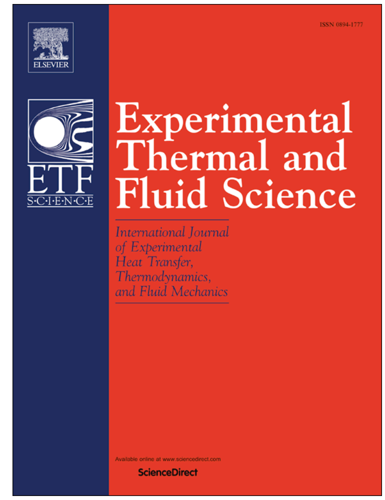

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The influence of ventilated cavitation on vortex shedding behind a bluff body

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Abstract

The objective of this paper is to investigate the influence of ventilated cavitation on vortex shedding in the wake behind a bluff body at Re=6.7×10^4 combining high-speed camera and TR-PIV measurement with POD analysis. The results show that three different vortex shedding behaviors exist in the wake. With the increase of gas entrainment coefficient Q_v, the ventilated cavity area increases, while the corresponding frequency decreases. The proper orthogonal decomposition (POD) analysis, containing the variations of the POD mode energy, POD coefficients, and POD modes, is used to reveal the influence of ventilated cavitation on the vortex shedding behavior. The results demonstrate that ventilated cavitation affects vortex shedding in both time and spatial scales. In terms of time scales, the frequency of the first two modes reduces with the increase of Q_v, which is consistent with the ventilated cavitation vortex shedding frequency obtained by high-speed image processing. In terms of spatial scales, the energy of large-scale structures decreases with the increase of Q_v, while the energy of relative small-scale structures increases. Based on the reconstruction by linear combination of the first four POD modes and the mean flow field, we obtain the dominant flow features and the influence of ventilated cavitation on the vortex-shedding process.

Keywords: ventilated cavitating flow, high-speed camera, particle image velocimetry, proper orthogonal decomposition, vortex shedding.

1. Introduction

Ventilated cavitation is obtained by injecting gas into the low pressure regions of liquid flows [1, 2, 3]. There is an increasing interest in ventilated cavitation because of drag reduction [4, 5, 6]. Although there are a great number of studies on ventilated cavitation, many researchers focus their attention on the ventilated supercavitation [7-11]. Karn et al. [7] shed light on the physical mechanisms of supercavity closure modes to investigate the closure formation and transition. They gave a closure maps to depict the flow regimes of each closure mode as a function of Fr and C_{Qs} for different blockage ratios. Skidmore et al. [8] explored a technique to control ventilated supercavity pulsation and noise. They indicated that modulation of the ventilation rate was effective at suppressing ventilated supercavity pulsation over a wide range of conditions. Fewer studies shed light on the effect of ventilated cavitation on vortex shedding and the near-wake characteristics [12, 13, 14]. The vortex shedding plays a vital role for underwater vehicle maneuverability, stability and the hydrodynamic performance. Therefore, ventilated cavitation vortex shedding is a topic worthy of further study [15, 16].