SAND2012-3195C

ICLASS 2012, 12th Triennial International Conference on Liquid Atomization and Spray Systems, Heidelberg, Germany, September 2-6, 2012

A Mesoscale Study of Pinch-off under High Strain

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Abstract

We study the dynamic behavior of a pinching liquid thread as a function of the time to pinch-off. The novelty of this work resides in the use of a particle method for the analysis (the Many-body Dissipative Particle Dynamics method, or MDPD) and in the inclusion of the interaction with a surrounding gas. This addition may be relevant to the process of spray formation at high Weber number.

Adding the effect of a second MDPD fluid requires the characterization of the friction factor between particles of immiscible fluids: unlike interfacial tension or solubility, this coefficient does not have a directly related physical property for specifying its value. Moreover, in order to subject the liquid thread to a stretching field, a two-phase, Non-Periodic Boundary Condition (NPBC) needs to be applied. In the proposed NPBC method, two layers of particles are built into the domain on each side of the computational box. The outermost layer is modified at every iteration by placing particles of the prescribed type: this buffer works as a barrier whose composition depends on the instantaneous location of the boundary. The innermost layer contains particles that are free to move according to the distribution of the surrounding particles.

By enabling the simulation of pinch-off under extensional flow, an arbitrary strain rate can be imposed via the gas phase. Thus, the capillary number Ca appears as an additional parameter controlling pinch-off. Simulations are carried out to display the role of stochastic effects for a range of Ca values.

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