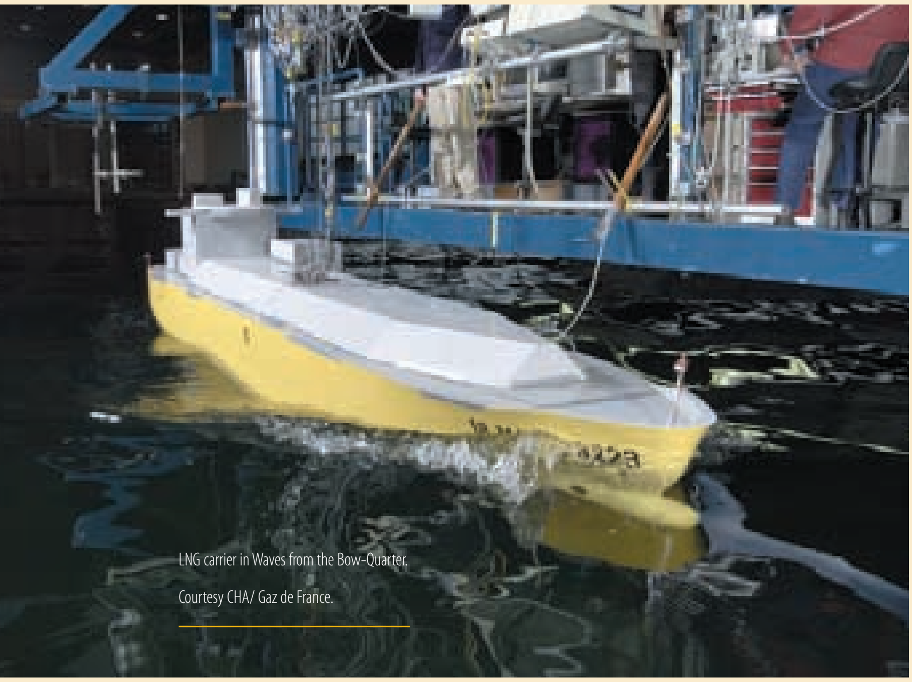
A huge fleet of LNG carriers is being built or under construction at the moment and many more will be built in the near future. MARIN is involved in many aspects of the design and operation of LNG carriers, working on projects on behalf of Kvaerner Masa Yards, Chantiers de l'Atlantique, IZAR and Hyundai, to name just a few. Report outlines MARIN's work in this with field with a special focus on LNG carrier design.

MARIN plays key role in



LNG carrier in Waves from the Bow-Quarter. Courtesy CHA/ Gaz de France.

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With the cost of a day's downtime at an LNG plant running into millions, the key issue for LNG operators is reliability. Just-in-time schedules that ships are tied into means that keeping to the time schedule is crucial. MARIN has several tools to investigate the implications of design aspects and here, a few are addressed.

The speed and the propeller loading on an LNG carrier is in general, large. This requires a low overall resistance and related good powering performance but also an excellent after body design, with a good flow towards the propeller(s) and rudder(s), without flow separation. Recently, there has been even more demand for this because of the latest trend to create ships with higher block coefficients (and higher speeds) and hence, with an increased change of said flow separation. To achieve a low wave resistance, it is necessary to shift the centre of buoyancy more aftward.

CFD tools prove invaluable

However, at the same time very good propeller inflow properties are needed. With the aid of MARIN's potential flow code, RAPID and MARIN's viscous flow code, PARNASSOS (very fast Navier Stokes solver) the hull forms are optimised and both the lowest possible wave resistance in combination with the best inflow characteristics are achieved. These so-called CFD tools have proven to be extremely valuable in the hydrodynamic optimisation process of the hull. For the hull form, particularly the fore body, RAPID can accurately predict the wave pattern, flow direction and pressure distribution, while PARNASSOS for the relatively full aft ships can predict optimum lines and helps to determine the optimum orientation in case of a twin gondolas concept to avoid flow separation. In addition, a reliable prediction of the wake in the propeller plane can be made, with or without propeller effects.

A typical design process will contain a preliminary estimate of the achievable target speeds and powers. Several propulsor and hull alternatives will be reviewed, together with the client. Next, the basic hull form is optimised from a resistance point-of-view for the two important loading conditions. This hull form forms the basis for the next step in the process: the study of the aft ship, the orientation of the gondolas, the study of the flow in the propeller field, as well as the creation and modification of possible stern bulbs.

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LNG carrier during manoeuvring tests.

design of booming LNG fleet

Propulsion

Various interesting propulsion plants are possible for LNG carriers. Recent research at MARIN included the traditional single screws, twin gondola propulsion, podded propulsors and hybrid propulsors. With the selection of podded propulsors the after body hull form can become rather "simple", reducing the building costs significantly. Given the combination of required higher speed and loading capacity, the propeller power density has significantly increased. For such a ship the hybrid arrangements especially, are very promising concepts and can result in surprisingly low fuel consumption. Improvements between five to 10 per cent are quite realistic, depending on the possibilities of the propeller diameters and number of revolutions. From a cavitation and propeller induced pressure point-of-view, large steering angles at high operational speeds should be avoided. Keeping the ship on course can then be a problem and this specific aspect needs further attention. Then the application of these aspects, propulsion, cavitation and steering capability, has to be verified for each ship.

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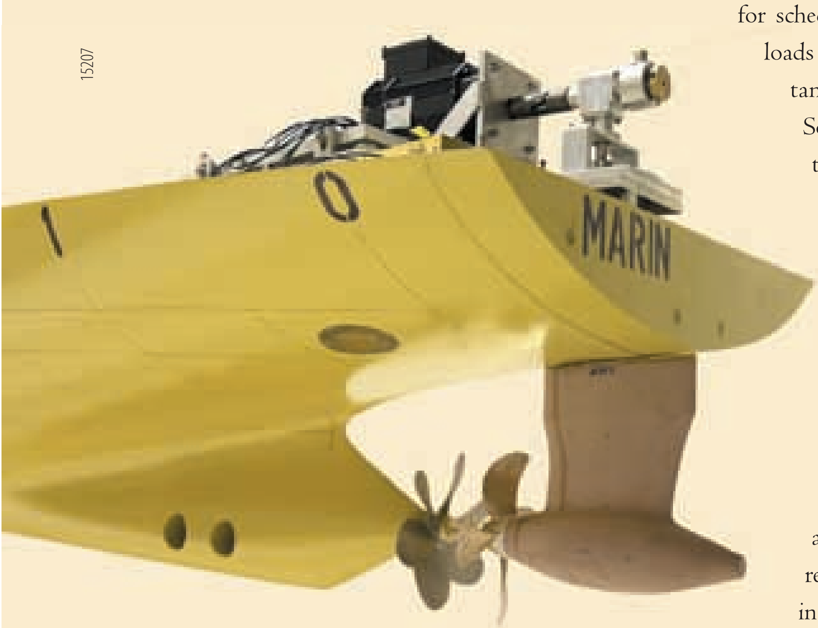

Steering

Due to the recent trend, the fore ship becomes slender and the aft ship full, so specific attention is needed on steering capability. This together with directional stability is therefore judged as part of the total design process. The optimum aft ship design focuses therefore not only on the flow towards the propulsor but towards the rudder and studies the required rudder area. This is typically validated with some free sailing manoeuvring tests.

Sloshing

One particularly important aspect related to seakeeping is not only the added resistance used for scheduling the voyage but also the sloshing loads in the tanks. Due to sloshing in large tanks, the forces can be really high. Sophisticated research is being carried out to investigate the loads in tanks due to sloshing motions. A combination of CFD calculations and model tests at appropriate scales are used.

Seakeeping

Operational reliability is a key issue in seakeeping. Because of this, most work focused on involuntary speed loss due to the added resistance in wind and waves, as well as reasons for a voluntary speed reduction or change of course. Slamming in the bow-flare in waves from ahead and

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LNG carrier during manoeuvring tests.

Courtesy CHA/Gaz de France.

from the bow-quarter and rolling in waves from the stern-quarter, are important issues in this respect.

A complete assessment of the performance requires quantification of the added resistance for all conditions. Experience with the accuracy of contemporary numerical tools shows that the tests provide essential information in the shorter range of wave periods and in waves from abeam and the stern-quarter.

Voyage scheduling

The impact of weather on operational reliability is governed by the hydrodynamic characteristics of the design, the prevailing wind/wave climate and an "operational scenario" for the reaction of the master to circumstances (including criteria for tolerable ship behaviour). To integrate these aspects MARIN developed tools for "scenario simulations". This technique evaluates the progress of the ship on the route on the basis of historical wind-wave information (from hindcasts). The results give a detailed insight into the nature of fuel consumption, efficient sailing strategies and the risk of exceeding the target trip duration. Recently the GULLIVER code was extended to account for multiple ship scenarios. MARIN