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XFEM MODELING OF MULTIPLE STAGE HYDRAULIC FRACTURE CONTAINMENT IN MULTI-LAYERED FORMATIONS

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ABSTRACT. One of the challenges of the hydraulic fracturing operation is the determination of the fluid-driven vertical fracture extent. In cases such as cuttings re-injection and CO2 sequestration fractures must be contained mainly to the pay zone since fracture breakout into overlaying or underlying formations with water-bearing zone can lead to irreparable water damage to the formation [1]. Generally, the completion of horizontal well hydraulic fracturing is performed using one of the following schemes: simultaneously hydraulic fracturing (Sim-HF), in which multiple fractures are potentially initiated and propagated together in one horizontal wellbore while in Sequentially Hydraulic Fracturing (Seq-HF), fractures are established one after another. On the other hand, in Modified Zipper-Frac (MZF), fractures on two or more lateral wells are situated in a staggered pattern with presence of a middle fracture between two consecutive fractures [2]. The stress perturbation owing to placement of multiple fractures can affect the fracture geometry such as length, aperture, height, and propagation direction, therefore, multiple hydraulic fracturing treatment should not be designed identical to a single hydraulic fracturing simulation [3]. Numerical modelling of hydraulic fracturing can reduce uncertainties in the reservoir integrity. In this work, The Extended Finite Element Method (XFEM) was implemented in a hydro-mechanical coupled formulation to simulate hydraulic fracturing processes considering the propagation of several vertical planar fluid-driven fractures for a transient analysis. This paper focuses on the stress shadowing effects, on the pressure required for crack extension and on the resulting fracture geometry considering the three different hydraulic fracturing schemes. Firstly, the numerical implementation is compared to the asymptotic analytical solution of KGD in the toughness dominated propagation regime (K-vertex) [4] for validation. Secondly analytical solutions proposed by Simonson [5] and Fung [1], which study symmetrical (no vertical variation in tectonic stress) and asymmetrical (vertical variation in tectonic stress) tri-layered formations. According to these results, the predicted pore pressure for crack propagation exhibits good agreement with the analytical solutions. As a result, the MZF scheme increases the risk of activating natural fractures enhancing fracture complexity and higher drainage area compared to others.

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