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Multi-field modeling of thermomechanical fracture and contact problems

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In this contribution we focus on a novel multi-field formulation for thermomechanically coupled fracture and contact problems. To be specific, we define the free Helmholtz energy density as a function of the deformation map $\mathbf{F}$, the temperature field θ as well as the crack phase-field $\mathfrak{s}$ and derive local constitutive relations in variationally consistent manner [1]. In sense of the Griffith theory for brittle fracture, a crack initiates or continues upon the attainment of a critical crack energy density, which exhibits a strong temperature dependency. Postulating that fracture requires a local state of tension, we apply an anisotropic decomposition of the principal stretches and reduce the tensile contributions by a suitable degradation function [2]. In case of fracture, the conduction (Duhamel's law) degenerates locally and the heat transfer depends on the crack opening width (pure convection). Therefore, we formulate the conductivity tensor in terms of $\mathfrak{s}$.

The thermodynamically consistent contact formulation involves thermomechanical contributions across the interface. Taking different contact reactions in normal and tangential direction into account, the Piola-traction vector on the interface is accordingly decomposed. The modeling of contact pressure and adhesion leads to a linear/exponential constitutive model in terms of the normal gap function. Furthermore, the traction in tangential direction is decomposed into isotropic and anisotropic surface contributions. For the spatial discretization we employ hierarchical refined NURBS (B-Splines) and apply a variationally consistent mortar method for the thermomechanical contact interface [3]. Numerical examples will show the accuracy and capability of the proposed approach.

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