Comprehensive technology for ship energy management

Real-time modeling and simulation of environmental conditions on energy consumption of ships

M. Loft, P.M. Mueller, T. Rung, *Institute for Fluid Dynamics and Ship Theory, Hamburg University of Technology (TUHH)*

In Short

- Optimization of fuel consumption for ships using data-driven decision-support systems.
- Data-driven surrogate models require comprehensive bases with numerical data for the offline training.
- Surrogate models enable the reliable prediction of resistance almost in near-to real time.

Global shipping governs 90% of the worlds trade. Ecological aspects are therefore becoming more and more relevant for the operation of ships. An environmental friendly operation hinges on the reduction of of greenhouse gas emissions due to reduced fuel consumption. Moreover, alternative fuel technologies will lead to a significant increase of operating cost and thus also recommend a reduction of fuel consumption. Means to optimize the ship operation with respect to the fuel consumption can have a significant influence on future shipping.

A major part of the total energy required, in particular for merchant vessels, is due to the drag of the ship hull and the approach flow of the propeller. The drag is composed of different parts which are influenced by operational and environmental parameters. Supplementary to hydrodynamic drag, the wind resistance of the superstructure, the roughness penalty due to fouling and the added resistance due to seaways are of relevance.

The simulations performed in this project are used to train data-based surrogate models for individual resistances and propulsion variations. These surrogate models will be fed by measurements using IoT and are employed in a decision support system that supplies the decision makers with suggestions for an energy efficient operation of the ship. The system considers environmental influences (sea state, wind conditions) and ship operation conditions, e.g. trim, fouling state and stored cargo on deck. For example the resistance of a vessel sailing in rough seas is substantially larger than in calm water conditions, partly due to the motion of the vessels. Figure 1 shows exemplary the KRISO Container Ship (KCS) in head seas at two different time instants. Such a multi-phase, rigid-body FSI simulations are individually quite demanding, not to mention a multitude

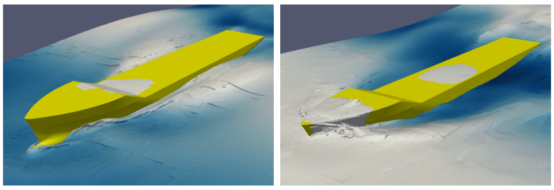

Figure 1: *KCS simulation at time $t = 3.2\,s$ (left) and $t = 6\,s$ (right) with wave length $\lambda/L = 1.5$ amplitude $\zeta/L = 0.035$ and angle $\mu = 160°$.*

of simulations required for the offline training of the surrogate models, and can only be performed on a super-compute systems using HPC capable multiphase flow solver that also model the dynamics of the ship. The present simulations are performed with help of the inhouse solver FreSCo⁺ which is also used by industrial partners.

WWW

https://www.tuhh.de/fds/institute/staff/thomas-rung

More Information

[1] Angerbauer, R., Rung, T., Hybrid RANS/LES Simulations of Aerodynamic Flows Around Superstructures of Ships. In: Notes on Numerical Fluid Mechanics and Multidisciplinary Design (143): 367-377 (2020).

[2] Pache, R., Rung, T., Data-driven surrogate modeling of aerodynamic forces on the superstructure of container vessels. In: Engineering Applications of Computational Fluid Mechanics 16(1): 746-763 (2022).

Project Partners

Hamburgische Schiffbau-Versuchsanstalt GmbH, AVL Deutschland GmbH, Entwicklungszentrum für Schiffstechnik und Transportsysteme e.V., Friendship Systems AG, Technische Universität Berlin, 52 North - Initiative for Geospatial Open Source Software GmbH, Universität zu Lübeck, Maritimes Zentrum der Hochschule Flensburg, AVL Software & Functions

Funding

BMWi 03SX528L

DFG Subject Area

404-03 Fluid Mechanics