Design Optimization Method for Additive Manufacturing Multiscale Structures with graded quasi-periodic microstructures

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ABSTRACT

It has been become very important to find and/or develop effective design methods to find high performance structures for additive manufacturing. Designing the geometric characters and material distribution in multiscale and their variation in the space is one of the most important ways to design high performance structures. In this paper, a new topology optimization method for multiscale structures with quasi-periodic microstructures is proposed. The so-called 'quasi-periodic' means the microstructures in different domains of the space have similar (same topology) but not the same geometric sizes, for example the square microstructures who have inner circles with varied radius. The first step is to determine the topology of the microstructure which is completed through topology optimization of microstructure for materials to optimizing the same objective function as the initial problem. Then, based on the obtained the topology, an erode-dilate operator is introduced, and the erode-dilate parameters are selected as the description parameters of the microstructures. The materials properties are related to the description parameters though homogenization method. Further, the relative density of elements are used to describe the topology of the structures and the erode-dilate parameters are selected as material property control variables, a topology optimization formulation is formed for multiscale structure desgin with graded quasi-periodic microstructures. By this way, we can optimize the structural topology and the microstructures, which are varied in macro design domain, simultaneously, for improving the performances of graded structure. The microstructures neighbored are connected in the obtained results which benefits the rapid trial-manufacture by additive manufacturing. Several numerical examples are used to demonstrate the effectiveness of the proposed method.

Keywords: Design for Additive Manufacturing, Multiscale Structure, Topology Optimization; Quasi-Periodic Microstructures; Erode-Dilate Operator