Scale-dependent dynamic capillary pressure effect for two-phase flow in porous media in relation to fluid viscosity ratio

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ABSTRACT

Non-uniqueness in the capillary pressure and saturation (P^c-S) relationship in porous media is a subject of several research reports on two-phase flow system. The dependence of P^c-S relationship on the rate of change of saturation in the porous domain is known as dynamic capillary effect quantified by dynamic coefficient (τ). Considering its importance, recent reports even proposed for its inclusion in the numerical models for simulation of two-phase system. While the dependence of the coefficient on fluid and porous media properties is less controversial, its relation to domain size appears to be dependent on artefacts of experiments, models as well as the averaging techniques. This paper attempts to reduce the uncertainties inherent in the averaging artefacts during upscaling τ-S relationships from local to larger scale. To achieve this, our laboratory experiment utilised cylindrical domains of three different sizes with porous media of the same permeability and porosity. For consistency, we impose the same boundary conditions in all three domains. Our findings show the scale dependence of the dynamic coefficient in relation to high viscosity ratios (μ_r). where μ_r is defined as the viscosity of non-wetting phase over that of the wetting phase. An order increase in the value of τ was observed across various μ_r and domain scales. Also, an order increase in τ is also observed when τ at the top and the bottom sections in a domain are compared. Magnitude of τ is found to be similarly affected by μ_r. We carry out a dimensional analysis of the dynamic coefficient which shows how different variables, e.g., dimensionless τ and dimensionless domain volume (scale), may be correlated and provides a way to determine the interplay of variables on τ.