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PRESSURE VARIABILITY IN CAVITATION BUBBLES INDUCED BY LOW-VOLTAGE DISCHARGE

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Abstract

Cavitation is a significant challenge in hydraulic turbines, restricting their operational flexibility and efficiency. The collapse of cavitation bubbles generates shock waves, leading to material erosion. A single cavitation bubble can thus be studied to better understand the phenomena, providing insight into cavitation bubble dynamics and its associated pressure load. Low-voltage discharge is one easy and affordable method for studying a single cavitation bubble. In this method, electrical current is discharged through the contact point between two electrodes (diameter of 0.1 mm). The localized heating generates plasma and water is locally vaporized, generating a single cavitation bubble. At the same time, the electrodes melt and break, needing to be replaced every time. In this experiment, single cavitation bubbles are generated in quiescent water using the low-voltage discharge method and their repeatability is investigated.

The stand-off parameter, defined as the ratio of distance to the nearest surface over the maximum bubble radius ($\gamma = d/R_{max}$) is kept higher than five to ensure spherical collapses. The bubble maximum radius ranges between 3.91 and 4.51 mm. The bubbles are recorded with a camera at 50 000 fps, and an in-house Python code is used to evaluate the bubble radius from the images. A bubble collapsing spherically will generate a shock wave when it reaches its minimum volume. Wall pressure is recorded using a dynamic pressure sensor at 50 MHz.

First, the literature mentions that longer electrodes lead to smaller bubbles. However, we show that the electrode length up to the contact point (i.e. the total electrode length minus the excess length) dictates the bubble radius rather than the total electrode length. Higher length up to the contact point generates smaller bubbles. The excess length does not influence significantly the bubble's size. Second, for similar-sized bubbles at constant distances from the pressure sensor (30, 40 and 50 mm), significant peak pressure variability at the collapse was measured, with values ranging between 100 and 800 kPa. The average maximum radius for those bubbles is 4.22 mm, with a standard deviation of 1.44 %. Thus, we measured the current flowing through the electrodes during the discharge and found a correlation between the peak pressure at the collapse and the time needed to melt and break the electrodes. Higher melting duration leads to bubbles with a longer lifetime and lower peak pressure at the collapse.