Topology Optimization of Channel Cooling Structures with Simplified Thermofluidic Models

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Abstract

This presentation introduces topology optimization approaches for channel cooling structural design with approximate but low-cost thermofluidic models, that considering thermal and coupled thermal-mechanical behaviors. The fluid flow is modeled using either the Darcy model [1] or a simplified convective heat-transfer model [2]. Linear problems are formulated and solved very efficiently instead of using the nonlinear Navier–Stokes equations. The governing equations are cast in a monolithic form such that the solid, fluid and void can be modeled using a single equation set. The material properties including permeability, conductivity, density and specific heat capacity are interpolated using the Solid Isotropic Material with Penalization (SIMP) scheme. Clear cooling channel and solid structural topologies are obtained by leveraging the pressure-drop constraint, the geometric length-scale control constraint and the phase-interface constraint when multiphase structure is considered. Several 2D and 3D numerical examples are given to demonstrate the applicability. Verification studies with a full turbulence model show that, although the simplified model has limitations in yielding a perfect realistic fluid simulation, it generally provides optimized channel cooling structural designs of desirable thermal and mechanical performances.

Reference

[1] X. Zhao, M. Zhou*, O. Sigmund, C. S. Andreasen, A "poor man's approach" to topology optimization of cooling channels based on a Darcy flow model, International Journal of Heat and Mass Transfer, 116, 1108-1123，2018.

[2] X. Zhao, M. Zhou*, Ping Hu, Topology optimization of channel cooling structures considering thermomechanical behavior, Struct Multidisc Optim (2018). https://doi.org/10. 1007 /s00158-018-2087-z