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Microjet Formation of a Two-Dimensional Bubble near A Slitted Rigid Wall

Kan Zeniya[1], Ryuichi Inoue[1] , Daiki Iwaya[1], Akihito Kiyama[2] , Donghyuk Kang[2] and Kotaro Sato[1]
[1] Mechanical Engineering Program in the Graduate School of Engineering/Kogakuin University
2665-1 Nakano-cho, Hachioji-shi, Tokyo 192-0015, Japan
am25058@ns.kogakuin.ac.jp; am24008@ns.kogakuin.ac.jp
[2] Department of Mechanical Engineering/Saitama University
Shimo-okubo 25, Sakura-ku, Saitama-shi, Saitama 338-8570, Japan
am24010@ns.kogakuin.ac.jp

Extended Abstract

Cavitation causes erosion primarily due to high-speed microjets formed during bubble collapse and shock waves emitted after rebound. In contrast, recent studies have proposed using cavitation bubbles as non-contact, optically controllable actuators [1], leading to active exploitation of bubble dynamics. Consequently, cavitation bubble behavior has been extensively investigated using computational fluid dynamics (CFD) and high-speed flow visualization [2]. However, detailed kinematic characteristics remain unclear, especially in two-dimensional (2D) configurations. Wang et al. studied the collapse and rebound of 2D bubbles[3], showing that a small dimensionless distance between a narrow gap's edge and the bubble center generates a strong jet into the gap. Shen et al. examined interactions of 2D bubbles between plates and cylindrical walls [4], identifying three collapse behaviors: (1) a collapsing liquid film; (2) asymmetric arc-shaped growth and splitting; and (3) symmetric growth followed by splitting. Inoue et al. observed discharge bubbles between glass plates [5], finding that 2D bubbles near rigid walls also generate wall-directed jets. Nonetheless, the mechanisms of microjet formation in 2D bubbles—especially near rigid walls with slits—are still poorly understood, posing challenges for applying bubble dynamics in micro/nanoscale actuators.

In this study, discharge bubbles were generated in a two-dimensional space between two parallel flat plates. The behavior of two-dimensional cavitation bubbles near a flat rigid wall and a rigid wall with a slit was captured using a high-speed video camera, and their dynamic characteristics were investigated in detail. The dimensionless slit width was defined as $B = {}^{b}/_{r_{bm}} = 0.32 \pm 0.01$ (b [mm]is the slit width and, r_{bm}[mm] is the maximum bubble radius.). A key finding is that when the non-dimensional distance between the wall and thebubble center is $L_w = {}^{l_w}/_{r_{bm}} = 1.20 \pm 0.01$ (l_w [mm] is distance from bottom of wall to tungsten electrode ,r_{bm}=3.22±0.03mm)the bubble near a flat rigid wall translates toward the wall and generates a jet directed at the wall surface. In contrast, for the rigid wall with a slit, the bubble exhibits almost no translational motion prior to collapse, and a jet is formed on the side opposite to the wall. Furthermore, after rebound, the bubble was observed to move slightly toward the wall.When the wall-bubble center distance was increased to $L_w = 2.18 \pm 0.01$ $(r_{bm} = 3.03 \pm 0.03)$ no significant qualitative differences were observed between the behaviors near the flat wall and the slit wall. However, in the case of the slit wall, no distinct jet formation was detected, and no apparent translational motion was observed during the second and third oscillation cycles.

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