An adaptive meshing approach to capture hydraulic fracturing

O. Omidi, R. Abedi, S. Enayatpour

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ABSTRACT

Hydraulic fracturing is widely employed to stimulate oil and gas reservoirs to increase the productivity of these naturally fissured rock domains. Different numerical techniques are available to examine how hydraulic fractures propagate. They are mainly categorized into continuum and interface-based methods. Cohesive models are among the most effective class of interfacial approaches representing crack surfaces as sharp material interfaces. In lieu of a traditional cohesive model, we have formulated and employed an interfacial damage model that incorporates the processes of nucleation, growth and coalescence on the fracture surfaces. Utilizing a dynamic adaptive meshing, we employed a Spacetime Discontinuous Galerkin (SDG) finite element method to simulate hydraulic fracture propagation. Our SDG implementation adaptively aligns the element boundaries with crack-path trajectories that are obtained as a part of the solution according to a crack growth criterion. Thus, this model does not suffer the mesh-dependent effects encountered in most other numerical fracture models. Furthermore, no discontinuous features are introduced within the elements as opposed to XFEM and generalized finite element methods. Adaptive mesh refinement in an area allows free nucleation, growth and branching of cracks oriented arbitrarily in the domain without any mesh bias whereas a coarse mesh can be used in other regions of the domain to utilize an efficient implementation. Presenting numerical examples, we performed a sensitivity analysis of some input variables such as the magnitude of *in-situ* stress components, number and orientation of induced fractures is performed to demonstrate the effectiveness of our approach in resolving hydraulic fracturing.

KEY WORDS: hydraulic fracture; interfacial damage; spacetime discontinuous Galerkin; crack branching; adaptive meshing; path-dependent solution