Contribution ID: **173** Type: **Oral Presentation**

The effect of surface tension and contact angle dynamics in averaged models for two-phase flow at the pore scale

Monday, 30 May 2022 16:20 (15 minutes)

The mathematical models for the capillary-driven flow of immiscible fluids in porous media are typically assuming a static contact angle at the moving contact line. However, the dynamics of the fluid-fluid interface, particularly of the contact angle is an important feature. Here, we consider the flow of two fluids in a single pore. The geometry is idealized to a long, thin tube with slowly varying radius. The fluids are separated by a moving fluid-fluid interface, which is in contact with the pore wall. Its movement is driven by the fluid flow and surface tension. The contact line model incorporates Navier-slip boundary conditions and a dynamic and possibly hysteretic contact angle law.
Assuming a scale separation induced by a small aspect ratio of the typical radius to the length of the pore, we apply matched asymptotic expansions to derive effective models for the two-phase flow in the limit as this ratio approaches zero. These models form a system of differential algebraic equations in terms of the interface position and the total flux. The resulting model combines Darcy-type equations for the flow with a capillary pressure - saturation relationship involving dynamic effects. Numerical examples highlight the role and importance of such effects.
In the context of capillary rise in circular cylindrical tubes, the effective model extends the classical Lucas–Washburn model by incorporating a dynamic contact angle and slip. Since inertial effects can be relevant at early times, we further extend this model to account for inertia. To validate the different models, their solutions are compared to experimental data. In contrast to the classical Lucas–Washburn model, the numerical results obtained using the models with dynamic contact angle are matching well with the experimental data, with respect to both the rise height and the contact angle, even at early times.
Finally, an outlook to ongoing work covers the upscaling from pore scale to Darcy scale. To this end, we include the effective model as pore-throat model in a dynamic pore-network simulation. Averaging over the pore network then yields the macro-scale behaviour including the effect of surface tension and contact angle dynamics.

References

- S. B. Lunowa, C. Bringedal, I. S. Pop, *On an averaged model for immiscible two-phase flow with surface tension and dynamic contact angle in a thin strip*, Studies in Applied Mathematics 147 (2021), pp. 84–126. doi.org/10.1111/sapm.12376
- S. B. Lunowa, A. Mascini, C. Bringedal, T. Bultreys, V. Cnudde, I. S. Pop, *Dynamic effects during the capillary rise of fluids in cylindrical tubes*, UHasselt CMAT Preprint UP-21-07. www.uhasselt.be/Documents/CMAT/Preprints/2021/UP21

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References

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S. B. Lunowa, A. Mascini, C. Bringedal, T. Bultreys, V. Cnudde, I. S. Pop, Dynamic effects during the capillary rise of fluids in cylindrical tubes, UHasselt CMAT preprint UP-21-07. www.uhasselt.be/Documents/CMAT/Preprints/2021/UP2107.pdf

Time Block Preference

Time Block B (14:00-17:00 CET)

Participation

Unsure

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