Experimental Investigation of Rotor Sail Power Requirements

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In accordance with global climate policies, the International Maritime Organization (IMO) has introduced strict regulations to reduce greenhouse gas (GHG) emissions in the maritime shipping industry. This has created significant impetus to pursue new technologies to meet these regulations all the while continuing to satisfy the increasing demand of international shipping. Rotor sails are a simple and fuel-efficient supplement to conventional propulsion methods and can be retrofitted onto existing ships. These devices, consisting of a vertical rotating cylinder, generate thrust from the wind through the magnus effect and can offer fuel savings of up to 25%. However, there are currently no reliable methods to accurately predict the operating power requirements, leaving engineers unable to design these rotors due to significant uncertainty. The development of a reliable and standardized method to determine power requirements for rotor sail operation is needed. The required power depends on the rotational speed and the torque acting on the rotor's surface to overcome frictional forces. In this work, the power required to operate a stationary rotor sail is characterized through a series of experiments in water and air, as well as at various rotational speeds. A scaled down rotor sail model, mounted in a large fluid tank and, equipped with a servo motor capable of rotational speeds and applied torques of up to 8000 RPM and 3.4 Nm, respectively, was used. Output RPM and torque data was collected during operation to determine the operating power of the rotor in each test. The rotor sail was tested between 100 and 4500 RPM in both water and air achieving a wide range of Reynolds numbers ($Re_D = \frac{V_\theta R}{\nu}$) up to 3x10^5. The results reveal the important influence of free surface effects and provide insights for design improvements for operating the rotor with translation and rotation. From the experimental data, a refined method to effectively predict power requirements for any rotor sail is proposed.

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