Wind Assisted Ship Propulsion Design Explorations

As part of MARIN's strategy to support the transition towards zero emission shipping, we are continuing research on Wind Assisted Ship Propulsion (WASP). Although WASP is seen as having the potential to significantly reduce power consumption, a lot of research still has to be done into how to integrate it into modern designs, logistics and operations.

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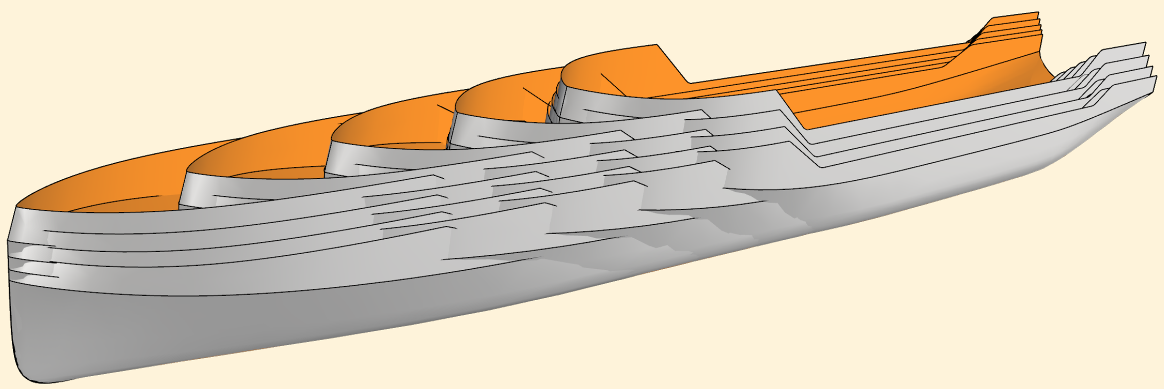
A recent project related to ships using WASP concerned the influence of a ship's main particulars on overall performance. The principal objective was to see how the design trends work for such ships and the specific focus was on wide versus narrow hulls, which is a design trade-off that also exists for sailing yachts. A wider ship has more heel stability and consequently can carry a larger sail plan. A larger sail plan means more propulsion. On the other hand, a wider ship, beyond a certain width, exhibits more resistance. What does this trade-off look like for wind assisted merchant vessels?

Case vessels and wind propulsors The pre-existing "Delft Wind-Assist Series" of hulls and related force predictions was reused. This dataset was generated at MARIN in collaboration with Delft University of Technology. The mother vessel in the series is the "WASP" design by Dykstra Naval Architects (previously named "Ecoliner"). The design is equipped with a single propeller and rudder. For the purpose of this project the design was also equipped with a centre line skeg. The mother shape was systematically stretched longitudinally and transversely, while the displacement was kept constant. A selection of the extreme dimensions in the series is shown in the figure.



A selection of extreme dimensions in the series

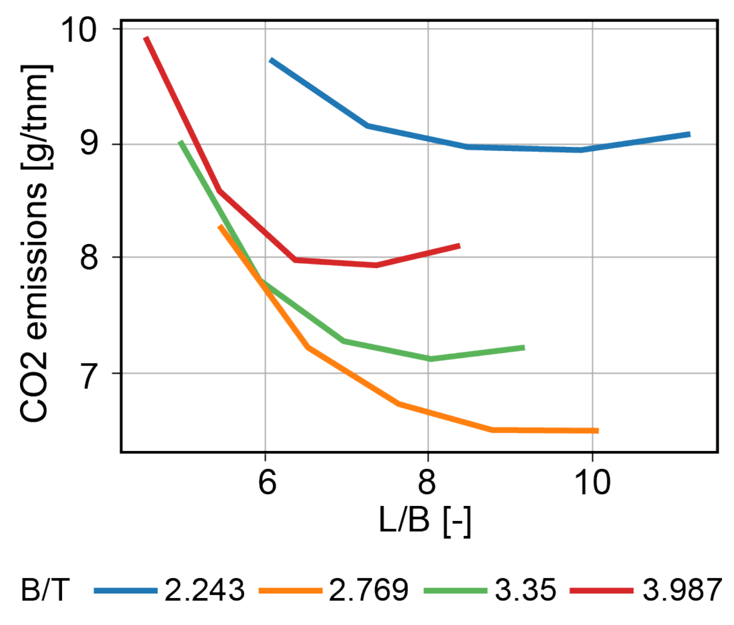
Both Dynarigs and Flettner rotors were dimensioned to the sample hulls. These two devices were selected as they can represent an entire category of devices:

- A Dynarig represents a wind propulsion option that does have implications for the ship operation. The structure is above (almost) the length of the vessel, so cargo operations may need to be changed. Without the use of water ballast some heeling angle is expected. Additionally, the air draught may restrict transit under bridges. However, the potential impact on operations is matched with a relatively large saving potential. The highest emission (and fuel) savings found in this study were 35% to 40%.
- By contrast a Flettner rotor is a "business as usual device". Considering the dimensions now being introduced to the market and the positioning that was considered in this project, the devices can be positioned such that they are (mostly) out of the way. Heeling is minimal.

The Dynarig was dimensioned for each case vessel and the height was restricted to Panamax air draught. Furthermore, it was restricted so that heeling did not exceed 10 degrees in Beaufort wind 5. This led to smaller sail plans for very narrow designs, as the stability was limiting the sail plan. The result per case vessel was a sail plan span and overall sail area.

The arrangement for Flettner rotors was fixed as it was assumed that neither heel or air draught would be limiting factors. The largest model, with a height of 18 m, that was operational at the start of the project was used.

Calculation methods The Energy Efficiency Design Index provides a framework[1] to calculate the performance of Wind Assisted Ship Propulsion. It was used because it provides a practical baseline.



However, it is also under discussion because predictions can be of widely varying quality. MARIN in fact has proposed the Joint Industry Project WISP to come up with better guidelines. In the present project, some specific additions were used to make the calculations more realistic and accurate:

- Not allowing "negative" propulsion (i.e. in some conditions at fixed ship the theoretical prediction would allow the thrust of the propeller (and related emissions) to be negative because the wind provides more thrust than the vessel requires).
- Limiting the heel angle at 10 degrees.

The IMO's worldwide wind probability distribution as circulated (but not ratified) was used. One can argue that wind assisted vessels will sail in their own specific area, so this varies on a ship to ship basis. Nevertheless, this data provided a reference point for comparing all the calculations.

The results showed that a ship with a modest set-up of Flettner rotors does not need to be very different from a vessel without wind propulsors. The best main particulars are identical, utilising the narrowest beam. Nevertheless, refinements in appendages and detail shape could still improve steering balance and the overall performance. Results for a ship with Dynarigs are shown in the figure. Here it is shows that the ship needs to have a beam-over-draught (B/T) ratio just higher than the minimum for the best performance, in contrast to the best performance for a conventionally driven ship.

MARIN is continuing its research on the performance of wind-assisted ships in follow-up projects. Experimental testing methods in real wind are also under scrutiny to be able to quantify performance in unsteady conditions when manoeuvring or in seas.

1 IMO MEPC.1/Circ.815 '2013 Guidance on treatment of innovative energy efficiency technologies for calculation and verification of the attained EEDI'