Promotion of Perforation in a Radial Liquid Sheet by Impingement of a Hot/Cold Airflow

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Abstract

Promotion of perforations in a radial liquid sheet through hot/cold airflow is investigated. The radial liquid sheet was produced by release of a liquid film spreading on a disk into the air. In the radial liquid sheet, a turbulent transition occurs beyond the disk edge. The liquid sheet is perforated after the transition, and atomized by the perforations increasing with liquid sheet velocity. In this study, the promotion of the atomization by the hot/cold airflow was attempted. The hot/cold airflow impinged on the transition point at a velocity of 4-6m/s, and the perforation promoted by the hot/cold airflow was observed by photography. The difference $\Delta T=T_g-T_l$ between airflow temperature T_g and liquid sheet temperature T_l was controlled in the range from –20 to +135°C. Even the airflow with slight temperature difference ($\Delta T=\pm 15$°C) had potential of promoting the perforation, however, the airflow without temperature difference had no effect on the perforation. Critical conditions for the perforation promotion by the hot airflow are organized based on the observations of the liquid sheets under the various conditions of temperature difference and liquid sheet velocity. The photographs and organized critical conditions show that patchy thin liquid membranes, which are formed in places after the transition at high Reynolds numbers, is necessary for the perforation promotion. A mechanism was proposed for the perforation promotion by the hot/cold airflow based on a Marangoni stress affecting on the liquid membrane, which is heated/cooled easily because of its ultimate thinness. The beginning point of the perforation in the liquid membrane and the thickness of the liquid membrane are determined by CCD images of the liquid membrane. The difference in the beginning point of the perforation by airflow temperatures and measured thickness (about 7μm) of the liquid membrane support the validity of the proposed perforation mechanism.

Key words: Atomization, Free surface flow, Thermocapillary, Marangoni stress, Turbulent transition

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