Influence of windsurfing fin stiffness distribution on the lift-drag characteristics

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ABSTRACT

This article addresses the problem of calculating the hydromechanical forces generated by flexible hydrofoils. The research was done on the example of the composite windsurfing fin for the RS:X monotype class. The motivation for this research was that significant differences between products were observed. It should not appear since monotype classes were introduced to Olympic sailing to mitigate the differences between the sailors' equipment. However, everyday practice shows that the variations occur anyway and it strongly affects the performance of the hydrofoil. Therefore, we decided to study the differences between the windsurfing fins and quantify how it influences performance. The study was done using mainly computational methods supported by the experimental investigation. We performed two-way Fluid-Structure Interaction (FSI) calculations to investigate this problem.

The variations between the idealized designed fin and the final product delivered to the end-user apply to the geometry and structure's mechanical properties. We focused only on the aspect of variations of mechanical properties and their influence on the hydrodynamic forces generated by the fin. From a large population of measured fins, three fins were selected for calculations, each representing various stiffness properties – rigid, moderate and flexible.

The FSI calculations were performed using Abaqus and Star-CCM+ explicit coupling. It required the generation of the Finite Element Method (FEA) model. Direct modelling composite material (number of plies, their orientation, thickness, etc.) was impossible since the composite stacking sequence was unknown to us. Each fin was divided into eight sections, and the material properties of each section were identified based on the experimental investigation results. The FSI calculations aimed to find lift and drag forces generated by the fins with various stiffness distributions and the quasi-static deformation of the structure (bend and twist). The calculations were performed for one speed and several angles of attack to represent various hydromechanical loading on the windsurfing fin. Based on that, the lift and drag coefficients and L/D ratios were evaluated. The results of the calculations obtained for flexible fins were compared to the rigid hydrofoil. Significant differences between the performance of the fins were obtained, depending on the hydrofoil angle of attack.