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Topology optimization of stationary flow heat exchangers for transient thermal performance

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Transient thermal phenomena are observed in a wide range of applications, for example combustion processes, (additive) manufacturing, and precision instrumentation. Often these systems are conditioned by fluid heat exchangers to minimize temperature fluctuations and induced mechanical deformations. Relatively small temperature fluctuations have significant impact on the instrument's performance. Therefore, to enable stable sub-nanometer precision requirements, we desire to design heat exchangers with an desired, optimized *transient* thermal response.

We consider topology optimization to effectively deal with the complex, transient multiphysical interactions between the imposed thermal loading and the available cooling systems. Recently, heat exchanger design by topology optimization has been an active research topic. However, present studies only consider, e.g. for forced [1, 2] and natural [3] convection optimization problems. In these studies, the steady-state advection-diffusion equations are solved together with a coupled fluid model to represent either laminar or turbulent flow regimes.

Compared to earlier works, we extend the formulation to consider the transient advection-diffusion equations to design *transient* heat exchangers. The velocity field is assumed stationary in time and obtained from either a Stokes or laminar flow model. The desired transient thermal response is reached by optimizing the cooling channel layout. The corresponding sensitivity analysis is presented together with multiple numerical examples comparing the performance of the obtained steady-state and transient heat exchanger designs.

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