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Influence of threshold pressure on two-phase coupling flow

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Two-phase coupling free flow and porous flow are encountered in a wide range of environmental and engineering applications, and several kinds of numerical models with different interface conditions have been built for it. Capillary pressure curve was usually considered in most models using J-function, but the threshold pressure was usually ignored because it's relatively small compared with the capillary pressure at lower wetting-phase saturation. Considering the wettability of porous medium, two kinds of physical models were built to study the droplet passing through interface. The experiment results showed that the non-wetting droplet can hardly flow through the interface from free flow region to porous medium, which is contrary to the previous numerical simulation results. Based on coupled Cahn-Hilliard and Navier-Stokes equation (phase field method), we simulated the non-wetting droplet flow through the interface firstly on micro scale. The simulation result indicated the pressure jump in the pores at the interface rather than normal stress continuity, which lead to the non-wetting droplet trapped on the interface. This pressure jump equals to the capillary pressure in the pores on the interface, so it can be regarded to the threshold pressure of the porous medium. Using coupled Cahn-Hilliard-Navier-Stokes equations in free flow region and two-phase Darcy equation in porous medium, the mathematical model was built to study the two phase coupling free flow and porous media flow. Based on experiment and micro scale simulation results, normal flux continuity, normal stress jump and extended BJS conditions were applied on interface. The simulation results had a very good agreement with experiment results. So the threshold pressure of the porous medium and normal stress jump can't be ignored in the two phase coupling flow.

References

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