Two-Phase Flow in Porous Media with Slip Boundary Condition

S. BERG, A.W. CENSE, J.P. HOFMAN, R.M.M. SMITS, Shell International Exploration & Production B.V. — 2-phase flow in porous media is typically described by Darcy’s law extended with the concept of relative permeability, $k_r$, for the water and the oil phase. Using a single phase permeability of a wetting fluid (water) as reference, $k_r$ naturally assumes a maximum value of $0 \leq k_r \leq 1$. Several reports in literature and our own experimental data show in some cases endpoint relative permeabilities of the non-wetting phase with $2 < k_r < 4$. That means that in 2-phase flow in the porous medium, the flux of the non-wetting phase is higher when a small amount of the wetting phase is present. We explain this behavior by drawing an analogy between $k_r \leq 1$ and a *slip-boundary condition* for the pore scale flow using a model description assuming flow in capillary tubes with a slip boundary condition. This model predicts that the flux increase due to slip depends on the equivalent capillary radius of the flow channels. Our $k_r$ data specifically follows this dependence indicating that slip is a plausible explanation for the observation of $k_r > 1$.

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