Experimental Study on Onset Condition of Boiling Entrainment from Falling Liquid Film with Gas Sheared Flow

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The visualization experiment has been conducted to clarify the two types of boiling entrainment which the dominant one called filament-type and the influence of various parameters on the onset condition of this filament-type boiling entrainment. Then, we develop a model to identify the onset condition of the filament-type boiling entrainment in a falling liquid film.

Keywords: Annular Two-Phase Flow, Boiling Entrainment, Boiling System, Dryout, Experiment

1. Introduction

Boiling entrainment from a liquid film is an important phenomenon to ensure safe operation in industrial boiling systems. This is because the boiling entrainment is closely related to the occurrence of dryout. In this study, we conducted a visualization experiment of boiling entrainment and identified the boiling entrainment into two types which the dominant one called filament-type. Ultimately, we develop a model to identify the onset condition of the filament-type boiling entrainment in a falling liquid film.

2. Experimental Condition

The schematic diagram of the experimental apparatus used in this experiment is shown in Fig. 1. In the experiment, the air and liquid film flowed down in the test section under atmospheric pressure conditions, and the heating was performed by a copper block heater installed downstream. The droplet entrainment processes were visualized from the front of the test section using a high-speed camera. The heat flux was varied in the range of 0.3 – 1.0 MW/m^2 and the liquid-gas phase velocity and subcooled degree were varied in the range of 0.1 – 0.3 m/s, 2 – 7 m/s and 3 – 10^{o}C, respectively.

3. Results and Discussion

Fig. 2. shows the mechanisms of the droplet entrainment according to the visualization results. Fig. 2 (a) shows the jet breakup type in low heat flux condition. Since the size of the droplet is very small which is less than 0.15 mm, this mechanism of droplet entrainment does not have a significant effect on the total amount of droplet entrainment. Fig. 2 (b) shows the filament breakup type in high heat flux condition. The size of droplet generated by this mechanism is about 0.9 mm and is frequently observed. Therefore, the phenomenon of filament breakup is more dominant and is an important mechanism that greatly affects the amount of the droplet entrainment. Fig. 3. shows the correlation of onset condition of filament type for all occurrence points. According to these experimental results, the Weber number tends to be constant with an assumed critical value of about 1.8. Below the critical value, the filament breakup type does not occur in these experimental conditions. Whereas above the critical value, the filament breakup type definitely occurs.

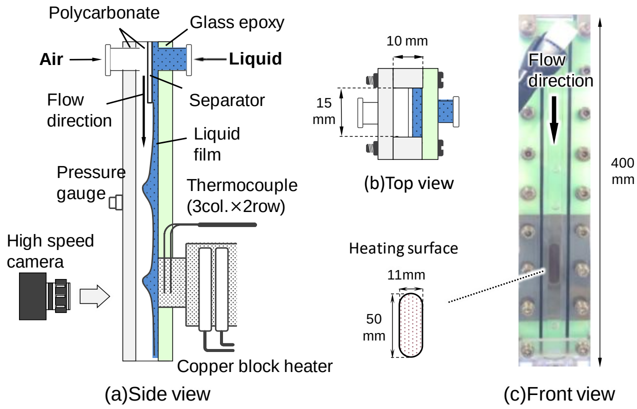

Fig 1. Schematic diagram of the experimental apparatus

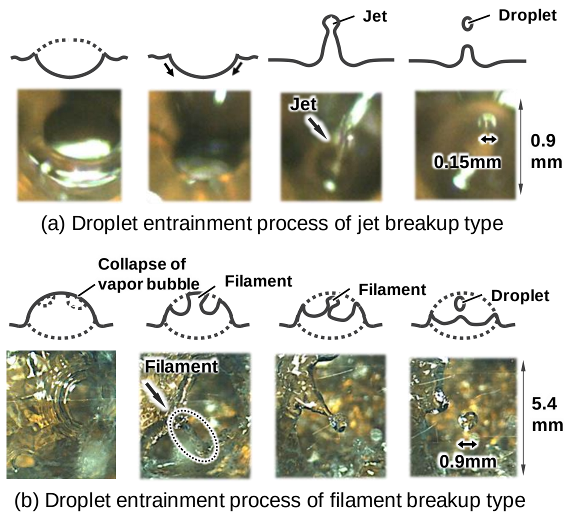

Fig 2. Visualization results of droplet entrainment mechanisms

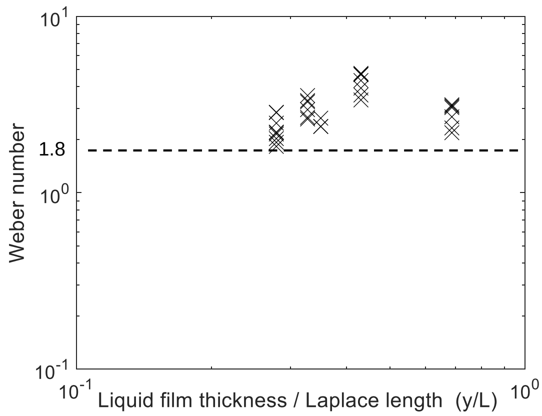

Fig 3. Correlation of onset condition of filament type

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