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Modeling Two Phase Flow in Fractured Rocks Considering Hydromechanical Behaviour and Fluid Leakage

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Introduction
Understanding the fundamental mechanism of the hydromechanical process and fluid leakage is crucial in modeling fractured reservoirs. Traditional simulation methods often assume impermeable and rigid fracture walls, which neglects the effects of fracture deformation and fluid leakage. This work introduces a Darcy-Brinkman-Stokes method to capture the effects of fracture deformation and fluid leakage in modeling the fluid flow in fractured rocks.

Methodology
To deal with the multiscale feature in fractured media, we employ the Navier-Stokes equation to model the fluid flow within the fractures and use Darcy's law to represent the flow with porous media. We then apply the stress-seepage model, based on Biot's poroelasticity theory and Terzaghi's effective stress theory, to capture the geomechanical deformation. Specifically, we use the Darcy-Brinkman-Stokes method to achieve this goal, in which a unified equation is deployed to model the flow both in the fractures and the porous media. By tuning the range of the porosity and permeability, the Darcy-Brinkman-Stokes can mimic the Navier-Stokes equation within the fracture and Darcy's law within the porous media. We then conduct various sensitivity analyses to investigate the leakage effects by varying the fracture and matrix permeability, fracture roughness, effective normal and shear stress, and Reynolds number.

Results and Conclusions
The velocity and pressure profiles demonstrate the eddy area's exits, which significantly block the fluid leakage between the fracture and matrix. We also observe the apparent effects of the degree of the fracture roughness, effective normal and shear stress, and inertia on flow predictions in modeling the fluid flow within the fractures. The hydraulic properties can be significantly affected under high fracture roughness, high matrix permeability, high effective normal stress, and low Reynolds number condition. We then verify the observations in laboratory tests. The lab tests demonstrate that the proposed method can predict the permeability well under different effective normal and shear stress, fracture roughness, inertia, and Reynolds number. Regarding the effective shear stress condition, the fracture aperture and permeability can be enhanced even with the increase of the effective normal stress. This situation could occur as long as more openness of the fracture caused by shear dilation exceeds the closure induced by the increase of effective normal stress.

We develop a fully coupled model to capture the hydromechanical behavior and fluid leakage in modelling two phase flow in fractured rocks. To our knowledge, the fully coupled framework is developed and applied to characterize fracture aperture displacement, further permeability change, and fluid leakage between fracture and matrix at the pore scale in fractured rocks for the first time.

Participation

In-Person

References

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