XI International Conference on Computational Methods in Marine Engineering

Investigation of Leeway Angle on Wake Fraction for a Twin-Screw Wind-Assisted Ship Using CFD and PIV Measurements

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ABSTRACT

The integration of wind-assisted propulsion systems in modern ships offers a promising pathway to reduce fuel consumption and greenhouse gas emissions. For these vessels, understanding the wake fraction—the proportion of the ship's speed lost due to the surrounding flow field—is critical for accurately predicting propulsion performance. The leeway angle, induced by side forces from wind-assisted devices, further complicates the wake dynamics, potentially altering the nominal and effective wake at the propeller. This study explores the influence of leeway angle on the wake fraction of a 3 meter model scale twin-screw bulk carrier, providing essential insights for optimizing wind-assisted ship designs.

Numerical simulations are conducted to model the flow field around the hull, rudders and propellers, with and without a leeway angle applied, using a RANS-based solver. Both nominal and effective wake fractions are analysed, capturing the detailed wake structures at and behind the propeller plane. The CFD simulations incorporate realistic hull geometries and operational parameters, enabling accurate representation of the wake dynamics. These numerical predictions form a critical part of the investigation, serving as a baseline for validating experimental findings.

Model tests complement the numerical work through Underwater Particle Image Velocimetry (UPIV) measurements performed at and behind the propeller plane of the twin-screw bulk carrier. The experiments are conducted in a Boldrewood Towing Tank facility under controlled conditions, with and without the application of leeway angle. The UPIV setup uses stereo imaging, capturing the three-dimensional velocity fields across the measurement plane in the wake, providing high-resolution data to calculate both nominal and effective wake fractions. These measurements offer a direct comparison to the numerical predictions, enabling the impact of various numerical modelling parameters on the CFD accuracy to be assessed and further understanding of wake modification caused by leeway.

This combined approach aims to deepen our understanding of how leeway and rudder angles impact wake fractions, providing critical insights to support the design and optimization of wind-assisted propulsion systems.