Volume of Fluid based study of the three phase dynamic contact line in the wetting of a thin channel.

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Résumé

A continuum sharp interface modelling of the molecular motion in the vicinity of the three-phase dynamic contact line is a significant research problem (1) having extensive practical relevance (2). To investigate the three-phase dynamic contact line in wetting of thin channels, we numerically design a setup consisting of a pressure gradient driven two-phase flow inside a thin channel (width _˜ 1μm - 1mm). The two phases are separated by an interfacial layer with surface tension, that meets the moving pipe wall, hence, a three phase dynamic contact line is formed. This setup is then studied numerically by solving the 2D two phase Navier-Stokes equation subject to three contact line boundary conditions: The Navier slip boundary condition, the super-slip boundary condition and the generalised Navier boundary condition (GNBC). We use the Basilisk flow solver to do Volume-of-Fluid method based simulations with the surface tension force computed using the Continuous surface force method and curvature calculation using the height function. Steady state solutions are found for all three boundary conditions and a critical capillary number, based on the contact line velocity, is predicted beyond which no steady state solution exists. The contact line capabilities of basilisk are already tested by the previous works (3) and (4). Similar to (3), we see that the Navier slip model with a constant microscopic contact angle is weakly singular, however, sufficient to predict the critical capillary number for wetting. The advantage of this hypothetical setup over the previous practical setup of (2) and (3), is that this setup does not have disparate length length scales and allows us to isolate the contact line dynamics in more detail. Due to the adaptive mesh refinement (AMR) and parallel processing capability of basilisk, a parametric study with nanometric slip length is possible and interesting flow features and scaling laws are discovered in the vicinity of the contact line. Then we study the problem using the super-slip boundary condition and a novel VoF based implementation of the generalised Navier boundary condition GNBC. The results from these methods give direct evidence of more regularised solution in the vicinity of the contact line.
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