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Ductile Fracture Representation using the Phase-Field Model in SIERRA

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ABSTRACT

The ability to computationally model the ductile fracture and failure of metals remains a compelling problem in the field of mechanical engineering. The ductile fracture mechanism involves the development of a finite plastic zone, the initiation of a crack with a blunted tip, and extension of the plastic zone and crack upon further loading. This problem is relevant to scientists and engineers at Sandia National Laboratories investigating material response to exceptional loadings. A class of numerical methods, known as phase-field models, have recently been applied to ductile fracture in scientific literature. Phase-field models approximate a discrete crack as a diffuse damage field in the crack vicinity. The introduction of a length-scale to limit the damage gradient acts to prevent spurious damage localization in the softening regime.

In this work, we introduce a phase-field model that has been developed at Sandia National Laboratories to aid scientists and engineers in computational fracture modeling using finite element analysis. This approach is implemented in *SIERRA*, a scalable multi-physics finite element code developed at Sandia. As implemented, the numerical model is inherently consistent with finite deformation mechanics and can be flexibly used with a variety of hardening models. We first give an overview of the mathematical formulation of the phase-field model and its implementation in *SIERRA*. Next, we present a model validation study using experimental fracture data of 6061-T651 aluminum. Lastly, we summarize our efforts to enable explicit time integration of the phase-field model for dynamic mechanical analysis.

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