XI International Conference on Computational Methods in Marine Engineering

Experimental Investigation of two Typical Hydrofoil Sections with Cavitation

P. Bot[1,*], P. François[1], F. Hauville[1], J.A. Astolfi[1], S. Soton[2]

[1] Arts et Métiers Institute of Technology, IRENav, CC600 29240 BREST Cedex 9, France.
[2] SEAir Solutions, 10, rue Chalutier les 2 Anges, 56100 Lorient, France

[*] Corresponding Author: patrick.bot@ecole-navale.fr

ABSTRACT

Hydrofoils are now largely used on high-speed sailing boats and leisure crafts, and their hydrodynamic behaviour is critical for the performance of the vessel. Cavitation is often a major constraint on these highly loaded lifting structures as it is generally considered to have a negative impact on performance. In foil design, a first common approach is to impose a non-cavitation constraint in the optimisation process (e.g. Galen et al. 2025), and the foil sections are adjusted to delay cavitation inception to the highest possible speed. However, at sailing speeds in the 40-50 knots, cavitation cannot be avoided, and the design should be able to consider the effect of a more or less developed cavitation on the hydrodynamic performance. Numerical simulation can predict the threshold of cavitation inception reasonably well when the minimum pressure in the non-cavitating flow reaches the vapor pressure ($Cp_{min} = -\sigma$), but predicting the hydrodynamic forces in the cavitating regime is a challenge and the existing cavitation models still need validation. At the highest speeds, supercavitating sections -not studied here- are preferred to promote cavitation and avoid instability due to strongly fluctuating vapor cavities (e.g. Vernengo et al. 2016). This work presents an experimental investigation in the IRENav cavitation tunnel of two foil sections typical of take-off and high-speed sailing operating points, corresponding to a two-element foil (main and flap) with two different flap deflection angles. Hydrodynamic forces are measured in the subcavitating regime, at the onset of cavitation and in developed cavitation. The cavitating flow is visualized with high-speed cameras. The velocity field is measured in the non-cavitating regime with time-resolved Particle Image Velocimetry. When cavitation sets in, a slight increase in lift coefficient is measured before a drop into well-developed cavitation. However, the drag coefficient increases too, gently as soon as cavitation appears, then strongly when the cavitation number decreases, up to double in developed cavitation. Thus, the lift to drag ratio only decreases under the effect of cavitation.

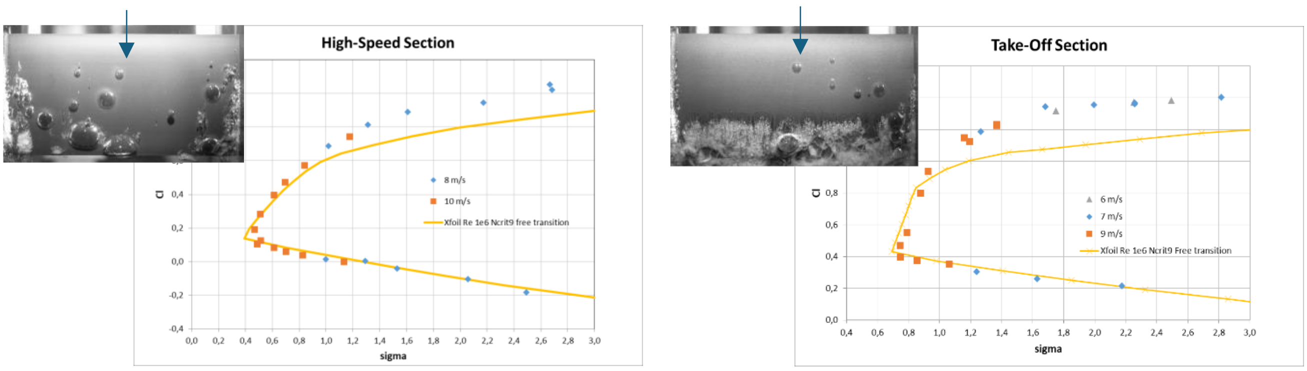

Figure 1: Cavitation Maps and typical cavitation patterns on both foil sections

References

Galen W. Ng, Yingqian Liao, Anil Yildirim, Joaquim R.R.A. Martins, Hydrostructural optimization of subcavitating cambered and symmetric composite foils, Composite Structures, Volume 351, 2025

Vernengo G., Bonfiglio L., Gaggero S. and Brizzolara S., Physics-Based Design by Optimization of Unconventional Supercavitating Hydrofoils, J. Ship Research **60**, 4, 187-202, 2016