Phase separation and flow measurement of dilute bubbly jet with 2-D PIV and LIF

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Abstract

A measurement technique with a combination of PIV and LIF is suggested to measure gas-phase and liquid-phase separately to resolve flow structures of a bubbly jet. In the bubbly jet, distribution of the bubble population shows a Gaussian-like function but translated outward. Spreading nature of each phase does not correspond to each other due to lack of the number of bubbles to be redistributed.

1 Introduction

Investigations on the bubbly jet and plume have been conducted with several techniques. Among those techniques, ADV and LDV can provide 3-component velocity information, but there is a disadvantage of disturbing the flow or complex tuning for the gas phase. Shadowgraphy, which is a kind of optical techniques, has been widely used to analyze bubbles, but it cannot resolve the specific structure inside the bubbly flow due to overlapped bubbles in an imaging plane. In this study, we investigate bubbly jet with 2-D PIV and LIF techniques, which can analyze the structure of bubbly jet inside the core region of the bubbly jet with a low void fraction (Dulin et al., 2012).

2 Method

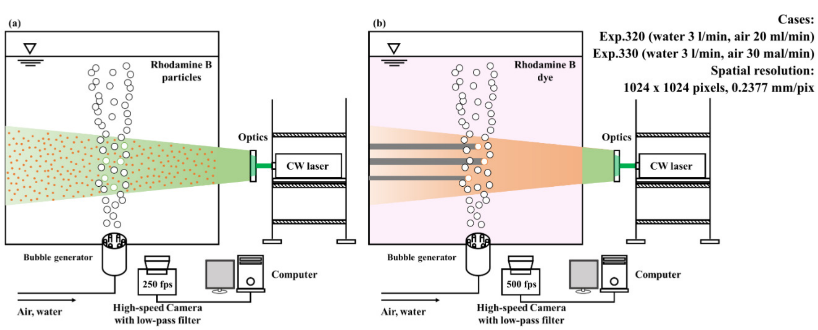

Figure 1: Schematic of experimental setup for (a) PIV (b) LIF

The schematic of the experimental setup is shown in Fig. 1. Gas phase information was calculated from highlighted bubble edge. The air-water mixture was injected into a 1 m^3 cubic tank from the outlet of 20 mm. Diameter of bubbles was around 1.7 mm.

3 Result

Radial profiles of the axial velocity mostly show good agreement with Gaussian-like distribution (Fig. 2 (a)). Fig. 2 (b) shows the evolution of the centerline velocity of the bubbly jet along streamwise direction.

The figure shows an acceleration of the bubbly jet and a potential core collapse in the early stage of the flow. Higher void fraction results in much intense acceleration and earlier collapse of the potential core. It implies that buoyancy of bubbles results in the acceleration of the bubbly jet (Morton and Middleton, 1973).

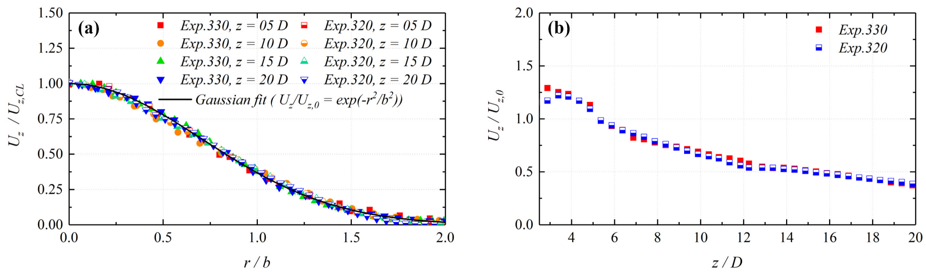

Figure 2: Axial mean velocity profiles (a) radial distributions of velocities (b) centerline velocity with height

In Fig.3, the population of bubbles is concentrated next to the centerline of the bubbly jet in a form of translated Gaussian function. Position of the center of each Gaussian function spreads out as the bubbly jet flows. It does not significantly spread out in the far-field. It contrasts to the spreading of the liquid phase structures with linear self-similarity respect to the height.

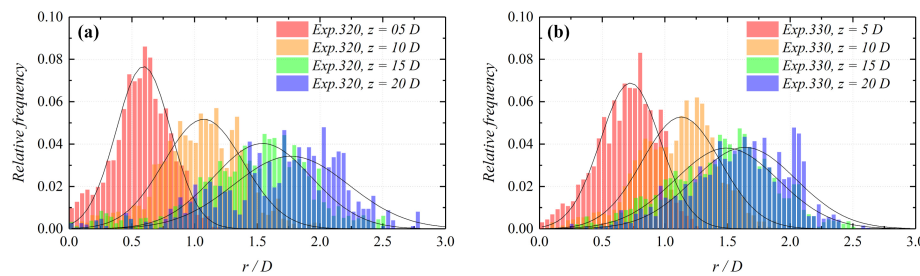

Figure 3: Radial population of bubbles with height

4 Conclusions

Each phase in bubbly jet is successfully measured by the combination of PIV and LIF. The bubbly jet looks like an annular truncated cone shape due to different spreading nature of each phase. It is attributed to the low void fraction condition where the redistribution of bubbles does not sufficiently occur.

Acknowledgements

This work was supported by the National Research Foundation of Korea (NRF) grant, which is funded by the Korean government (MSIT) (No. 2021R1A2C2012469, NRF-2018-Global Ph.D. Fellowship Program).

References

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