MSc. Thesis Proposal

Title: RANS-CFD analysis of the hydrodynamic forces (behaviour) of ships at leeway angles

Supervisors

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Introduction

Motivation

The use of Wind Assisted Ship Propulsion (WASP) has been increasingly studied and developed to be an alternative to merchant ships to be more efficient and to reduce the fossil fuel consumption. Although the new ship designs using WASPs have some impressive reduction in fuel consumption, as in the Oceanbird project, where the project foresees a 90% reduction in fuel oil consumption by using WASP as the primary propulsion source, for existing ships the use of this type of technology barely reaches 10% reduction in fuel consumption. The reason is with the introduction of this wind force, the ship will face some forces and momentum in addition to the propulsion force. These forces result in a steady angle of heel and leeway angle. Ships operating with leeway angle increase the resistance and face a powerful momentum around the y-axis. This also affects the pressure at the rudder and can cause cavitation and vibration in the thrusters.

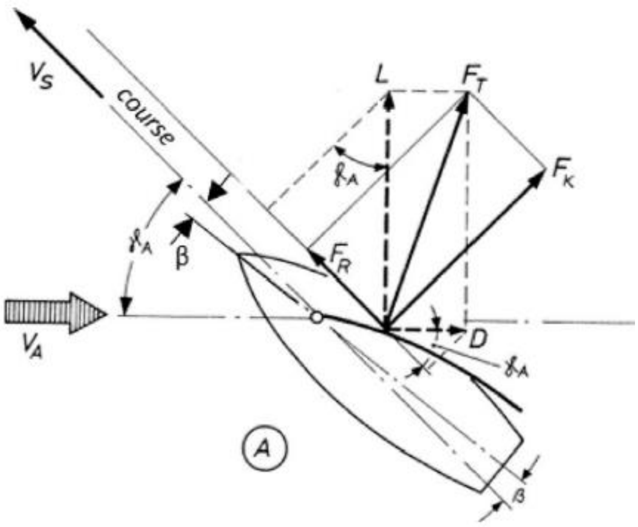

Figure 1: Aerodynamic Forces[2]

Existing work

The relationship between the leeway angle and the resistance force is largely studied for sailing boats, where in the absence of a propeller, the prevailing wind force of the sail causes the boat to rarely keep at the same heading and course angles, thus a detailed study of the keel must be done to reduce the resistance of the boat. With the growth of the study of WASPs for merchant ships, this type of analysis should be done for conventional ships, where there are very few studies developed recently, making it a challenge to develop and implement WASP technologies efficiently.

Objectives

The objective of this thesis is to develop CFD models to study the impact of leeway angles in existing ships, studying the resistance of the ship, the momentum created, also, the impact at the rudder and the propellers. A RANS method using ReFRESCO will be applied, with the use of Rhyno and Hexpress softwares to develop the domain and mesh.

The tasks are as follows:

- To study the ship's hydrodynamic relations, as well as those of the propeller and rudder. [1]
- State-of-the-art study of the impact of WASP technology with ship leeway angles. [2], [3]
- Study the usage of Hexpress
- Study the usage of ReFRESCO [4]
- Develop CFD models to analyse the impact of the leeway angle in the ship resistance. [5], [6]
- Analysis of ship at leeway angle with different speed and angles.
- Preliminary analysis of the impact of the modified wake at ruder and thruster region.

The student should provide a methodology and model to calculate the impact of the leeway angle on the ship resistance; a preliminary study of the effects of the modified wake at the rudder and the propeller is desired; also is expected recommendation for future work and improvements to the model/methodology.

Requisites

Applicants must have:

- General knowledge of Hydrodynamic
- General knowledge of CFD
- Coding experience with Python or similar

Good to have:

- Linux experience
- LateX experience
- Git experience

Location

blueOASIS (www.blueoasis.pt) Edificio D.Pedro, Quinta da Fonte, R. Malhões, 2770-071 Lisboa The student is invited to join the team in the office when the supervisor is present (at least three days per week).

Companies Involved

blueOASIS is a young team with more than 45 years of combined knowledge and experience on Aerospace, Mechanical, Naval and Maritime engineering. The multicultural and multidisciplinary team is committed to make our oceans safer and greener, using state of the art numerical and data science tools. BlueOASIS focuses on renewable energies, ocean cleaning, decarbonization, sustainable offshore structures and green ships optimization.

Bibliography

[1] V. Bertram, *Practical Ship Hydrodynamics*. 2012. doi: 10.1016/C2010-0-68326-X.

[2] D. E. Elger, M. Bentin, and M. Vahs, "Comparison of different methods for predicting the drift angle and rudder resistance by wind propulsion systems on ships," *Ocean Engineering*, vol. 217, no. August, p. 108152, 2020, doi: 10.1016/j.oceaneng.2020.108152.

[3] T. Sauder and S. A. Alterskjær, “Hydrodynamic testing of wind-assisted cargo ships using a cyber–physical method,” *Ocean Engineering*, vol. 243, no. November 2021, p. 110206, 2022, doi: 10.1016/j.oceaneng.2021.110206.
[4] MARIN, “ReFRESCO.” https://www.marin.nl/en/facilities-and-tools/software/refresco
[5] N. J. van der Kolk, J. A. Keuning, and R. H. M. Huijsmans, “Part 1: Experimental validation of a RANS-CFD methodology for the hydrodynamics of wind-assisted ships operating at leeway angles,” *Ocean Engineering*, vol. 178, no. December 2018, pp. 375–387, 2019, doi: 10.1016/j.oceaneng.2018.12.041.
[6] N. J. van der Kolk, I. Akkerman, J. A. Keuning, and R. H. M. Huijsmans, “Part 2: Simulation methodology and numerical uncertainty for RANS-CFD for the hydrodynamics of wind-assisted ships operating at leeway angles,” *Ocean Engineering*, vol. 201, no. February 2018, p. 107024, 2020, doi: 10.1016/j.oceaneng.2020.107024.