



Modeling of Fracturing in Fluid Saturated Porous Media

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Abstract

In solid mechanics, except for dynamic problems, crack propagation is considered without invoking the time dimension. This is not the case in crack propagation in fluid saturated porous media. The first difference is that here the fracture lips are not stress free since the fluid pressure acts on them. The second difference is that there are three velocities involved: the crack tip advancement velocity on one side and the seepage velocity of the fluid in the domain, and the fluid velocity within the crack on the other side. All three velocities interact and strongly influence the outcome of the process: as the crack tip advances the newly created space has to be filled with fluid, which comes from the porous media volume surrounding the crack and from flow through the crack itself. Hence, time clearly matters in this case. Evidence of the interaction can be found in the fact that different fluid permeability (or dynamic viscosity) influences not only the length of the fracture and the pressure distribution, but also its direction. But the most important aspect of the interaction between the velocities is the stepwise advancement of the fracture and the pressure oscillations. Experimental evidence for the stepwise advancement has been obtained by Pizzocolo et al. (2012). Pressure fluctuation has been evidenced by Tzschichholz and Herrmann (1995) with a 2D lattice model for constant injection rate and homogeneous and heterogeneous materials which only break under tension. These aspects will be investigated with two methods of fracture advancement technique: the first one, in conjunction with Standard Galerkin Finite Element Method (SGFEM), requires continuous updating of the mesh because of the continuous variation of the domain as a consequence of the propagation of the cracks. The second one avoids updating of the mesh by means of an Extended Finite Element Method, XFEM. Examples deal with pressure induced fracture and peel test of a fluid saturated specimen. Results on mesoscale with methods from statistical physics will also be shown.

Bio

Bernhard A. Schrefler holds a ME degree in Structural Engineering from the University of Padua (summa cum laude), a PhD and DSc from the Swansea University, Wales. He is Secretary General of the International Center for Mechanical Sciences (CISM) in Udine, Professor Emeritus of Structural Mechanics at the University of Padua and Senior Affiliate Member of the Department of Nanomedicine of the Houston Methodist Research Institute, TX. For his research work Dr. Schrefler has been awarded the Maurice A. Biot Medal from ASCE, the Euler Medal from ECOMAS, the Olgierd C. Zienkiewicz Medal from PACM, the Computational Mechanics Award from IACM, the IACM Award and the Palmes Académiques in France. He has received honorary doctorates from the St. Petersburg State Technical University, the University of Technology of Lodz, the Leibniz University of Hannover, the Russian Academy of Sciences and the Ecole Normale Supérieure at Cachan, an honorary fellowship from the University of Wales Swansea and an honorary professorship from the Dalian University of Technology. Dr. Schrefler is a member of the National (Italian) Academy of Sciences ("dei XL"), of the Accademia Galileiana di Scienze, Lettere ed Arti, of the Istituto Veneto di Scienze, Lettere ed Arti. His current research focuses on tumor growth modeling and transport of nanoparticles in diseased microvasculature and on hydraulic fracturing.