Effect of hydrofoils' twist on the lift-drag characteristics based on serial production sampling

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ABSTRACT

Hydrofoils are designed to achieve specified characteristics, but in most cases, the final product is not an ideal representation of the design. In the case of racing sailing, where hydrofoils are made of composite materials, competitors claim significant performance variations of the apparently same products. Differences in performance are noticeable even within the products produced by one manufacturer within one production series, which makes the purchasing of the equipment challenging This paper aims at addressing the problem of assessment of the hydrofoil twist impact on lift-drag characteristics. The twist of the profile manifests itself in the variable angle of attack of individual sections, thus, the actually achieved lift and drag forces remain out of control to a certain extent.

The serial-produced hydrofoils were sampled and ten hydrofoils were measured in total. They were produced by one manufacturer for the monotype racing class and are made of carbon fiber composite. The first stage of measurement was carried out by means of a 3D scanning device, subsequently, the obtained models were analysed in Rhino3D. The parameters of foils and their sections were measured using codes written in the Grasshopper plugin. From a practical point of view, 3D scanning was too time-consuming and expensive to measure a larger number of foils. Therefore, the alternative method for measuring hydrofoil geometry was proposed.

Physical measurement was introduced, which allowed testing more foils but was limited to measuring specified preselected parameters. Parameters were chosen arbitrarily and measurements on existing foils had to be practically feasible. In the course of the research, the following quantities were measured: foil span, foil tip coordinates, angle of attack for specified sections, sections' coordinates (for specified locations defined by foil mounting holes), and sections' chord lengths.

The aim of this article is to show the influence of differences in angles of attack of corresponding sections of the hydrofoils on their resultant lift and drag characteristics. We began by comparing the foils' geometry. The first criterion for comparison was the symmetry of both sides of the hydrofoil. Secondly, differences between foils for the same section were compared. Next, ranges and typical deviations of the angle of attack for this population were determined.

Characteristics of wings were calculated by performing CFD simulations using OpenFOAM. The finite volume method with steady, turbulent k-w SST flow models was applied. Calculations were performed for the scanned hydrofoils and models with a modified angle of attack at particular sections based on previously defined ranges. The obtained results allowed us to define the influence of changes in the angle of attack on foil lift and drag for the specified magnitude of deviations.