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A NURBS-based interface-enriched generalized finite element scheme for the computational analysis and design of high temperature microvascular composites

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ABSTRACT

Computational studies on multifunctional microvascular composite materials for high temperature application have focused on simple microchannel geometries [1–2]. Motivated by recent advances in the manufacturing of microvascular composites based on a sacrificial fiber technique that allows a complex network of curved microchannels to be embedded in the material [3], we develop an Interface Enriched Generalized Finite Element Method (IGFEM) [4] with Non-Uniform Rational B-Splines (NURBS) to analyze the impact of the microchannel network on the thermal field in the composite component [5]. By capturing the gradient discontinuity present at the microchannels, the method is able to simulate efficiently and accurately the thermal response of the microvascular composite without the need for a mesh that conforms to the geometry of the microchannels. We show that near-optimal convergence rate can be achieved and that IGFEM is more accurate than standard finite element method for coarse meshes when the enrichment functions are constructed using the NURBS description of the curved microchannels. Verification studies conducted against a detailed multiphysics model based on the Navier–Stokes equation for the fluid shows that the much simpler line source/sink model is very accurate for problems involving microvascular plates and fins. Various application problems are presented to demonstrate the efficiency, flexibility and accuracy of the proposed method.

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