An experimental and numerical investigation of droplet coalescence

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Abstract

Droplet spreading flows are of enormous significance in a wide range of industrial coating processes and in many microfluidic devices and consequently received much attention in the scientific literature [1]. In contrast, despite its industrial importance in, for example, ink-jet printing and spray coating applications [2] the collision dynamics of multiple liquid droplets has been studied in far less detail than is the case for individual droplets. This paper focuses on the particular problem of droplet coalescence in which two identical droplets come together and merge to form a single drop.

Since most previous studies of droplet collision and coalescence have been purely numerical in nature [3] in the present study droplet coalescence is studied both experimentally and numerically. The former is conducted using an experimental apparatus in which one droplet is positioned on a glass slide and a second drop is formed next to it by slowly pumping fluid through a small hole. Images of the coalescence process are captured from both the side and the top using a high-speed digital camera. The evolution of the free surfaces of the coalescing droplets is recorded for water / glycerol solutions with a range of concentrations. Since impurities are found to have a profound influence on the coalescence, particular care is taken to ensure that the apparatus is thoroughly cleaned between experiments.

Experimental data is compared with corresponding numerical predictions of the coalescence obtained using the thin film lubrication assumption that is commonly used to model droplet spreading flows. The lubrication equations are solved using an efficient full approximation storage (FAS) Multigrid algorithm with an adaptive time-stepping scheme that enables the numerical solution to be optimised subject to a specified error tolerance [4]. The experiments reveal a complex, oscillatory free surface evolution during coalescence, the main features of which are predicted successfully by the corresponding numerical simulations.

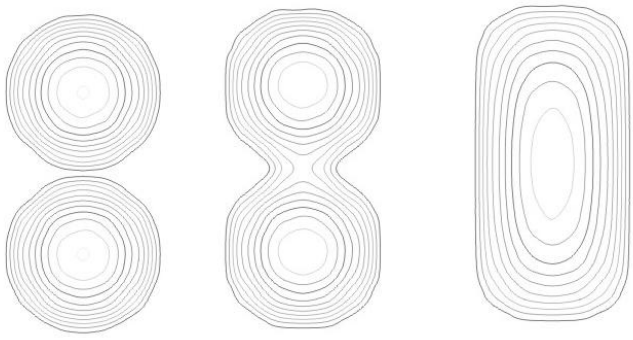

Figure 1: Numerical simulations of droplet coalescence as time evolves: left to right.

References

[1] A.A. Darhuber, S.M. Troian. (2005). *Ann. Rev. Fluid Mech*, 425-455.
[2] Nobari MR, Jan Y-J, Tryggvason G (1996)) *Phys. Fluids* 8 (1): 29-42
[3] Mashayek F, Pandya RVR (2003) *Prog Energ Combust* 29 (4): 329-378
[4] P.H .Gaskell, P.K. Jimack, M. Sellier & H.M. Thompson. *Int. J. Num. Meth. Fluids*, 2004, Vol. 45, 1161-1186.