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Major steps forward in LNG carrier design

The world has enormous quantities of natural gas but much of it is located in areas far from where the gas is needed. As natural gas becomes an increasingly important energy source a large fleet is needed to transport it in liquefied form, hence the development of specially-designed LNG carriers. Report outlines the importance of CFD tools in LNG carrier design.

Henk Valkhof &
Klaas Kooiker
H.Valkhof@marin.nl

In the overall design process of an LNG carrier, the hull form and propulsors play an important role from a hydrodynamic point of view. The twin-gondola aft-body has proven to be an adequate design concept but due to the complexity of the flow around the aft-body, the design must be carried out with great care.
Computational Fluid Dynamics (CFD) tools are extremely valuable in the hydrodynamic hull form optimisation process. Both potential flow and viscous flow codes are used to obtain the optimum hull form.

Particular attention is always paid to the shape and the orientation of the gondolas. Usually the design process starts with calculations carried out by MARIN's non-linear potential flow code, RAPID. In such a pre-design phase the bulbous bow and the shape of the hull can be optimised. In addition, the pressure distribution around the gondolas is often studied to obtain a first impression of the optimum gondola orientation.

PARNASSOS also plays vital role

Viscous effects play an important role in the flow around the aft body and therefore, the shape of the aft-body and the orientation of the gondolas can be further improved by using MARIN's viscous flow code, PARNASSOS. With the results of the PARNASSOS calculations it is possible to make decisions with regard to the horizontal angle and the inclination of the gondolas and the slope of the buttocks in the area between the gondolas. The wake field in the propeller plane can also be improved by optimising the shape of the gondolas. And these have to be oriented in such a way that maximum efficiency is achieved. Furthermore, the effect of a working propeller can be investigated by applying an axial force field in the propeller plane. Scale effects can be studied by conducting calculations for both model and full scale. Although the CFD part is of great importance during the pre-design stage of the project, verification of the performance of the ship by means of model tests is still needed. The combination of CFD calculations and model tests makes it possible to compare the calculated and measured results. For the model measurement of the wake field, a 5-hole Pitot tube is mounted in the propeller plane. The results of the axial velocity components show a wake peak depth of about 60 percent. The gradient of the velocity through the propeller plane is soft on the outer side of the gondola, while on the inner side the gradients are somewhat steeper.

Further improvement expected

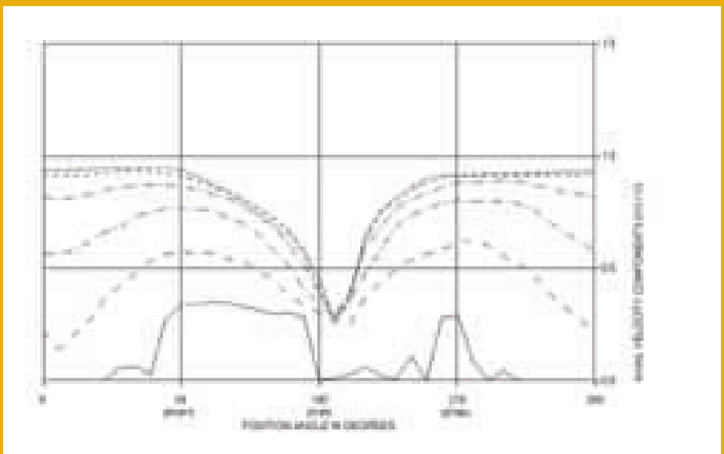
A few aspects are still being studied through a research programme with internal MARIN funding. In this programme, PARNASSOS calculations for full scale Reynolds numbers are carried out. Propulsive coefficients will be determined to study the sensitivity of the change of the position of the gondola on the hull efficiency and other relevant parameters. In the near future, several CFD calculations will be carried out with gondolas perfectly oriented in the flow but also with gondolas deliberately placed somewhat out of the flow to increase hull efficiency. It is expected that these additional studies will lead to a further improvement in performance.

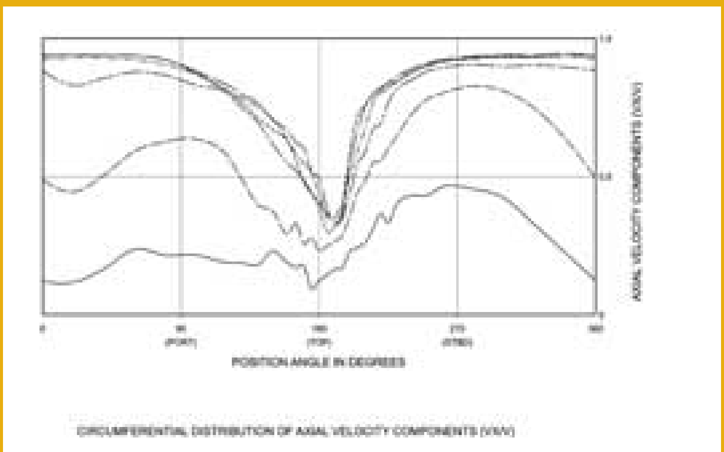
twin-gondola with the aid of CFD

At the right a comparison between the calculated circumferential axial velocity field (through PARNASSOS) and the measured wake survey is presented. Both the slopes and the depth of the wake peak compare well.

Several design approaches

From recent studies it became clear that the design of a twin gondola aft-body can be approached in several ways. Whether the priority is to minimise resistance, or whether it is to maximise hull efficiency, both approaches can lead to good designs. For both approaches a thorough understanding of the flow over the aft body is needed. In this regard CFD tools like PARNASSOS are vital and it is believed that an even more extensive use of these tools will lead to better design in which the optimum combination between resistance and hull efficiency can be found. A few recent designs following the approach described above have resulted in significantly (between 10 and 15 percent) improved powering performance, leading to significant reductions of fuel consumption, or in some cases to an increased payload at equal fuel consumption characteristics.





Comparison calculated (above) and measured (below) wake field.