COMPARISON OF HYDRODYNAMIC PERFORMANCES OF AN IMOCA 60’ WITH STRAIGHT OR L-SHAPED DAGGERBOARD

L. Mazas and Y. Andrillon, HydrOcean, France, loic.mazas@hydrocean.fr
A. Letourneur and P. Kerdraon, VPLP, France, letourneur@vannes.vplp.fr
G. Verdier, Verdier Architecture Navale, France, gverdier@guillaumeverdier.com

The milestone of the 8th edition of the Vendée Globe in 2016 was the apparition of foils on IMOCA 60’. These foils are L-shaped daggerboards pointing out of the sides of the hull; they were designed so as to create lift on leeward. The combined effect of lifting the hull partially out of water and increasing the righting moment improves the yachts’ performances. The match between “foilers” and “classical” IMOCAs gave advantage to foilers.

The evaluation and prediction of sailing yachts hydrodynamic performances in waves is crucial to draw reliable speed polars. IMOCA 60° dynamic behaviour and hydrodynamic forces and moments depend very much on their appendages. The aim of this study was to compare the performances of two types of daggerboard: one “classical” with a straight shape, one “foil” with a L-shape, called “CLOUT”; they were appended on the same IMOCA hull. Some of the CFD simulations were performed by HydrOcean, an engineering company specialised in marine CFD, for naval architects at VPLP design and Guillaume Verdier Architecture Navale, while another CFD group was operating foil and hull resistance analysis under the direction of Leonard Imas. This specific comparison of CLOUT versus STRAIGHT daggerboard was performed by HydrOcean.

Two sailing configurations were evaluated: upwind with 30° incident waves and downwind with 135° incident waves. The simulations showed that CLOUT daggerboard was very disadvantageous upwind, with an increase of 15% in drag and a loss of 7% in righting moment. However, it seemed interesting downwind, with a drag reduction of 9% and a gain in righting moment of 8%. Still, these advantages are to be balanced with the sensitivity of CLOUT’s dynamic behaviour to waves: the boat drifts to leeward. That study enabled to point out the advantages and drawbacks of this daggerboard concept and it gave some clues for the improvements that could be brought to foil design.

NOMENCLATURE

- \( \lambda \) Wave length (m)
- DOF Degree of freedom
- \( F_x \) Drag force (N)
- \( F_y \) Side force (N)
- \( F_z \) Lift force (N)
- \( H \) Wave height (m)
- \( M_x \) Righting moment (N.m)
- \( R_y \) Dynamic sinkage (°)
- \( T \) Wave period (s)
- \( T_z \) Dynamic sinkage (m)

1 INTRODUCTION

The sailing yacht studied is an IMOCA 60’ heeled at 25°, appended with a keel canted 38° leeward and a daggerboard.

Two geometries of daggerboards were evaluated with the same IMOCA 60’ hull form: one straight daggerboard; called “STRAIGHT”, and one L-shaped called “CLOUT” (for C-shaft, L-tip, outward pointing). Figure 1 presents views of the two daggerboards appended on the same hull. STRAIGHT has a 590 mm chord while CLOUT’s is 450 mm.

2 MODEL SETUP

2.1 COORDINATE SYSTEM

All presented hydrodynamic forces \((F_x, F_y, F_z)\) and moment \((M_x)\) are averaged values and given in the coordinate system linked to boat’s centre of gravity (cf. Figure 2). \(x\)-axis is oriented to the bow, \(y\)-axis portside and \(z\)-axis up. Positive leeway is leeward, positive trim is bow down and positive dynamic sinkage means the boat goes up. It is fixed in orientation and its origin follows the boat’s motions. The centre of gravity varies depending on sailing upwind or downwind due to different ballast configurations.