11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

3D ERROR CONTROLLED ADAPTIVE XFEM SIMULATION OF DUCTILE FRACTURE ON MULTIPLE SCALES

Stefan Loehnert[1*], Matthias Holl[2] and Corinna Prange[3]

[1] Institute of Continuum Mechanics, Leibniz Universitaet Hannover, Appelstr. 11, 30167 Hannover, loehnert@ikm.uni-hannover.de, www.ikm.uni-hannover.de
[2] Institute of Continuum Mechanics, Leibniz Universitaet Hannover, Appelstr. 11, 30167 Hannover, holl@ikm.uni-hannover.de, www.ikm.uni-hannover.de
[3] Institute of Continuum Mechanics, Leibniz Universitaet Hannover, Appelstr. 11, 30167 Hannover, prange@ikm.uni-hannover.de, www.ikm.uni-hannover.de

Key words: *XFEM, Cracks, Multiscale, Error Control, Ductile Fracture*

Fracture processes in general are a multiscale phenomenon. In most modern materials microcracks or microvoids develop in highly stressed domains. They coalesce and eventually form a macrocrack. Similarly, the propagation of a macrocrack is often accompanied with the nucleation of microcracks and microvoids in the vicinity of the propagating macrocrack front and their coalescence with the macrocrack. These microdefects may have a strong influence on the rather complex propagation behaviour. Crack shielding and amplification effects occur, and the direction of propagation is strongly influenced by the microstructure as well.

To accurately simulate such crack propagation phenomena multiscale techniques such as the multiscale projection method [1] are necessary, since influencing microcracks may be of several orders of magnitude smaller than the macrocrack or even the engineering part considered. Such simulations are still hardly possible to perform as a singlescale simulation on modern standard computers. Due to the fact that a fine scale analysis in the entire domain of the engineering part is neither of interest nor computationally reasonable, only the highly stressed domains need to be resolved accurately in a fine scale simulation. Additionally, the propagation of the macrocrack leads to a change of the highly stressed domain. This necessitates an adaptive update of the fine scale domain where fine scale features are modelled explicitly.

In this contribution we present an error controlled model and discretization adaptive multiscale method for the accurate simulation of fracture processes on multiple scales. The method is based on the multiscale projection technique [1]. Cracks are modelled using level set techniques as well as the eXtended Finite Element Method. Within the multiscale approach the fine scale domain is chosen automatically via a model adaptivity procedure. The combination of model adaptivity and error controlled discretization adaptivity enables the 3D simulation of the influence of microcracks that are at least three orders of magnitude smaller than the macrocrack. The complex material behaviour within the fracture process zone is modelled by a simple elastoplastic material model. A non-local equivalent strain model is used for the evaluation of the ductile crack propagation criterion. This criterion needs to be evaluated on the fine scale. The performance of the technique is demonstrated with a number of examples.

REFERENCES

[1] S. Loehnert, T. Belytschko. A multiscale projection method for macro / microcrack simulations. *Int. J. Numer. Meth. Engng.*, Vol. **71**, 1466–1482, 2007.

[2] C. Prange, S. Loehnert, P. Wriggers. Error estimation for crack simulations using the XFEM. *Int. J. Numer. Meth. Engng.*, Vol. **91**, 1459–1474, 2012.

[3] M. Holl, S. Loehnert, P. Wriggers. An adaptive multiscale method for crack propagation and crackcoalescence. *Int. J. Numer. Meth. Engng.*, Vol. **93**, 23–51, 2013.

[4] S. Loehnert, C. Prange, P. Wriggers. Error controlled adaptive multiscale XFEM simulation of cracks. *Int. J. Fract.*, Vol. **178**, 147–156, 2012.

[5] M. Holl, T. Rogge, S. Loehnert, P. Wriggers, R. Rolfes. 3D multiscale crack propagation using the XFEM applied to a gas turbine blade. *Comput. Mech.*, DOI 10.1007/s00466-013-0900-5, 2013.