Pore-Scale Simulation of Two-Phase Flow with Heat Transfer Through Dual-Permeability Porous Medium

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Abstract

This paper addresses one of the major challenges in water-flooded oil reservoirs, which is early water breakthrough due to reservoir heterogeneities such as high permeable layers. COMSOL Multiphysics is used to model two phase (water and oil) flow in dual-permeability porous medium at micro-scale. Because temperature profile can affect the flow patterns in the reservoir through modifications of physical parameters, heat transfer module is coupled with two-phase flow module (Cahn-Hilliard phase field) in this work. Physical properties such as density, viscosity, specific heat and thermal conductivity are defined as function of temperature and order parameter for smoothing variation from one phase to another through the interface. The coupled two-phase flow and heat transfer methods is validated using analytical solutions. A dual-permeability porous medium is simulated in a rectangular domain in which the grains are represented by equilateral triangular array of circles. Permeability contrast is created using two different grain sizes, with oil as initial saturating phase. When the water is injected, it follows the high permeable layer, hence an early breakthrough occurs. This would leave most of the low permeable layer unswept (Figure 1). A polymer that would increase the flow resistance in high permeable layer is injected. In order to model the injection of polymer for enhancing sweep efficiency, the viscosity of the aqueous phase is defined in a way that increases as a function of time and temperature. Upon injection of polymer and viscosity enhancement, the followed injected water would then be diverted from high permeable zone toward low permeable zone, hence increase sweep efficiency.

Reference

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Figures used in the abstract

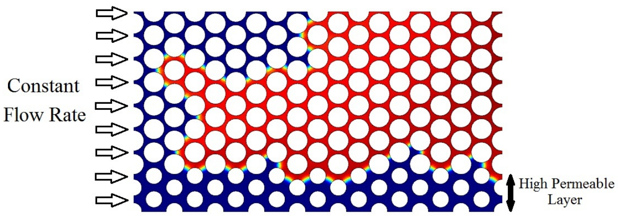

Figure 1: Phase distribution after water breakthrough, in dual-permeability medium.