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Aerodynamic Breakup of Droplets Arrayed in Gas-flow Direction

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Abstract

This paper deals with aerodynamic breakup of liquid droplet which flies in droplet groups. Several numerical models of droplet breakup have been developed based on the previous studies and utilized in numerical simulation of spray. Most of the studies focused on the droplet breakup under ideal condition; single droplet was exposed suddenly to uniform steady gas-stream. However, in actual spray field, droplets may be attached to group of several droplets. The droplet breakup should be influenced by the presence of other droplets. Aiming to obtain insight into the phenomenon, experimental investigations were performed employing the simplified setups, that water droplets of the same size were arrayed in air-flow direction. The breakup behavior of two droplets was examined preliminary within the range of dimensionless droplet distance 3–15 and the range of Weber number 8–18 (Case-0 of figure 1). The upstream droplet behaved like isolated droplet. The critical Weber number of downstream droplet was slightly larger than that of upstream droplet, and the breakup of downstream droplet was delayed from the breakup of upstream droplet. However, the breakup behavior of downstream droplet was affected not so much by the upstream droplet when the dimensionless droplet distance was larger than about 15. It was suggested that the setup of two droplets is too simple to simulate the droplet breakup in droplet group. The breakup behavior of inline four droplets was investigated next in the range of Weber number 9–28 and the cases of dimensionless droplet-distance of 15 and 24 (Case-1). The 1st droplet behaved like isolated droplet and the 2nd droplet broke up by almost similar manner to 1st droplets, but the 3rd and the 4th droplets showed different breakup manner. The breakup manner of 3rd and 4th droplets altered every observation. The breakup time and the acceleration of 3rd and 4th droplets differed much from those of 1st droplet, and the data of breakup time and acceleration were widely distributed. The breakup behavior of eight droplets arrayed in two lines was also observed (Case-2). Finally, following were deduced: the aerodynamic droplet breakup was influenced much by the presence of upstream droplets. One cannot predict determinately the aerodynamic acceleration during breakup, the breakup time, the breakup manner and the results of breakup, when there are some other droplets in the upstream. For reliable numerical simulation of spray, it is encouraged to involve the influence into the model of droplet breakup. The statistical treatment should be necessary to do so. The data presented here will provide useful hints to develop more realistic models.

Key words: Droplet, Aerodynamic Breakup, Group of Droplets, Array of Droplets, Numerical Modeling, Critical Weber Number, Breakup Manner, Breakup Time, Acceleration

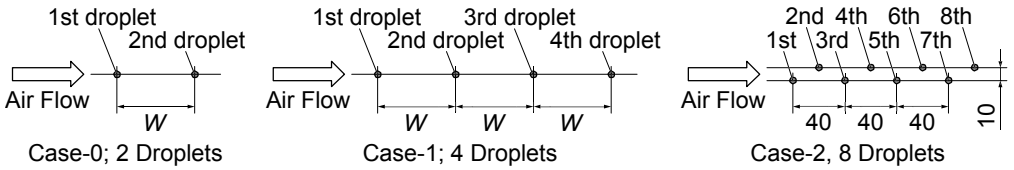

Figure 1. Arrengement of Droplets (Top View)

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