Kinetics of Liquid Film Disintegration at “Bag” and “Claviform” Modes of Drop Breakup

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Abstract

The process of “bag” film disintegration at “bag” and “claviform” modes of drop breakup is connected with mechanism of hydrodynamic instability of Kelvine – Helmholtz type under action of air stream, and theoretical model for liquid film breakup is elaborated. The investigation of hydrodynamic instability of drop surface in gas flow allowed to explain [1] the mechanism of blowing off of a thin wide film of bag from parent drop after extreem drop deformation. It helps us to estimate the important values of the liquid mass in the ring and the thickness of the bag film, which are necessary to evaluate sizes of daughter droplets.

The model of liquid film disintegration is developed, which describes two stages of the process – initial perforation of the film and further dynamics of the expanding hole, which is accompanied by film splashings. The process of liquid film fragmentation itself is connected in our study also with mechanism of hydrodynamic instability of film in air stream.

After initial film rupture, caused by instability, behavior of liquid film near the hole edge is governed by two factors: liquid gathering there into moving toroidal roller by the action of surface tension forces and further action of instability mechanism near the streamlined film edge. When characteristic time of first process is smaller, than of the second one, the surface tension grasps significant amount of liquid into roller before unstable disturbance shakes it off from the edge. Therefore, the diameter of the roller and the sizes of shaken-off droplets are greater than thickness of the film.

Solution of a simplest problem about instability of liquid film in gas flow was applied to determine the characteristic size and time of dominant unstable disturbance. The comparison of the former with experimentally observed [2] values of perturbations on film, which are probably produce initial rupture, showed a qualitative agreement.

At simplest assumptions (media are ideal, film is plane, liquid roller has a form of torus) the ordinary differential equation of torus motion under action of surface tension forces and reactive forces is derived and laws of torus motion (for mass center of its cross section) and history of its radius are calculated. Taking into account simultaneously both mechanisms of unstable shaking-off and of the liquid roller growth, the main regularities of film disintegration kinetics have been calculated: histories of roller radius and of quantity of shaken-off droplets, sizes and moments of their generation and the period of the entire film disintegration.

The comparison of computed values with experimentally observed [3] values of daughter droplet sizes, dispersity, film thickness and volume of liquid ring showed a good agreement.

References

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