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Transient dynamic crack analysis in multifield coupled smart functional materials by XFEM

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Functionally graded piezoelectric materials (FGPMs) are increasingly attracting more attention in a wide range of advanced engineering applications. FGPMs offer many challenging opportunities for engineers to design and apply novel intelligent devices and structures such as transducers, sensors, actuators, supersonics, microwave, etc. Imperfections, defects or cracks in FGPMs are generally unavoidable, and they may significantly affect the performance of the structures and are primary sources that not only result in damage and failure of the structures, but also disturb energetic exchanges of transmitted information in the process among the physical fields. In the present study, transient analysis of stationary cracks in homogeneous and linear FGPMs solids under impact loading (e.g., coupled or thermal loading) is presented. A dynamic extended finite element method in conjunction with the level-set method and the Newmark stable implicit time integration scheme is developed. The generalized dynamic intensity factors are computed using the interaction integrals taking the inertial effect into account and the asymptotic crack-tip fields in piezoelectric materials. Numerical examples for stationary cracks in FGPM solids with impermeable electromagnetic crack-face boundary conditions under impact loading are presented. Comparisons of the present numerical results with the reference solutions available in literature show very good agreements.

Keywords: Smart materials, Piezoelectric, Functionally graded piezoelectric materials, Dynamic fracture, XFEM, Finite element