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

CRACK NUCLEATION AND PROPAGATION IN HIGHLY HETEROGENEOUS MATERIALS MODELS OBTAINED FROM MICROTOMOGRAPHY IMAGES USING PHASE FIELD METHOD

T.T.Nguyen[1,2] , J.Yvonnet[1], Q.-Z.Zhu[1], M. Bornert[2], C. Chateau[2]

[1] Université Paris-Est, Laboratoire Modélisation et Simulation Multi Echelle, 5 Bd Descartes 77454 Marne-la-Vallée Cedex 2, France

[2] Université Paris-Est, Laboratoire Navier, Ecole des Ponts ParisTech, 6,8 avenue Blaise Pascal, 77455 Marne-la-Vallée, France.

Key Words: *Phase-field, heterogeneous materials, microtomography images, crack nucleation, crack propagation.*

Abstract: In this work, we propose an accelerated phase field method for crack nucleation and propagation in highly heterogeneous materials. In the treated problems, the microstructure models are obtained from microtomography images and thus consist into fine, regular grids of voxels, each converted into a single element. In that context, crack nucleation and propagation is a very challenging problem, due to the presence of a very large number of inclusions and pores with arbitrary shapes. To avoid remeshing and issues related to explicitly describe discontinuities, a phase field method is adopted [1]. Due to the highly complex geometrical models involved, we propose an accelerated version of the method by (a) using a modified projection operator for computing the traction/compression split of the strains, which is highly time-consuming and (b) a straightforward parallel algorithm combined with efficient iterative solvers to treat very large problems.

Phase field models for fracture employ a continuous field of variables to describe cracks. The width of the transition zone between cracked and uncracked areas on a small length scale is controlled by a regularization parameter. Phase-field description, based on the Griffith theory [2] of brittle fracture and the variational approach to fracture mechanics proposed by B. Bourdin, et al. (2008) [3], does not require numerical tracking of discontinuities in the displacement field, and allows to greatly reduce computational complexity.

We illustrate the methodology through several numerical examples involving crack nucleation and propagation in microtomography-based concrete models and other complex microstructures in two and three dimensions.

REFERENCES

[1] C. Miehe, M. Hofacker and F. Welschinger. A Phase Field model for rate-independent crack propagation. *Computer Methods in Applied Mechanics*, 199:2765-2778 (2010)

[2] A.A. Griffith, The phenomena of rupture and flow in solids, *Philosophical Transactions of the Royal Society London* A, 221:163-198 (1921)

[3] B. Bourdin, G.A. Francfort, J.J. Marigo, The Variational Approach to Fracture, *Springer Verlag, Berlin*, 2008