Shape optimization for a heat exchanger in Navier-Stokes flow with dynamic pressure at the outlet

Atsushi Suzuki
Cybermedia Center, Osaka University, Japan

We would like to maximize heat transfer from the metal part of the heat exchanger to the outer air. We now consider a stationary incompressible flow with enough moderate Reynolds number, which is passing through around a metal cylinder between the upper and bottom plates. For simplicity, we assume that the heat is transferred by the convection diffusion equation without buoyancy term. Our objective is to maximize surface-integrated heat flux by changing the shape of the cylinder surface.

A mathematical tool for this kind of optimization is the shape derivative calculated by variations of a smooth function that describes the shape. The sensitivity is calculated with solution of the state and adjoint equations. The shape of the cylinder-like object is optimized by a gradient flow solver with an inner product that is induced from a linear elasticity problem with some boundary conditions for the domain shape. To keep the deformed shape within a certain box, we use inequality constraint for the deformation.

For engineering purpose, we want to put dynamic pressure at the outlet of the flow. Therefore a bilinear for the Navier-Stokes equations consists of a curl-curl form and other nonlinear terms. Furthermore, a div-div form is added to enhance the coercivity of the discretized operator.

We will show FreeFEM implementation using distributed computation by `hpddm' and a technique to update boundary information by changing labels according to moved surface, which is obtained as a solution of the variational inequality.