XFEM modelling of hydraulic fracturing

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ABSTRACT

A computational model based on the extended finite element method (XFEM) is developed for hydraulic fracture analysis. The porous media equations are obtained by applying the balance equations of mass and momentum for both solid and fluid phase and assuming the Biot-Coussy poroelastic constitutive equations for modelling the behaviour of the solid phase, whereas the Darcy's law is employed to describe the fluid transport within the intact part. As opposite, the flow through the crack is modelled by generalizing the Poiseuille's law for viscous fluids to the flow between two parallel plates, and assuming the conductivity dependent on the dynamic viscosity and the crack opening displacement. The full coupled equations between the flow and the displacement field of the matrix are obtained by applying the mass balance equations within the discontinuity.

The displacement field, pressure, and the discontinuities are approximated in the space using the XFEM, whereas the time discrete scheme is obtained by applying the backward Euler method. The resulting discrete nonlinear equations are solved by applying the Newton-Raphson's method.

A model problem of hydraulic fracturing is analysed, by looking particularly at its behaviour near the crack-tip. Numerical experiments on the convergence with respect to mesh discretization and orientation are also presented.

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