ID de Contribution: **152** Type: **Non spécifié**

Topology optimization of fluid-to-fluid heat exchangers.

vendredi 4 décembre 2020 12:30 (30 minutes)

We present a topology optimization approach for the design of fluid-to-fluid heat exchangers which rests on an explicit meshed discretization of the phases at stake, at every iteration of the optimization process. The considered physical situations involve a weak coupling between the Navier–Stokes equations for the velocity and the pressure in the fluid, and the convection–diffusion equation for the temperature field. The proposed framework combines several recent techniques from the field of shape and topology optimization, and notably a level-set based mesh evolution algorithm for tracking shapes and their deformations, an efficient optimization algorithm for constrained shape optimization problems, and a numerical method to handle a wide variety of geometric constraints such as thickness constraints and non-penetration constraints. Our strategy is applied to the optimization of various types of heat exchangers. At first, we consider a simplified 2D cross-flow model where the optimized boundary is the section of the hot fluid phase flowing in the transverse direction, which is naturally composed of multiple holes. A minimum thickness constraint is imposed on the cross-section so as to account for manufacturing and maximum pressure drop constraints. In a second part, we optimize the design of 2D and 3D heat exchangers composed of two types of fluid channels (hot and cold), which are separated by a solid body. A non-mixing constraint between the fluid components containing the hot and cold phases is enforced by prescribing a minimum distance between them. Numerical results are presented on a variety of test cases, demonstrating the efficiency of our approach in generating new, realistic, and unconventional heat exchanger designs.

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Classification de Session: Session parallèle 8