Thermal Effects during Hydraulic Fracturing in Low-Permeability Brittle Rocks

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ABSTRACT: A three-dimensional finite-element model for hydraulic fracturing has been developed that accounts for local thermal non-equilibrium between the injected fluid and host rock. The model also accounts for fluid flow and heat transfer within the fracture, heat conduction through the solid rock, deformation of the rock, and propagation of the fracture. Fluid flow through the fractures is modeled using the lubrication equation, and is fully coupled to the thermoelastic mechanical model through the pressure exerted by the fluid on the fracture walls, as well as by ensuring compatibility of fracture volumetric strains. Fractures are discretely modeled using triangular surfaces in an unstructured three-dimensional mesh. The growth of fractures is modeled using linear elastic fracture mechanics (LEFM), with the onset and direction of growth based on stress intensity factors that are computed for unstructured triangle-tetrahedral meshes. The model has been verified against analytical solutions available in the literature for penny-shaped (3D) fractures. A radial hydraulic fracture from a horizontal well is simulated to investigate the effects of the thermal non-equilibrium between the fracturing fluid and the host rock. For the case of very low matrix rock permeability, results show very little influence of thermal effects on the creation of hydraulic fractures.

Saeed obtained his BSc in Civil Engineering and MSc in Structural Mechanics and Materials from Sharif University of Technology, Tehran, Iran; and his PhD in Geotechnical Engineering from University of New South Wales (UNSW), Sydney, Australia. As a Research Associate in the Rock Mechanics group at the Department of Earth Science and Engineering, Imperial College, Saeed is co-investigator in CONTAIN project: *The impact of hydrocarbon depletion on the treatment of caprocks within performance assessment for CO2 injection schemes*. Saeed is developing tools for the CSMP (Complex Systems Modelling Platform), an object-oriented software coded in C++, to be used for coupled thermo-poroelastic modelling of CO2 sequestration, as well as hydraulic fracturing.