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A Study on Improving Rotor Sail Performance through Flow Control of the Upper Deck Structure of a Ship

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ABSTRACT

Rotor sails have gained attention as a practical and effective short-term solution for reducing greenhouse gas emissions from ships, and extensive research and trials are being actively conducted worldwide. While the vessel is in operation, it has been reported that rotor sail-equipped vessels have saved up to 20% fuel under optimal wind speed and angle conditions, with numerous prior studies addressing these ideal environmental conditions. However, rotor sail performance is not solely influenced by environmental factors such as wind speed and direction but is also significantly affected by factors such as the upper deck structure of the ship. In particular, non-uniform flow entering the upper deck can create stagnation zones and vortices between the rotor sail and deck structures, reducing aerodynamic efficiency. Therefore, additional research is required to minimize the impact of non-uniform flow and optimize the flow environment to further enhance rotor sail performance.

In this study, a numerical analysis was conducted using commercial CFD (Computational Fluid Dynamics) software, STAR-CCM+, to investigate the effects of additional upper deck structures on improving rotor sail performance. The simulation results suggest that the installation of upper deck structures may enhance the uniformity of flow entering the rotor sail, potentially mitigating stagnation and vortex phenomena between the rotor sail and the deck. Such flow control significantly contributes to enhancing the aerodynamic performance of rotor sails. Furthermore, effects of design changes in upper deck structures, including factors such as shape, angle, and orientation, were analyzed to identify key design variables. Optimal design conditions suitable for practical applications on the considered vessels were proposed.

The findings of this study offer practical solutions for ship owners seeking to implement rotor sails in an effi cient and sustainable manner. Moreover, the results may provide valuable insights for the future commerciali zation and optimization of wind-assisted propulsion systems.

References

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