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Internal-stress-induced 3D brittle crack propagation within the configurational mechanics framework

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Internal-stress-induced brittle crack propagation is relevant for numerous industrial applications and is currently attracting significant research [1]. The present work involves extension of the authors' previous implicit crack propagation formulation, within the framework of configurational mechanics [2], to incorporate the effect of internal stresses. The formulation has been implemented as a module of open-source parallel finite element library MoFEM [3]. The elastic deformation and crack propagation are solved as a coupled problem. The classical conservation of linear momentum is described in the spatial domain, with Newtonian forces work conjugate to changes in spatial coordinates. In the material domain, an equivalent conservation law is described, where configurational forces are conjugate to changing material positions. In addition, the internal stress state is described by means of moving weighted least squares to provide a smooth stress field that is key to the robustness of the implicit crack propagation. In this study, stability of crack propagation in a heated glass plate which is progressively immersed in a cold bath is analysed, following previous works of [1]. For this problem, thermal stresses play the role of internal stresses and they are provided by an analytical solution that is a function of the immersion speed. An arc length control enables the nonlinear dissipative load path to be traced, ensuring monotonic crack increments by uniformly scaling the thermal stresses. Depending on the scaling needed to propagate the crack at a given immersion state, the propagation can be categorised as: spontaneous, stable or arrested. Results are compared to previously published numerical data.

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