Model of Pressure Drop Separation During Aqueous Polymer Flow in Porous Media

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Abstract

Aqueous polymers used in enhanced oil recovery (EOR) applications exhibit Newtonian and Non-Newtonian behavior depending on the interstitial velocity or the stress magnitude that is submitted during the flooding process. This behavior will cause different pressure changes while flowing through the porous media. A new correlation proposed by the authors is utilized as an input to COMSOL Multiphysics® software. The correlation describes the polymer flow by examining the pressure drop associated with the flow dominated by extension and differentiate them of those dominated by shear. Commercial reservoir simulators are able to simulate the total pressure drop measured from the laboratory experiment by only assuming shear thickening behavior throughout the flooding experiment. Meanwhile, the total pressure drop from the flooding experiment itself actually results from both the shear thinning behavior and the shear thickening behavior. In other words, the simulators cannot separate the pressure drop contribution from shear (shear thinning) and elongation (shear thickening) deformation of the polymer molecules, which will take place due to the contraction and expansion in the pore geometry. Therefore, the main objective of this paper is to implement the proposed correlation in COMSOL Multiphysics to take into account the contribution of shear and elongation deformation to the total pressure drop observed during the experiment.

The Darcy Law interface was used to calculate the pressure difference in single phase condition. 3-D core model (Figure 1) was constructed in COMSOL® and the flow direction is assumed to be only in the x-direction. The free tetrahedral mesh (Figure 2) was selected as the mesh type of the simulation model with the element size of extra coarse to reduce simulation time. The mesh was calibrated for fluid dynamics. In the laboratory experiment, the core sample was surrounded by the confining pressure to create the linear flow direction, while no flow boundary was selected in the simulator to replace the confining pressure. The proposed correlation was utilized as variables in COMSOL.

Due to Multiphysics capabilities of COMSOL, we can implement the new correlation to separate shear and elongation contribution to the pressure drop during aqueous polymers flow in the porous media (Figure 3). As a result, we can reproduce the total pressure drop from the experiment, particularly in the high rate region (shear thickening) by using the simulator. Moreover, the implementation of the proposed correlation leads us to the new insight of the displacement efficiency by polymer enhanced oil recovery (EOR) method.

Reference

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Figures used in the abstract

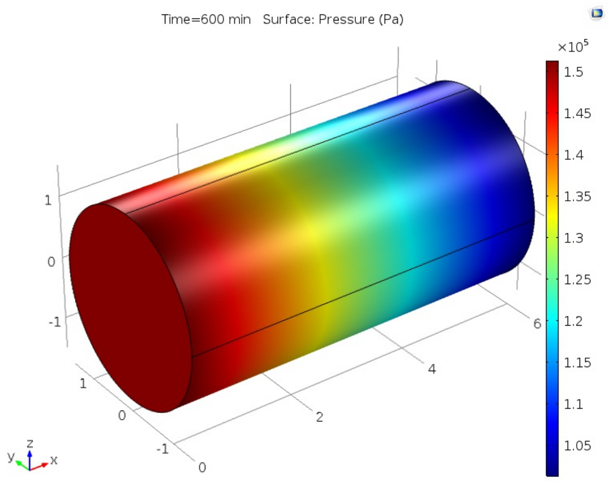

Figure 1: Core Model.

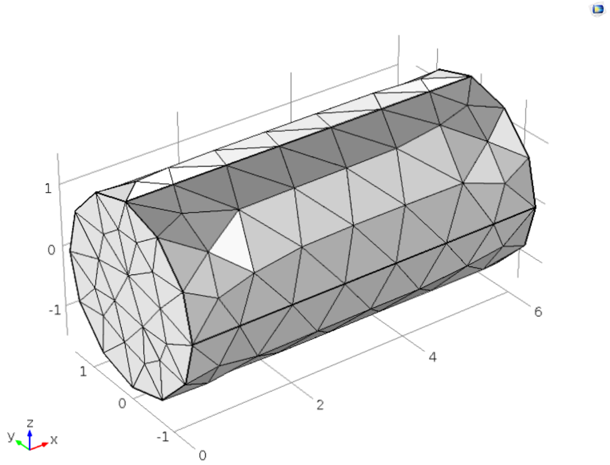

Figure 2: Mesh COMSOL.

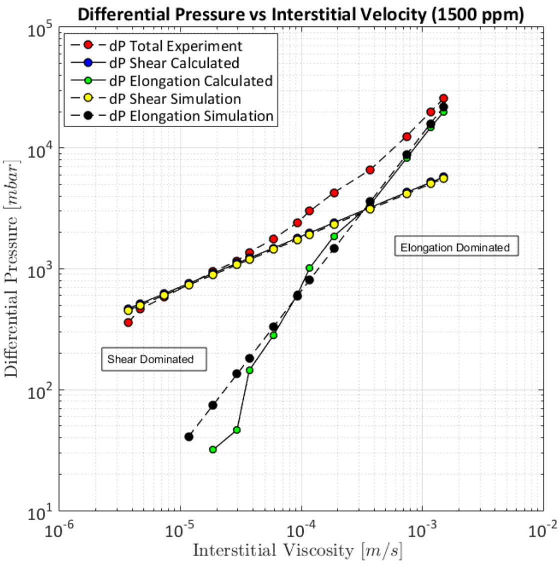

Figure 3: Simulation Result.

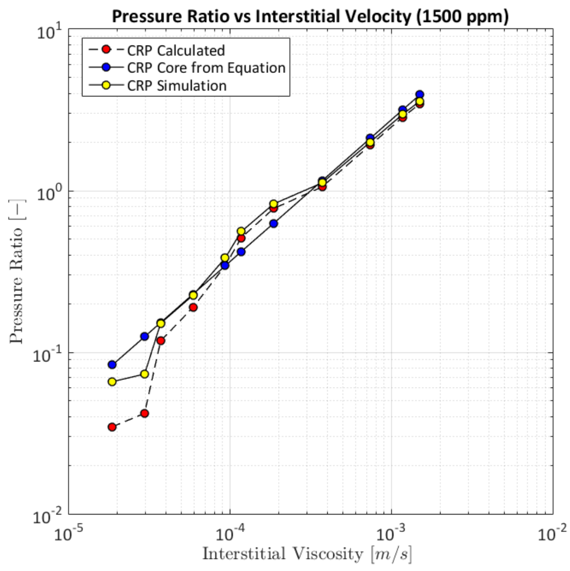

Figure 4: Correlation Results.