Resolving Dynamic Contact Line Behavior with a Volume-of-Fluid (VOF) Approach

C.W. Hirt

Flow Science, Inc.
683 Harkle Rd.
Santa Fe, NM 87505
cfd@flow3d.com

In small scale fluid devices surface tension is often a dominant force. When fluid surfaces intersect solid surfaces to form contact lines, the combined surface tension and surface adhesion forces may govern the overall dynamic behavior of the fluid. Not only do such problems pose difficulties because of the presence of free surfaces they also include the classic difficulty of how contact lines move on solid surfaces which should have a no-slip velocity boundary condition.

In this presentation we show that the VOF method possesses advantages that make it especially useful for modeling dynamic contact lines. In contrast to other numerical approaches, the VOF method automatically computes the location and contact angles of contact lines as part of the solution process.

Simulations will be presented that show how this numerical approach has been validated. When embedded in a general purpose computational fluid dynamics program, the VOF method described here becomes a kind of "computational laboratory" that may be used to investigate a wide range of phenomena. Examples of this approach are presented that provide an understanding of a variety of physical problems associated with dynamic contact line behavior. For instance, the effect of roughness on advancing and receding contract lines, how small drops can stick on sloping surfaces, and how an apparent boundary slippage may occur.