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A CFD-based Performance Prediction of Roller Wing Sail for Wind-Assisted Ship Propulsion

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ABSTRACT

In this study, a parametric study on the characteristics of a plain wingsail was carried out using numerical calculations. Later, in order to improve the aerodynamic performance, the plain wing was fitted with a rotary cylinder (denoted as "roller") on the suction side. As the first step for the wingsail analysis, a cylinder is installed in a plain airfoil. Then, the cylinder location was systematically changed, aiming to find the optimal location of the cylinder. The simulations were performed using the same assumptions and mesh used in the 2D analysis of the plain wing. For the rotor to have a positive effect and help move the flow separation point, it is important to set the rotor before the flow separation occurs. The simulation results showed that the optimal location of the cylinder is located at one meter (x/C = 40%) from the leading edge (Fig. 1). As can be observed in Fig. 2 that the simulation results showed that the highest lift coefficient is obtained when the cylinder spin ratio is 4, improving the lift coefficient by almost 25% (Fig. 2).

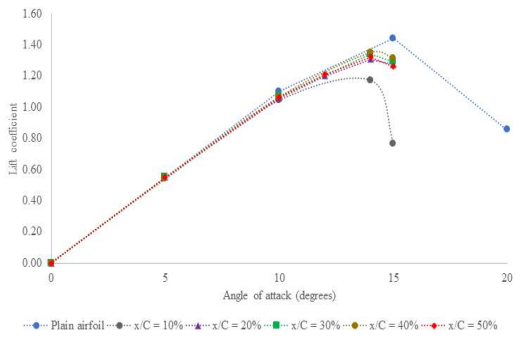

Fig. 1. Comparison of the wing sail lift with the stationary cylinder at variable locations

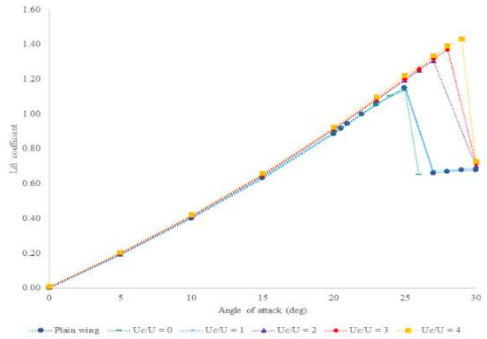

Fig. 2. Comparison of wing sail lift with the rotating cylinder

When employing wind propulsion systems within the framework of the Energy Efficiency Design Index (EEDI) regulations, users must utilize the global wind probability matrix to appropriately account for the impact of the wind propulsion system. However, recent years have witnessed substantial controversy concerning the precision of this wind probability matrix. Hence, it becomes necessary to conduct an investigation into the performance of the 3 rigs, plain wingsail, rotor sail, and the present optimized wing sail, excluding the utilization of the wind speed and direction probability matrix provided by the IMO. The calculation results are presented in the Table 1. This difference represents the 8% for the plain wing and 11% for the Roller wingsail.

Table 1 Comparison of the available effective power for 1 unit

	Plain wing sail	Roller wing sail	Rotor sail
$F_{eff} \cdot P_{eff}$ (kW)	561.3	610.0	489.3

References

I. M. Viola, M. Sacher, J. Xu, and F. Wang. A numerical method for the design of ships with wind-assisted propulsion. Ocean Engineering, 105, 33-42, 2015