Numerical simulations of a 2D dispersed system of droplets and bubbles

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A two-dimensional dispersed system with multiple liquid droplets and gas bubbles in a continuous phase of another immiscible liquid is modelled numerically. This system is assumed to be isothermal with constant interfacial tension. Both droplets and bubbles are subject to gravity and capillarity, fully accounted for. Its time evolution is investigated and the influence of the initial condition discussed.

This system is a typical example of multiphase, unsteady, free interface problem known to raise challenging questions regarding to numerical stability. Here a multiphase volume of fluid (VOF) code is employed [1-2]. It solves the continuity and Navier-Stokes equations for an incompressible medium along with the advection equation for a color function. In VOF methods, different immiscible fluids are treated as a unique continuous phase but with changing material properties (density and viscosity) according to the local value of color function. The interfacial stresses are directly included into Navier-Stokes equations in form of an equivalent body force according to the continuous approach of Brackbill [3]. Interfacial curvature is computed with the aid of height-function [4]. The numerical scheme is based on 2^{nd} order discretization in both time and space. The finite volume method on a staggered computational mesh is used for spatial discretization of all the equations. Heat transfer, action of thermocapillary and solutocapillary stresses as well as reactivity at interfaces will be implemented in future.

A straightforward application of this work is emulsion stability. But the actual research frame is the simulation of severe nuclear accidents. The meltdown of nuclear reactors generates a material called corium that consists of a mixture of nuclear fuel together with zircaloy (material of the first confinement barrier) and stainless steel. Corium actually shows up like a metal-gas-oxide dispersion where the metallic phase is initially confined in droplets. After cooling of the corium bath, experiments [5] demonstrated configurations in which this phase is preferably close to the vertical concrete walls of the concrete containment pit instead of being distributed in stratified layers. This unexpected behavior is most probably the result of a complex interplay between heat transport and reactivity at the metal/oxide interfaces. We believe that the simplified 2D model under development here and its accurate simulation will provide relevant insights for the understanding of this phase segregation phenomenon.

Keywords: Droplet hydrodynamics, Multiphase unsteady free interfaces flows, Surface tension

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