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Hydraulic Fracture Propagation in a Multi-Layer Fractured Media

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ABSTRACT

Unconventional reservoirs contain rock discontinuities such as faults and natural fractures that have the potential to control how a hydraulic fracture grows and interacts with the rock formations during fracture stimulation operations. Natural fractures and faults, when intersected by a hydraulic fracture, can be activated by opening and/or slipping processes, diverting injection fluid into them, and increasing their fluid pressure and aperture. Alternatively, natural fractures can be crossed by a hydraulic fracture with little or no fluid intake. Stress perturbations could lead to reactivation of other optimally-oriented discontinuity planes, even in cases where they remain sealed or closed. The objective of this study is to explore the role of natural fractures for hydraulic fracture propagation, and quantify its effect in fracture geometry, (e.g., fracture containment, fracture dimension, effective fracture area, and proppant placement, etc.) and identify conditions that promote an effective stimulation, using a 3D fully-coupled finite-element simulator. This is accomplished by running several instances of a single hydraulic fracture growing in a multi-layer formation containing layers of variable stress, elastic properties, and fracture toughness, and systematically varying parameters such as the coefficient of fault friction, stress contrast, fracture intersection angle, fluid viscosity, and proppant size. Results indicate that the presence of natural fractures has a considerable effect on the hydraulic fracture geometry. When compared to a reference case without natural fractures, presence of natural fractures reduced the length and average width of the hydraulic fracture, and increased its height and maximum width, except for a case with 60° fracture-intersection angle dipping 90°, in which the fracture height was reduced but its average width increased. A relative reduction in the friction coefficient generated an overall hydraulic fracture width reduction, and a relative increase in the stress contrast generated a hydraulic fracture height increase. To maximize the effective fracture area and create conditions for the proppant to enter the natural fractures, the “right” combination of proppant size and fluid viscosity must be considered.