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Numerical study of crack propagation in anisotropic materials using the phase field method

Edgar Zembra[1], Hervé Henry[2]

[1] Institut Polytechnique de Paris, France. edgar.zembra@polytechnique.edu
[2] CNRS, France. herve.henry@polytechnique.edu

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Abstract

3D-printed materials display strong anisotropic properties as their conception follows a layer by layer printing process. Accurate prediction of crack evolution in 3D-printed systems enables to evaluate their reliability for industrial applications. This study focuses on simulating crack propagation in such anisotropic materials and identifying the dominant mechanisms for a consistent modeling. The anisotropy can affect either the fracture energy or the material laws. In order to understand the respective effects of both anisotropies we present a numerical study using a phase field model. The phase field method enables the characterization of a cracked body in an implicit and diffuse manner by introducing an order parameter called the phase field. The evolution of the fractured system is based on the minimization of its total free energy and leads to solving a damped wave equation and a Ginzburg-Landau type equation. This system is solved by applying the finite difference method for a regular square mesh. The considered structure is a 2D plate initially cracked along its symmetry line and undergoing traction. First simulations are performed in the case where the sole anisotropy is due to the surface energy. The results are compared to Linear Elastic Fracture Mechanics (LEFM) predictions using the Generalized Maximum Energy Release Rate (GMERR) criterion. These results are then compared to those obtained by considering an anisotropic constitutive law (corresponding to a transversely isotropic elastic material). Finally conclusions are drawn.

Keywords:

fracture phase-field anisotropy