A Phase-Field Model for Crack Propagation in 3D using the Finite Cell Method

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Abstract

Phase-field models have become very popular in the field of fracture simulation, due to their elegant way of approximating the crack using a diffusive field which altogether avoids the modeling of discontinuities. The regularization of the sharp crack is based on a length-scale parameter which governs the extent of diffusion and determines the numerical width of the crack. For small length-scale parameters, a very fine mesh is needed at least in the vicinity of the crack to fully resolve the resulting crack profile. As this can quickly become expensive, Nagaraja et. al [2] combined multi-level hp-refinement [4] and a phase-field approach for brittle fracture in two dimensions to allow for a locally refined mesh which dynamically adapts to the crack path. In a second step, the Finite Cell Method (FCM) [1] was successfully integrated into the model to enable the efficient simulation of complex geometries.

In the following, we extend this promising framework to three dimensions and present a verification on several examples of torsional and pure bending fractures. The validity of the physical model is discussed for a series of loading experiments of V-notched specimen conducted in [3]. The presented numerical examples demonstrate the advantages of combining FCM and multi-level hp-refinement for large-scale problems and in the presence of heterogeneous structures.

References

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