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Topology Optimization of Heat and Mass Transfer for Two Fluids under Steady State Laminar Regime: Application on Heat Exchangers

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Abstract : Topology optimization technique presents a potential tool for the design and optimization of structures involved in mass and heat transfer. The method starts with an initial intermediate domain and should be able to progressively distribute the solid and the two fluids exchanging heat. The multi-objective function of the problem takes into account minimization of total pressure loss and maximization of heat transfer between solid and fluid subdomains. Existing methods account for the presence of only one fluid, while the actual work extends optimization distribution of solid and two different fluids. This requires to separate the channels of both fluids and to ensure a minimum solid thickness between them. This is done by adding a third objective function to the multi-objective optimization problem. This article uses density approach where each cell holds two local design parameters ranging from 0 to 1, where the combination of their extremums defines the presence of solid, cold fluid or hot fluid in this cell. Finite volume method is used for direct solver coupled with a discrete adjoint approach for sensitivity analysis and method of moving asymptotes for numerical optimization. Several examples are presented to show the ability of the method to find a trade-off between minimization of power dissipation and maximization of heat transfer while ensuring the separation and continuity of the channel of each fluid without crossing or mixing the fluids. The main conclusion is the possibility to find an optimal bi-fluid domain using topology optimization, defining a fluid to fluid heat exchanger device.

Keywords : topology optimization, density approach, bi-fluid domain, laminar steady state regime, fluid-to-fluid heat exchanger
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