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A multiscale projection method for the thermomechanical simulation of the interaction of microcracks with a macrocrack

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ABSTRACT

The multiscale projection method [1, 2, 3] has shown to be an efficient and effective technique to accurately simulate the interaction of microcracks and macrocracks and the possibly strong influence cracks that are orders of magnitude smaller than a macrocrack may have on the propagation behaviour of a the macrocrack. In [1, 2, 3] the method has been applied to two and three dimensional purely mechanical fracture problems of brittle materials. It employs the eXtended Finite Element Method (XFEM) to accurately capture cracks and their propagation on all scales independent of the finite element mesh.

In this contribution we extend the method to strongly coupled three dimensional thermomechanical problems taking into account the discontinuities of the temperature field across the microcracks and macrocracks as well as thermal expansion. Here, we restrict ourselves to two scales. The problem is solved on both scales in a monolithic way. The coarse scale displacement field as well as the temperature field along the boundary of the fine scale domain are transferred to the finie scale by means of a least squares projection. The refined stress field and the heat flux of the fine scale simulation is projected onto the coarse scale mesh. This way the fine scale features are implicitly taken into account in the coarse scale simulation. Several examples showing the capabilities of the method are presented. Additionally the method is applied to thermomechanically loaded turbine blades that exhibit microcracks in certain parts of the domain.

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