Heat Flow Control via Optimized Composite Structures

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1. Abstract

The development of novel composite structures for heat flow control has significant potential for modern electronics systems. Thermal analogues of electronic transistors, rectifiers, and diodes are potentially possible through the informed structural combination of multiple bulk materials with different thermo-physical properties. In this presentation, a numerical optimization method is proposed for the development of such anisotropic heat flow control structures, and the technique is verified using benchmark results taken from the literature.

Recently, novel *a priori* arrangements of materials have been proposed to achieve the focusing, shielding, and reversal of heat flux in composite structures embedded in a surrounding thermally conductive medium [1]. Such unique results have previously been obtained by way of assumed anisotropic material structural configurations defined using analytical techniques and assumed coordinate transformations. However, a more general approach is to use numerical gradient-based optimization techniques in the development of anisotropic material thermal conductivity layouts for arbitrary geometries. Hence, this work builds off previous research related to the simulation and optimization of heat flow via anisotropic material thermal conductivity [2]. Specifically, the prior computational method has been extended to consider new optimization objective functions for heat flux focusing, shielding, and reversal. The corresponding numerical studies have been performed using a standard composite structural arrangement, and comparisons have been carried out with experimental results from existing literature.

Thus, the presentation will focus on this recent research, [3], related to the formulation of the anisotropic material thermal conductivity optimization problem. The three aforementioned objective functions will then be explored in depth. The overall validity of the approach will be examined through numerical experiments comparing our recent design results for a standard circular composite structure with benchmark results from the literature. Numerically optimizing the anisotropic material thermal conductivity of an arbitrarily shaped composite structure will also be demonstrated. Additional ongoing work related to the fabrication of real-world prototypes for advanced heat flow control applications will be briefly introduced.

2. Keywords: Anisotropic, Heat conduction, Structural optimization

3. References

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