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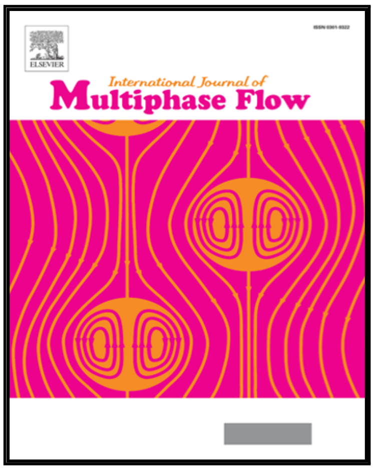

An improved image processing technique for determination of volume and surface area of rising bubble

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An improved image processing technique for determination of volume and surface area of rising bubble

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Abstract

Bubble volume and bubble surface area are key parameters that affect the working performance of bubble columns. Due to their non-intrusive characteristics and high spatial resolution, image processing techniques can be used to measure bubble volume. However, bubbles in practical application are not always perfectly spherical or ellipsoidal. In homogenous flow regimes where bubble interaction is weak, the bubble geometry can be classified into three types: round cap, ellipsoidal, and disk-shaped. For large and severely distorted bubbles, it is difficult to employ existing image processing methods for measuring the bubble volume. This study describes an image analysis technique that was developed to obtain the volume and surface area of large and severely deformed bubbles. This proposed image processing method is based on a differential segmentation concept and possesses better adaptability because it considers both the bubble geometry and deflection angle of the bubble. The developed image processing technique is verified using the results of a bubble collection experiment. By making use of the developed image processing algorithm, the volume and surface area of discrete bubbles have been calculated. The relationship between bubble volume distribution and gas flow rate is discussed and the characteristics of bubble surface area variance are shown. Moreover, the influences of bubble volume and surface area on the bubble rise velocity are analyzed.
Keywords: bubble column, bubble size distribution, image processing method, bubble geometry

1. Introduction

Bubble columns have been widely used as multiphase contactors and reactors in many industrial applications such as chemical processes, coal liquefaction, metallurgy, and wastewater treatment (Smith, 1991; Zhang and Fan, 2003). The surface area of bubbles has a critical influence on the working performance of bubble columns. A high interface area concentration is beneficial to mass, momentum, and energy transfer between phases. Small bubbles have a larger surface area to volume ratio compared to large bubbles with the same cumulative volume; thus, the Sauter mean diameter determined by bubble size distribution is often used to characterize the interface area concentration.

Owing to the importance of bubble size, there are many methods of measuring bubble volume. These methods are classified into two types: intrusive and non-intrusive methods. Typical intrusive methods applied in bubble columns include fiber optics (Lasa et al., 1984; Saberi1 et al., 1995), conductivity (Kim et al., 2000), sampling probe (Alves et al., 2002), phase-sensitive constant temperature anemometry, and wire-mesh sensors (Prasser, 2008). These methods are able to measure a wide range of void fractions. Almeras et al. (Sun et al.) employed constant temperature anemometry to measure liquid phase fluctuation velocities and showed high sensitivity of intrusive methods for local velocity fluctuation. Compared to intrusive methods, non-intrusive measurement techniques possess some advantages. An outstanding point is that the flow condition can avoid the disturbance from inserted measuring probes. In addition non-intrusive methods possess higher spatial resolutions