Proceedings of the 10th World Congress on Mechanical, Chemical, and Material Engineering (MCM'24)
Barcelona, Spain –August 22-24, 2024
Paper No. HTFF 199
DOI: 10.11159/htff24.199

Observation of Two-Dimensional Bubble Motions near Various Boundaries

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Extended Abstract

In recent years, the environment surrounding cavitation bubbles has significantly changed. Because cavitation causes material damage and abnormal vibrations in turbomachinery, they are regarded as challenging, and research has focused on suppressing them. However, research on flow generation that actively utilizes the kinetic characteristics of bubbles, such as sonoporation using jet formation in the microregion of cavitation bubbles [1] and the generation of synthetic jets by the nonlinear volume fluctuations of bubbles [2], has recently attracted attention. The motion of a cavitation bubble is generally expressed by the upwelling and suction (without momentum) of a potential flow; therefore, it is necessary to restrict the motion of the bubble to generate a directional flow with momentum using bubbles. Therefore, the behavior of bubbles under various boundary conditions in addition to rigid plates and free surfaces should be clarified. Tomita et al. conducted experimental and theoretical studies on curved rigid boundaries and elucidated the effect of rigid-body curvature on bubble motion [3]. Li et al. performed numerical simulations on the collapse behavior of a single bubble and two bubbles in an inclined V-shaped corner and established the relationship between the angle of the V-shaped corner, the distance between the corner and cavitation bubbles, and the distance between bubbles by obtaining the temperature, density, velocity, and pressure fields [4]. Yin et al. generated laser-induced single bubbles at the tip of a conical rigid body and determined the relative distance between the bubbles from the tip of the conical rigid body; they also investigated the effect of the cone angle on the pressure peak and other parameters through experimental and numerical studies [5]. However, these studies were conducted on three-dimensional (3D, axisymmetric) bubbles but are unsuitable for generating two-dimensional (2D) flows.

In this study, a roughly 2D bubble was generated in a liquid between flat plates by electrical discharge, and its behavior was filmed at high speed. The motion of 2D bubbles under rigid wall conditions with various geometries was clarified, focusing mainly on the relationship between the wall geometry and time characteristics, and the difference between 2D and 3D bubbles was analyzed. The results show that the dimensionless collapse period $\theta = 90°$ increases as the dimensionless distance ${l_w}^*$ (the ratio of the distance between the wall and the bubble to the maximum bubble equivalent radius) decreases. The value of the dimensionless collapse period τ^* for $\theta = 90°$ exceeds that of $\theta = 180°$ when the rigid body boundary angle $\theta = 180°$ (flat wall) and $\theta = 90°$ (L-shaped wall) are compared for the dimensionless distance ${l_w}^*$. The value of the dimensionless collapse period τ^* of $\theta = 90°$ exceeds that of $\theta = 180°$.

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