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SURFACE TENSION EFFECTS ON THE BEHAVIOR OF TWO RISING BUBBLES*

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Abstract: In the inviscid and incompressible fluid flow regime, surface tension effects on the behavior of two initially spherical bubbles with same size rising axisymmetrically in an infinite and initially stationary liquid are investigated numerically with the VOF method. The numerical experiments are performed for two bubbles with two different bubble distances. The ratio of gas density to liquid density is 0.001, which is close to the case of air bubbles rising in water. In the case of $Dis = 2.5$, where Dis is defined as the ratio of the distance between the bubble centroids to the radius of the bubble, it is found from numerical experiments that there exist four critical Weber numbers We_1, We_2, We_3 and We_4, which are in between 10 and 100, 3 and 4, 1.5 and 1.8, and 0.2 and 0.3, respectively. In the case of $Dis = 2.3$, similar phenomena also appear but the corresponding four critical Weber numbers are lower than those in the case of $Dis = 2.5$. The mechanism of the above phenomena is analyzed theoretically and numerically.

Key words: two bubbles, buoyancy, surface tension, VOF method

Introduction

Bubble dynamics in gas/liquid flow plays an important role in many natural and industrial processes such as combustion, petroleum refining, chemical engineering and cleaning. Most of the early works were concentrated on one rising bubble in water. However, in many practical applications, bubbles occur in a large amount. For example, in the performance of fermentors, bubble coalescence and break-up might be crucial so that a fine dispersion of disperse phase is an important requirement for successful operation of any bioreactor. Therefore, it is important to investigate the interaction of bubbles. A lot of theoretical and experimental work on bubbles has been done[1-4]. However, it is difficult to study the mechanism of the bubble interaction through pure theoretical methods because of the strong nonlinearity accompanied by bubble large deformations, or through experimental methods because of the limited measurements of velocity and pressure distributions. Numerical methods can overcome these drawbacks. Large amount of numerical studies on the interaction of bubbles have been conducted with different methods, such as the level set methods[5], front tracking methods[6], Volume Of Fluid (VOF) methods[7-9], vortex method[10], Direct Numerical Simulation (DNS) method[11], Coupled Level Set and VOF (CLSVOF) methods[12], and other methods[13]. However, most of these works focused mainly on the numerical methods and gave only results without the mechanism analysis of bubble behaviors.

In this article, we are trying to analyze numerically the interaction and deformation mechanism of two bubbles with the VOF method. The Weber

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