

Level set-based topology optimization of heat control devices

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Abstract

The aim of this research is to construct a design methodology of a heat control device that has recently attracted attention in the research field of electric devices. The heat control device is typically employed to control the temperature distribution of an electronic board on which various electric devices, e.g., the transistor and diode, are intricately put. For the appropriate evaluation of the heat control devices, previous study [Ercan M. Dede et al (2013)] proposed performance indexes, the so-called *focusing* and *cloaking*. The aim of focusing is to concentrate the heat flux to a target region on the electric board. On the other hand, the aim of cloaking is to avoid the influence of an obstacle that disturbs the temperature distribution. To radically improve these performances, we propose a topology optimization method for the design of highly efficient heat control devices, in which the performances of focusing and cloaking are maximized as the objective functional in the formulation of the optimization problem. In addition, we further define a new objective functional, the so-called *uniforming*, which aims to uniform the temperature distribution at a target region on the electric board. Based on the above formulations, we construct the optimization algorithm, in which the governing equation of heat conduction is solved using the finite element method, and the design sensitivities are derived based on the adjoint variable method. Furthermore, we use a level set boundary expression for completely eliminating grayscale in the optimal configurations [T. Yamada et al. (2010)]. Several numerical examples are provided to demonstrate the validity of the proposed method.

Keywords: Topology optimization, Level set method, Heat conduction, Heat control device.

References

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