Body-fitted topology optimization of 2D and 3D fluid-to-fluid heat exchangers

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This talk is concerned with a topology optimization approach for the design of fluid-to-fluid heat exchangers which rests on an explicit meshed discretization of the solid and fluid phases, 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.
A first example is 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.
A second example is 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.
This is a joint work with C. Dapogny, F. Feppon and P. Jolivet.