ID de Contribution: **3** Type: **Oral presentation**

On the physical mechanism of tip vortex cavitation hysteresis

mercredi 1 juin 2022 15:00 (30 minutes)

Inception and desinence thresholds of tip vortex cavitation (TVC), generated by an elliptical NACA 16-020 hydrofoil, are measured at different flow conditions for various gas contents. It is observed that TVC often disappears at cavitation indices significantly higher than the inception thresholds introducing large hystereses. Our measurements reveal that TVC desinence pressure increases with gas content and, under specific flow conditions, may reach to atmospheric pressure. When the pressure of the cavitating core is below the initial saturation pressure of the dissolved gases, water flowing adjacent to the interface becomes supersaturated, which leads to the diffusion of air molecules into TVC. To estimate the outgassing rate, a simple diffusion model is proposed and analytically solved. In addition, we demonstrate that the extent of the delay in desinence due to outgassing is also dictated by the bulk flow parameters, i.e., the incidence angle and freestream velocity. Owing to flow visualizations, we assert that formation of a laminar separation bubble of appropriate size and shape at the hydrofoil tip is a necessary condition for a delayed desinence.

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