Hydrodynamics for efficient ship operations

Managing vessel hydrodynamics can help vessel operators to reduce their fuel costs and safeguard the cargos and crews aboard their ships – a process that can be simply achieved through the use of software-based tools, *write Dr Lars Grünitz and Christian Beiersdorf, Germanischer Lloyd*

The hydrodynamic characteristics of ships are important to know for each vessel, because they set important parameters such as the relationship between speed and power, manoeuvrability, motions and loads in waves. They are different for each ship under different sailing conditions.

Today we can know the hydrodynamic characteristics for a specific vessel in advance, and are not dependent on the single sailor's experience with this or a similar vessel.

Model tests in tanks provide one source of insight, and more and more computations with specific codes, commonly grouped under the name Computational Fluid Dynamics (CFD), are introduced to obtain a closer look into the performance of a ship in different sailing conditions.

Computational Fluid Dynamics provides a powerful tool to predict the behaviour of a vessel in situations such as loading in waves, manoeuvrability or resistance.

Numerical models account for sailing conditions (i.e. speed, headings, geometry of the hull, trim and drafts, ship weight, waves, wind, confined waters) and the physics and properties of the water such as the free water surface (wavy surface), density and viscosity.

Different tasks are tackled with different models. The expertise at the end not only lies in applying a computational model, but in choosing the right one for a problem. Today the main use of these tools has been made during the design phase of vessels.

Using CFD requires extensive computational power, which is mainly provided by the use of parallel computing. The complexity of the problems that are analysed using CFD are in many cases greater than in the aerospace industry.

This is mainly due to the fact that a 2-phase flow (air and water) is to be analysed, and the surface between these two phases is not given. Examples for such analysis include slamming load predictions and shipping green water on deck.

How can these tools now be used for ships in operations? Given the computational power required it is still not practical to perform such a calculation on board of the vessel, so as a solution to this problem pre-calculated results are used for many applications on board of the vessel. This includes tools for finding the optimum trim and draft of the vessel, or to predict ship motions.

In the following, two such areas of applications will be described.

Optimisation of trim

In times of increasing fuel prices and environmental awareness the fuel efficiency of ships is becoming more and more important.

For newly built ships it is becoming essential to optimise the fuel efficiency wherever possible to ensure competitiveness in the market. Even for existing ships, modifications to increase fuel efficiency can have short payback periods.

Such modifications can be, for example, modernisation of the main engine to increase its fuel efficiency, or replacing the bulbous bow with a new shape to reduce resistance for slow steaming operation.

Although the payback period for such modifications might be short, capital investment is required to realise the modifications.

Another option to increase the fuel efficiency without modifications to the vessel, and hence requiring much less capital investment, is to consider the operational efficiency. The operational efficiency has many aspects which can be investigated to reduce fuel consumption.

One aspect is to help the crew to sail their vessel at optimum trim for the current operating condition.

The influence of trim on fuel consumption has been known for quite some time. There is no global optimum trim for a vessel – besides the specific hull shape, the optimum value depends on the operating parameters, such as speed, displacement and water depth.

Compared to trim assistance tools based on logged operational data, decision support systems which purely rely on pre-computed CFD-databases do not require interfacing with the onboard systems, and no sensors to monitor operational parameters are required.

This gives such systems the advantage that they can be installed on any computer on the vessel. No additional hardware and measurement equipment is needed, which makes the non-interfacing tools very cost effective. Those newly developed tools rely solely on the database input of pre-computed values and the operational parameters entered by the crew.

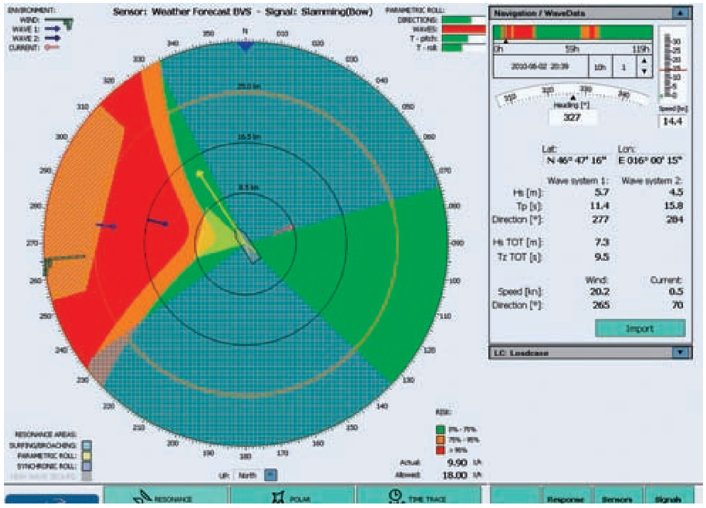
Vessel specific hydrodynamic data is required for the full range of operational conditions specified by the parameters speed, displacement (mean draft) and water depth. This results in a four-dimensional trim matrix.

About 3,500 data points are required to fill the trim matrix. It is therefore not economical to obtain the full trim matrix of the ship specific performance data through towing tank tests, as this would mean 3,500 trials.

Instead, CFD is utilised with 3,500 calculations which will take about two weeks in the office using parallel computing.

Weather routing

As ships become larger and respond less directly to the seaway it becomes more difficult for the ship officers to correctly judge the seas and to consistently make the right decisions for safe operation of the vessel, particularly on container vessels, where highly stacked containers on deck in front of the bridge further contribute to a distancing of the officers from the sea.



Hydrodynamic data can be combined with weather information to plan optimum speed and route

Weather routing assistance systems can be used to combine performance-monitoring of a ship in transit with information on the weather and the sea itself, to supply active routing assistance to the navigating personnel.

The objective of such a system focuses on the prevention of dangerous conditions which could lead to cargo loss and possibly structural damage to the ship when operating in bad weather.

One of the new innovations of the latest weather routing systems, as compared to the classical ship response monitoring systems, concerns the continuous shipboard measurement of the seaway surrounding the ship in terms of seaway spectra.

Prepared at regular intervals, the corresponding response calculations have the aim of recognising situations potentially dangerous to ship and cargo.

The seaway spectra are derived from measurements taken with a special wave radar system. Again, CFD is used, providing pre-calculated ship response functions.

With this data, in combination with the actual loading condition and ship speed and heading to the waves, the ship motions and hull girder loads can be predicted for the actual sea conditions onboard.

These results can be permanently updated and displayed on a monitor in the wheelhouse. Active routing planning is then possible by combining the system with weather forecasts, enabling the ship's master to prepare for, or to avoid, critical situations ahead and to minimise any risks.

The risk assessment is done by comparing the onboard predicted ship responses (based on the current seaway, loading condition and operational parameters) against ship specific configured responses derived from design value estimates, which again are achieved through the use of CFD calculations.

Proactive planning also helps the crew to reduce fuel consumption as they can plan the optimum speed and route through heavy seas. This ensures schedule integrity.

Conclusion

Two areas of application of computational fluid dynamics (CFD) in decision support systems onboard vessels have been presented.

In both cases, pre-calculated results are used on board which can be easily derived using today's CFD tools and computational power on-shore.

A trim assistant can reduce the fuel consumption of vessels without the need for any modification to the ships' design, while weather routing systems ensure safe operation of vessels in heavy seas.

Both systems can thus play an important part in modern shipping, by ensuring efficient and safe operation. DS

About the authors

Dr Lars Grünitz is a business development manager for Germanischer Lloyd in Singapore. He holds a Master of Science degree in Structural Engineering, and a Doctoral degree in Engineering.

Christian Beiersdorf is a product manager for onboard decision support systems at GL Maritime Software, Hamburg. He holds a Diplom Ingenieur degree in Naval Architecture.

GL Maritime Software is a subsidiary of Germanischer Lloyd, providing software and systems integration services to improve clients' processes and decisions in ship operations and fleet management, both onboard and onshore. The company also offers implementation and integration services, training, and support - for more information visit: www.gl-maritime-software.com