-structures and the reduced macro-structure.

Using the homogenization theory, the material design assumes that the macrostructure material is made of periodic base cells. The macroscopic properties of the heterogeneous material are homogenized, according to the micro-scale topology. This work presents an approach of the Bi-directional Evolutionary Structural Optimization (BESO) method for designing microstructures of cellular materials. The objective function is to minimize the mean compliance of structures or to maximize the natural frequency of the dynamic response for predefined macro-scale problems.

Numerical examples are presented to validate the effectiveness of the algorithm. The influence of the mesh refinement and the initial design in the final topology of the microstructure are discussed. Finally, this article presents results of the design algorithm for cellular materials and evaluates the structural efficiency of optimized micro-structures for different macroscopic boundary conditions.

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