The Role of Propagative Capillary Waves in Droplet Formation from Ligament

J. Shinjo[*1], S. Matsuyama[1], Y. Mizobuchi[1], S. Ogawa[1] and A. Umemura[2]
[1]Numerical Analysis Group, Japan Aerospace Exploration Agency
Tokyo Japan
[2]Department of Aerospace Engineering, Nagoya University
Nagoya Japan

Abstract

A newly proposed understanding of droplet formation mechanism from a ligament considering the role of propagative capillary waves is numerically investigated in detail in a low-speed liquid jet configuration similar to the previous experiments. Two modes of pinch-off are reproduced by the present numerical simulation, and both modes can be explained by the new understanding. In the short-wave mode, a relatively large steady wave generated by the tip is locally destabilized and induces pinch-off. At the same time, shorter waves can travel much faster on the liquid column surface, so if they can reach the nozzle exit, they are reflected and elongated by the Doppler shift. These waves induce the long-wave or Rayleigh mode if the liquid column is long enough. It implies that the system has a disturbance source in itself, while external unknown disturbances are usually given in the classical Rayleigh analysis setup. By changing flow parameters such as the Weber and Ohnesorge numbers, the interaction of adjacent wave crests is dynamically observed and this is a clear indication of wave dynamics. In this study, it is shown that two pinch-off modes can be consistently explained by considering the propagative capillary waves.

Key words: Fundamental simulation of droplet pinch-off, Propagative capillary waves, Ligament

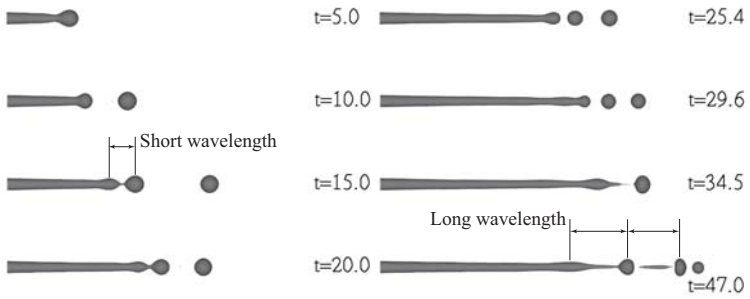
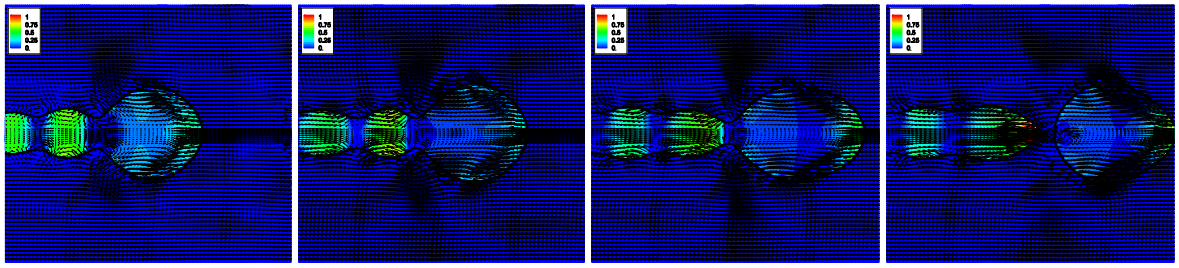


Figure 2. Overall behavior of case 1



t=153.7 *t*=157.0 *t*=160.2 *t*=161.8

Figure 7. Typical motion in one cycle for case 2. The left boundary corresponds to the nozzle exit position. The relative velocity vectors are drawn with a skip for clarity.

[*]Corresponding author, shinjo.junji@jaxa.jp