

Modeling of Free Surface Flows: Understanding Falling Drops

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Multi-fluid systems play an important role in many natural and industrial processes such as bubble column reactor, boiling, ink jet printing, painting, biological systems, rain drop impact phenomenon etc to mention few. A full understanding of the behavior of multiphase flows is still lacking, although a number of experimental, theoretical analysis and numerical studies have addressed this problem. The various numerical techniques used to solve these multi-fluid systems are like volume of fluid method (VOF), level set method (LS), coupled level set and volume of fluid method (CLSVOF), front tracking method (FT) etc. We have used the CLSVOF method to investigate the partial coalescence phenomena during drop impact on liquid-liquid interface.

Our study deals with the understanding of drop dynamics during partial coalescence. When a droplet of liquid 1 falls through liquid 2 to eventually hit the liquid 2-liquid 1 interface, its initial impact on the interface can produce daughter droplets of liquid 1. In some cases, a partial coalescence cascade governed by self-similar capillary-inertial dynamics is observed, where the fall of the secondary droplets in turn continues to produce further daughter droplets. Results show that inertia and interfacial surface tension forces largely govern the process of partial coalescence. Below the specified lower bound and above the specified upper bound, the partial coalescence is suppressed by the viscous force and gravity force, respectively. The critical Ohnesorge numbers and Bond number are determined. Generation of secondary drop is observed for systems of lower Ohnesorge number for liquid 1, lower and intermediate Ohnesorge number for liquid 2 and for low and intermediate values of Bond number. Whenever the horizontal momentum in the liquid column is more than the vertical momentum, secondary drop is formed. A transition regime from partial to complete coalescence is defined based on oscillation of the neck radius. The transition is seen to occur when the neck radius oscillates twice. In this regime, the main body of the column can be fitted to power-law singularity model within a specific time range.