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Phase-field modeling of fracture propagation under hydraulic stimulation in pre-fractured rocks

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The presentation presents the numerical analysis of hydraulic fracturing within Griffith theory of brittle damage. The phase-field method [1] is employed to model brittle fracture propagation driven by pressurized fluids within fully saturated porous rocks. The phase-field equation is coupled with the Biot-theory using the effective stress concept. The porous rock is assumed as fully saturated with incompressible fluid and deforms within elasticity theory. The hydraulic fracturing propagates under mode I crack opening in quasi-static regime with slow fluid flow in porous matrix and fracture. The phase-field approach for the modelling of brittle fracture [2] coincides with the maximum energy release rate criterion in fracture mechanics theory. The phase-field equation is approximated over entire the domain and introduces new degree of freedom (damage variable). Crack surface is represented by a smooth regularized damage distribution over the fractured area.

The presented numerical investigations are characterized by different scenarios of hydraulic stimulation and the interaction of a new fracture emanating from the bore hole with pre-existing cracks. The scenarios include predefined fractures with different oriented to specific angle and spatial distribution over the entire domain. The undamaged rock matrix is modeled as an isotropic elastic material with initial porosity and isotropic matrix permeability. The flow within the undamaged region is governed by Darcy's law while the fluid flow in fractures is approximated by cubic law with the crack opening computed from the displacement solution and the damage variable distribution [3]. Initial fractures are modeled by an initial distribution of the damage variable and by special zero-thickness interface finite elements. Adaptive algorithms in conjunction with appropriately chosen refinement criteria are utilized to reduce the computational costs.

References

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