A renaissance of wind-powered ships

With IMO’s newly adopted strategy for cutting greenhouse gas emissions by at least 50 percent over the next thirty years, the international shipping industry is in for some radical changes. Gradual improvements to today’s vessel concepts will simply not be sufficient. Recently, wind power has resurfaced as an option worth taking seriously and suppliers of innovative wind technology are appearing on the market. But which ones of the numerous solutions are most suitable? To what extent will they really reduce carbon emissions? SSPA has developed efficient prediction tools for both wind-driven and wind-assisted ships in order to support the development of more sustainable maritime transports.

What is the right solution?

Today, an increasing number of shipowners are contacting SSPA to find out whether wind propulsion could be a solution for them. In shipping there are no general answers – each case is unique. A shipowners’ way towards wind propulsion often starts with a broad review of available technologies. The first thing to decide is whether the target is wind assistance or wind propulsion?

Wind assistance technology is typically a device that provides a forward thrust resulting in about 5–10 percent fuel reduction. Apart from the wind technology device, the ship is a conventional ship. Recently, several wind assistance technologies have been installed on commercial vessels, for example Flettner rotors on Viking Grace and Maersk Pelican. The number of available solutions may seem large, but practical considerations often limit the options. The ship may have to pass under certain bridges, restricting the rig height. A container ship has limited space on deck for wind propulsion devices. Dry bulk carriers need to allow space for cargo loaders or cranes to access the cargo holds. Most shipowners do not favour a solution that requires a larger crew and absolutely not a solution that puts the crew at risk when handling the device. Bridge visibility may also be a limiting factor on smaller vessels. A customised technology review makes a solid basis for the decision process.

Ranking the options

The main question when ranking technologies is often the amount of reduction in CO\textsubscript{2} emissions provided by the wind technologies under consideration. The efficiency can, however, differ considerably from case to case depending on the ship size, route, speed and other substantial issues, and therefore published numbers from other vessels with the same technology can be misleading. Ranking of wind propulsion technology options at this preliminary stage should be based on a numerical model of the ship in question and reliable data on the aerodynamic performance of the wind devices.

It is also important to consider the weather on the intended route. Some types of sail work excellently in a limited range of wind angles: kites, for instance, operate best in a following wind. The performance in all wind directions needs to be considered.
SSPA's route simulation software, SEAMAN, together with our ship hydrodynamics database, is an efficient tool to predict the CO₂ reduction. The largest uncertainty is the data of the wind propulsion device. Published numbers must be combined with engineering judgements and our experience of similar devices. The power consumption from operating the device is, of course, also considered as well as the installation costs.

**Concept design and 3rd party assessment**

When a supplier is selected, the concept can be evaluated in detail. Computational Fluid Dynamics (CFD) is an invaluable tool at this stage. The studies are often done in cooperation with the supplier to improve and customise the design for the given vessel.

The example illustrated shows a detailed flow analysis of a generic Flettner rotor. The flow is complex, with unsteady vortices which may cause vibrations. It should be noted that the flow is highly affected by the presence of the vessel freeboard and superstructure and by the atmospheric boundary layer. If there is more than one rotor, there may be strong interactions between them. These effects have a large impact on the total performance and must not be neglected. The figure shows a generic design.

Influence of ship hull on flow around a rotor sail. The flow is highly affected by the presence of the vessel freeboard, superstructure and by the atmospheric boundary layer. If there is more than one rotor, there may be strong interactions between them. These effects have a large impact on the total performance and must not be neglected. The figure shows a generic design.
The dynamic behaviour of the vortical flow behind a Flettner rotor can be categorised in three regimes depending on the spin ratio SR (i.e. the ratio of the peripheral velocity of the rotor to the freestream velocity). 

In Regime 1, where the SR is low, a pair of bound vortices is shedding alternately from the pressure and the suction side of the rotor. The tip vortices are weak and stable.

Regime 2 is in a quasi-steady state, in which the bound vortex is not shedding and a pair of tip vortices are created at the end disc. A trailing vortex is also formed near the root. These vortices are strong and persistent.

In Regime 3, the tip vortices generated at the end disc are fluctuating. There is one or more trailing vortices started at the root and wandering along the rotor between the root and the tip.

How does a wind-powered ship influence the logistics performance?

The logistics performance of a wind-powered ship is crucial for shipowners to consider in order to attract new and keep current customers. Applying wind propulsion technologies may influence the logistics performance, especially if the aim is a high degree of wind propulsion. Major logistics aspects to consider are the cost of the operations, emissions, service level (such as transport time, frequency, reliability), route and risk of damage of goods.

A ship with a high degree of wind propulsion will most likely have a slower speed than a conventional ship, and, for it to be successful in its implementation, the customers’ sensitivity to transport time needs to be assessed. Large emission savings might be an order winner for new customers.

SSPA is a world-leading maritime company that offers the latest knowledge within maritime solutions. 80 years of experience has placed us at the forefront of maritime development. Applied research and qualified consulting services. The vision is to be recognised as the most rewarding partner for innovative and sustainable maritime development.

We have 100 employees with a head office in Gothenburg and a branch office in Stockholm. The company is owned by Chalmers University of Technology Foundation. The basis of our work is in the areas of hydrodynamics, systems engineering, shipbuilding, logistics, environment, risk and safety as well as simulation modelling. We use our resources such as databases, analysis and calculation capabilities, laboratories, collaborative platforms and skills to create value.

Our clients and partners are shipowners, shipbuilders, ports, manufacturers and maritime authorities all over the world. We work towards customers who take a long-term holistic approach to their maritime systems. Together, we develop a safer, more energy-efficient and environmentally sustainable maritime sector.

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