Statoric blades effect on the efficiency of a RANS-optimized rim-driven thruster

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ABSTRACT

Based on the pioneering works of Kort, who first proposed driving a propeller via its blade tips, rim-driven thrusters has emerged as a ground-breaking advancement in maritime propulsion. In fact, these thrusters, in addition to the optimal integration with electric motors, due to the almost total elimination of tip vortices promise a significant reduction in cavitation. Several works have been conducted on the investigation of a methodology for the hydrodynamic design of rim driven thrusters, highlighting the need of high-fidelity simulations (RANS) to correctly capture the hydrodynamic effects and the interaction between duct and blades (Yan et al., 2017). The results obtained show that thrusters of this type are indeed able to reduce cavitation while maintaining efficiencies comparable with those of ducted propellers (Gaggero, 2020).

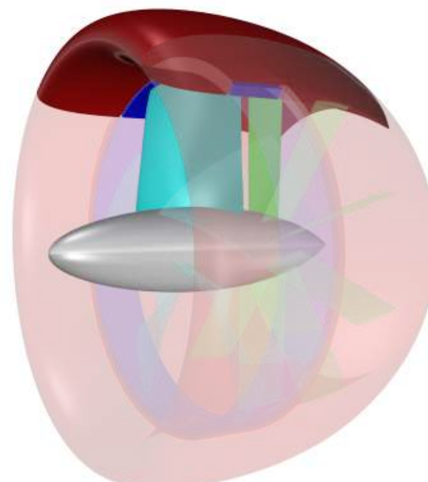

Figure 1: Example of RDPJ-R/S geometry.

Picking up on the idea of pumpjets, in this work, the effect on efficiency of adding a stator stage to a rim driven thruster is investigated. In addition, with a view to experimental validation, parameters that take into account the actual constructability of the object are included in the object optimization process, which is named rim driven pumpjet (RDPJ). Taking advantage of the existing Simulation Based Design by Optimization (SBDO) paradigm, the thruster was optimized in three different configurations: (1) RDPJ with the rotor positioned upstream from the stator (RDPJ-R/S), (2) RDPJ with the rotor posiaizoned downstream with respect to the stator (RDPJ-S/R) and (3) rim driven without stator (RD). The working framework consists of a parametric description of the rim blades, duct and stator blades geometries and a multi-objective optimization algorithm which makes use of the results from high-fidelity RANS calculations to drive the choice towards optimal shapes. In distinct design runs, the three different configurations are considered for the optimal design with the contrasting objectives of maximizing the propulsive efficiency while minimizing the cavitation which is monitored through the simplest cavitation inception criterion based on the analysis of the non-cavitating pressure distribution over the blade. The effectiveness of the RDPJ is verified by comparing the optimal configurations obtined with the performance of the RD thruster while design trends and guidelines are extracted from the analysis of the amount of data collected during the optimization process.

References

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