Multi-Objective Topology Optimization Design of Heat Exchangers

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Abstract

In the fields of aerospace, new energy equipment, and other related areas, the demand for compact and lightweight heat exchangers is increasingly growing. However, traditional designs often struggle to simultaneously meet the optimized requirements of structural compactness and thermofluidic performance. To address this contradiction, a topology optimization design method based on a multi-material model is proposed. This method can directly generate structures featuring both a compact morphology and a rational flow channel layout, with the capability to form two independent flow channels for the respective fluids. By constructing a weighted objective function, it takes maximizing heat transfer rate and minimizing pressure drop as dual optimization goals, and adjusts the priority of the two goals through a weight factor w to generate differentiated topological structures. The influence of the weight factor on the topological optimization structure, heat transfer rate, and pressure drop was systematically investigated via two-dimensional and pseudo-three-dimensional numerical simulations. These simulations not only revealed how the weight factor regulates the morphological evolution of the optimized flow channel structure but also provided quantitative insights into the trade-off between thermal performance and flow resistance. This study offers an efficient technical approach for the design of high-performance compact heat exchangers in the aerospace and new energy fields.

Keywords

Topology optimization, heat exchanger, weighted objective function, multi-material model.