The importance of open-water performance for ice-going vessels

Good vessel design will reduce the impact on the environment and have a positive effect on the financial life-cycle cost for the ship and its operators. This much is clear, but how do we achieve this? And what can be considered a good open-water design when it comes to vessels trading in areas obstructed with ice? The answer lies in a correct interpretation and adaption to the operational profile for the trade or service intended for the vessel. But how do we ensure that this performance is attained?

This 170,000m³ LNG carrier with ice-class Arc 7 was built for Sovcomflot for a charter to Yamal LNG for 28 years. Courtesy of DSME.

It is obvious that an icebreaker operating in the Port of Sabetta has different requirements for open-water performance than an ice-breaking LNG (liquefied natural gas) carrier operating to ports in Northern Europe or for polarresearch vessels or even exploration-cruise vessels. They all operate in icy waters, but with different purposes and different operating profiles.

Meeting required performance demands

The ship owners and ship operators are the ones who understand the importance of open-water performance. The difficult part is describing the performance required and formalising and quantifying the correct requirements for designers, builders, charterers or brokers, and ensuring that the ship will meet or even exceed the required demands.

Describing the problem and the needs early in the process, leading to a good description of the task and a common internal vision, will ensure a project where issues are addressed and taken care of in time. This formulation of the internal view of the vessel task to be solved is all too often neglected and a solution often chosen too early in the process. At SSPA, we have the knowledge and skills to help in these situations. If high performance from the vessels is required, then it is wise to include experts on both ice and open-water performance to provide support in these discussions.

Transport demand, assignment type and sailing routes

First of all, over the years ship design has had a very strong focus deep-water full-load condition. This is naturally a very important focus point. But instead of digging too deep into the technical side of things from the very start of the process, a better approach would be to take a helicopter view of the process and start with the transport demand. The transport demand often dictates how the vessel will operate. For ice-going vessels this is even more important. Ice coverage will change over the season and dramatically change the operability, and thus sailing schedules.

Manoeuvring demands and sea-keeping

When the sailing route and schedule are determined, the manoeuvring demands are also set. The percentage of manoeuvring in ice can have a huge impact on the design of the vessel and its propulsion system. This will also have a direct impact on the performance in open water. As an example, we can study the new Yamal LNG project and the 16 ice-breaking LNGC (liquefied natural gas carrier) vessels connected to it, which have been tested at SSPA and are now being continuously launched at DSME (Daewoo Shipbuilding & Marine Engineering) in South Korea.

These vessels are propelled using a triple-pod system and are part of the DAT concept (double-acting tanker; the vessel proceeds astern while breaking ice). It is a system with extremely good manoeuvrability, but with an immense impact on the openwater performance compared to an equally large LNGC not designed for ice-breaking. In order to make the correct choices during the new-buildning process of a vessel, reliable decision support is required. With its vast knowledge in hydrodynamics, SSPA is able to quantify the different alternatives. This is a great support for ship owners looking for unbiased decision support and expert advice.

Wave and wind statistics will also play an important role in the ship design. Added resistance and sea-keeping performance are factors to which skilled ship owners and ship designers pay a lot of attention. Let us return to the old governing design point on deep-water full-load condition (design draught) in calm seas. A vessel with good sea-keeping performance will be able to reduce the installed main engine power and thus the EEDI (Energy Efficiency Design Index) according to the Minimum Power Requirement set out by the IMO. If sea-keeping properties are proven at a renowned test facility, the engine power could be reduced compared to the standard IMO (International Maritime Organization) formulae that otherwise need to be fulfilled. The often-used design point "design draught at design speed" should be questioned – is this really a good design point?

Sea-keeping properties are not only about reducing fuel consumption, they are about comfort and seaworthiness as well. Designing and verifying the ice-going or ice-breaking performance of a vessel is a difficult and extensive task in itself and requires special skills. For new building projects, good cooperation between ship owner, shipyard, ice experts and open-water experts is crucial for a successful outcome.

Another issue that should be taken into account for ships such as research vessels sailing in ice and waves with sensitive equipment mounted to the hull is which way the water will travel along the submerged part of the ship. The hull and especially the bow shape is often primarily designed to cope with ice performance and fulfil the ice class rules, with a focus on one thing potentially having a negative impact on another, such as flow fields.

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For this typical case, SSPA has a very effective and quick investigation and test method called the "coffee test". This method shows the way the water and air/water mix will travel from the bow and aft, as seen in the picture.

Efficiency at sea and economics

What is most important, the consumption and emissions for a single design point or for the intended sea route? At SSPA, we talk about "overall performance". Overall performance, or "efficiency at sea", is an expression that SSPA uses to cover performance at different draughts, speeds, trims and sailing conditions →

Coffee test: the test method uses stained water, which is let out through the hull in certain representative locations. This method is quick and effective, and shows how and where sensitive equipment can be placed in order to minimise the disturbance from unwanted flow fields.

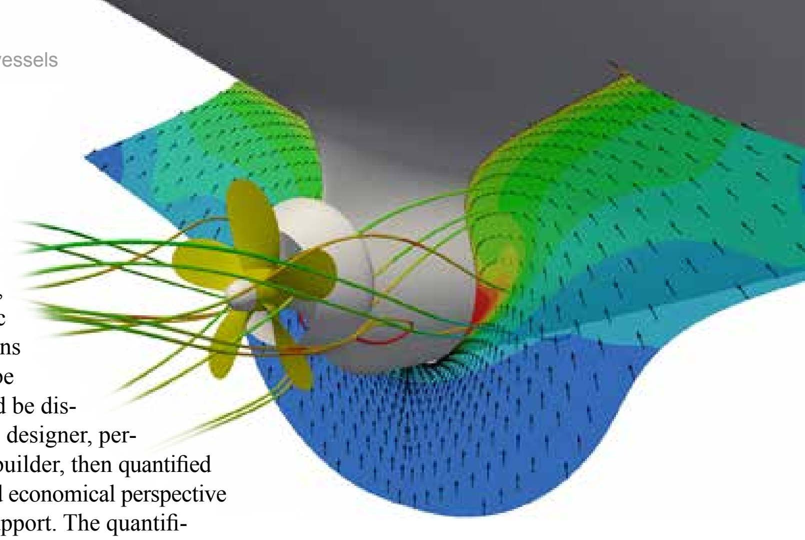
that the vessel will encounter. We believe that this approach is the way ahead for ship design and optimisation, since ships in commercial trade seldom only sail at one draught and one fixed speed.

Ice operation also sets special requirements for the propeller and propulsion system. Ice class rules can have an effect on the shape and material of the propeller, making it harder for the propeller designer to achieve high efficiency and durability. SSPA's vast knowledge within the area of cavitation, erosion and propeller-induced noise will help the most experienced propeller designer or manufacturer to design and build an outstanding propeller, whatever the configuration might be.

Efficiency at sea starts with a correct analysis of the ship's functions. A functional analysis for ship performance can be carried out using a defined working environment, i.e. transport demand, sailing route, stakeholders, technical and economic issues, etc. The functions that the vessel should be able to carry out should be discussed between owner, designer, performance experts and builder, then quantified from a performance and economical perspective for the best decision support. The quantification will show how important open-water performance is and what measures need to be taken for a correctly balanced solution.

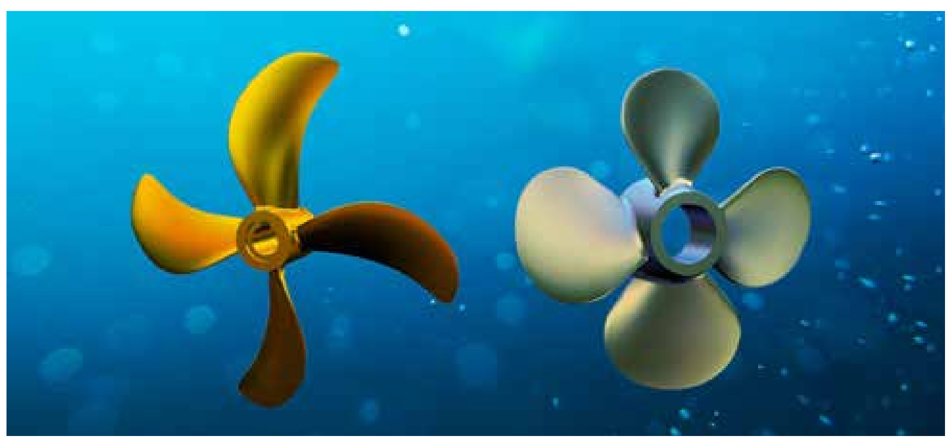
The quantified functional analysis can also be used as input to a life-cycle cost (LCC) analysis. You can read more about LCC in a separate article in this issue of SSPA Highlights.

If you want to know more about how SSPA can help you, do not hesitate to contact us.



With its vast knowledge of hydrodynamics, SSPA is able to quantify the different alternatives.

SSPA's many different design tools, test facilities and 75 years of experience are a good starting point for an efficient vessel at sea.



These two propellers are both designed for 170,000 m³ LNG carriers with a design speed of 19.5 knots at design draught. The same type of vessel but with totally different operational profiles. One is designed and optimised for open water, the other for operation in ice. The difference in installed power and thus the fuel cost for the two cases is substantial. A correctly balanced solution with regards to operational profile saves money.

You can also download SSPA Highlights at www.sspa.se

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SSPA is a dedicated partner that offers a wide range of maritime services, including ship design, energy optimisation, finding the most effective ways to interact with other types of transportation, and conducting maritime infrastructure studies together with safety and environmental risk assessments.

Our experts have a broad range of knowledge and profound expertise and we use our resources such as databases, analysis and calculation capabilities, laboratories, collaborative platforms and skills to create value.

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