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Three-dimensional crack nucleation, growth and coalescence using the Thick Level Set approach to fracture

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ABSTRACT

The thick level set (TLS) model [1, 2, 3] is a unified theoretical model able to model nucleation, growth and coalescence of cracks. It is based on a non-local model for damage. Its originality with respect to existing other non-local damage model (integral, second order, phase-field,...) is twofold. First, the boundary of the fully damage area (crack) is explicitly given by a level set. The introduction of a discontinuous kinematic is thus made easy in particular with the extended finite element method (X-FEM). The crack placement adjusts exactly to damage growth. This avoids drawbacks of ad hoc crack placement in damage zone, that is: convergence issue of the global solve if the crack is placed too late and abrupt loss or energy if the crack is placed too quickly. In the latter case, a remedy is to introduce a cohesive crack but this requires yet another model on top of the damage model. The second originality of the TLS is that non-local damage is restricted to a narrow band around the crack. The extra cost to deal with non-locality is thus small. Both originalities stem from the fact that the non-locality of damage is formulated by an Eikonal constraint and not a Laplacian constraint. Three-dimensional examples will demonstrate the capability of the TLS to model crack initiation, growth and coalescence.

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