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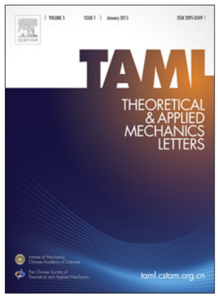

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PII: S2095-0349(17)30098-3
DOI: https://doi.org/10.1016/j.taml.2017.09.003
Reference: TAML 178

To appear in: *Theoretical & Applied Mechanics Letters*

Received date : 20 April 2017
Revised date : 6 August 2017
Accepted date : 22 August 2017

Please cite this article as: J. Huang, C. Yu, Y. Wang, C. Xu, C. Huang, Passive control of cavitating flow around an axisymmetric projectile by using a trip bar, *Theoretical & Applied Mechanics Letters* (2017), https://doi.org/10.1016/j.taml.2017.09.003

Passive control of cavitating flow around an axisymmetric projectile by using a trip bar

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Abstract: Quasi-periodical evolutions such as shedding and collapsing of unsteady cloud cavitating flow, induce strong pressure fluctuations, what may deteriorate maneuvering stability and corrode surfaces of underwater vehicles. This paper analyzed effects on cavitation stability of a trip bar arranged on high-speed underwater projectile. Small scale water tank experiment and large eddy simulation using the open source software OpenFOAM were used, and the results agree well with each other. Results also indicate that trip bar can obstruct downstream re-entrant jet and pressure wave propagation caused by collapse, resulting in a relatively stable sheet cavity between trip bar and shoulder of projectiles.

Key words: unsteady cavitating flow; trip bar; re-entrant jet; passive flow control

Cavitation occurs in low-pressure regions on surfaces of high-speed underwater vehicles. Unsteady evolutions, such as shedding and collapsing of cavity, can lead to negative influences, including vibration, noise, and cavitation erosion, on underwater vehicles. Consequently, effective flow control methods must be designed to improve stability of cavitating flow and to ensure safety of high-speed underwater cruising. Previous research showed that re-entrant jet inside cavities is a key factor causing transformation of sheet cavitation to cloud cavitation and eventual cavity collapse [1-3]. Unsteady cavity evolution can also be affected by pressure wave caused by collapsing [4-6].

Two main kinds of cavitating flow control methods are available. Active controls commonly realized by ventilation. Cavity shedding and collapsing are suppressed, and when flow pattern changes from bubble-layer to air-layer with increasing gas-injection mass flux, sailing resistance can be decreased simultaneously [7]. However, difficultly arises from achieving such process. By contrast, passive control is easier to implement. Attaching a trip bar on the upper surface of a NACA16012 hydrofoil can change boundary layer and local flow characteristics, suppressing the unsteady evolution of cavity flow [8]. Further studies must be conducted for adjustments for other geometric shapes of underwater vehicle.

For cavitation of axisymmetric projectiles, shedding and collapsing induced by re-entrant jet become more significant. Re-entrant jet is generated at the trailing edge of cavity then moves to the leading edge along projectile surface and finally cuts off cavitation that leads to shedding and collapse. Collapse pressure possibly further strengthens re-entrant jet in the next cycle [9]. Evolutionary characteristics of axisymmetric projectile cavitation are similar to those of hydrofoil cavitation. Consequently, the trip bar may improve cavitation stability by weakening re-entrant jet. Thus far, no work discussed this subject.

In this paper, typical experiments of unsteady cavitating flow around axisymmetric projectiles

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