Heat Transfer Maximization with the aid of a BEM-Isogeometric solver

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ABSTRACT

In this work, we consider heat transfer in a bilayered composite structure of infinite length comprising two different materials with varying conductivity coefficients. Specifically, we investigate the 2-D steady-state heat conduction across the periodic interface that separates the two aforementioned, conductive and conforming media, while the exposed surfaces of the composite structure are flat and isothermal. For the case of a flat, separating interface, the dimensionless heat transfer rate is given by $h_T = \frac{1}{H_1/\lambda + (H - H_1)}$, where λ is the ratio of the two conductivity coefficients, H is the thickness of the whole structure and H_1 the thickness of one of the layers; see [1]. Our focus in this paper is the modification of separating interface's shape with the aim of maximizing heat transfer under several constraints.

In our analysis, we assume a free-form, separating interface that is represented as a cubic NURBS curve, $s(t) = \sum_{i=0}^{n} \mathbf{b}_i R_{i,k}(t)$ where $\{R_{i,k}(t)\}_{i=0}^{n}$ is a rational $B-$spline basis of order, in our case, $k = 4$ defined over a knot sequence $\mathcal{J} = \{t_0, t_1, \ldots, t_{n+k}\}$. Using the Boundary Value Problem formulation described in [2], we end up with a system of boundary integral equations, having as unknowns the temperature and its normal derivative along the interface $s(t)$. Following the isogeometric analysis concept, introduced by Hughes et al [3], we employ in the representation of the field quantities (temperature & its normal derivative) the same basis used for the separating interface curve and solve the linear system resulting from the application of a collocation projection scheme. This leads into the formation of an BEM-Isogeometric solver that has superior convergence and accuracy properties when compared with classical low-order boundary element methods.

The major part of this work is devoted in the investigation and analysis of several practical cases of heat transfer maximization via shape modification of the interface separating the bilayered structure. Example cases involving the maximization of heat transfer under area and/or perimeter constraints will be demonstrated for scenarios, where all or part of the interface geometry is allowed to change.

REFERENCES

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