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Recent Developments in the Generalized Finite Element Method for the Simulation of 3-D Hydraulic Fracture Propagation and Interactions

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ABSTRACT

Computational methods adopted in the oil and gas industry for the simulation of hydraulic fractures assume planar crack geometries. Several recent laboratory experiments and monitoring of actual field treatments however, suggest that a hydraulic fracture can grow in complex shapes due to misalignment of the fracture relative to maximum horizontal in-situ stress, geological layering, existence of natural fracture networks in the reservoir and interactions among hydraulic fractures. This presentation reports on recent advances of the Generalized or Extended Finite Element Method (G/XFEM) for three-dimensional hydraulic fractures. In particular, we present new algorithms able to handle (i) Simulations of 3-D non-planar fractures with complex geometries [2]; (ii) Interaction and coalescence of 3-D non-planar crack surfaces and (iii) Simulations involving highly non-convex crack fronts. Computational aspects and challenges in this class of methods such as representation of 3-D crack surfaces with sharp features [1] and numerical stability [3], are also discussed. Discretization errors and computational cost are controlled through adaptive mesh refinement and enrichment. Strongly graded 3-D discretizations are automatically updated as the fracture evolves. The asymptotic expansion of the elasticity solution in the neighborhood of a hydraulic crack front is adopted as enrichment functions for the GFEM. Various non-planar geometries are investigated to demonstrate the flexibility and robustness of the simulation methodology.

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