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

XFEM-SIMULATIONS OF HYDRAULIC FRACTURING IN 3D WITH EMPHASIS ON STRESS INTENSITY FACTORS

Thomas-Peter Fries[1], Nikolai Weber[2]

[1] Institute of Structural Analysis, Graz University of Technology, Lessingstr. 25/II, 8010 Graz, Austria, fries@tugraz.at, www.ifb.tugraz.at

[2] Chair for Computational Analysis of Technical Systems, RWTH Aachen University, Schinkelstr. 2, 52062 Aachen, Germany, weber@cats.rwth-aachen.de, www.xfem.rwth-aachen.de

Key Words: *XFEM, 3D fracture, hydraulic fracturing.*

Hydrocarbon and thermal reservoirs are routinely treated by fracturing the rock with a pressurized liquid in order to increase the permeability, hence the production. This “hydraulic fracturing” involves a number of physical phenomena taking place on different length and time scales. A multitude of models and approaches have emerged that focus on different aspects of the complex physical processes [1]. Often, the focus is on the fluid flow inside the fracture and the situation at the crack front whereas the rock is often highly simplified (i.e. homogeneous, isotropic, and mostly two-dimensional).

Our long-term aim is to model the rock and the developing fracture in 3D with the ability to account for an arbitrary layering and in the presence of arbitrarily oriented faults. We use the XFEM [2] with a hybrid explicit-implicit description of the fracture as proposed in [3]. The advantage is that, for the XFEM-simulation of the deforming rock, the highly beneficial implicit description by means of level-sets is employed. On the other hand, an explicit description in terms of a triangle surface mesh is used for the propagation. When simulating hydraulic fracturing, the additional advantage of this approach is that the model for the fluid flow inside the fracture is solved on the triangle mesh. This is naturally a physical problem taking place on a potentially curved manifold.

We discuss different approaches for the reliable evaluation of stress intensity factors for fluid-filled cracks under pressure. The pressure distribution inside the fracture is based on well-known solutions from different regimes (viscosity- and toughness-dominated) [1]. Pressure values at the nodes of the triangle mesh are taken as input, and consistently transformed to the appropriate loading within the XFEM-solver, which also determines the evaluation of the fracture. The advantage is that the resulting approach is very modular and provides an interface to external simulation codes as long as they are able to correctly specify pressure values on the triangulated fracture surface.

REFERENCES

[1] J. Adachi, E. Siebrits, A. Peirce, J. Desroches: Computer simulation of hydraulic fractures, *Int. Journal of Rock Mechanics & Mining Sciences*, **44**, 739-757, 2007.

[2] T.P. Fries, T. Belytschko: The extended/generalized finite element method: An overview of the method and its applications, *Int. J. Numer. Methods Engrg*., **84**, 253-304, 2010.

[3] T.P. Fries, M. Baydoun: Crack propagation with the XFEM and a hybrid explicit-implicit crack description, *Int. J. Numer. Methods Engrg.*, **89**, 1527-1558, 2012.