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Non-Isothermal Variational Phase-Field Modeling in Hydraulic Fracturing

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In this research, we present a novel numerical framework for hydraulic fracturing that incorporates thermo-hydro-mechanical coupled effects. Unlike previous studies that have employed the phase-field method for hydraulic fracturing modeling, our work introduces a THM coupling scheme grounded in the variational phase-field approach, a significant advancement in the field. The THM coupling is crucial for understanding underground fracture propagation, and our study extends the variational phase-field model to a thermoporoelastic medium. This integration enables the inclusion of fluid flow and heat transfer elements in fractured materials. We model fluid flow and heat transfer in the matrix and fracture independently and derive unified flow and heat transfer equations using phase-field calculus. To solve the THM coupled system, we develop an iterative solution algorithm based on the fixed stress method. This algorithm effectively addresses the challenges associated with the coupled system. We discretize the proposed equations using the finite element method and employ a generalized Streamline Upwind Petrov Galerkin method for 8-node elements to mitigate numerical oscillations in advection-dominant issues within the heat transfer model. The accuracy of our model is validated by comparing the numerical results of fracture propagation with an analytical solution under the $\mathcal{K}$ regime. Additionally, we investigate the heat transfer process in a fractured domain, known as the Barends problem, using our model.

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