

論文 / 著書情報  
Article / Book Information

題目(和文)	
Title(English)	Study on Velocity Distribution Measurement in Air-water and Sub-cooled Boiling Bubbly Flow Using Ultrasound Technique
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出典(和文)	学位:博士(工学), 学位授与機関:東京工業大学, 報告番号:甲第11993号, 授与年月日:2021年3月26日, 学位の種別:課程博士, 審査員:木倉 宏成,加藤 之貴,赤塚 洋,相樂 洋,筒井 広明
Citation(English)	Degree:Doctor (Engineering), Conferring organization: Tokyo Institute of Technology, Report number:甲第11993号, Conferred date:2021/3/26, Degree Type:Course doctor, Examiner:,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

(博士課程)  
Doctoral Program

## 論文要旨

THESIS SUMMARY

系・コース : Department of, Graduate major in	Mechanical Engineering, Nuclear Engineering	系 コース	申請学位 (専攻分野) : Academic Degree Requested	博士 Doctor of	(Engineering)
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要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words )

In the thesis, the Study on Velocity Distribution Measurement in Air-water and Sub-cooled Boiling Bubbly Flow using Ultrasound Technique, the new ultrasonic velocity profiler (UVP) techniques to obtain the velocity distribution of bubbly flow in air-water and sub-cooled Boiling condition is presented. The thesis consists of six chapters, as summarized below.

Chapter 1. "Introduction" outlines the importance of the gas-liquid two-phase bubbly flow, which occurs in the sub-cooled boiling region on the safety aspect in BWR. The behavior in this region affects the downstream boiling and void distribution. Numerical analysis to elucidate the behavior of the two-phase flow in this region is required to assess the safety margin in the reactor. To obtain the correlation model used in the analysis, the experimental data of gas (bubble) and liquid phase is required, such as pressure and void fraction. In particular, the flow velocity value of both phases is a key factor in the constitutive equation. This parameter strongly affects heat transfer enhancement and phase distribution. It plays an important role in the safety of the reactor. Therefore, the experimental investigation of this parameter is a necessity. Conventional two-phase flow measurements are contact measurement methods that disturb the flow. The UVP, a non-contact technique for velocity distribution measurement, is appropriate for gas-liquid two-phase flow measurement. As the disadvantages of previous developments, considering system minimization and high efficiency of the UVP method, ability in high velocity range on the real reactor, and possibility for multi-dimensional measurement, it is necessary to simplify the ultrasonic sensor, expand the velocity range, and extend to the multi-dimensional measurement. This states purpose of this research.

Chapter 2. "Velocity Distribution Measurement in Air-water Bubbly Flow" the single ultrasonic frequency is considered to pursuit the target. A new UVP, namely, single ultrasonic gas-liquid two-phase separation (SUTS), is proposed in this study. In the signal processing, the Doppler signal reflected from gas bubble and particle (tracer of liquid) is multi-frequency and difference on amplitude which is a non-stationary signal, Time-Frequency Analysis (TFA) and Doppler Amplitude Classification (DAC) is applied to analyze the signal and separate both phase velocity data. To verify this method, the method was applied to demonstrate in an air-water bubbly flow on vertical circular pipe apparatus with an inner diameter of 20 mm. The velocity distribution of gas bubbles and liquid was obtained by this method and validated with particle image velocimetry (PIV). The discrepancy between techniques was inside  $\pm 10$  percentage except at near-wall region. Lastly, the allowable bubble diameter and void fraction were evaluated.

Chapter 3. "Velocity Range Extension for Velocity Distribution Measurement in Bubbly Flow" as the velocity range that allowable for measurement by the SUTS proposed in Chapter 2 is limited by the Nyquist limit. We have developed a new velocity range expansion algorithm that solves a problem using cross-correlation. This method extends the velocity range of SUTS. The method was applied to velocity measurement of  $Re = 5,500$  (velocity 300 mm / s) and at a high velocity up to  $Re = 42,500$  (velocity 2,300 mm / s) in an air-water bubbly flow on the vertical circular pipe with an inner diameter of 20 mm to obtain the velocity of both phases beyond Nyquist limit. The velocity range can be expanded up to about 3 times the conventional UVP, which covers the actual value in the real reactor.

Chapter 4. "Velocity Distribution Measurement in Sub-cooled Boiling Bubbly Flow" focuses on measuring the boiling two-phase flows in sub-cool boiling condition by applying the Extended SUTS proposed in chapter 3. The experimental apparatus was a vertical circular pipe with an inner diameter of 50 mm in which a heating rod with a maximum of 2,000 W was installed. First, the transmission characteristics of ultrasonic waves in high-temperature liquid were clarified. The ultrasonic transmission efficiency and wave path angle under the conditions were evaluated to confirm the ultrasound's applicability in this application. Subsequently, the velocity distribution of the gas bubble and liquid phase in sub-cooled boiling bubbly flow was measured. The applicability of this method was shown.

Chapter 5. “Two-dimensional Velocity Distribution Measurement in Bubbly Flow” shows the method that can measure two-dimensional velocity distribution in bubbly flow. It is called a 2D vector UVP gas-liquid separation system. The multi-ultrasonic element sensor is developed. The sensor configuration has clarified the effects of element size and the gap distance between the elements. A 2D vector UVP gas-liquid separation system is constructed by applying the Extended SUTS algorithm and the multi-ultrasonic element sensor to the UVP method. In order to show the ability of this method, we measured the 2D velocity vector distribution of the air-water bubbly flow in bubble column and compared it with the result by the PIV method to evaluate effectiveness of the measurement technique. The discrepancy between both techniques was inside  $\pm 15$  percentage. Furthermore, this method was applied to air-water swirling bubbly flow and sub-cool boiling bubbly flow, respectively. The maximum measurable bubble diameter was investigated.

Chapter 6. “Conclusion” Insights from the Chapter 2 to 5 are summarized in this chapter. Developed measurement system allows obtaining velocity data in the bubbly flow; gas, and liquid phase, which is proposed to utilize for an experimental investigation. This shows the effectiveness of this system in the elucidation of the complicated two-phase flow behavior in the sub-cooled boiling region for the safety aspect in a nuclear reactor. Moreover, this has a great contribution to engineering and industry.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).

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