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论文

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基于导热性能的复合材料微结构拓扑优化设计

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Topology Optimization for Microstructures of Composite Materials Based on Thermal Conductivity

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摘要

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摘要 基于均匀化理论和拓扑优化技术,提出了复合材料稳态导热性微结构构型的设计方法。根据均匀化理论给出的周期性材料微结构(单胞)等效导热系数的计算公式,结合有限元分析手段对单胞的等效导热系数求解;定义设计区域内微结构每个单元的导热系数为伪密度设计变量,约束材料用量,分别以材料微结构某个方向导热性能最好为目标和宏观结构的散热性能最佳为目标;采用实体各向同性惩罚函数法(SIMP)构造单胞拓扑结构优化数学模型,导出材料等效导热系数的灵敏度计算公式;采用凸规划对偶求解与周长控制约束相结合进行拓扑优化并获得了优化的微结构构型,数值算例结果验证了所提出的拓扑优化方法可以有效地进行复合材料微结构的导热性能设计。

关键词: 复合材料 导热性 均匀化方法 微结构 拓扑优化

Abstract: A new method is presented for thermal conductive microstructures of composite materials based on the technique of homogenization method and topology optimization. From the mathematical formulation of effective thermal conductivity for periodic microstructures, the effective conductivity matrix is evaluated by means of the finite element method. By defining the pseudo-density variable of each element in the design domain and constraining the total material cost, a topology optimization model with SIMP method is built to maximize either the effective thermal conductivity of the microstructure in specified directions or the thermal conduction efficiency of the macrostructure. The sensitivity of the objective function is then given. The optimal solution can be obtained by means of the dual optimization algorithm and perimeter constraint. Numerical results verify the validity of the proposed topology optimization method in the thermal conduction design of the microstructures.

Keywords: composite materials thermal conductivity homogenization method microstructure topology optimization

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