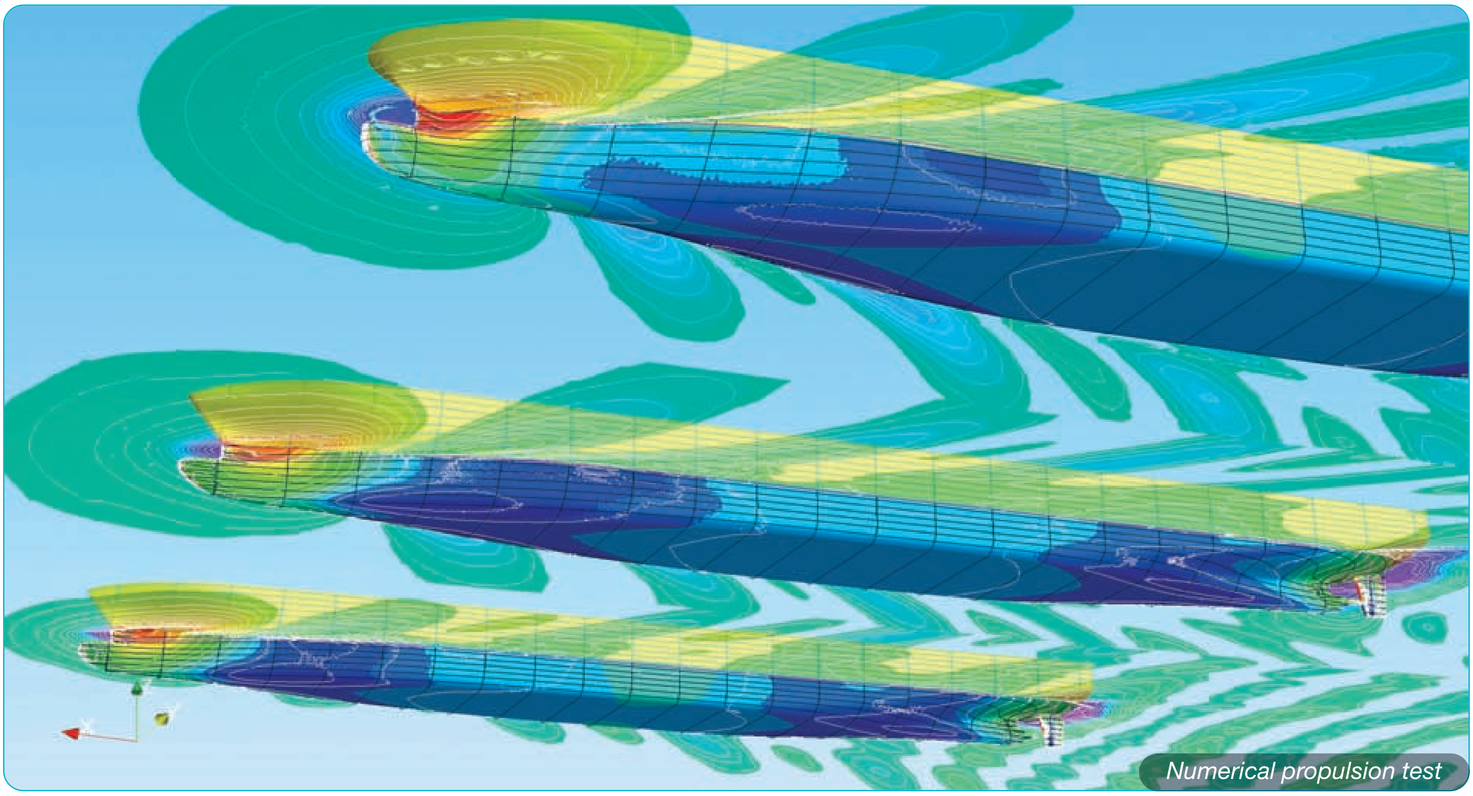
HSVA Newswave 2011/2

THE HAMBURG SHIP MODEL BASIN NEWSLETTER



Numerical propulsion test

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Dear reader,

Our industry has been quite active in the last months. Nevertheless, the overall situation of shipping and shipbuilding remains challenging. But some segments show significant promise. They include the offshore industry and the need of improved, innovative and more efficient technical solutions concerning ship efficiency to lower cost and to reduce emissions.

A main driver on environmentally friendly solutions is the IMO decision to include the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP) in Annex VI of the MARPOL convention.

Even if a general trend in the design objectives can be recognized, each project still is unique and the selection of the specific numerical tool and the necessary model tests should be made in close cooperation with our hydrodynamic experts.

Green Ships, EEDI, Ship Noise and Ship Transport in the Arctic were also the primary topics of the 26th International Towing Tank Conference ITTC.

Among others, a specialist committee has been formed to tackle tasks related to performance of ships in service covering the whole life cycle of the ships and take into account all EEDI developments. The noise committee has been tasked with digging into identification of noise sources that impact marine life. The ice committee shall address all questions related to transport in ice covered waters. HSVA experts are members of these three committees to testify the ongoing commitment of HSVA to all environmental issues related to shipping.

In the next months there will be several chances to meet our experts to discuss all your questions related to ship and offshore hydrodynamics. Events will be the meeting of the German Society of Naval Architects STG and the MARINTEC'11 in China. I hope to meet you there.

Juergen Friesch
Managing Director

Setting Energy Efficiency TARGETS for Ships

by Jochen Marzi, Hannes Renzsch and Scott Gatchell

Energy efficiency and environmental considerations are today's driving forces for both, ship operators to reduce costs and become greener and for ship builders to achieve a competitive edge. Economic pressure and international legislation require a sensitive use of energy resources and a reduction of the associated emissions. The EU funded TARGETS (Targeted Advanced Research for Global Efficiency of Transportation Shipping – www.targets-project.eu) project provides substantial improvements to overall ship energy efficiency by adopting a holistic approach covering the most important energy consumers as well as energy generation/transformation including unconventional sources. The TARGETS concept is explained in the figure below.

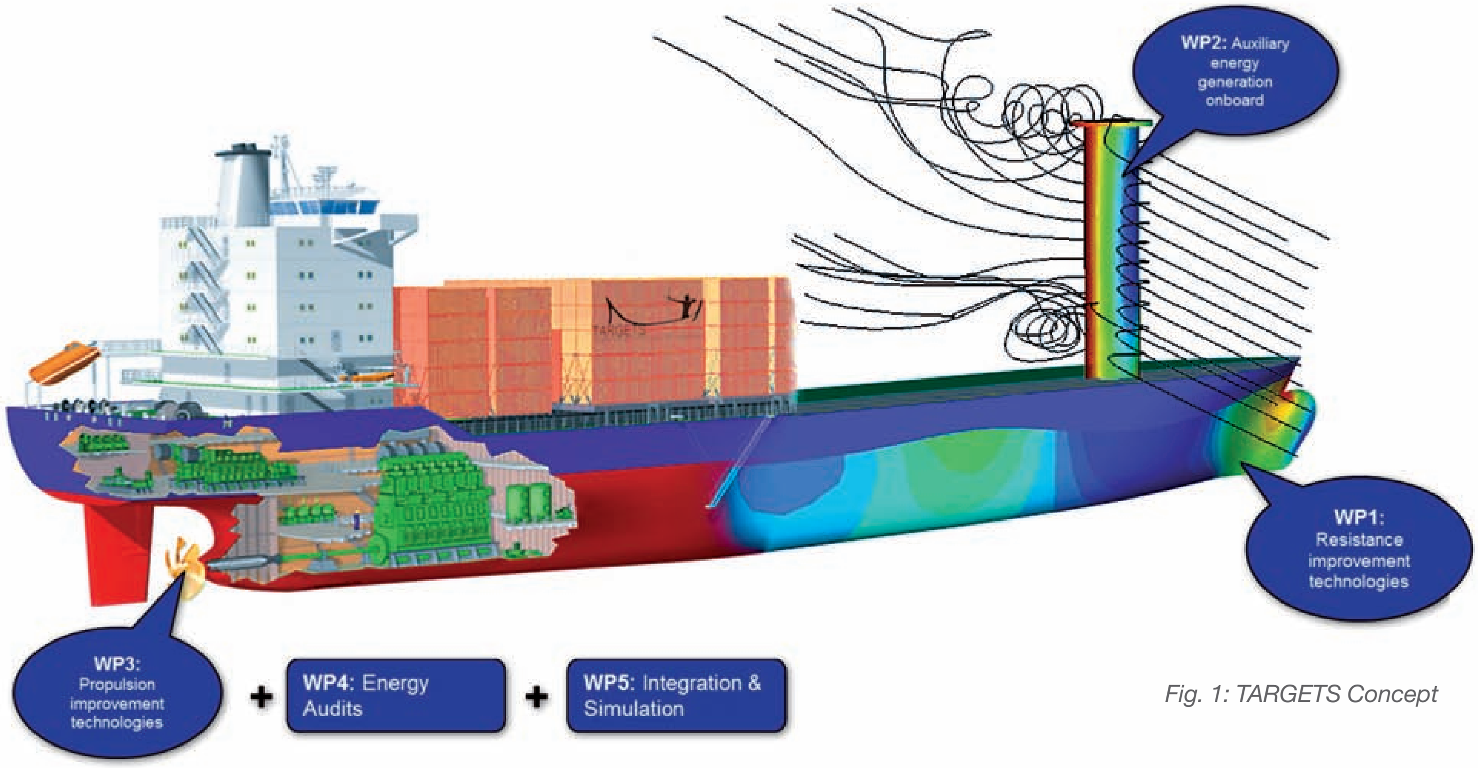


Fig. 1: TARGETS Concept

Structured into five Work Packages the project analyses the hydrodynamic influences of resistance and propulsion and explores the potential use of alternative energy sources. Accompanied by thorough energy audits performed on a number of ships, these feed the overall dynamic energy model which will in turn form the basis for holistic simulation and optimisation of energy consumption on board a ship.

Ship resistance is the prime cause of energy consumption on board a cargo vessel. Up to 50 % of the useful energy is spent to overcome the calm water contributions to the overall resistance, i.e. pressure and viscous parts, adding another 15 % for environmental effects such as added resistance in a seaway and wind effects on the ship superstructure. With propeller efficiency usually being up to 70%, this adds another 30 % of losses due to hydrodynamic reasons which in total accounts for more than 90 % of the energy used on board standard cargo vessels. Although it must be noted that for other type of vessels, e.g. PAX or ferries, the balance is shifted very much towards other consumers, the last IMO Green House Gas Study clearly indicates that the bulk of all seaborne CO_2 emissions (> 70 %) stems from cargo vessels. Any significant reduction to ship emissions will hence rely on improvements in this sector. Based on our superior knowledge of resistance characteristics and propulsive efficiency HSVA is ideally placed in the TARGETS project to lead the developments for hydrodynamic improvements and provide the fundamental inputs for energy consumption to the overall dynamic energy simulation system which is being developed in the project. Fig 2. indicates the "hydrodynamic contribution" to the complete dynamic energy model of TARGETS.

Starting from classic calm water hullform optimisations based on potential flow methods, using HSVA's standard free surface panel code ν-SHALLO, overall shape parameters and the bulb form can be optimised for wave resistance. Fig. 3 indicates the performance gains which can be obtained for a bulb optimisation of a smaller container vessel for a given design speed. Due to the speed advantage, panel codes lend themselves to large numbers of investigations and allow addressing different operational conditions including speed and draft variations. Optimising hullforms for varying operational conditions is an important contribution to the increase of overall energy efficiency of maritime transportation today, as fewer ships tend to sail at design conditions only. Optimising trim in partially loaded conditions can yield significant savings as has been described in earlier editions of NewsWave already.

Although panel codes give a good insight into overall resistance characteristics and can be used to determine and optimise principal hull parameters, the overall accuracy of such predictions is usually not sufficient to base a full power prognosis on these results. As details such as breaking waves, the influence of viscosity on the pressure resistance and in particular the stern flow topology can either only be approximated or not accounted for at all, further analysis is required to obtain tangible information on ship resistance.

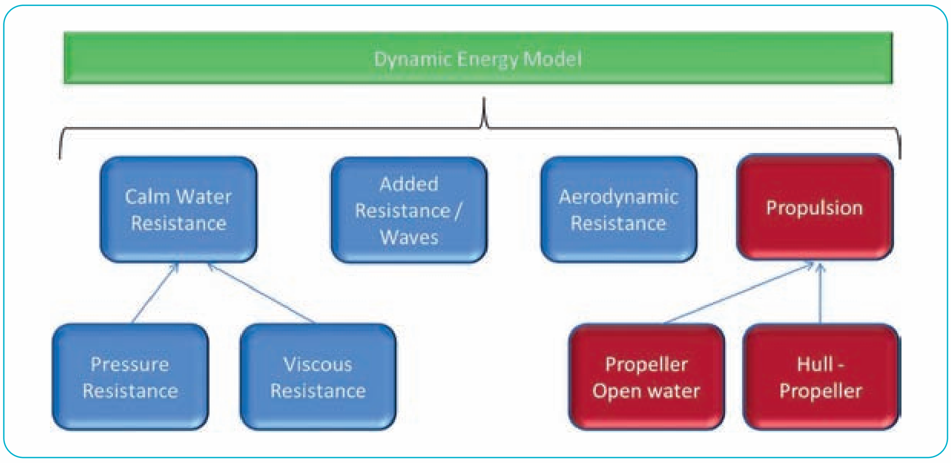


Fig. 2: TARGETS hydrodynamic model as part of the overall Dynamic Energy Model

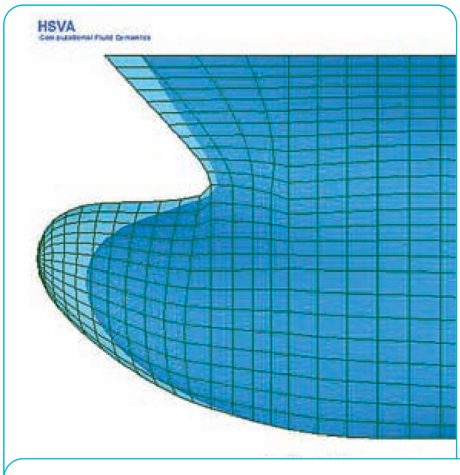
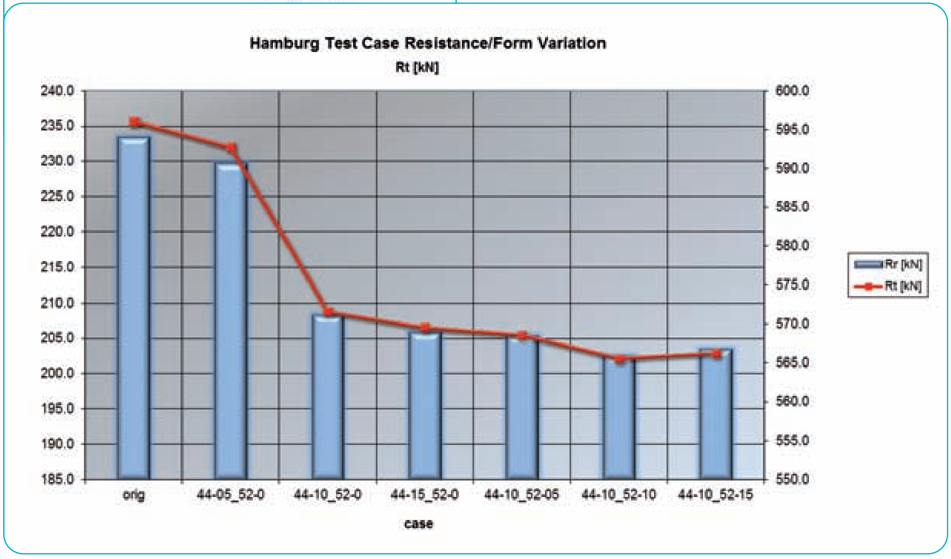


Fig. 3:
Bulbous bow optimisation
and respective resistance gains
for a small container vessel



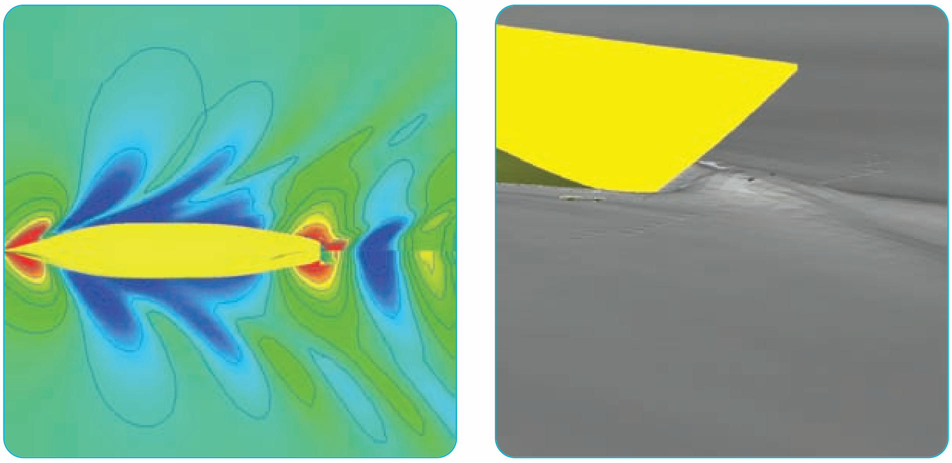


Fig. 4: Comparison of predicted wave pattern for a Car Carrier - panel code (bottom) vs. RANS (top) and detail of the stern flow from RANS prediction

Recent advances in full scale wave resistance predictions using the in-house RANS code FreSCo$^+$ allow performing even more realistic free surface computations whilst delivering also the ship resistance within towing tank quality. The following figure indicates the differences between free surface predictions performed with a panel code (bottom) and FreSCo$^+$ (top). The detail shows the particular formation of a rooster tail behind the stern which is not appropriately captured by the panel method. Due to significant speed-ups obtained for full scale free surface predictions these find their way into routine work at HSVA today.

Besides pure resistance issues, the interaction between ship hull and propeller largely determines the overall propulsive efficiency of a vessel. Having established the concept of the numerical propulsion test in FreSCo$^+$ already more than a year ago, the next step is to embed the RANS-BEM linked propulsion simulation into the adjoint solver presented in the previous issue of News-Wave. This concept now allows analyses of the effect of form variations on different objective functions, e.g. resistance, wake quality etc. from predictions which are performed taking the effect of the running propeller into account. Based on the different objective functions implemented in the code so far, even compound formulations accounting for more than a single objective can be used. The following figure shows form sensitivities computed for the aft body of a container ship with active propulsion (left) and the axial velocity field in the propeller plane (right).

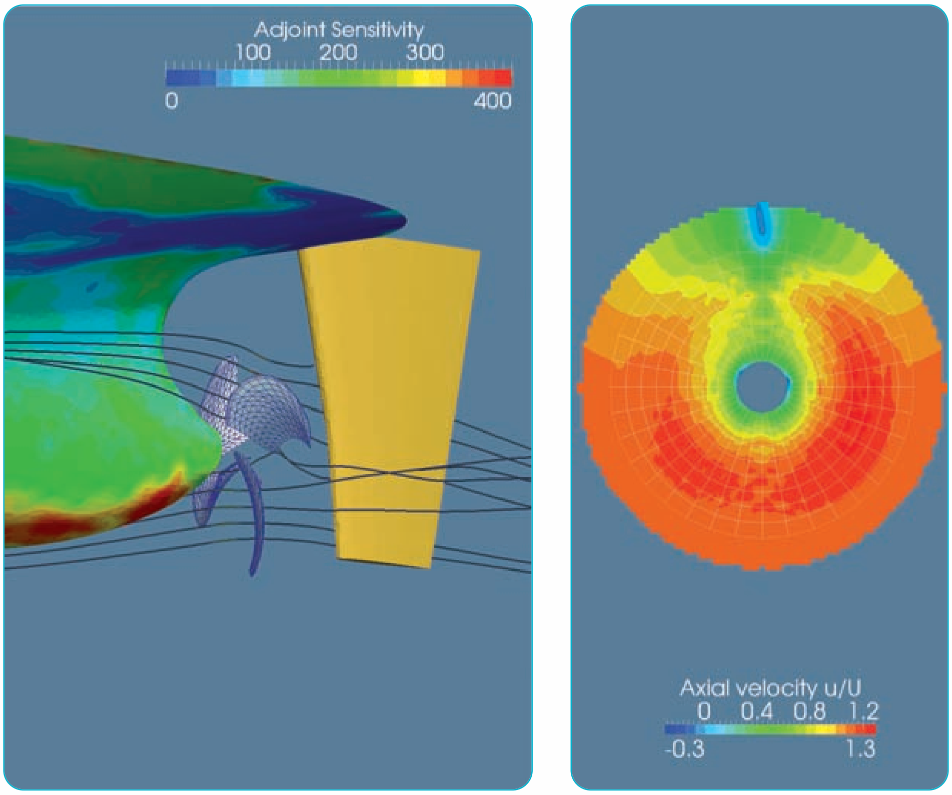


Fig. 5: Sensitivities computed for a container ship with active propulsion

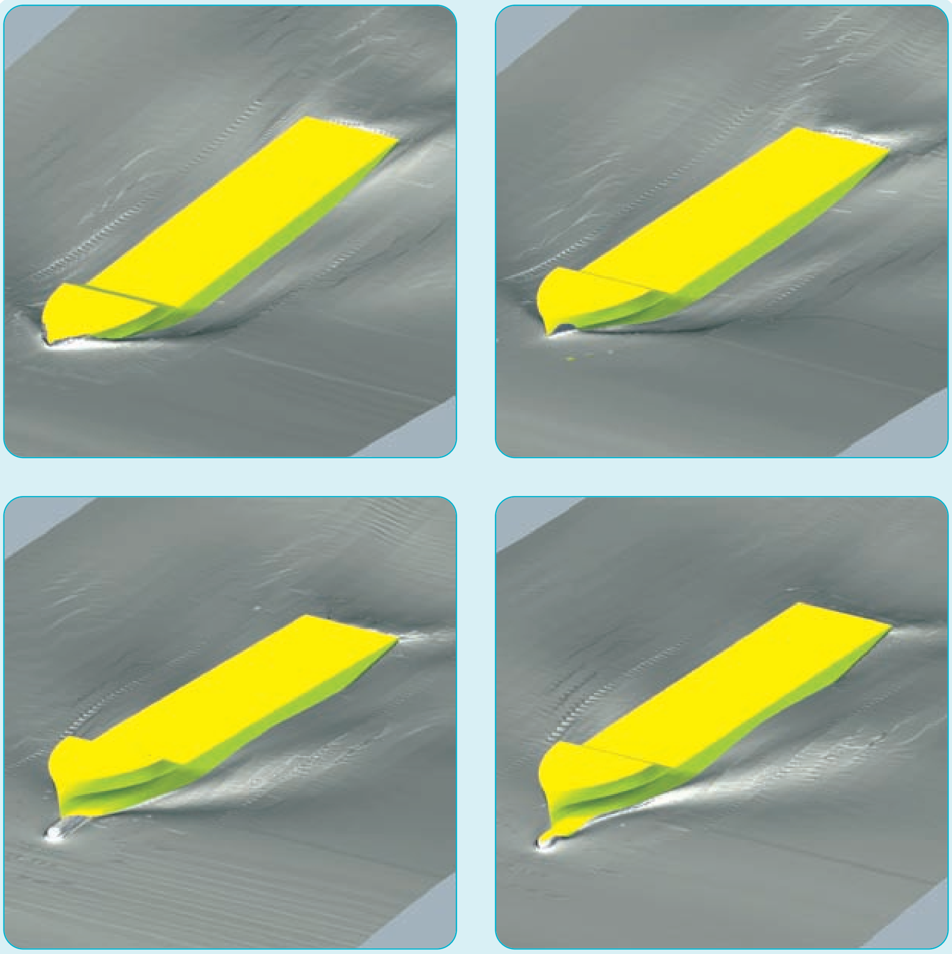


Fig. 6: Time instances of ship motion in severe head seas

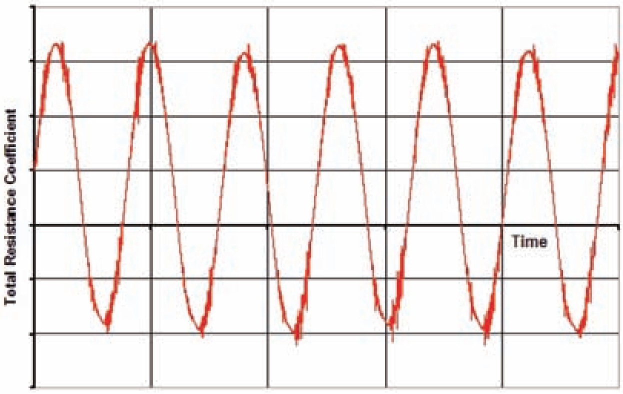


Fig. 7: Time series of added resistance

Added resistance in a seaway is the second largest contribution to the hydrodynamic part of the ship's resistance. While potential flow methods, strip theory of panel codes, provided reasonable conclusions for relatively slender ship forms in moderate waves in the past, new ways are pursued in TARGETS in that RANS based predictions are made for a range of hullforms covering modern container vessels as well as blunt ship forms such as tankers and bulk carriers also in more extreme seaways. The following example indicates instances from a time series computed for a container vessel (L = 230 [m], v = 22 [kts]) in extreme head seas with a wave length of 2*L and a wave height of 7.7 [m].

The variation of the longitudinal forces (=added resistance) for these extreme conditions are shown in the graph below. Added resistance for these conditions is as much as 40 % higher than the calm water resistance. Although the case is a rather unrealistic example of ship operational conditions it shows that the methods are capable of predicting the effects of added resistance well beyond the limits of present days' typical seakeeping analysis codes.

Based on the modules described above, further amended with additional elements for viscous resistance and aerodynamic drag in the future, TARGETS develops a complete simulation environment for hydrodynamic influences to feed the global dynamic energy model of a ship. This will allow placement of the influence of hydrodynamic factors such as resistance of propulsive efficiency into the context of overall energy consumption on board a ship and further to simulate and optimise energy consumption for a wide range of operational conditions already at the design stage of a new vessel.

“Multiple-Point” Hull Form Optimisation of Containerships

by Uwe Hollenbach and Grete Ernst

These days model basins face a high demand for hull form optimisation by means of numerical calculations as well as model tests. Like in the years around 2008, tank facilities are fully booked so that next available slots can be offered to our customers in approximately six months time the earliest. What is the reason for this high demand for hydrodynamic services?

Since last autumn the number of container ship projects on the market has been picked up significantly. Customers from Korea, Taiwan and China are developing numerous newbuilding projects. These projects can roughly be divided into three different sizes of container ships: for one the “old” Panmax size with capacities between 3,500 TEU and 4,800 TEU, however, now coming with a larger breadth (typically 37.4 m) and with lower speed requirements (around 21 knots). Secondly “new” Panmax sized vessels around 9,000 TEU and as third various projects of very large containerships with capacities between 12,500 TEU and 16,000 TEU.

Common design features of all new projects are the - compared to the past - lower speed requirements and the corresponding higher block coefficient of the designs. Some ship owners still require an optimisation following the “single-point” optimisation philosophy, where the hull is optimised for just one single speed-draught condition. But the demand for a “multiple-point” optimisation is constantly increasing to make the designs more flexible for future services. The draught and speed range chosen as design constraints in these cases base on past experience with operation profiles and future expectations for the intended service of the ship and may differ from shipping company to shipping company. Still, some general conclusions can be drawn from these developments.

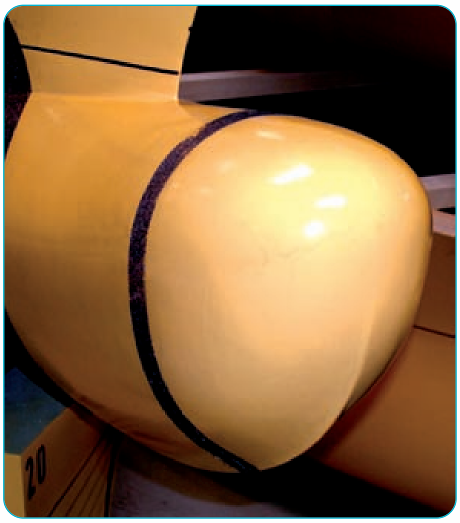


Fig. 1: Pronounced bulbous bow as result of a “single-point” optimisation

Fig. 2: Moderate bulbous bow resulting from a “multiple-point” optimisation

The “single-point” optimisation of past projects typically result in pronounced bulbous bows and wide flat transom sterns. When operating such designs on larger draughts than the design draught the large wetted area of the submerged transom stern has been shown to worsen the performance significantly. On smaller draughts than the design draught and operating at lower speeds the pronounced bulbous bow generates unfavourable wave systems, which also results in a reduction of performance. It can even be observed that the power requirement on smaller draughts is higher than on the design draught, although the vessel has much less displacement in this condition.

The “multiple-point” optimisation for a draught and speed range typically results in a much less pronounced bulbous bow, finer entrance angles and less bow flare in the fore body and a more v-shaped transom stern to

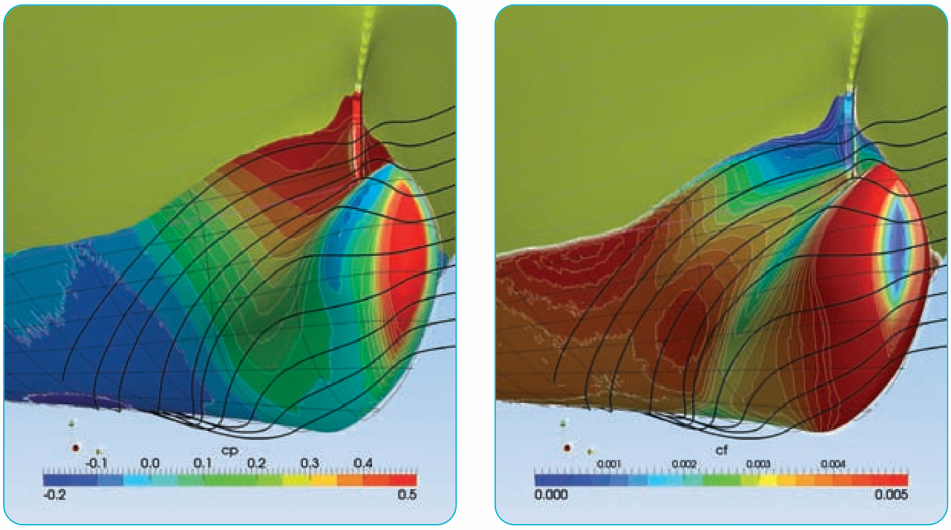


Fig. 3: Numerical self-propulsion test, calculated coefficients cp (pressure - left) and cf (friction - right)

fit the various sailing conditions. Depending on the probability distribution of draughts and speeds the bulb designs are less prominent to ensure a proper flow around it also for the lowest draught condition and the transom sterns are arranged in a way to compromise the specified draught range. Thereby, compared to "single-point" optimised hull forms gains in performance for the whole draught and speed range have reached at the end of the optimisation process.

Serve as a typical example can a 9,000 TEU container ship, which is currently being developed for a German ship owner. The cooperation started well in advance of the model tests with a study varying the main dimensions - namely length, breadth, draught and block coefficient - to find the most economical combination of these parameters for given speed and capacity requirements. When starting the hull form design itself the ship owner provided a draught and speed range with corresponding probabilities in the future operation profile which had to be taken into account in addition to design draught and design speed during the optimisation process. The operational draught and speed range was based on the evaluation of noon reports of the existing vessels of the ship owners' fleet, combined with his expectations for future services of the new vessels and can be seen in Table1.

Design speed	21 knots
Design draught	12.5 m
Scantling draught	14.0 m
Operational speed range	15.5 knots to 20 knots
Operational draught range	10.5 m to 13.5 m

Table 1: Design constraints for a 9,000 TEU container vessel for a German ship owner

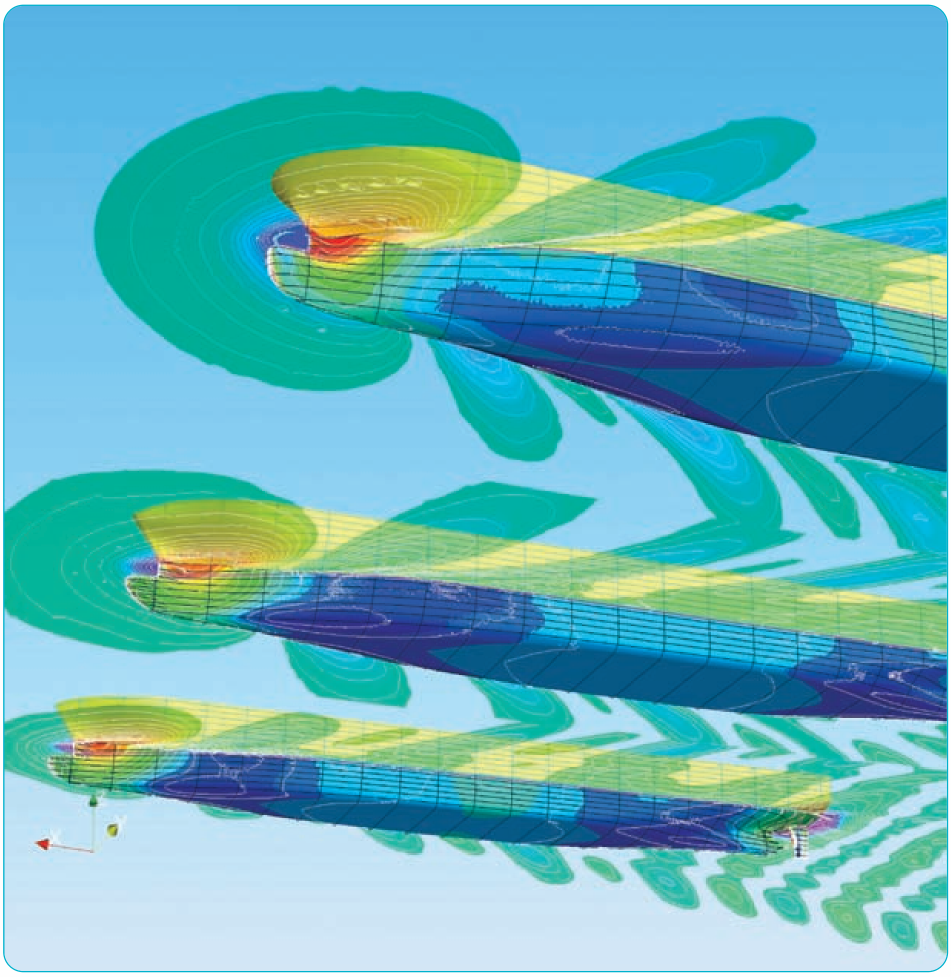


Fig. 4: Wave elevation and pressure distribution of the three competing hull form designs

For this project three competing hull form designs have been developed. One by the ship yard itself; the other two have been developed by order of the ship owner respectively at HSVA. Although optimised within the same constraints, the three designs that have been derived differ quite significantly in terms of bulbous bow design and transom stern design.

The different hull form designs have been tested at HSVA's tank facilities just recently this year throughout the whole speed-draught range defined for the optimisation and again the moderate bulbous bow design has been proven to be the most favourable for the defined operation profile.

During design stage numerical propulsion tests have been performed by means of RANSE codes for all three hull forms. The results of these have shown good correlation with the model tests and, therefore, the RANSE analysis has been proven to be a reliable tool in comparing competing hull form designs. Results of the RANSE calculations for the three hulls can be seen in Figures 3 and 4.

Analysis of Breaking through Sea Ice Ridges to develop a Prediction Method

Fig. 1: Sea ice ridge by Salvesen (1990)

by Daniela Ehle

Within the research project IRO (Ice Forecast and Route Optimization) the process of a ship breaking through sea ice ridges was analysed. The major interest was to determine the behavior of resistance and ship's velocity during the break through.

IRO: At least nine month of the year Arctic shipping has to deal with varying ice conditions like level ice in sheltered sea bays, pack ice and sea ice ridges with up to twenty meter keel depth. With respect to this challenging environment even the strongest nuclear icebreakers lose their optimal maneuverability leading to passive drifting with the sea ice. Due to this, the overall aim of the research project is to develop a tool for nautical staff by providing support for navigation in ice covered seas. Therefore model tests were performed to improve the accuracy of velocity prediction in deformed ice. The results were analysed to determine the averaged velocity during the ridge breaking.

SEA ICE RIDGES: Sea ice ridges are one of the most difficult obstacles for ice navigation. Depending on their age and formation process, sea ice ridges can be found in many different sizes, consolidations and shapes. A sea ice ridge is a line or a wall of broken ice forced up by pressure. This pressure results from a combination of different environmental factors, mainly from wind and current induced stresses.

BREAKING THROUGH SEA ICE RIDGES: Ships can break through sea ice ridges either continuously or by ramming. In both cases the ship impacts a sea ice ridge at a certain penetration velocity. With encountering the ridge, the ship's resistance increases significantly so that its velocity decreases. If the ship can maintain progress, in general with a low velocity of advance, it passes the ridge in one run otherwise it gets stuck and has to overcome the sea ice ridge in several rams. After passing through the ice ridge the ship accelerates again until it accomplishes a higher velocity in the surrounding level ice.

RIDGE RAMMING TESTS: Six ridge ramming tests were performed in HSVA's large ice model basin. Two ship models with different main dimensions and ice breaking capabilities were tested. The tests were performed with a free running model, whereupon the model thrusters were remote controlled. In all cases the model was sailing ahead.

Test Run	Model No.	Averaged Penetration Velocity [m/s]	Keel Depth [m]
1010	1	3.10	12.9
1020	1	2.45	12.9
2010	1	3.28	15.5
2020	1	4.70	15.7
3010	2	2.39	7.6
3020	2	4.52	13.4

RESULTS: The ice resistance could be determined as a function of the ship's characteristics, especially of the bow shape, the ridge geometry and the penetration velocity. It is very much depending on the ship model's position relative to the ice ridge. When the ship's fore shoulder advances to the point of maximum keel depth the ice resistance reaches its maximum. By means of thrust and kinetic energy the ship is able to overcome this resistance. Due to this a good combination of thrust and kinetic energy can significantly improve the ridge breaking capability.

Moreover it turned out that the ice resistance characteristics are independent of ridge size, number of necessary rams to transit the ridge and particular ship data. For this reason it is

Fig. 2: Ship model breaks through model ice ridge

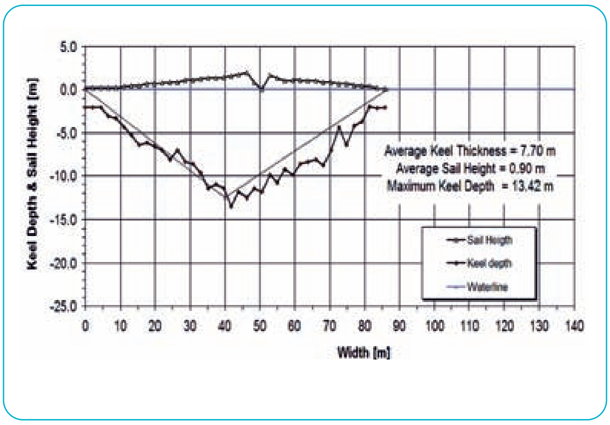


Fig. 3: Center profile of model ice ridge in full scale

possible to develop a general ice resistance distribution over the width of the ridge (Fig. 4). In doing so different ridge breaking processes can be compared with each other.

With the ice resistance distribution the target parameter - the average transit velocity - could be analysed. The velocity during the ridge breaking strongly depends on the ship's penetration velocity. For a given ship with a certain propulsion power and ice-breaking capability an optimum penetration velocity exists. Its value is the maximum possible velocity in level ice which is either limited by the available thrust or by the strength of the hull. In practice another limitation of the thrust is given by the event of extraction. Due to the ice model tests a typical curve shape of the ship's average transit velocity as a function of distance could be outlined (Fig. 5). Thereby distance means the position of the midship frame.

As an overall result a general method to predict the ship's average transit velocity could be established. The method takes into account the ship's hull shape and its power. The relevant ship and ridge parameters were defined as the method's input quantities. The method is based on a query which compares the ship's kinetic energy to the difference of resistance and thrust integrated over the time. By means of this the average penetration distance (per ram) can be determined. Moreover the average penetration time (per ram) can be deduced from the curve shape of the velocity as a function of distance. Finally the calculation of the average transit velocity is possible.

The results from the ridge ramming model tests can be regarded as a pre-condition for an efficient ice route optimization. They will be embedded in a tool for the determination of the average velocity in varying ice conditions. Thereby the overall average transit velocity for a certain route will be calculated stepwise by summing up the average velocities in different ice types along the route. The average velocity in sea ice ridges can be included directly by using the characteristic behaviour of the model test results. Using this tool will allow to find the most efficient route through ice covered waters.

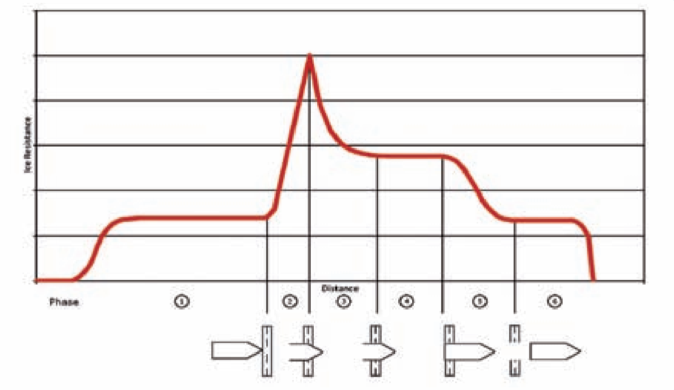


Fig. 4: Ice resistance distribution

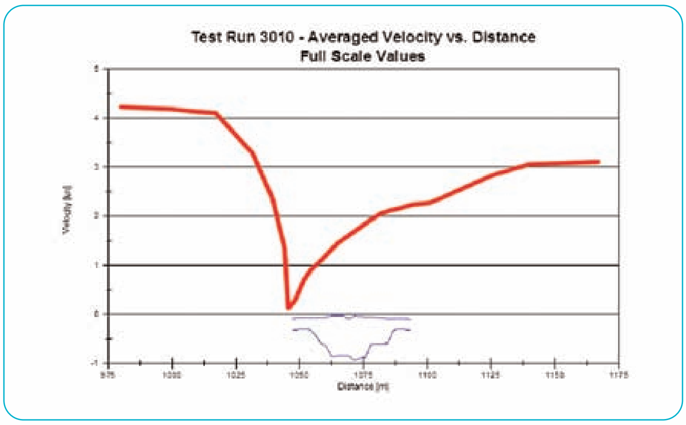


Fig. 5: Transit velocity

High Speed Cavitation Tunnel Modernized

by Christian Johannsen

Indeed, it is "the old boy" among HSVA´s cavitation tunnels. But with its fabulous water speed of almost 20 meters per second the large conventional cavitation tunnel is still an interesting toy for our customers as well as for our engineers. After fifty years of faithful operation it was time now to renew the whole electric control system of this tunnel.

Since HYKAT, HSVA´s famous Hydrodynamics and Cavitation Tunnel started to operate with complete ship models inside its test section, the old large conventional tunnel has been suffering from a somewhat shadowy existence. The latter tunnel is a Kempf & Remmers K 16 type cavitation tunnel with a closed circular test section of 750 mm diameter and a fabulous top speed of 19.5 m/s (Fig. 1). Corresponding to this high speed the tunnel is equipped with two strong dynamometers of 130 kW and 30 kW respectively, one driving the model propeller from upstream, one from downstream. The tunnel was built in the early sixties of last century and up to year 2010 its electric installations were exactly of this age!

In 2010 and 2011 the control systems of all three main tunnel components have been replaced in two stages by Siemens type state-of-the-art equipment. The water pump, the main dynamometer as well as the inclined shaft dynamometer are now controlled by just one movable and handy size control panel. All auxiliary drives as well as the starter system are controlled automatically. Not only the ease of use but especially the reliability of the facility have been improved dramatically. Since then the tunnel is back into the light to be used for various kinds of non-standard purposes.

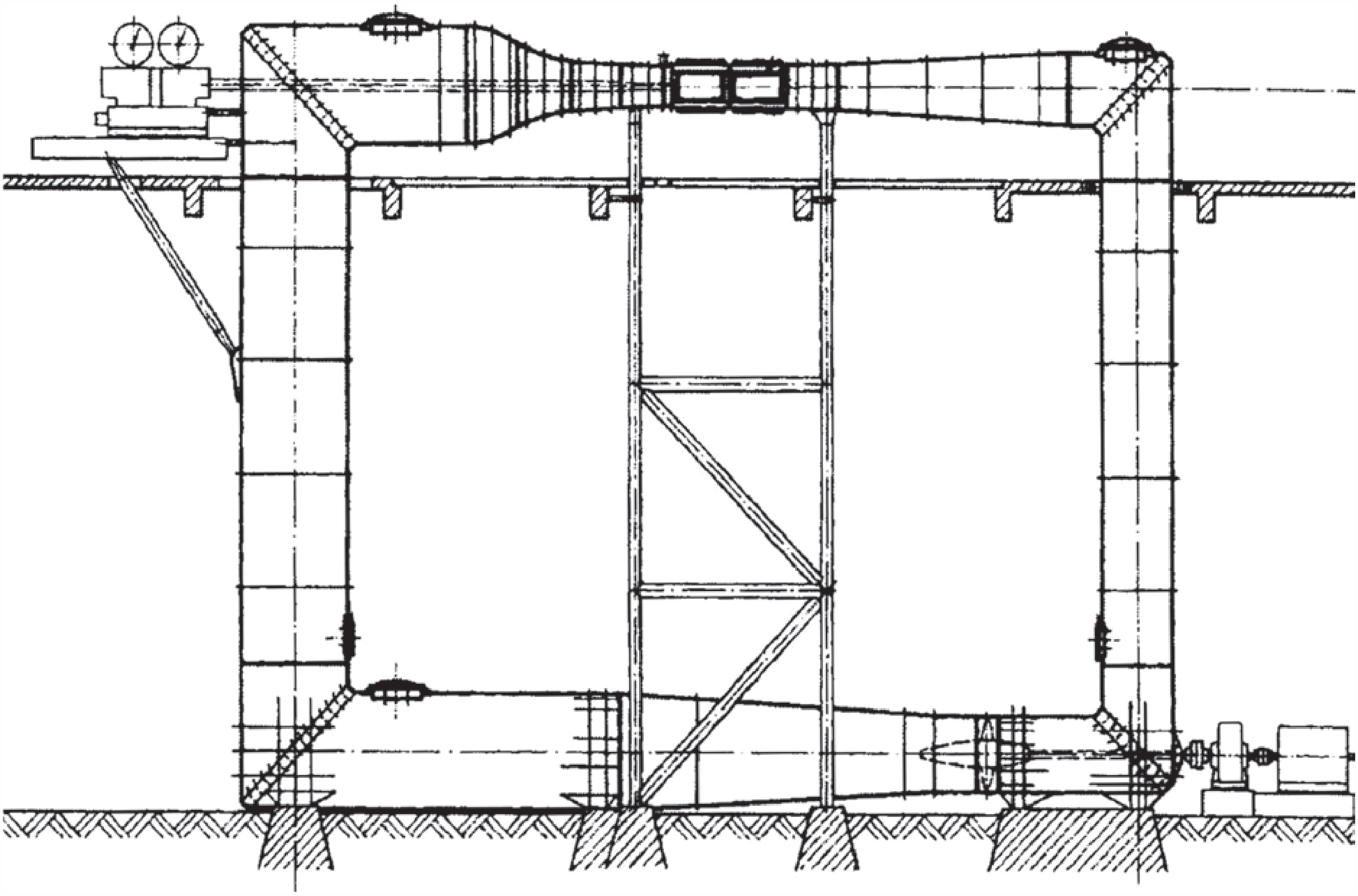


Fig. 1: The Large Conventional Cavitation Tunnel

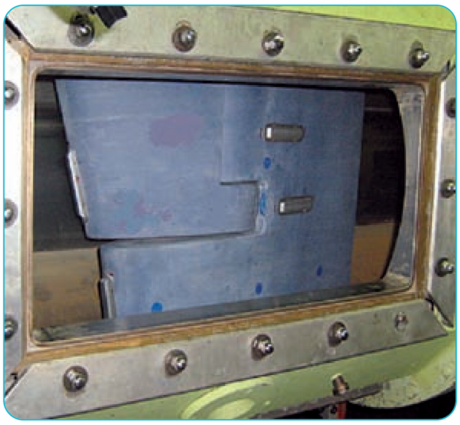


Fig. 2: Large Scale Part Rudder Model

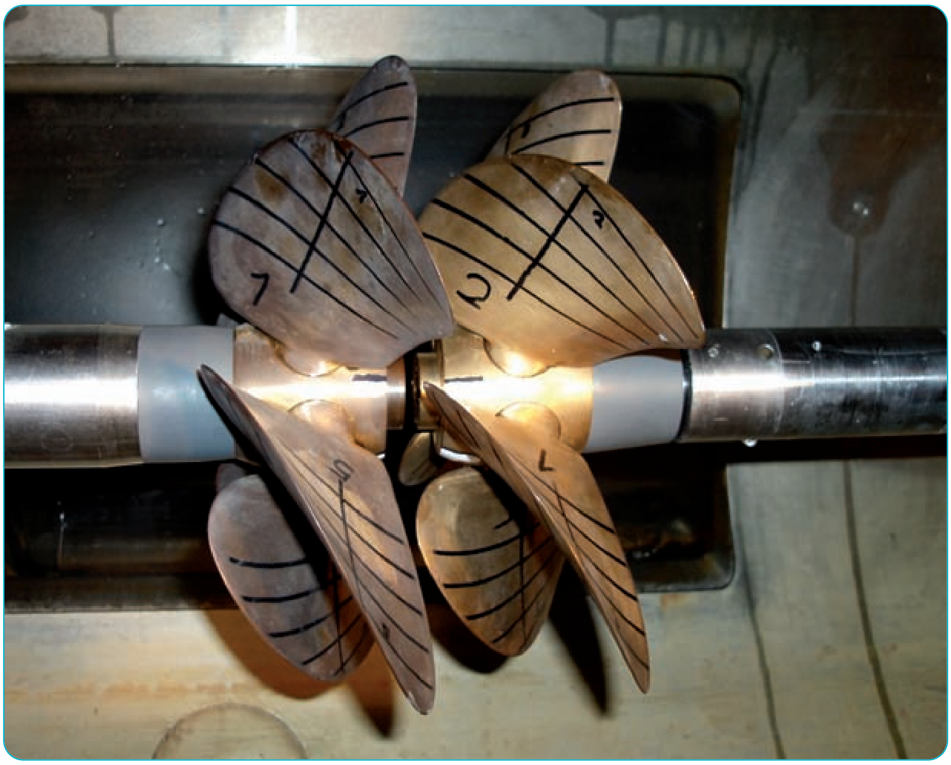


Fig. 3: Tandem Propeller Pair – for Research Purposes Separately Driven by Different Dynamometers

Semi-spade rudder part models of large scale have meanwhile been installed (Fig. 2) to investigate the influence of surface and geometry imperfections on the rudder´s cavitation behavior. The large span of these rudder models together with the high water speed resulted in high Reynolds numbers and led to impressive cavitation phenomena. This kind of rudder investigation is always interesting when small geometry details for cavitation improvement have to be judged.

The two independent tunnel dynamometers formed recently the perfect environment for the investigation of so-called Tandem Propellers. While placed in reality on the same shaft, the present set-up (Fig. 3) allowed easy insight into the dependence of the propeller load share on the advance coefficient of those units. Efficiency and cavitation dependence on the phase relation between the fore and aft propeller was studied as well.

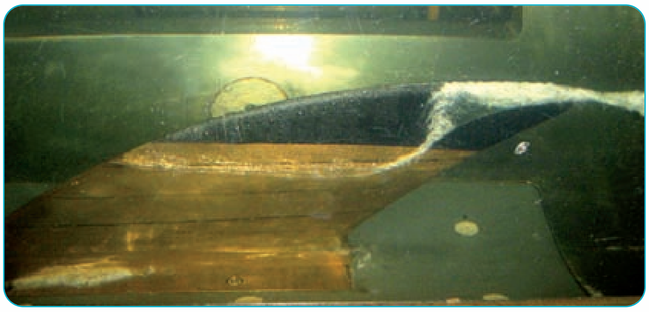


Fig. 4: Large Scale Propeller Tip Model – Cavitating at Almost Full Scale Reynolds Number

Again it was the high tunnel water speed that allowed investigation of large propeller blade tip models (Fig. 4) at almost full scale Reynolds number. The influence of smallest geometry details on the critical transition from sheet to vortex cavitation could be studied this way. Interesting conclusions with respect to erosion prevention could be drawn. Other investigations like contra-rotating propeller arrangements or calibration of speed logs have been performed in the tunnel as well. For the latter purpose the tunnel offers a speed range up to almost 40 knots! For high Reynolds number propeller open water testing the tunnel offers perfect environment. Reynolds numbers of up to $3.5 \cdot 10^6$ have been reached recently within a research project. Even more would be possible.

Of course, the old boy will never be a serious rival to HYKAT. But with its regained reliability and manageability it is an interesting addition whenever highest water speed is an important testing feature.

Recent Developments of Model Testing and Computations in the Seakeeping Department

Fig. 1: Flaps of the snake type Side Wave Generator generating oblique waves

by Katja Jacobsen and Peter Soukup

Due to new standards and increasing requirements on safety as well as economic aspects of ships in seaways it is essential for modern model basins to be prepared for changing demands. With new testing facilities together with improvements in and developments of numerical seakeeping codes HSVA significantly enlarges its scope of investigations on seagoing ships and offshore structures at zero and at forward speeds.

With the new Side Wave Generator (SWG) HSVA improves its seakeeping test facilities dramatically. With the aim to acquire new markets and thus new orders HSVA extends as first model basin worldwide its towing tank with a new computer controlled Side Wave Generator in order to investigate seagoing ships in beam and oblique sea scenarios.

The new Side Wave Generator is a snake type wave generator consisting of 80 flaps each having the width of 0.5 m (Figurte 1). Each flap is controlled individually and therefore arbitrary waves and sea states can be generated:

- Regular waves
- Multichromatic waves with limited number of frequencies
- Irregular long-crested seaways (JONSWAP, PM, TMA and user-defined spectra)
- Selected subseries of irregular sea states satisfying given parameters (e.g. steepness)
- Irregular short-crested sea states
- User-defined wave trains
- The above described waves and seaways can be generated within angles from 20° to 160° with respect to ship course, thus enabling investigations in beam and in oblique sea states.
- Together with the existing wave generator, which can generate long-crested waves in the longitudinal tank direction, the combination of wind seas and swell can be simulated.

The Side Wave Generator is mounted in the middle of the long side of the Large Towing Tank. This gives the advantage that the acceleration and deceleration phases of the ship model can take place outside of the actual measuring region. Thus the whole length of the Side Wave Generator can entirely be exploited for the measurements. This enables the efficient investigation of vessels also in beam and oblique seas at nonzero speeds.

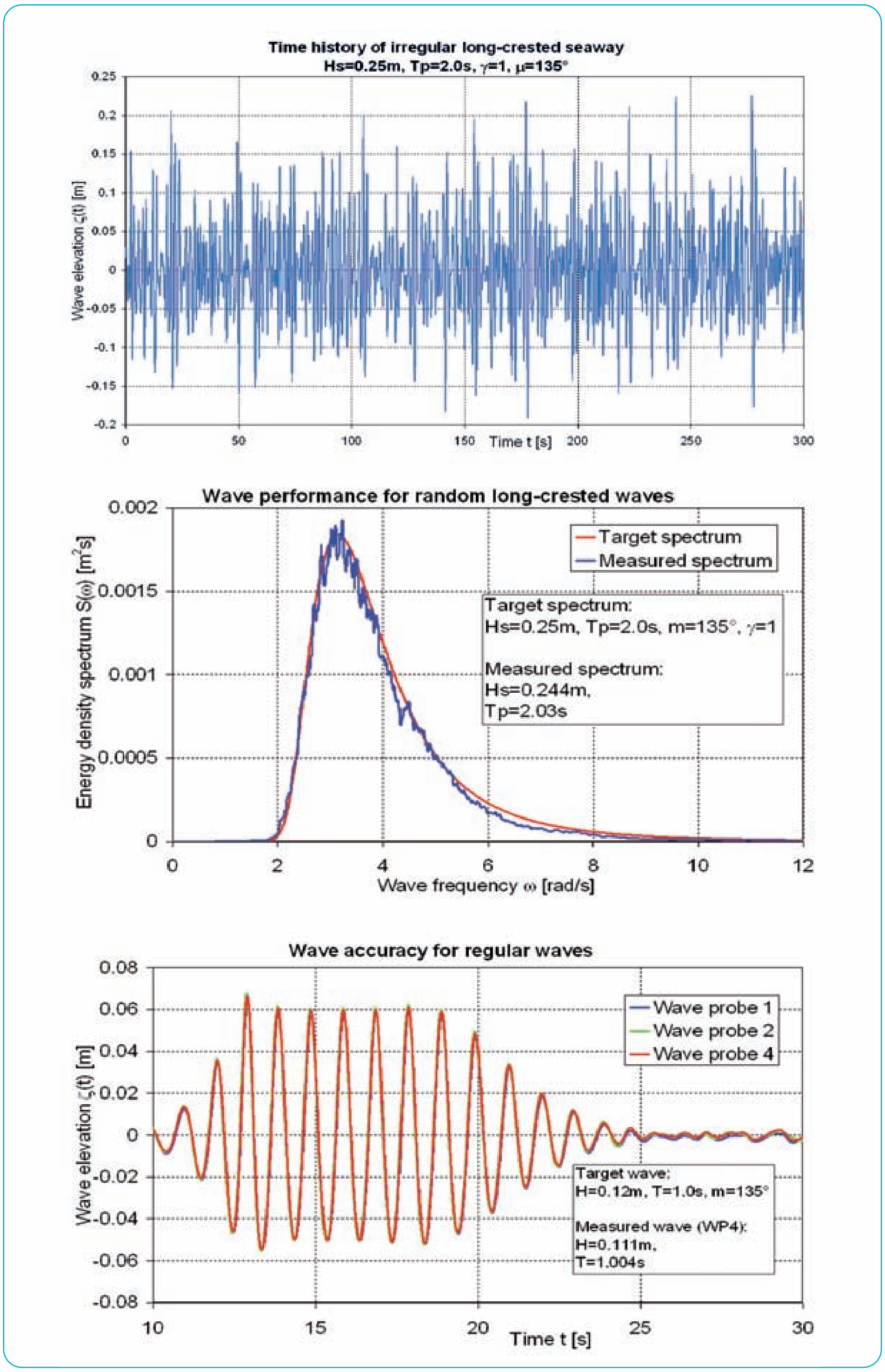


Fig. 2: Results of an irregular long-crested seaway and an oblique regular wave

The first tests for wave performance showed very promising results (Figure 2). The spectral shape of an irregular long-crested seaway with a significant wave height of 0.25m and a peak period of 2s was met with less than 3 percent of deviation. The straightness of oblique waves of 135° heading was tested with 3 wave probes aligned in this direction. The result was convincing: Absolutely no phase shift was measured (Figure 2 bottom).

Figure 3 shows the results for the heave, pitch, and roll motion of the freely running model in oblique irregular long-crested seas gained from a model test with the SWG together with computed results.

Figure 4 shows a typical scenario of a container ship in high stern quartering short-crested irregular seas, whereas in Figure 5 a semisubmersible in severe long-crested beam seas is presented. Both examples demonstrate nicely the capability of the new side wave generator and show the highly realistic environment conditions which can now be realized in the towing tank.

Besides standard ship models also offshore structures like semisubmersibles and pipelayers, as well as special ship types from fast monohulls to small waterplane area twin hull catamarans and surface effect ships can now be investigated in arbitrary, highly realistic wave scenarios.

Of frequent interest regarding the overall linear motion performance of ships and offshore structures is the determination of the Response Amplitude Operators (RAO). In former times the RAOs were determined by performing tests in regular waves, which is a fairly time consuming procedure. Alternatively, HSVA uses the transient wave packet technique to determine the RAOs. By exploiting the dispersion characteristic

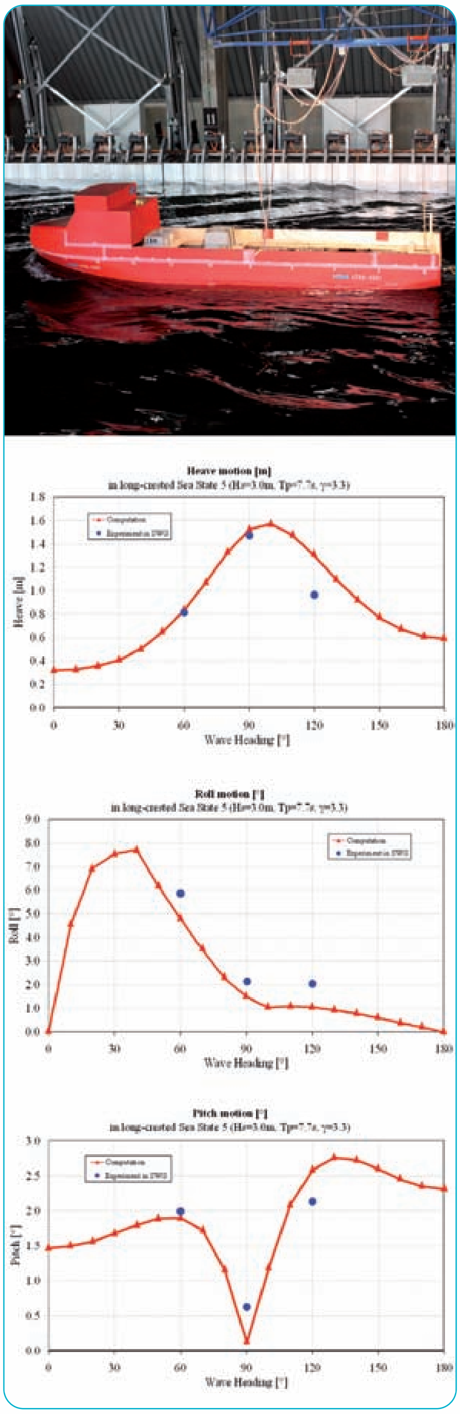


Fig. 3: Model in Side Wave Generator with results for heave, roll and pitch motions compared to results from numerical calculation

Fig. 4: Container Ship in Severe Stern Quartering Short Crested Seas

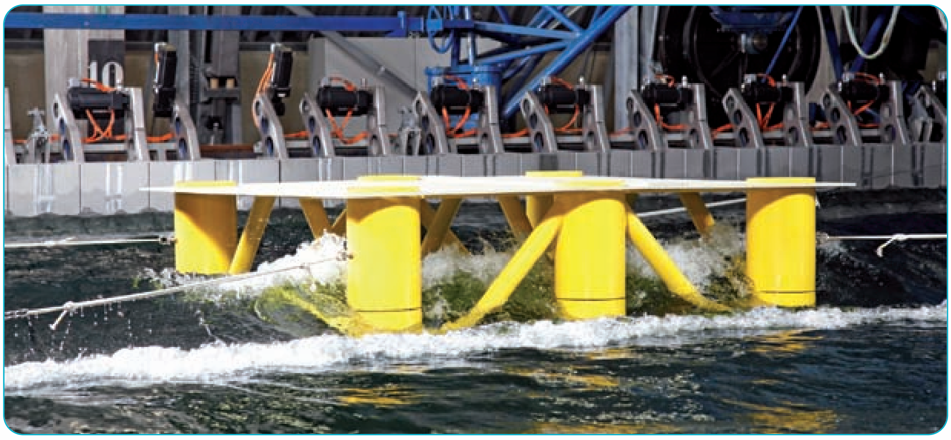


Fig. 5: Semi-Submersible Floating Platform in Severe Long Crested Beam Seas

of water waves the components of a spectrum are arranged so that a transient wave train is generated, which includes wave components over a wide range of frequencies. Thus with the wave packet technique a large range of wave frequencies can be realised within one single test of short duration. In addition no unwanted reflections from the tank wall have to be considered, nearly no statistical spreading of results and very good resolution of the RAOs in the frequency domain is obtained. In Figure 6 the Response Amplitude Operators resulting from one single test run per wave heading are shown.

Progress, however, has not only been made in the model testing, but also in numerical computations. The program ROLLSS, which is very fast in simulation of parametric rolling, is being used more and more frequently at HSVA. While the heave, pitch, sway and yaw motions are computed by a linear strip method, and the surge motion by a simple nonlinear approach, the roll motion is computed nonlinearly in the time domain using the righting lever curves of static stability in waves. This approach is as simple as effective. The computation time for a full scale simulation in the time domain is very short. Thus a large number of simulations can be done within a short time. This makes it

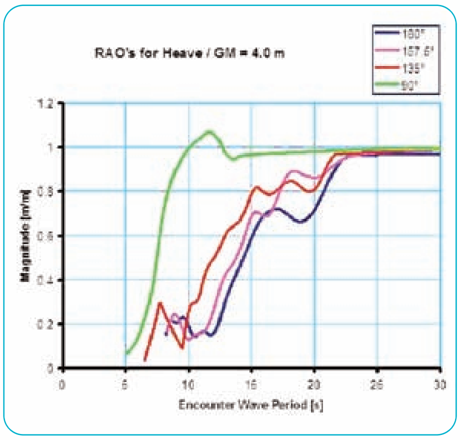


Fig. 6: Response Amplitude Operators obtained within one single test run of very short duration

possible to carry out systematic studies efficiently by varying significant parameters, like e.g. wave length, wave height, ship speed and encounter angle for various loading conditions to identify potentially dangerous zones. The result of each computation is the maximum roll angle. Figure 7 shows these results for one computation series in regular head and following waves for a Panmax container vessel.

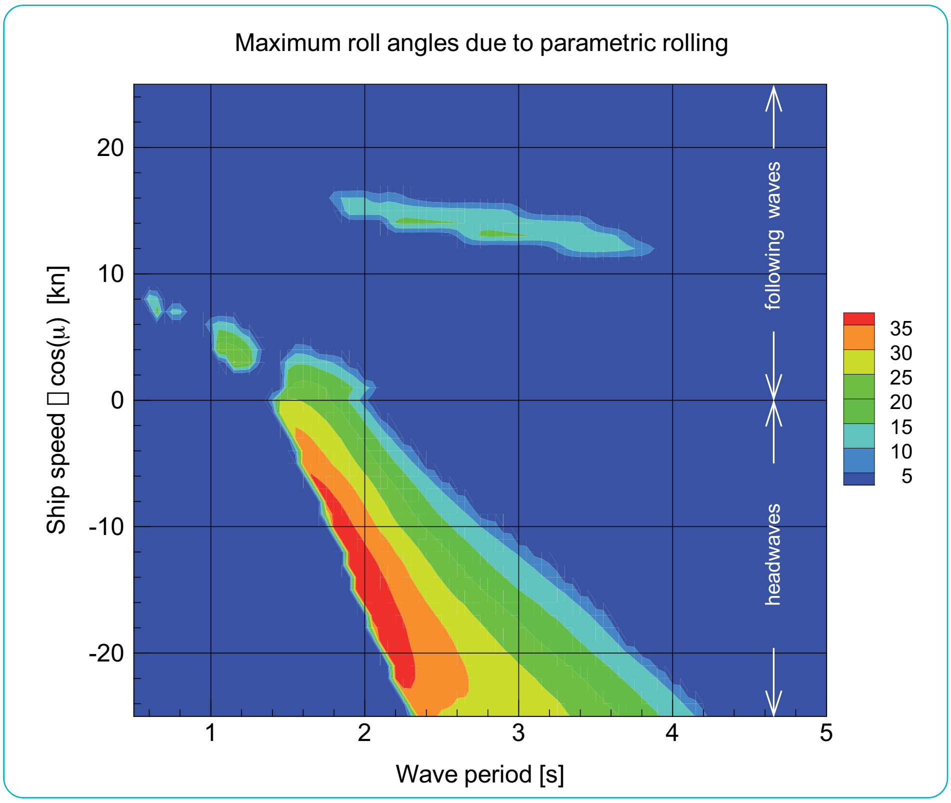


Fig. 7: Maximum roll angles in following waves (positive speed) and in head waves (negative speed) for 10 metres wave height and different wave periods.

In other cases it helps to detect parametric rolling where it was not expected. Figure 8 shows the maximum roll angles obtained in irregular head seas for a vessel with a significant stern flare, where parametric rolling occurred. The computations were carried out for several peak periods. A total of 10 sea state realizations each with 30 minutes of duration were performed to underline the random nature of the sea state and thus of the responses. The results of these computations were compared to the maximum roll angles measured during model tests of 30 minutes (full scale) duration. The comparison in Figure 8 shows the accuracy of ROLLSS and the random nature of the irregular sea state. Exposing the vessel to sea states of longer duration leads to higher maximum roll angles, both in the model test as well as in the numerical simulation.

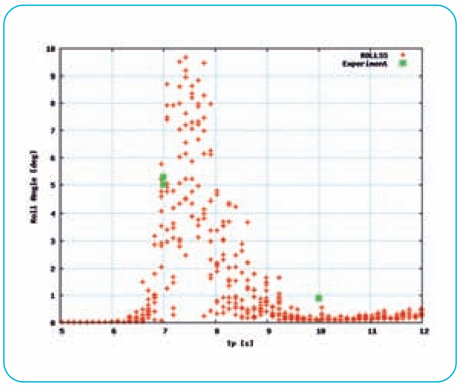


Fig. 8: Comparison of the results from model tests (green) and ROLLSS computations (red) for parametric rolling in irregular head seas.

It is further possible to generate a large database of roll angles to be expected at different sea states for several loading conditions to generate an operational guidance with clear diagrams to inform the master of the ship's abilities and limits to run in rough sea conditions.

The three examples show that HSVA's experimental and numerical seakeeping tools are improving to be up to date and to allow more than standard investigation of ships and offshore structures. Also special problems and phenomena can be investigated with the test facilities and numerical methods. The new facility extension, the technique of transient wave packets and the numerical tools help to analyze and improve the seakeeping performance of ships and offshore structures for the benefit of HSVA customers.

Fotographs by Marc Asmussen and HSVA

Member of staff

Grete Ernst joined the CFD department of HSVA in November 2008 where she has been involved in different CFD related research projects. Since July 2011 she is member of the project management team of HSVA's resistance and propulsion department. In her position as project manager she is in charge of performing and evaluating model tests for customers from Europe as well as Asia. She will be the contact person for customers currently managed by Mrs. Jutta Zerbst who is going into retirement by the end of this year.

Grete Ernst studied Naval Architecture and Ocean Engineering at Technical University of Berlin and University of Newcastle upon Tyne. In 2008 her diploma thesis has been rewarded with the WHC Nicholas Prize by the Royal Institution of Naval Architects.

Grete Ernst takes much pleasure in offshore sailing – her numerous long distance sailing trips took her along most parts of the European cost, across the Atlantic Ocean and even as far as the Pacific Ocean. None the less she enjoys strolling around the headlands south of Hamburg with her horse.

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