

More efficient propulsion solutions with Wärtsilä's Energopac

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The price of fuel is dominating the operational costs of coastal and seagoing vessels. Wärtsilä is striving to improve the fuel efficiency of propulsion systems, and thereby reduce these costs. Reducing fuel consumption goes hand in hand with reducing emissions.

During recent years, the environmental impact of marine transportation has become a major field of focus throughout the entire maritime industry. Nevertheless, for many ship operators commercial considerations take a higher priority than the environment. While these two interests may appear to be incompatible, the fact is that by improving energy efficiency, both fuel consumption and emissions of carbon-, nitrogen- and sulphur-oxides, as well as solid particles, can be reduced.

In June 2008 the price of heavy fuel oil in Rotterdam was around USD 550 per ton (see Figure 1), and USD 1100 for marine diesel oil. Driven by these high fuel

prices, operators are willing to invest more and more in new technology, which will help them to increase energy efficiency throughout their fleets. Improving energy efficiency affects both fuel consumption and emissions, meaning that both commercial and environmental interests will benefit.

Wärtsilä contributes to its customers' businesses by continuously looking for measures that improve energy efficiency onboard their ships. This article will mainly concentrate on the new Energopac, an integrated propulsion and manoeuvring solution, fully optimized to save fuel costs. Energopac will be officially introduced to the market at the SMM 2008 trade fair in Hamburg, 23–26 September.

Energopac

The key objective is to reduce the vessel's fuel consumption by integrating both propeller and rudder design. Each Energopac will be designed to meet

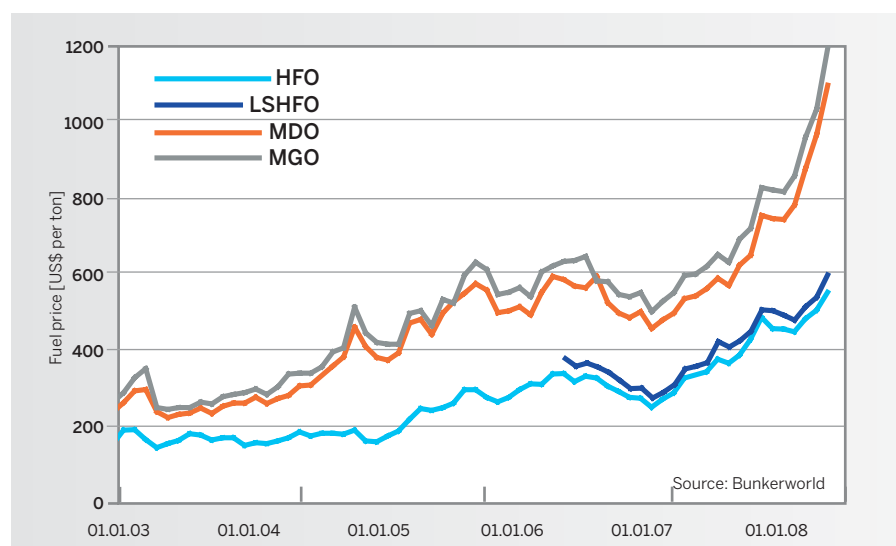
the specific vessel's requirements; this allows for Energopac to be optimized for maximum possible fuel savings. This is done without compromising on either manoeuvrability or comfort levels.

Figure 2 shows a schematic view of the concept, which consists of a rudder bulb behind the propeller hub, mounted on a sophisticated spade rudder, with a fairing hubcap to guide the propeller slipstream around the rudder bulb. The propeller blade design is also adapted to this configuration. This means we make the best use of the propeller-rudder interaction by minimizing losses and maximizing gains in the design procedure.

Energopac is a joint development of two pioneering companies in the field of energy efficient ship propulsion and manoeuvring: Wärtsilä and Becker Marine Systems. Each of these companies has built a notable track record in this field with customers all over the world.

The basis of Wärtsilä's efficient rudder technology dates back to the 1990s. Although this technology was patented at that time, the patent still remains pending today. Well over 30 vessels have been equipped with the concept since then, and all have achieved successful energy savings.

The Energopac lay-out is somewhat different from earlier fuel-saving rudders from Wärtsilä. In the new design, the bulb is fixed to the rudder blade and will turn, together with the rudder, for a non-zero steering angle. This separation of physical components allows for easier installation at the shipyard. Additionally, maintenance and repair works on the propeller and rudder can be carried out more easily. The patented KSR rudder support results in very slim rudder blade designs. This is very favourable in terms of rudder drag. Additionally, the leading edge of the rudder will be twisted and aligned with the incoming



■ Fig. 1 – History graph showing marine fuel prices in Rotterdam, the Netherlands.

■ Fig. 2 – Example arrangement of a typical Energopac solution, showing the main components.

flow from behind the propeller. This will not only reduce the rudder drag, but it will, to a very high degree, also reduce cavitation erosion on the rudder blade. The flap system allows for the rudder blade area to be reduced significantly. Furthermore, the vessel can maintain its course in transit with relatively minor steering angles, again reducing the rudder drag. The fairing cap and rudder bulb are designed to reduce separation losses behind the propeller hub. Another effect of the bulb is that it will lower propeller induced pressure pulses. Subsequently, the propeller design is matched to this, resulting in maximized propeller efficiency.

Research reveals the working principles

Several model tests were carried out to ascertain the effects of Energopac on propulsion performance and steering capabilities. The results were compared and verified with in-house CFD (computational fluid dynamics) calculations. This was done for both single screw and twin screw applications, of which the latter is shown in Figure 3.

The results of these tests show a significant reduction in required power. When Energopac is compared with other sophisticated rudder designs, the decrease

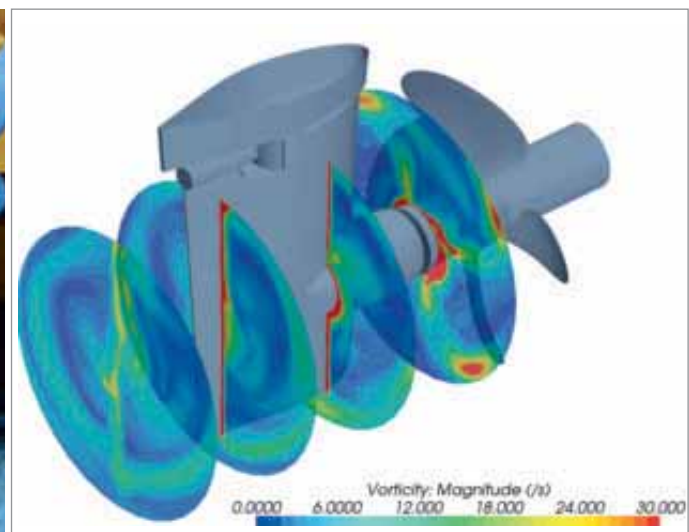


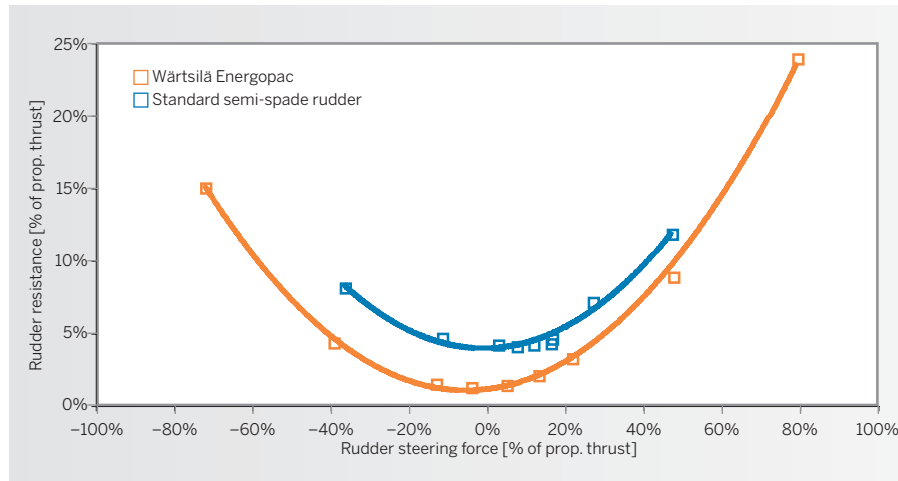
in power – and thus in fuel consumption – can already be 2%. However, when compared with a standard propeller and rudder arrangement, the combined efficiency gain can reach as much as 8% for the example vessel shown in Figure 3.

The research has focused heavily

on improving energy efficiency, while at the same time not compromising manoeuvring capability. Model tests have shown that the rudder bulb in itself has no negative effect on the course-keeping abilities of Energopac. Lift and drag curves were established and the results are very →

■ Fig. 3 – Combined model tests and CFD calculations (left and right respectively) have been performed for a series of six RoPax vessels on order





■ Fig. 4 – Energopac yields a much lower resistance force than a standard rudder for the same steering effort (plotted as produced steering force or lift).

positive. They indicate that Energopac has even lower resistance than a standard rudder, for the same steering effort (Figure 4).

Of course, the rudder bulb will cause additional drag for larger steering angles. However these steering angles are used almost exclusively when a vessel is manoeuvring in port, and not while it is sailing at transit speed. In such operations a higher rudder drag is actually an advantage, as the vessel will have more sideward motion instead of forward.

Extensive CFD calculations have been correlated with the performed model tests. The results show that the predictions with CFD are well in line with those of the model tests. With CFD calculations

the working principles of Energopac can be visualized more easily. Figure 5 gives an impression of the turbulent kinetic energy in the flow field, which is a measure for the energy losses. Since the red colour means high turbulent kinetic energy levels, it can be seen in an instant that Energopac performs much better than standard rudders.

More design freedom

Pressure pulse measurements on the concept have indicated that the application of a rudder bulb helps to reduce vibration levels significantly. This is illustrated in Figure 6, in which an original propeller design is compared with an improved one and with Energopac,

both on model scale and full scale.

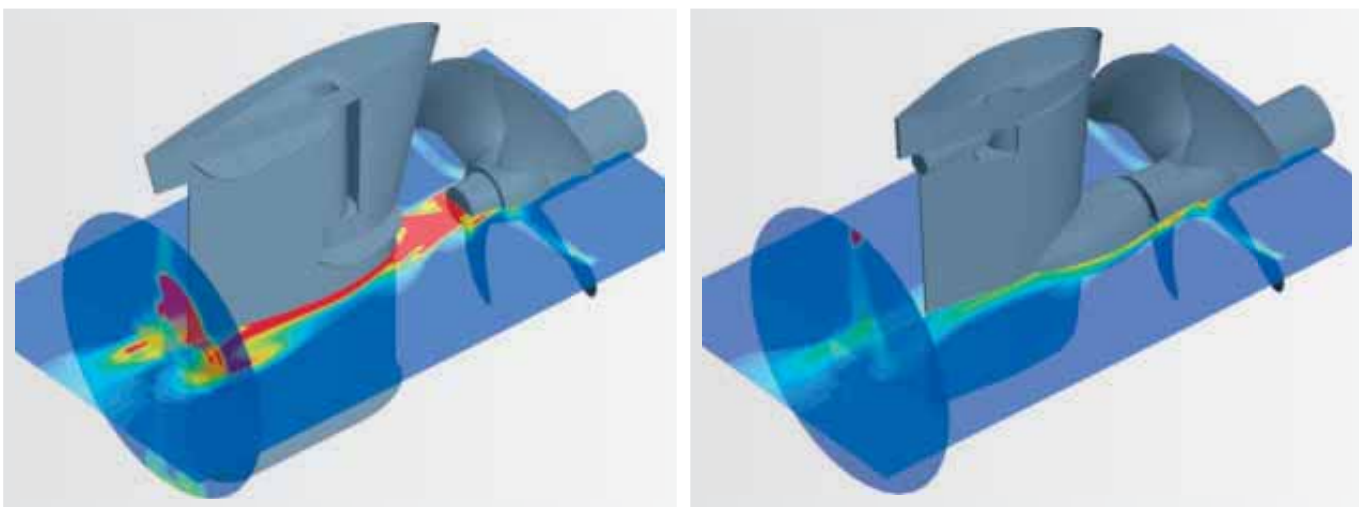
The reduction in vibration is caused by the rudder bulb, as it creates a more homogeneous inflow of water into the propeller. This effect means either an increase in comfort level onboard the vessel, or more design freedom for the same level of pressure pulses, meaning that the propeller's efficiency can be increased even further.

Because of the good correlation between CFD and model tests, all newly designed Energopac systems will be analyzed through CFD calculations, in order to ensure that the best fuel-saving solution is presented to each customer.

Applicability and savings

The reduction in fuel consumption, when applying Energopac, depends very much on the vessel type and on the operational profile of the vessel and on the reference propeller and rudder. Consequently, a good estimate of the annual fuel savings can be given after a detailed investigation of both the vessel design and the alternative propulsion solutions. With the working principles in mind however, some rules of thumb can be stated.

The Energopac system works very well for propellers with a relatively large propeller hub, such as highly loaded controllable pitch propeller systems as on RoRo-vessels, ferries, container and multipurpose vessels, or cargo vessels with an ice class notation. Due to the larger propeller hub diameters, the hub losses would be significant for a conventional



■ Fig. 5 – CFD was used to visualize the turbulent kinetic energy in the flow. The rudder bulb of Energopac (on the right) shows a significant reduction when compared to a standard rudder (left).

system. With the application of Energopac, losses can largely be avoided.

Generally speaking, for any coastal or ocean going vessel with considerable transit times, Energopac will show a very favourable return on investment.

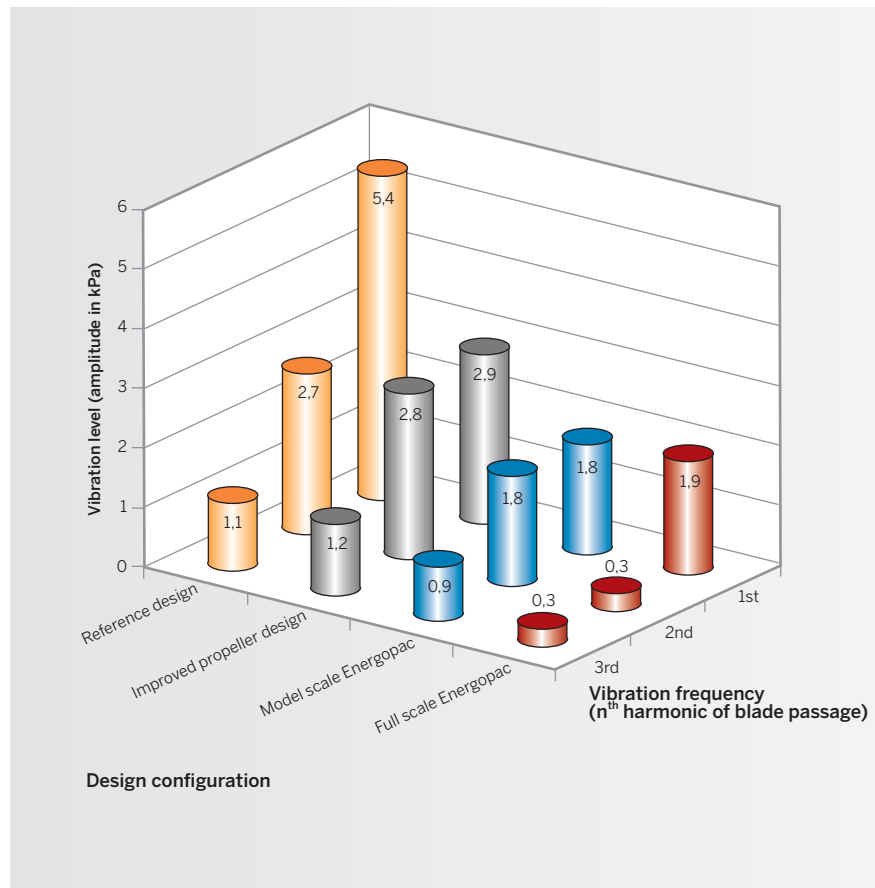
Summary of benefits

The most important benefits of applying Energopac are summarized below. They add up to significantly reduced fuel consumption, lower vibration levels onboard, excellent course-keeping and superior manoeuvring.

- Patented rudder support system allows for the largest rudder sizes.
- Streamlined rudder bulb and hub cap design reduces hub losses.
- Slim rudder profile design lowers rudder resistance.
- Flap system reduces steering angles in course-keeping mode, which gives low rudder drag.
- Twisted leading edge rudder minimizes risk of rudder cavitation erosion.
- Propeller design adapted to rudder and bulb allows optimization for either highest efficiency or highest comfort levels, and any combination in-between ●

NOTE:

Energopac is a registered trademark.



■ Fig. 6 – Pressure pulse measurements on the ship's hull reveal a reduction in vibration levels onboard the vessel; at full scale this is even more noticeable.

BACKGROUND ON PROPULSIVE EFFICIENCY

Once the engine has produced power and transferred this to the main shaft line in terms of torque and rpm, the propulsion equipment converts this rotational energy to translational energy, resulting in the forward motion of the vessel. The propulsive efficiency of the vessel is defined as being the ratio between propulsion (also called effective) power PE and delivered power PD. The weather component for wind & waves is usually incorporated within the effective power, since technically it is part of the hull resistance.

A primary way to increase this propulsive efficiency is to reduce the resistance of a vessel, for example with a better hydrodynamic hull design. This leads to lower required propulsion

power at the same vessel speed.

A second measure closely related to this is simply to sail at a lower speed than before. Since the ship resistance follows a quadratic curve depending on speed, and sailing time a linear curve, the total fuel consumption during the voyage is reduced.

Finally, a third option for the propulsion system to be readily improved is if it is optimized to meet the specific characteristics and requirements of the vessel.

The prediction of the sailing speed of a vessel for a certain power is usually done through model scale tests. The propulsive efficiency – defined as being the ratio between the effective power and delivered power – consists

by definition of the product of open water efficiency, hull efficiency, and relative rotative efficiency.

The simple concept of efficiency consisting of three components was developed more than 100 years ago in the model testing practice of those days. It suggests that the propeller and ship's hull can be viewed and analyzed separately.

In reality, they are not independent parts of the propulsion equipment. When investigating the total energy efficiency of the vessel, the interaction between the components is a very important aspect. All components should be integrated and tuned to one another if optimal performance is to be reached. This also holds for the interaction effects between the propeller and rudder of a vessel.