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Numerical Borehole Breakdown Investigations using XFEM

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During pressurization of a wellbore a typical downhole pressure record shows the following regimes: first the applied wellbore pressure balances the reservoir pressure, then after the compressive circumferential hole stresses are overcome, tensile stresses are induced on the inside surface of the hole. When the magnitude of these stresses reach the tensile failure stress of the surrounding rock medium, a fracture is initiated and propagates into the reservoir. [1]

In standard theories this pressure, the so called breakdown pressure, is the peak pressure in the down-hole pressure record. However experimental investigations [2] show that the breakdown did not occur even if a fracture was initiated at the borehole wall. Drilling muds had the tendency to seal and stabilize fractures and prevent fracture propagation. Also fracture mechanics analysis of breakdown process in mini-frac or leak off tests [3] show that the breakdown pressure could be either equal or larger than the fracture initiation pressure.

In order to gain a deeper understanding of the breakdown process in reservoir rock, numerical investigations using the extended finite element method (XFEM) for hydraulic fracturing of porous materials [4] are discussed. The reservoir rock is assumed to be pre-fractured. During pressurization of the borehole, the injection pressure, the pressure distribution and the position of the highest flux along the fracture for different fracturing fluid viscosities are recorded and the influence of the aforementioned values on the stability of fracture propagation is discussed.

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[3] DETOURNAY, E.; CARBONELL, R. (1996), “Fracture Mechanics Analysis of the Breakdown Process in Minifrac or Leakoff Test”, Society of Petroleum Engineers, Inc.
[4] MESCHKE, G.; Leonhart, D. (2015), “A generalized finite element method for hydro-mechanically coupled analysis of hydraulic fracturing problems using space-time variant enrichment functions.” Computer Methods in Applied Mechanics and Engineering, 290:438 - 465