75-years of experience helps provide the answers

Full block ships always a

MARIN has had a long history of working with full block vessels, actually becoming involved in its first full block design way back in 1932. Here, the development of full block ships is examined, along with the work MARIN has undertaken to help optimise designs.

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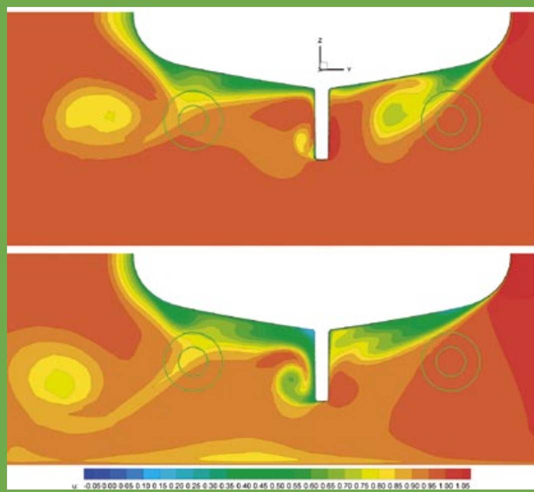

Axial velocity field in aft ship under drift angle of 10 degrees, deep water (above) and shallow water.

Then known as NSMB, MARIN's first full block ship was a tanker for RDM – CB of 0.76, ship model No. 6. This vessel became the starting point for the design of the hundreds of full block ships that followed through the years at MARIN. In terms of the largest ship, the peak came during the late sixties/early seventies at the time of the Suez crisis with a design for a VLCC of nearly 900,000 tonnes (CB of 0.83).

Nowadays, full block VLCCs are back to "normal" dimensions with deadweights of around 300,000 to 350,000 tonnes. As well as VLCCs, the full block ship category also covers modern dredgers with the trend towards higher fullness and shorter length-beam and beam-draught ratios, as the industry explores the boundaries of economical and safe designs. This trend influences the course-keeping and course-checking ability and makes the design of the aft ship even more complex.

In the first few decades of MARIN, the speed power prediction was the most important part of the investigation. Based on methods like the Fransen and De Jong diagram, the speed in relation to the power was often very well predicted in combination with the extrapolation method of Froude. However, during these years the prediction of the correct full-scale propeller rate of revolution was problematic. This was related to the wake-scaling between model and full-scale.

For the most part, it is clear that the struggle with Reynolds effects (model-scale to full-scale) was always present and this is still the case. The flow around the after body of full block ships is particularly dominated by the structure of the boundary layer. It is established that the boundary layer on model-scale is more pronounced when compared to the full-scale situation. In the case of shallow water, these differences are even more apparent. While on model-scale important regions of flow separation can be found, this phenomenon can be absent on full-scale.

So how is it best to solve this problem in an appropriate way? Firstly, modern CFD tools like MARIN's code PARNASSOS are capable of accurately calculating model and full-scale Reynolds numbers. Based on a comparison of the calculated and measured wake distribution on model-scale and the calculation of the full-scale wake distribution, an improved prediction for the real full-scale situation can be made. Increasingly, this allows the designer and the propeller designer, to optimise the ship and propeller based on full-scale information rather than model-scale. Certainly, this will lead to improved designs in which the limits of the loading capacity can be further stretched.

Full block ship designs are more sensitive for course instability and track-keeping ability problems than

challenge

more slender ship designs. With a trend for designs with even more extreme length / beam and beam / draught ratios and operational areas moving to ever more shallow water, the risk of course instability and hence, controllability problems increases.

The full block limits the freedom of the design of the aft ship. The main focus is on minimisation of flow separation problems and optimum propeller and rudder inflow conditions. Wake distribution should not only be optimised for the deep water condition but also for shallow water. The inflow and hence, effectiveness of the rudder always depends on the propeller loading reducing the ships response on the rudder during stopping and breaking manoeuvres.

Designing an aft ship shape which performs well in deep and shallow water, while sailing straight ahead but also during manoeuvring remains the challenge. In shallow water operations the ship will manoeuvre a lot. An acceptable flow pattern in the aft ship and flow towards the propeller and rudder in drift or turning motion is crucial to ensure an effective and safe operation.

In shallow water depths, squat becomes an issue. For full block ship designs squat behaviour can be extremely sensitive on design details like the bulb and fore shoulder shape. Squat depends on speed and on the water depth draught ratio but also on the turning rate and drift angle. Squat and the dynamic trim component especially, can significantly influence the manoeuvring characteristics of the ship.

Optimising the design of full block ships to cover all of these aspects is a challenge, indeed. However, 75-years of experience at MARIN, together with the use of modern CFD tools like PARNASSOS and RAPID and the model-testing facilities, gets the job done.