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# Profile of Void Fraction with Fine Radial Spacing in the Close Vicinity of the Heated Wall in Subcooled Flow Boiling

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## 1. Introduction

Prediction of the local void fraction with subcooled liquid is considered as a milestone to understand flow boiling [1]. This is because subcooled boiling is described as a complex interplay of a bubble generation, a boiling heat transfer, and a condensation of the detached bubbles. Thus, experimental data, especially the local void fraction in the radial direction, is required to explore the flow boiling. Previous studies have been conducted for showing the profile of the void fraction [2-7]. However, the profile of the void fraction in the close vicinity of the heated wall was not fully identified.

In this paper, we discussed the experimental result which was conducted at Jeju National University [1-2]. We focused on the occurrence of the subcooled boiling in the close vicinity of the heated wall. Furthermore, the effect of the flow conditions which are subcooling and heat flux on local bubble parameters was evaluated.

## 2. Methods and Results

### *2.1 Experimental Facility and condition*

An experimental study was conducted in the flow boiling test facility and details of the facility are reported in the papers from our group [1-2]. In a short description regarding the facility, a test section is a concentric annulus with a heater rod in the center (inner diameter: 10 mm, outer diameter: 30 mm, and effective heated length: 2000 mm). Conditions of subcooled liquid (deionized water) are controlled by other flow systems such as pump, preheater, and pressurizer. Inlet subcooling (20, 22, 24, 26, 28, 30, and 34K) and heat flux (100, 150, 200, 250, and kW/m$^2$) are considered as variables for this experiment.

### *2.2 Measurement technique*

In this study, the single-sensor optical fiber probe was considered for measuring local bubble parameters such as void fraction, bubble velocity, chord length, and bubble arrival frequency. When we consider the difference in the refractive index between the liquid and gas, local bubble parameters can be obtained by calculating the intensity of the laser beam which is reflected in the medium at the tip. Details of how the local bubble parameters can be obtained based on the reflected intensity are described in the papers [1-2].

### *2.3 Void fraction*

Figure 1 presents the local void fraction along the radial direction at the position of $L/D_h$=21.5. We can observe that the profiles of the void are enlarged when the heat flux is increased and inlet subcooling is decreased. How the profiles transform seems different when the heat flux increases and inlet subcooling decreases. When the inlet subcooling increases, the peak of void fraction shifts towards the center of the pipe and the void fraction close to the heated wall (first two or three points from the zero of normalized distance from the heated wall) is kept low. However, when the heat flux increases, the peak of the void fraction shift toward the heated wall after 200 kW/m$^2$ of heat flux and the void fraction close to the heated wall is significantly increased.

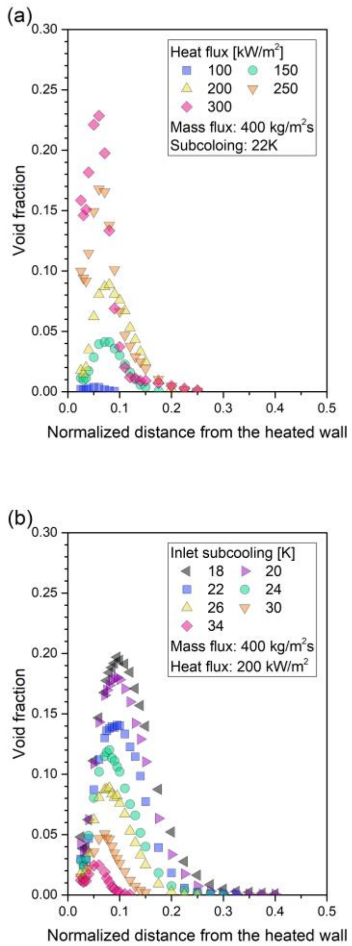


Figure 1. Void fraction with varying heat flux (a) and inlet subcooling (b) [1]

*2.4 Bubble velocity*

Figure 2 shows the bubble velocity along the radial direction. We can observe different characteristics between two cases which are increasing heat flux and increasing inlet subcooling. The major difference is that fast bubbles were observed when there are significant increases of local void fraction close to the heated wall (first two or three points from the zero of normalized distance from the heated wall) when the heat flux is high.

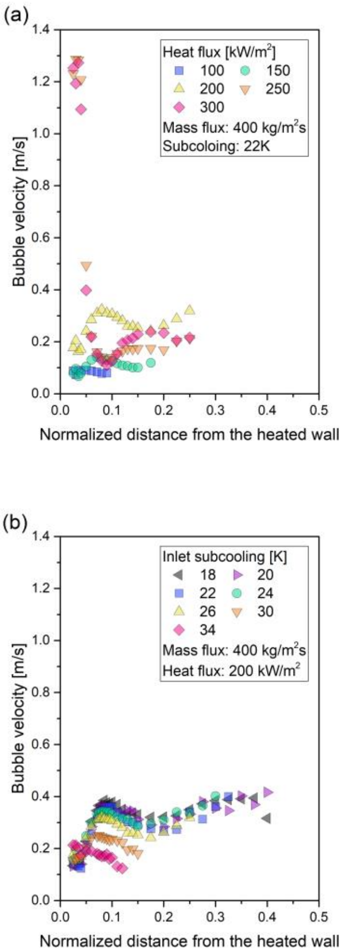


Figure 2. Bubble velocity with varying heat flux (a) and inlet subcooling (b) [1]

*2.5 Wall and fluid temperature*

Figure 3 presents the profile of the liquid temperature along the radial direction and the wall temperature which is depicted at zero of the normalized distance from the heated wall. This can be used when we attempt to predict the subcooled boiling. It seems that there is also a rise of liquid temperature for the points which are close to the heated wall in high heat flux case.

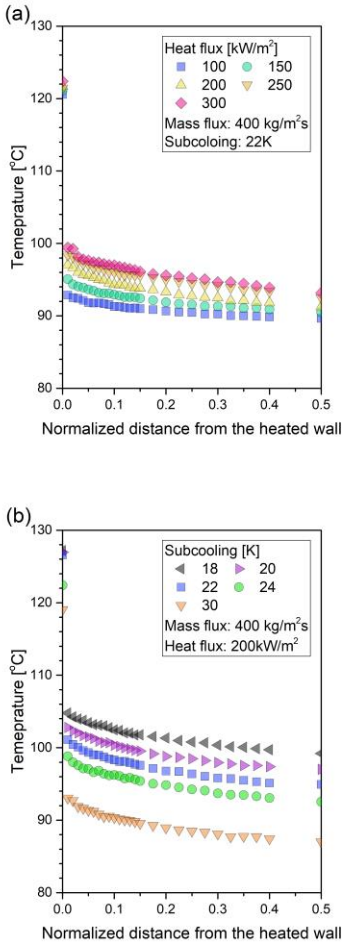


Figure 3. Wall and fluid temperature with varying heat flux (a) and inlet subcooling (b)

*2.6 Discussion*

It should be mentioned that in cases of the high heat flux case, there is a different characteristic compared to the other cases. It seems that there is a phenomenon that is not identified in that condition. We would like to comment that it is important to identify this phenomenon to predict the subcooled boiling. In further study, we will focus to identify the phenomenon that is discovered in this study.

## 3. Conclusions

Profiles of void fraction and velocity are observed for the close vicinity of the heated wall with fine radial spacing. From this we found the shift of the local void fraction which has not been reported or identified. We will focus on this phenomenon in further study.

**Acknowledgments**

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