Paper ID: 10178
oral
student

MICROGRAVITY SCIENCES AND PROCESSES (A2)
Fluid and Materials Sciences (2)

Author: Mr. Mohammad Movassat
University of Toronto, Canada

Dr. Nasser Ashgriz
University of Toronto, Canada
Dr. Markus Bussmann
Canada

THREE-DIMENSIONAL NUMERICAL SIMULATION OF BUBBLE DYNAMICS, OSCILLATION AND BREAKUP UNDER FORCED VIBRATION IN MICROGRAVITY

Abstract

In microgravity condition, dispersed gas bubbles inside liquid containers do not separate from the host liquid. An external acceleration is required to induce an artificial buoyancy force and make the bubbles move. Separation of bubbles is needed in multi-phase flow systems in applications such as thermal management and life support. Forced vibration of liquid containers with dispersed bubbles provides such an acceleration and this method can be used for phase separation purposes. In this work, behavior and response of a multi-bubble system under forced vibration is studied. As a result of forced vibration, an oscillatory buoyancy force is applied to bubbles. Bubbles go through oscillatory translational motion as well as shape oscillations as a result of asymmetric pressure distribution around the bubbles. Response of the bubble depends on vibration characteristics, frequency and amplitude, and fluid properties. A parallel three-dimensional numerical model is employed to investigate the effects of above parameters on bubbles behavior. The model solves for conservation of mass and momentum equations and uses a level-set based algorithm to capture the interface between liquid and gas phases. Results for oscillation of single bubble, which is necessary to understand the underlying physics of the problem, show that as the amplitude of oscillations and frequency increases, nonlinearities appear and bubble response changes from a regular repeating behavior to chaotic pattern. In large amplitude and frequency cases, i.e. large imposed accelerations, surface tension is not strong enough to maintain the spherical shape of the bubble. As a result of coupling between shape oscillations and translational motion, both of these motions show a chaotic pattern. Results also show that if the acceleration is strong enough, and as a result of liquid inertia, a liquid jet starts to form and penetrate into the bubble. Formation and penetration of the liquid jet result in a torus shape bubble, which in literature is referred to as “pierced bubble”. In practice, there are numerous bubbles in liquid containers and bubbles interact with each other making the behavior more complex. Presence of each bubble changes the pressure field inside the container and adds a force on other bubbles. Interaction of bubbles in a multi-bubble system is examined and it is shown that interaction can result in attraction and collision of bubbles which makes larger bubbles. Effect of vibration characteristics and fluid properties on the interaction force is examined as well.