THE SUMMARY OF Ph.D. DISSERTATION

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Title

Bubble motion and flow microstructure in gas-liquid two-phase flow.

Abstract

The motion of bubbles in liquid media has been extensively studied, experimentally and theoretically for many years. There are relevant industrial applications such flows in nuclear and chemical reactors. Recent numerical simulations based on the knowledge gained from experimental studies however, are still imperfect in terms of the available phase-interaction models. There is a need for more data to provide a complete description of interaction between the two phases. The geometric distribution of the phases in fully bubbly flow makes it difficult to interpret the experimental results. Therefore, we considered the problem in a much simpler situation, that of a single bubble motion interactions with the surrounding flow structure. The objective of the present study is to elucidate the interaction between bubble deformation and surrounding flow structure at both micro-mezzo and macro scales, and to clarify the interaction mechanism between various scales to understand various conditions of bubbly flow.

Chapter 1 describes the background of the present work, industrial application, the state of knowledge of gas-liquid two phase dispersed flows and objective of the present study. Next the basic flow macrostructure of gas-liquid two phase flows, the deformation dynamics of a bubble, basic equations of bubbly flow and numerical analysis methods are mentioned in Chapter 2.

In recent years image processing has been effectively applied to flow measurement via Digital Particle Image Velocimetry. Nevertheless DPIV in the vicinity of the bubble interfere the study of microstructure of bubbly flow. In Chapter 3, we describe

DPIV in conjunction with Laser Induced Fluorescence technique using original fluorescent tracer particles and a shadow projecting technique in order to quantitatively measure the flow structure in the vicinity of the bubble along with deformation of the bubble shape simultaneously. The measurement uncertainty of DPIV is about 6%.

By using this measurement technique an experimental investigation on flow around and in the wake region of a single bubble and two similarly-sized air bubbles is described in Chapter 4. The results reveal that the difference in wake structure between bubble and solid occurs in the vicinity of the interface defining the bubble's oscillatory motion. Moreover the turbulent energy production in between two bubbles became larger than that of single bubble, because the interaction between the respective wakes increases the streamwise normal stress.

The influence of the force on bubbles with respect to its motion induced by the bubble deformation and surrounding flow field is presented in Chapter 5. The flow structure surrounding a rising bubble in a linear shear flow field and its shape were measured using a Lagrangian PIV technique in order to capture the phenomena for an expected period. We found that the bubble acceleration can be estimated by a bubble lateral force parameter, which consists of the relative velocity and the circulation around the bubble measured by PIV/LIF, with respect to the delay which depends on the circulation around the bubble.

In Chapter 6, the interaction mechanism between macro and microstructure of turbulence, especially the influence of inter-bubble spacing on the microscopic flow structure in bubbly flow was investigated. The experiment was conducted in fully developed vertical upward channel flow with 0.5% and 1.0% void fraction. For narrow inter-bubble spacing, wake interaction is significant in that the turbulent flow structure, especially the turbulent energy budget, as indicated by high intensity of enstrophy distributed, momentum mixing and turbulent energy dissipation, is relatively most distinguishable in this region.

The experimental work described in Chapter 7 presents the striking features of turbulent flow structure of bubbly flow. First, the lateral force on the bubble induced by shape deformation influences the local void fraction of bubbly flow. Moreover, for narrow inter-bubble spacing wake interaction influences the global turbulent structure characterizing bubbly flow.