Phase-field modeling of thermomechanical porous-ductile fracture

J. Schulte*, **M. Dittmann***, **F. Aldakheel†**, **F. Schmidt***, **M. Krüger*** **and C. Hesch***

* Chair of Computational Mechanics
University of Siegen
Paul-Bonatz-Strasse 9-11, 57076 Siegen, Germany
e-mail: jonathan.schulte@uni-siegen.de, maik.dittmann@uni-siegen.de,
felix.schmidt@student.uni-siegen.de, melanie.krueger@uni-siegen.de, christian.hesch@uni-siegen.de,
web page: https://www.mb.uni-siegen.de/nm/mitglieder/

† Institute of Continuum Mechanics
Leibnitz University Hannover
Appelstr. 11, 30167 Hannover, Germany
e-mail: aldakheel@ikm.uni-hannover.de , web page: https://www.ikm.uni-hannover.de/aldakheel

ABSTRACT

Phase-field methods to regularize sharp interfaces represent a well established technique nowadays. In fracture mechanics, recent works have shown the capability of the method for brittle as well as ductile problems formulated within the fully non-linear regime [1, 2].

In this contribution, we propose a novel framework to simulate porous-ductile fracture in isotropic thermo-elasto-plastic solids undergoing large deformations [3]. Therefore, a modified Gurson-Tvergaard-Needelman GTN-type plasticity model is combined with a phase-field fracture approach to account for a temperature-dependent growth of voids on micro-scale followed by crack initiation and propagation on macro-scale. The multi-physical formulation is completed by the incorporation of an energy transfer into thermal field such that on the other hand the temperature distribution depends on the evolution of the plastic strain and the crack phase-field.

For the spatial discretization of the proposed multi-field formulation, advanced finite-element schemes are required. In particular, NURBS based shape functions are applied to account for the biharmonic operator used within the phase-field regularization, whereas linear Lagrangian shape functions defined on the physical mesh representation of the NURBS geometry are applied for the equilavent plastic strain and its dual force to account for stability issues.

Eventually, a number of numerical investigations show not only the possibilities of the approach for a multi-physical analysis of complex material behavior, but also the accordance with experimental results in terms of hardening, necking, crack initiation and propagation. Moreover, a further example based on third Sandia Fracture Challenge is applied to demonstrate the capability of the model for the prediction of three-dimensional fracture pattern in complex geometries.

REFERENCES

[1] Dittmann, M. and Aldakheel, F. and Schulte, J. and Wriggers, P. and Hesch, C. Variational Phase-Field Formulation of Non-Linear Ductile Fracture. *Comput. Methods Appl. Mech. Engrg.*, **342**:71–94, (2018).

[2] Dittmann, M. and Krüger, M. and Schmidt, F. and Schuß, S. and Hesch, C. Variational modeling of thermomechanical fracture and anisotropic frictional mortar contact problems with adhesion. *Computational Mechanics*, Computational Mechanics, **63(3)**:571-591, (2019).

[3] Dittmann, M. and Aldakheel, F. and Schulte, J. and Schmidt, F. and Krüger, M. and Wriggers, P. and Hesch, C. Phase-field modeling of porous-ductile fracture in finite thermo-elasto-plastic solids. *Comput. Methods Appl. Mech. Engrg.*, submitted, (2018).