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A New Formulation for Volume-of-Fluid Simulations of Drops on Solid Surfaces: Inclusion of Adhesion Force

C. Chang[1*], A. Criscione[1], N. Linder, S. Jakirlić[1], C. Tropea[1], A. Amirfazli[2]

[1] *Department of Mechanical Engineering, Darmstadt University of Technology, Germany*
[2]*Department of Mechanical Engineering, University of Alberta, Edmonton, Canada*

The capillary forces acting on a sessile drop placed on a solid surface has two basic components: (1) the Laplace pressure (LP) due to the curvature of the liquid-gas interface, and (2) the Surface Tension Force (STF) as a concentrated force acting at the three-phase contact line. STF can be thought of adhesion force for a drop placed on a solid surface. To date, Volume-of-Fluid (VoF) simulations of drops on solid surfaces have only considered LP, and ignored the STF. Ignoring the STF can lead to incorrect description of the physics for systems involving sessile drops (e.g. shedding of a drop from a surface) especially when capillary and external (e.g. inertial) forces are of the same order of magnitude. Continuum Surface Force (CSF) method is widely used in VoF to model the LP. By modifying the CSF implementation at the contact line, we have added the STF to the VoF formulation. Two case studies, i.e. water drops on an inclined surface and a sessile drop exposed to a shearing airflow are considered. When the STF was ignored, a drop placed on an inclined surface moved at an unrealistically low inclination (e.g. 1 degree for a system with considerable contact angle hysteresis of 10-30 deg.). Same unrealistic motion for the drop was observed when exposed to very low air velocities. Inclusion of the STF corrected both of these unphysical outcomes. A discussion of various systems with different wettabilities (adhesion force values) for each of the two case studies will be provided and comparisons with experiments will be presented.

* *chang@sla.tu-darmstadt.de*