Contribution ID: **331** Type: **Oral 20 Minutes**

3D simulation-based study of shear-thinning fluid flow in a sandstone fracture

Monday, 14 May 2018 14:43 (15 minutes)

Shear-thinning fluids flow in the rough fracture is encountered in numerous industrial applications such as hydraulic fracturing fluids flow in rough hydraulic and natural fractures to carry the proppants, polymer gel extrusion through rough fracture to reduce excessive water production in naturally fractured reservoirs, CO2 sequestration and leakage through rough fractures, etc. We investigate both the macroscopic flow behavior and microscale flow details of shear-thinning fluids through a realistic rough fracture for both linear and inertial flow regimes.

For the first time, a fully-3D flow simulation of Cross power-law shear-thinning fluids through a rough fracture is conducted. The flow domain is extracted and refined from a computed microtomography image of a fractured Berea sandstone. The modified Navier-Stokes equation incorporating Cross power-law fluid rheology model is solved. The critical Reynolds number above which the linear Darcy's law is no longer applicable is evaluated for both Newtonian and shear-thinning fluids.

First, the Newtonian fluid flow simulations are conducted, and the hydraulic/equivalent aperture and inertial coefficient in Forchheimer's equation are fitted. Second, based on the simulation results of shear-thinning fluid flow, both the shift factor and inertial coefficient are obtained. Specifically, the shift factor is a critical parameter in the definition of "in-situ shear rate"which could be used to evaluate the "equivalent"viscosity based on the "bulk"viscosity. Our results show that the shift factor is dependent on both the fracture geometry and fluid rheology properties while both the inertial coefficient and critical Reynolds number are only functions of fracture geometry, which is consistent with the recent experimental results. Third, to explain the above phenomena, a detailed analysis of microscopic flow patterns is conducted.

Based on the analysis of a large number of simulations, we propose a correlation for shift factor which is quantified by the product of one fluid property parameter and tortuosity. The fluid property parameter is obtained from the analytical/semi-analytical solutions of the same shear-thinning fluids flow in a smooth slit. Two approaches are provided for tortuosity quantification. One is based on the detailed pore-scale velocity field and produces a very accurate shift factor. The other is the geometric tortuosity obtained by image analysis without doing any pore-scale simulations, which provides an approximate value for shift factor. The Forchheimer's equation with our newly improved shift factor correlation can be used in the higher-level macro-scale simulators to direct the relevant industrial applications.

References

Acceptance of Terms and Conditions

Click here to agree

Primary authors: ZHANG, Min (The University of Texas at Austin); Prof. PRODANOVIĆ, Maša (The University of Texas at Austin); Dr MIRABOLGHASEMI, Maryam (Mississippi State University)

Presenter: ZHANG, Min (The University of Texas at Austin)

Session Classification: Parallel 2-G

Track Classification: MS 1.08: Non-linear flows in porous media: impact of inertia and non-linear rheologies on pore scale processes and applications