Multiphysics Topology Optimization of Heat Transfer and Fluid Flow Systems

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Introduction

Advanced electrical machine design is widely recognized as requiring both simulation and optimization of systems for multiple physical processes. Within this active engineering field several types of multiphysics problems may be defined including those related to heat transfer and fluid flow. Accordingly, this paper is focused on topology optimization of thermal/fluid systems in both two and three dimensions (2-D and 3-D) for multiphysics objectives.

Use of COMSOL Multiphysics

Following [1,2], COMSOL Multiphysics is coupled with a Method of Moving Asymptotes (MMA) optimizer [3] within the COMSOL/Matlab environment. Various governing equations (e.g. pure conduction, convection-diffusion, and/or Navier-Stokes) are implemented using the General PDE application mode and linked to the MMA optimizer in a custom Matlab script. The method is applied to a benchmark problem involving single-physics heat conduction for code validation purposes and then extended to include systems involving convection, diffusion, and fluid flow.

Expected Results

The 3-D model geometry and optimization results for the aforementioned single-physics heat conduction benchmark study are shown in Figures 1 and 2, respectively. The design domain shown in Figure 1 was subjected to a volumetric heat source. Additionally, a uniform fixed temperature boundary condition was applied to a partitioned bottom surface area representing a heat sink for the design domain. All remaining external boundaries were treated as adiabatic. The objective for the optimization problem was to determine the optimal structural topology that minimized the mean temperature of the domain while satisfying a predetermined volume constraint. The 3-D optimal topology shown in Figure 2 is a logical extension of 2-D results found in the literature [4].

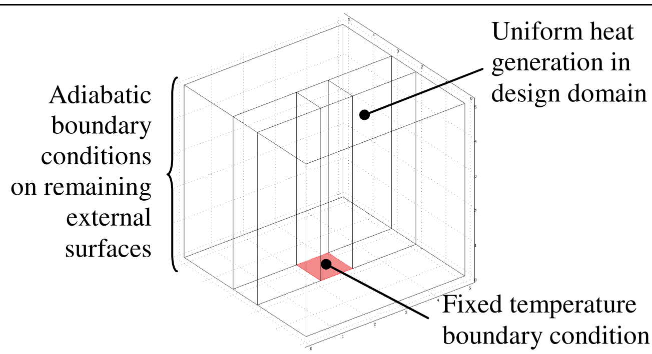

Figure 1. 3-D model geometry.

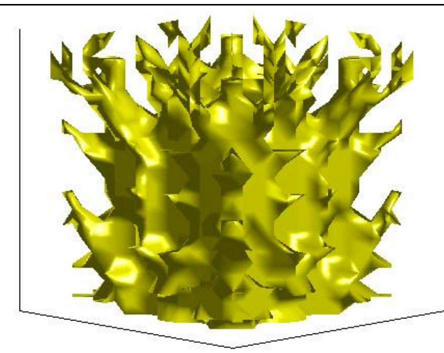

Figure 2. Optimal topology for pure conduction.

Conclusion

This abstract provides a basic overview of topology optimization results for a single-physics system. The final paper will focus on thermal/fluid multiphysics problems plus general method applications and limitations.

References

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