HSVA Newswave 2013/1

THE HAMBURG SHIP MODEL BASIN NEWSLETTER

IN THIS ISSUE:

NEVA 2013

MARINTEC CHINA 2013

Dear reader,

Sincere greetings to all our clients, partners and colleagues. 2012 again was a very successful year for HSVA. The need for energy optimized ships, the need for shipping in harsh environments like the arctic kept us very busy and will, as it looks at the moment, keep us also very busy this year and in the near future. In other words: here we expect business as usual.

But 2013 is also a very special year for HSVA. We will celebrate the 100th anniversary of our foundation on September 10 this year. A milestone which we are very proud to share with you.

Any such anniversary might raise suspicions that the past will be the primary consideration. But the contrary is true: Also in year 100 we see ourselves confronted with new and future assignments. We just carry on in the tradition of conducting research and development going beyond the current state of the technology, as you may see in some of the articles in this issue of Newswave.

And all this is definitely not done purely for its own sake, instead the process is used to create the foundations for solving future questions and requirements submitted by our industry. We are proud to have earned our customers long-term confidence and trust but we also take pride in our employees who made all this happen. Without their engagement the translation of our observations, the interpretation of our results, both the experimental and the numerical ones, into and for practical applications would not have been possible. Thanks to all our customers, supporters, friends and employees for your confidence, your visions and your efforts.

We are proud of our history, but we look forward to the future with even more interest. Still being fully booked we nevertheless will do our best to accommodate all your expectations within a short time.
Besides our anniversary celebration there will be different opportunities for you to meet our team over the year. Among others we will be present at the NEVA 2013 in St. Petersburg and at the end of the year at MARINTEC 2013 in Shanghai.

Juergen Friesch - Managing Director

HSVA 100 – A Hundred Years of Research and Development for Maritime Industries

by Juergen Friesch

For a century, the private and independent Hamburg Ship Model Basin HSVA has been at the forefront of hydrodynamic research. HSVA has influenced and led developments of testing technology, methods, standardization and numerical procedures to solve many complex problems related to ships and offshore structures in open water and in ice covered waters.

In 1913, after more than 10 years of discussions the necessity of a large hydrodynamic test institute in Germany, mainly for commercial shipping was stipulated. 16 German shipyards and ship owners founded the Hamburgische Schiffbau-Versuchsanstalt GmbH, HSVA, as the world's largest facility of its kind in Hamburg-Barmbek with a substantial financial contribution from the state of Hamburg.

The large towing tank was 350 m long, had two cross sections 16 and 8 m wide, therefore two carriages with maximum speeds of 10 m/s. Model testing activities started in 1915 with resistance test for submarines of the Imperial German Navy.

After the First World War it was at least for a short time discussed, to shut the facilities down. Fortunately Dr. Kempf became director in 1922 and it was mainly his activities which helped to overcome the difficult post-war times. During his time the testing technology was improved dramatically. One example is the introduction of the self-propelled propulsion test with the motors and dynamometers installed inside the model. Until that time the propellers were driven from behind with an open water like dynamometer. In 1930 not only a high-speed tank for testing aircrafts but also a first cavitation tunnel according to the design of Lerbs was erected. This tunnel can be seen as the forerunner of all closed type cavitation tunnels that followed in the next decades.

In 1932, Dr. Kempf initiated an international conference on "Hydrodynamic Problems of Ship Propulsion", during which the cooperation with other model basins concerning the exchange of information was formulated. This idea led to regular meetings of the model basins directors which later became the International Towing Tank Conference, ITTC.

Shortly before and also during the fateful times of the Second World War HSVA was extended further. The large towing tank was lengthened up to 450 m with a carriage of 100 tons powered by 2000 hp.

The maneuvering basin was enlarged and a large cavitation tunnel with a 2.4x1.2 m^2 test section was built, but did not start operation before the war ended.

After World War II all facilities were dismantled, destroyed or transported to other countries. The very large cavitation tunnel was reassembled in England where it is still operating today.

The hard core of HSVA staff under the leadership of Dr. Kempf founded an engineering company so that they were able to work at least to a certain extent in their old fields using foreign or own small makeshift facilities. One of the jobs they made was the development of hydrodynamic test facilities and equipment. Together with Dr. Remmers, Dr. Kempf founded the company Kempf & Remmers which became a partner for most of the model basins in the world for more than 40 years.

HSVA was rebuilt in today's location a few hundred meters away from the old HSVA, in 1952. Testing started in 1953 again under the leadership of Dr. Kempf and Dr. Lerbs, and since those days, the facilities have been continuously expanded and improved:

The small towing tank was built in 1952, a small cavitation tunnel in 1954, a new and larger towing tank of 200 m length and 18 m

Fig. 1: Aerial view on today's HSVA

width started operation in 1957. In the sixties this tank was lengthened to 300 m and a second high-speed cavitation tunnel (speed up to 20 m/s) was built. Testing of ships in ice started in the late fifties with a very small tank (8 m long), followed by the first ice tank in 1972, and the computerized Planar motion Carriage CPMC in 1975 to improve the maneuvering characteristics of ships dramatically. In 1980 the request for more tests in waves resulted in the installation of a new double flap wave maker. The success of the work for ice-going ships led to the construction of an additional Ice Basin in 1985 which is still one of the largest in the world. In 1989 a very large cavitation tunnel of the new generation was erected. This tunnel allows the installation of up to 12 m long models used in the towing tank for detailed cavitation observations on the propellers in behind conditions. The latest achievement is a 40 m side wave generator which allows the investigation of ships and offshore structures in realistic seaways.

For more than 20 years numerical investigations play an ever-increasing part in HSVA's services. HSVA is not only a key player in developing software tools but uses these tools to answer many of the sophisticated questions of the customers. Our leading role in national and international research programs makes HSVA a competent partner for numerical applications in the fields of hydrodynamics and related areas.
There is no doubt that facilities are the backbone of every model basin, but who, you may wondering, are the researchers who accounted for HSVA's various and many milestones?

The early work of Kempf on the basics of ship resistance and propellers and the leading work of Lerbs on cavitation formed the basis for HSVA's reputation in ship powering. Research in Naval Architecture in Hamburg is inseparable connected with Grim and his contributions to ship theory on the one side and his very practical suggestions for improving ship performance. One example is the vane wheel. A gallery of great

Fig. 3: Professor Kempf 1938

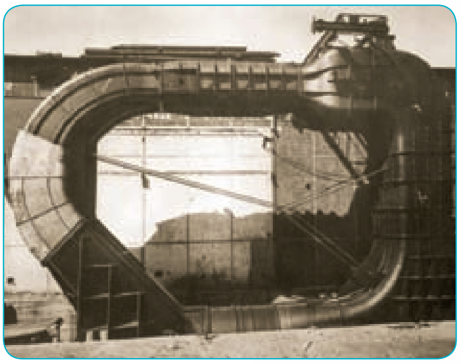


Fig. 4: The large cavitation tunnel 1943

Fig. 2: The old HSVA in 1928

Fig. 5: Model manufacturing 1925

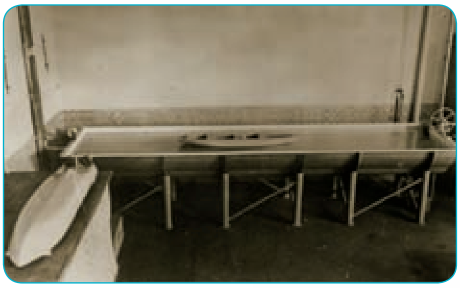


Fig. 6: The first towing tank after World War II

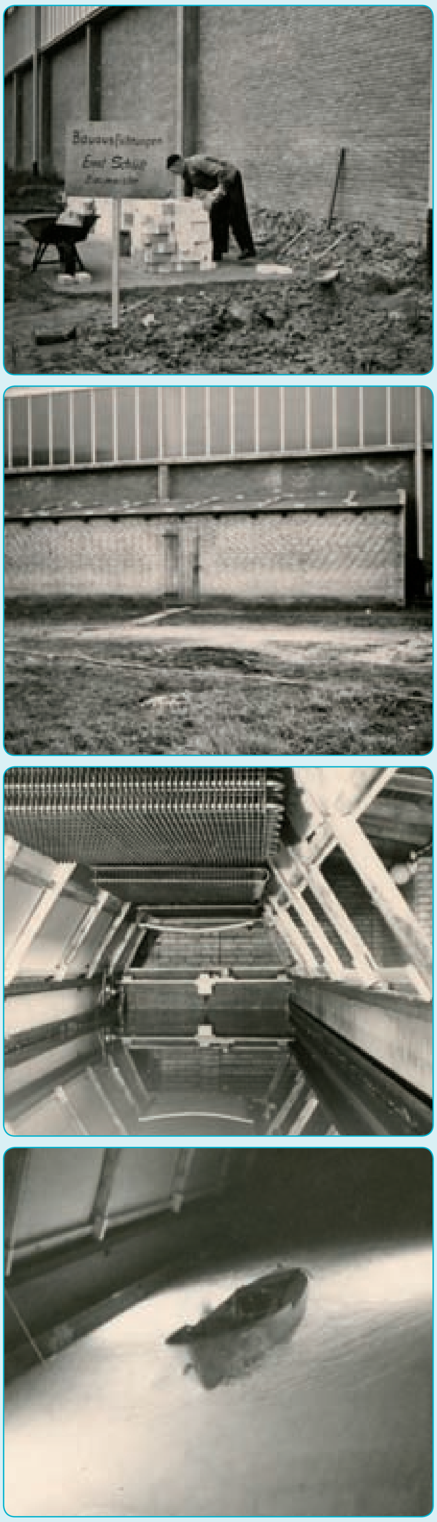


Fig. 7: The first ice tank in 1958

moments would not be complete without mentioning the work of Collatz, again related to ship propulsion. And then there are Hattendorff and Blume who spent many years on developing and fine-tuning the methods to perform seakeeping tests and their contributions to ship safety. Oltmann who set standards for maneuvering and Weitendorf's work on the cavitation phenomena and their relationship with nuclei content. Another important field is HSVA's contribution to ice related topics. Waas, Grim, Krappinger and Schwarz played an important role in these developments. Krappinger's work for the modern research vessels of Germany was honoured world-wide. And then there are those like Jensen, who spent more than 20 years developing, perfecting and fine-tuning their numerical studies and software programs so that the flow around ships and propellers can be calculated accurately.

There have been many such people in HSVA's 100 years history but behind each and every one of them stand a team of engaged, dedicated specialists without whom they could not have been successful –

THE PEOPLE OF HSVA!

HSVA has seen many downs – from being almost shut down in the 1920ties and being destroyed after World War II – but fortunately more ups – the good times for German shipyards between 1925 and 1935, the golden times of shipbuilding in the 50ies, the 70ies and between 2005 and 2008. Any such anniversary might raise suspicions that the past will be the primary consideration. But the contrary is true: Also in year 100 we see ourselves confronted by testing new and future assignments. We just carry on in the tradition of conducting research and development going beyond the current state

Fig. 9: Hydrodynamics and Cavitation Tunnel – HYKAT

of technology. And all this is definitely not done purely for its own sake, instead the process is used to create the foundations for solving future questions and requirements submitted by our industry. At the end of the nineties, HSVA changed from a company working mainly for public interest to a commercially orientated consulting company. This is marked by a continuous and rapid increase of orders from customers from foreign countries. Additionally HSVA still has a large amount of research work, partly financed by the German ministries and the EU.

We are fully convinced that testing will continue to be a necessity, although the development and use of CFD in our daily work is increasing. The strong request for our services at the moment strengthens this opinion.

Fig. 10: The state-of-the-art ice tank

Launch of a new Energy Saving Device

by Uwe Hollenbach & Hilmar Klug

Our shareholder and one of our most important German customers, Becker Marine Systems (BMS) has launched a new energy saving device: the Becker Twisted Fin®. With the introduction of this new device BMS responds to the strong demand of container ship owners for whom such a device was not available in the market until now. After two years of research, based on the experience with the Becker Mewis Duct®, the Becker Twisted Fin® has been developed, especially designed for fast, slender merchant ship types.

This new device evolved from the Becker Mewis Duct®, which has been successfully applied on numerous full block vessels like Tankers and Bulk Carriers of all sizes during the last five years. It is also installed in front of the propeller to recover losses in the wake field of a ship and to generate a pre-swirl in the inflow to the propeller to reduce rotational losses in the propeller slipstream. To minimize the additional drag at higher speeds, the nozzle ring of this new device is significantly smaller and has a special, flat profile compared to the Becker Mewis Duct®. The fins familiar from the Becker Mewis Duct® on the inside of the nozzle ring here extend outwards beyond the nozzle. The nozzle ring additionally supports the fins and insures the fatigue strength of the device.

Becker's and the ship owner's first choice for model testing for the first applications of the Becker Twisted Fin® was HSVA. Manufacturing this complex geometry in model scale and enabling a quick and reliable adjustment of different fin pitch settings during the optimization tests, separately for the fins inside and outside of the nozzle ring, was quite challenging. As has been proven during the manufacturing of numerous Becker Mewis Ducts®, the nozzle ring and the inner fins have been made from brass, while the outer fins have been made using rapid prototyping. This enabled us to exchange and test different designs of the outer fins very quickly.

Numerical viscous flow calculations performed by the Rostock based company IBMV during the design of this device predicted an average of 3% energy savings for container vessels. Model tests being carried out at HSVA in March 2012 confirmed these savings. The first full scale installation on a large Container Vessel owned and operated by Hamburg based company Hamburg Süd already entered service and within today further six sister vessels have already been fitted with a Becker Twisted Fin®.

Fig. 1: From model tests to the original sized Becker Twisted Fin®

Fig. 2: Hamburg Süd's Santa Teresa – one of the first ships equipped with the newly developed energy saving device

New Strip Method for Propeller Performance Scaling

by Heinrich Streckwall, Hanno Stöhrmann and Uwe Hollenbach

HSVA has now introduced a new strip method for scaling the propeller performance. The new method, developed within the European PREFUL project, replaces the scaling method by Lerbs/Meyne, which previously has been used at HSVA for a long time. More detailed information on the project PREFUL was presented in the former NewsWave 2012/2.

In this article we highlight the advantages of the new strip method and compare the scaling results of the new strip method with the former Lerbs/Meyne method based on the HSVA trials database.

Advantages of a Strip Method

The quality of a scaling method can be expressed by its ability to derive the behavior of the in-viscid propeller (no surface friction acting) from any Reynolds Number level. While there are reliable methods to do this for the full scale Reynolds number and for sufficiently high open water test Reynolds number, where pure turbulent flow can be expected, this is not an easy task for the much lower self-propulsion test Reynolds numbers. The mixture of laminar and turbulent flow which typically occurs at the low Reynolds numbers in the self-propulsion test, and which is determinant for the quantification of friction forces, is strongly dependent on the model propellers environment. Considering the mixed flow on the model propeller blade the strip method provides the necessary level of complexity to handle such conditions in general.

This principle is displayed in Fig. 1 showing here a coarse arrangement of strips and a color code to indicate the significance of friction on each strip. The blade sections must not necessarily follow a straight generator line. The strip method can account for extreme rake, a feature of tip raked propellers.

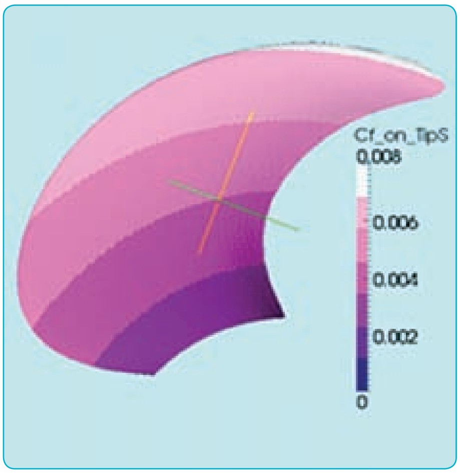


Fig. 1: Principal of strip method representing the relevance of different strips for viscous drag

A strip method is especially suitable to support the idea of two friction lines for either the open water test mode or the self-propulsion test mode, which is an important feature of the new scaling approach of HSVA.

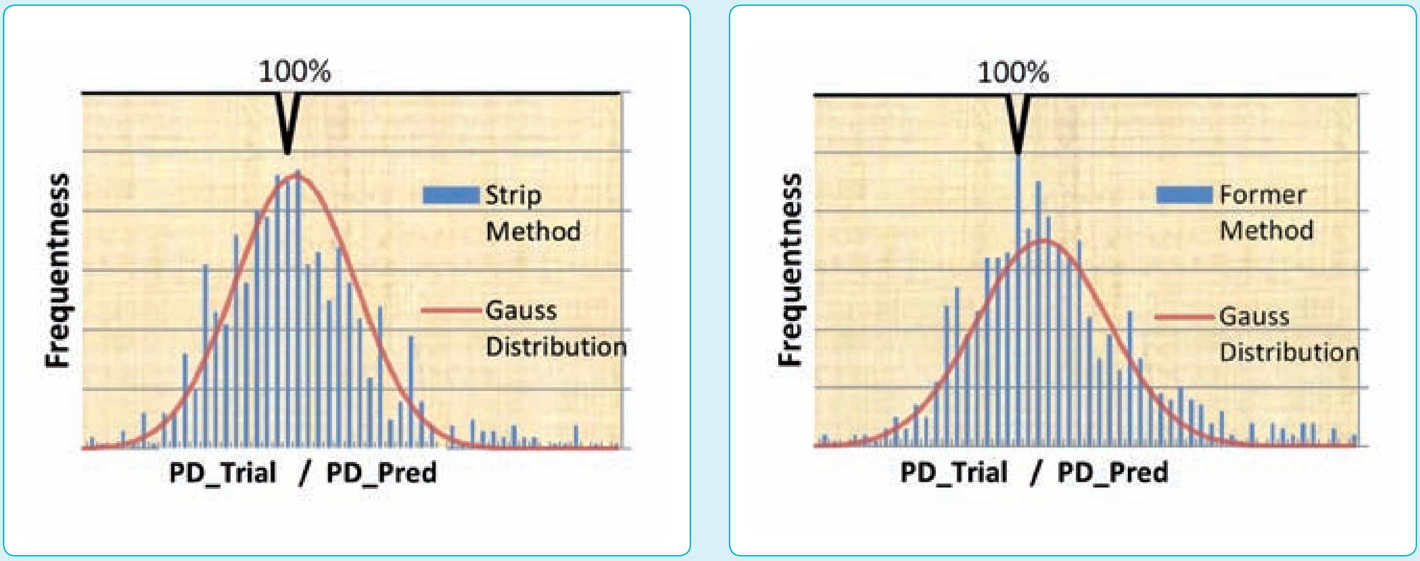


Fig. 2: Comparing Strip Method (left) and former Lerbs/Meyne method (right) indicates smaller average error for the new strip method. The hook (∇) indicates the position for a case where 100% match of predicted and measured power is achieved (PD_Trial=PD_Pred). The actual mean ratio Trial-power vs. predicted power (PD_Trial/PD_Pred) is to be taken from the maximum of the Gauss-Distribution.

Validation of the Strip Method

How did we verify the new strip method? The difficulty in judging the new scaling method is the fact that the in-viscid propeller is impossible to investigate experimentally. Paint tests have revealed the type of the flow on the propeller blades and helped identifying the flow mix on the blades at different Reynolds numbers. Reasonable reliable results of corresponding RANS calculations have been used to arrive at the in-viscid performance of the propellers investigated. Finally standard lines for local surface friction in laminar and turbulent flow as a function of the local Reynolds number have been derived, simulating the mixed flow for the strip method.

With the PREFUL project we had the opportunity to go through all these validation steps.

Application of the Strip Method

The propeller scaling is one step in the extrapolation process from model test results to full scale. Changing the methodology has forced us to investigate how this change affects the whole scaling procedure.

For all results within HSVA's sea trials database we reprocessed the former model test predictions, replacing the Lerbs/Meyne method with the new strip method, and calculated the deviation between actual full scale power derived from the trials and the predicted power according to model tests. Comparing the results of both methods we found the predictions of the new strip method resulting in a smaller average error.

Conclusion

We conclude that the new strip method improves the quality and accuracy of HSVA predictions. While the new strip method does not so much affect the predictions with fixed pitch propellers, the predictions for vessels equipped with a CPP with larger hub/diameter ratio are affected to a larger extent. The former Lerbs/Meyne method was supposed to over-predict the efficiency of CPP-type full scale propellers. Considering especially the results of vessels equipped with a CPP in our comparison the strip method indeed delivers more realistic results being in line with the feedback from trials for this type of ship.

3D-Printing at HSVA

Our new Objet Eden 350V 3D-printer helps our continuing efforts to reduce costs and production time. It produces strong and stiff plastic parts much faster and cheaper without compromising our high standards of quality, repeatability and accuracy. The printer uses a wax-like support material in addition to the solid model material. This combination aids quality and makes cleaning and preparation a lot easier. 3D printed appendages have already proven themselves suitable in a variety of tough tests at all our different testing facilities.

The shown flap rudder took less than 12 hours of unsupervised overnight printing. After another hour of cleaning the parts were ready for final assembly. This extraordinary short production time paired with a very low amount of necessary preparation gives us a lot more flexibility especially concerning last minute changes. The material costs are less than 250 € with even lower costs for man-hours.

Fig. 1: Our new EDEN 350 V 3D printer

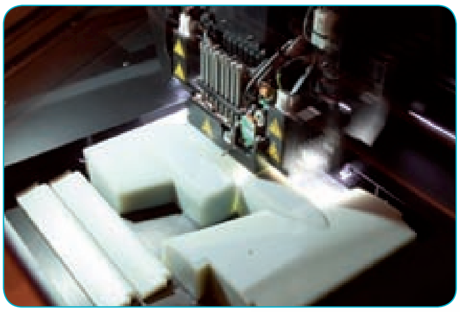


Fig. 2: Printing of flap rudders

Fig. 3: Finished rudder parts

Speed Trials at Design Draft: On the Effect of Water Sloshing in Cargo Holds

by Petri Valanto

The speed trials of the CSBC Corporation's new 8000 TEU container vessels need to be performed at both design draught and ballast draught. One way to ballast a container vessel to the desired draught is to fill ballast water into chosen cargo holds. The CSBC Corporation, Taiwan contracted HSVA to investigate the effect of water sloshing in the cargo holds on the speed-power curve, and for a good reason.

For this investigation the Cargo Holds 4, 5, and the not identical hold 6 were built into the ship model. Figure 1 shows their positions in the ship. Simplified frame lattices were arranged in the middle of each cargo hold in order to simulate the effect of the container racks on the water sloshing in the cargo holds. In order to measure the water motion, the Cargo Holds 4 and 6 were equipped with six wave gauges each, as shown in Figure 2. Figure 3 shows the ship model with the cargo holds prepared for the tests.

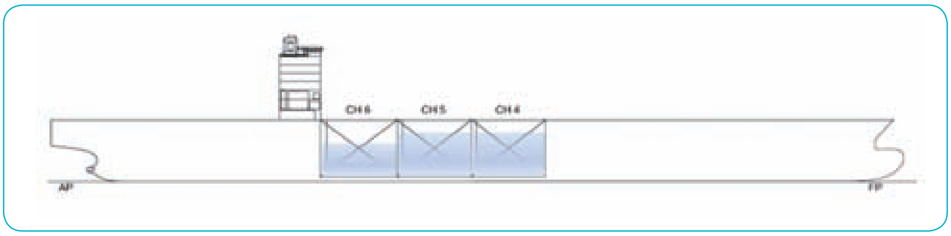


Fig. 1: Location of the Cargo Holds 4, 5 and 6 on the CV8000

Fig. 2: A transverse frame lattice modeling a container rack in the middle of the Cargo Hold 4. In the ship longitudinal direction a set of six wave gauges are shown.

HSVA carried out propulsion tests in head and following seas for two load cases:
(1) With solid ballast weights commonly used in model tests;
(2) With water ballast replacing the solid ballast weights, providing exactly the same draught and trim in both cases. An educated guess would suggest that if the surge, heave and pitch motions of the ship excite the water in the holds into a synchronous sloshing motion, this could lead to a small increase in the resistance in the second load case, as the water motion in the cargo holds and the ship motion are coupled.

The propulsion tests in irregular seas were carried out with constant propeller revolutions providing the model a predefined speed in calm water, and the average speed in seaway was recorded. As the speed differences between the two load cases, if any, were expected to be very small, the tests were carried out with exceptionally great care:
(1) In the tests each sea state was represented by a wave train reproducing the desired wave spectrum. In order to provide a reliable comparison of the two load cases, the very same wave train was used for each load case. That is, the ship model with solid ballast met the same wave sequence in the test as the ship model with water ballast.
(2) In the analysis of the recorded signals the same cut was used for the determination of the average model speed, thrust, propeller torque and revolutions in each test.
(3)The water motion in the cargo holds was recorded by wave sensors as well as observed by video.

Before the tests with water ballast the three holds were filled with water: The measured natural frequency of the sloshing motion in the holds in the ship longitudinal motion was

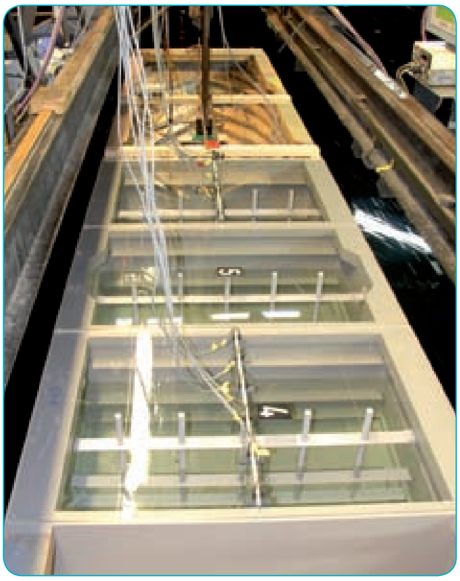


Fig. 3: The instrumented model in test

6.95 s for the Cargo Hold 4 and 7.14 s for the Cargo Hold 6.
The propulsion tests in irregular head and following seas were carried out with the model of the CV8000 at the design draught. In order to gain information for the possible "full scale trial conditions", the tests were carried out in relatively small to moderate head and following long-crested irregular seas, that is, in a light (Sea State 3), in a moderate (Sea State 4) and in a higher sea state (Sea State 5). The corresponding

on Contract Speed

significant wave heights and peak periods were 0.8 m /7.5 s, 1.88 m /8.8 s, and 3.25 m /9.7 s, respectively. Each sea state was tested at three different propeller revolutions leading to three ship speeds.

The reference power level of 78 percent MCR (90% of MCR including 15% sea margin) was used in the analysis. The predicted calm water speed of the ship with this power level is here defined as the calm water reference speed V_{REF}. Figure 4 shows an example of the predicted speed-power curves without wind.

In irregular Sea State 3 from ahead the speed loss with solid ballast in the cargo holds was mostly higher than with the water ballast. Only at speeds clearly higher than V_{REF} the speed loss with water ballast exceeded the speed loss with solid ballast. These differences are, however, relatively small. The same tendency was found in Sea State 5. In Sea State 4 the speed loss with solid ballast was higher than with water ballast over the whole speed range. Only around the reference speed V_{REF} the speed-power curves were coinciding or slightly intersecting. This means that the water ballast in the cargo holds mostly has a small positive effect on the speed in head Sea State 4 over a large speed range around the reference speed V_{REF}.

In following waves the opposite behavior was observed. A clearly increased speed loss was observed with the water ballast at all investigated sea states over the whole speed range.

The test results in Sea States 3, 4, and 5 without the effect of wind for the calm water reference speed are shown in Table 1. The values give the difference to the calm water reference speed V_{REF}. The small value [0.04] kts in square brackets is not very reliable due to interpolation in the two intersecting speed-power curves. The values $\Delta V_{WATER\text{-}SOLID}$ give the speed difference, when water is used as ballast in the cargo holds instead of solid ballast. A positive value indicates speed gain, a negative speed loss.

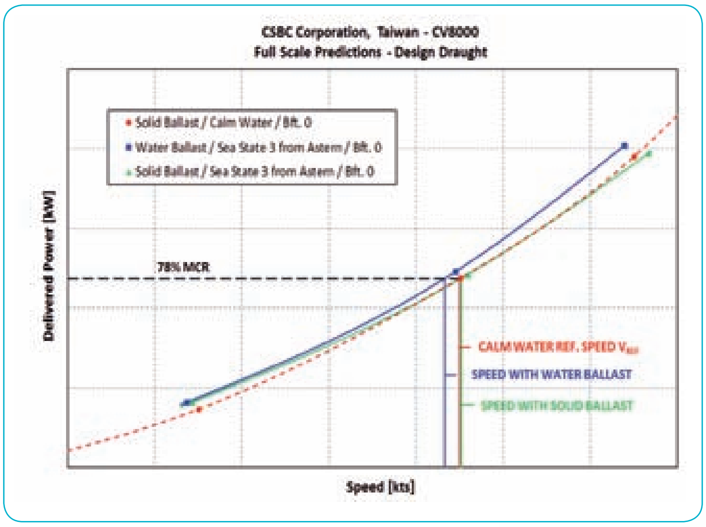


Fig. 4: Speed-power prediction for CV8000 in irregular following Sea State 3 comparing the tests with solid ballast and water ballast with the calm water results without considering wind

The consideration of the additional wind shifts the speed-power curves, but does not essentially change the relative differences between the curves in the investigated load cases. These results are shown in Table 2.

The effect of the ballast water sloshing in the Cargo Holds 4, 5 and 6 on the power performance in irregular head and following seas was investigated with two test series with solid ballast and with water ballast in the cargo holds. The test results can be summarized as follows:
No significant difference in the measured ship motion behavior could be observed between the two load cases with solid and with water ballast in the cargo holds.

The largest speed loss connected to the use of water ballast in the cargo holds instead of solid ballast was measured in following Sea State 5 with 6 Bft wind. Maximum speed loss related to the reference speed V_{REF} was 0.29 kn.

In many cases the speed loss or gain increased with ship speed. The peak encounter frequency of the ship in the tested sea states changes with the ship speed, which has an effect on the ship motions. The sloshing in the cargo holds depends on the ship motions and their frequency having a small, but not a negligible effect on the ship resistance and speed in seaway. In these tests the highest speed differences of about 0.5 kts between the cases with solid ballast and water ballast were measured at the highest speed values tested, a few knots more than V_{REF} in following seas.
In full scale trials it is common to conduct these into and against the waves; i.e., in following and head seas, respectively.

The model test results obtained with solid ballast in head and following seas show that even without wind the average value of the speeds measured in head and following seas deviates from the speed measured in calm water. Thus speed loss in head seas and speed gain in following seas were not equal. If wind is taken into account, the mentioned deviation is even larger. This is to be expected as the wind resistance of the ship is related to the relative velocity between the ship and the true wind in a non-linear manner.

In view of the use of water in the cargo holds instead of solid ballast to obtain the required draught the following aspects arise: For the CV8000 in Sea State 3 and in Sea State 5 the individual effects of the water in the holds on the ship speed are in general not negligible, but the total effect of the two trial runs into opposite directions is smaller as the effects of water in the holds to some extent cancel each other.

In Sea State 4 the total effect during both trial runs is not much smaller as the individual effects of water in the holds do not cancel each other due to the trial runs in opposite directions. In both head and following seas the sloshing effects result in speed loss and the total effect is simply the mean value of these contributions. In the tested case the average speed loss amounts to 0.15 kts with the effect of wind and 0.125 kts without, due to use of water in the holds instead of solid ballast to obtain the desired full draught.

The measured speed differences in head and following seas between the cases with solid ballast and with water ballast were quite small as expected, but not negligible. The measurements were carried out with great care and the recorded signals were scrutinized critically: Due to the very small differences in the measured speeds and due to the limited measuring time in a seaway the relative accuracy of the speed loss or gain determined is not as good as in calm water propulsion tests. However, nothing in the measured signals indicates that the measured differences could result from something else than from the water motion in the Cargo Holds 4, 5 and 6.

The results of these model tests are published with the kind permission of the CSBC Corporation, Taiwan. For the CV8000 the results provide important information for the use of water ballast in cargo holds to obtain full draught in connection with speed trials. For other ships the results give an order of magnitude of the size of possible speed gain or loss due to the use of water ballast in cargo holds.

SEA STATE /BALLAST S=SOLID, W=WATER	CALM WATER SPEED [kts]	HEAD SEAS SPEED [kts]	FOLLOWING SEAS SPEED [kts]
SS3, S.	V_{REF}	V_{REF} - 0.15	V_{REF} + 0.02
SS3, W.	V_{REF}	V_{REF} - 0.08	V_{REF} - 0.17
$\Delta V_{WATER-SOLID}$ (SS3)		+0.07	-0.19
SS4, S.	V_{REF}	V_{REF} - 0.27	V_{REF} + 0.02
SS4, W.	V_{REF}	V_{REF} - 0.31	V_{REF} - 0.19
$\Delta V_{WATER-SOLID}$ (SS4)		[-0.04]	-0.21
SS5, S.	V_{REF}	V_{REF} - 0.81	V_{REF} - 0.04
SS5, W.	V_{REF}	V_{REF} - 0.68	V_{REF} - 0.28
$\Delta V_{WATER-SOLID}$ (SS5)		+0.13	-0.24

Table 1: Measured speeds in tested sea states without wind for solid and water ballst in Cargo Holds 4, 5 and 6

SEA STATE + WIND /BALLAST S=SOLID, W=WATER	CALM WATER SPEED [kts]	HEAD SEAS SPEED [kts]	FOLLOWING SEAS SPEED [kts]
SS3 + BFT 4, S.	V_{REF}	V_{REF} - 0.65	V_{REF} + 0.32
SS3 + BFT 4, W.	V_{REF}	V_{REF} - 0.55	V_{REF} + 0.11
$\Delta V_{WATER-SOLID}$ (SS3,BFT4)		+0.10	-0.21
SS4 + BFT 5, S.	V_{REF}	V_{REF} - 1.05	V_{REF} + 0.36
SS4 + BFT 5, W.	V_{REF}	V_{REF} - 1.11	V_{REF} + 0.12
$\Delta V_{WATER-SOLID}$ (SS4,BFT5)		[-0.06]	-0.24
SS5 + BFT 6, S.	V_{REF}	V_{REF} - 2.11	V_{REF} + 0.37
SS5 + BFT 6, W.	V_{REF}	V_{REF} - 1.89	V_{REF} + 0.08
$\Delta V_{WATER-SOLID}$ (SS5,BFT6)		+0.22	-0.29

Table 2: Speeds in tested sea states with wind for solid and water ballast in Cargo Holds 4, 5 and 6

Trim Investigations for a Container Vessel by means of Viscous Flow Computations

by Peter Horn

HSVA was contracted by Schifffahrtsgesellschaft Oltmann mbH & Co. KG to perform numerical trim variation test for the slow speed range of a container ship. The series of 4250 TEU container vessels is expected to operate on a route between Asia and the Caribbean at speeds lower than what they are designed for. The task was to predict the required delivered power at different draughts for different trim angles, with the aim to define the optimal trim angle for a given draught at a desired speed.

The vessel has a length of 252.00 m and a beam of 32.25 m at a design draught of 11.00 m. The design speed is 24.5 kts, but owed to the economic situation in the past years the ships tend to operate at significantly lower speeds. Thus, the speed range to investigate was set from 12.0 kts to 20.0 kts. For this speed range no model test data is available.

As the hull and the bulbous bow are designed for a speed of 24.5 kts, it is expected that the vessel operates less efficiently when sailing at low speeds. A variation of trim seems to be a promising way for improving the vessels' performance for the new operation profile without having to apply constructional measures.

For investigating these effects, computational fluid dynamics with high accuracy have to be applied. Former projects showed that the varying immersion of the bulbous bow and the transom stern are having a major influence on the power consumption for different trim angles. Therefore, calculations have been performed with HSVA's in-house RANS solver FreSCo+ capable to resolve these effects. The calculations have been performed with free surface and dynamic trim and sinkage, adjusting the floating position according to the pitch moment and the heave force in several adaptation steps. Taking into account the dynamic trim and sinkage of the vessel is leading to more accurate results which are crucial in this particular trim investigation task.

After the adaptation of the floating position the numerical propulsion was activated. The propeller effects were simulated by a propeller panel code. With the nominal wake of the preceding computation the total wake, propeller revolutions, thrust, torque and finally the delivered power can be predicted. In view of calculation time, the numerical propulsion was conducted only for one draught-speed combination. All other combinations were performed as resistance computation. The results derived in the numerical propulsion test were used with the help of the propeller open water diagram to predict the propulsive efficiency and therefore the power consumption of the other trim conditions.

In addition to the even keel condition, three angles of trim were investigated: 1 m bow down, 1 m stern down and 2 m stern down. The trim conditions were calculated for constant displacement. The CAD model, provided by the ship owner, was set into a computational domain in model scale and was meshed for each different trim condition separately. Altogether, twelve different conditions were investigated at four different speeds each. The results

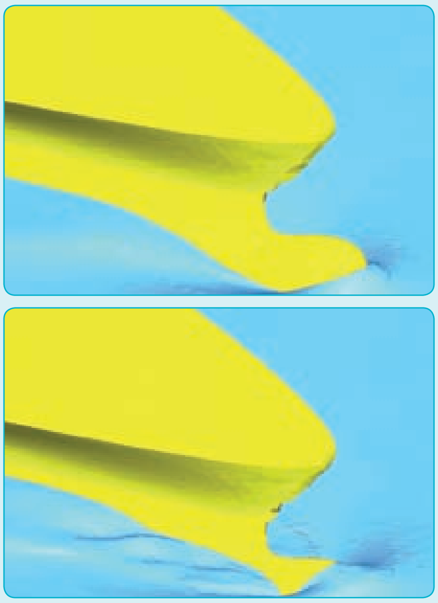


Fig. 1: Draft – Speed Condition A: good trim angle in the upper figure, poor trim in the lower figure

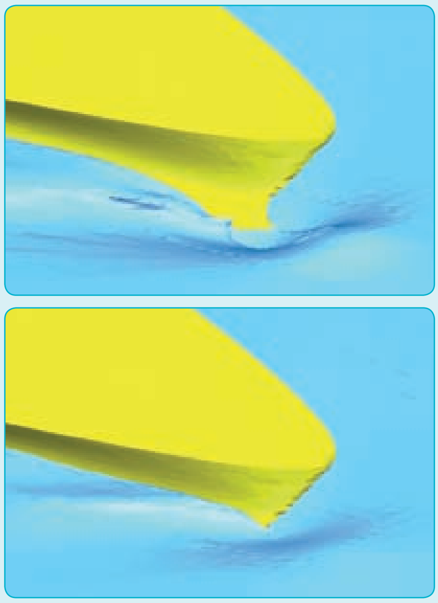


Fig. 2: Draft – Speed Condition B: poor trim angle in the upper figure, good trim in the lower figure

were converted into full scale according to HSVA's standard correlation method.

As a result of the investigation a decrease of delivered power of up to 13.3% has been predicted for one trim condition when compared to the even keel condition. But also power increments of up to 17.6% for other scenarios were detected. From this, it can be seen that trim variation can have significant influence on the power consumption of a vessel. Furthermore the investigations by means of CFD have proven to be an adequate alternative to model tests.

Within this project, an Excel tool was developed, to compute the optimal trim condition for a draught at a given speed by interpolating the results from the viscous flow calculations. This tool, displayed in figure 3, will be a helpful instrument for the crew aboard to define the optimal trim condition easily.

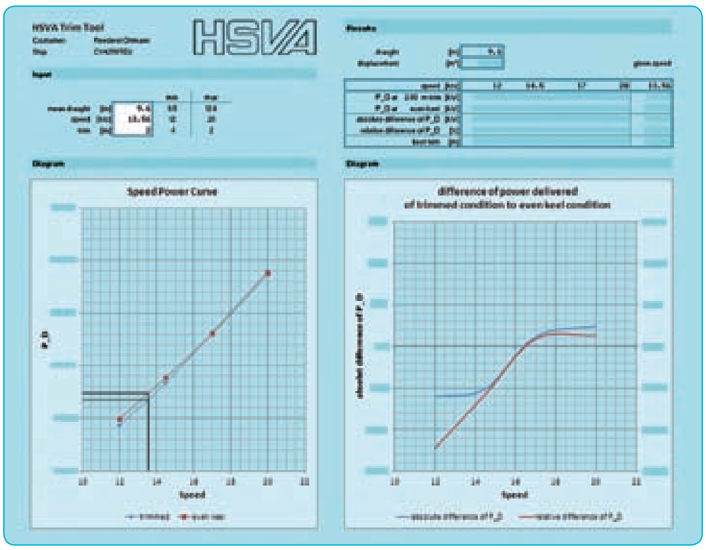
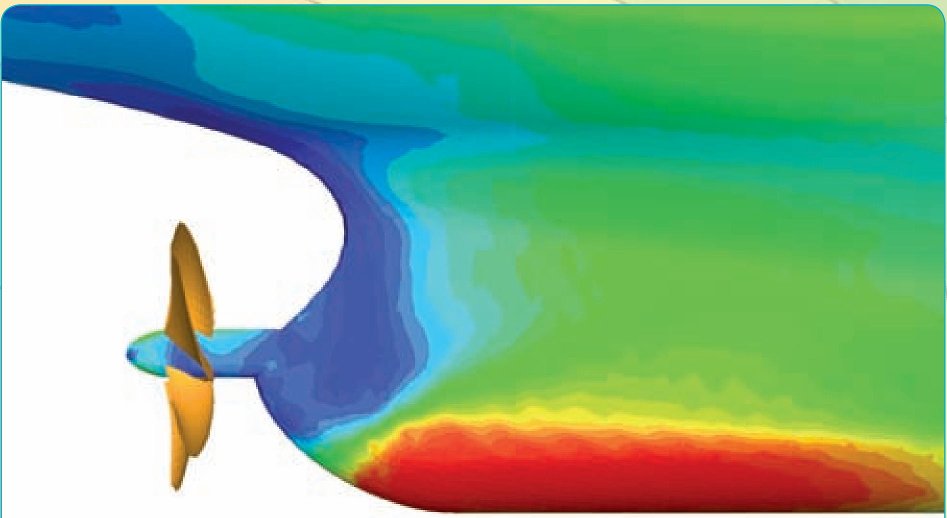


Fig. 3: Screenshot of HSVA trim tool

Form-Pro to Revive the Asymmetric Single-Screw Ship

by Jochen Marzi & Scott Gatchell

The recently accomplished Form-Pro project which was introduced already in Newswave 2011-1 ended with a "bang". As a final task in the project HSVA applied the newly developed adjoint solver – now being part of ***FreSCo+*** – to the optimisation of a bulk carrier with active propulsion. The fully automated optimisation cycle including parametric geometry definition, grid generation and RANS prediction resulted in an asymmetric aft body. This result evoked the success these hull forms initially created by Nönnecke in the 1970ies and 80ies.

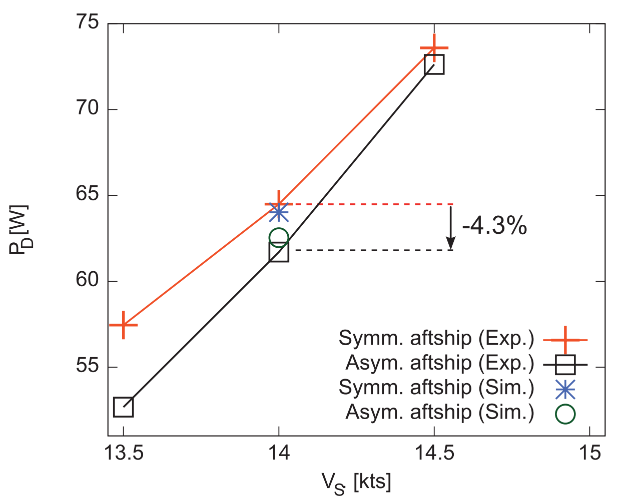


Starboard Side

Starting with the parametric form description of a baseline design, the optimisation was set up using the delivered power (P_D) as an objective function in the adjoint equation. Computations were run in "propulsion mode" using the well-established RANS-BEM coupling algorithm in ***FreSCo+***. The form modifications followed the predicted sensitivities on the hull depicted in the figure above. The result obtained after less than 20 iterations indicated a reduction of P_D for a target speed of 14 kts by more than 2.5%.

To validate the computational results, model tests were performed for the – symmetric – base line design and for the optimised asymmetric aft body in HSVA's large towing tank. The experiments confirmed the superior performance on the asymmetric hull, indicating an even greater reduction of more than 4% for the design speed.

Asymmetric hull form for towing tank test



Although the asymmetric hull form is clearly not an option for retro-fit of existing vessels, the concept – once again – indicates a clear way forward for new ship designs with improved propulsive efficiency. The main advantage of the design is the negligible penalty on resistance. Simulations as well as the experiment indicate that the total resistance of the bulk carrier was not affected by the asymmetric stern shape. This is hardly the case for "external" energy saving devices such as fins or ducts which can also be found on newly built ships to improve propulsive efficiency. The present design approach used for the bulk carrier also maintains a vertical stem contour which limits the asymmetry to frame sections inside the hull only. This is expected to further ease the production of such vessels.

The Form-Pro project was conducted with the support of the German Federal Ministry of Economics and Technology (BMWi).

Calculation of Travelling Time and Exhaust Gas Emission for different Ships on

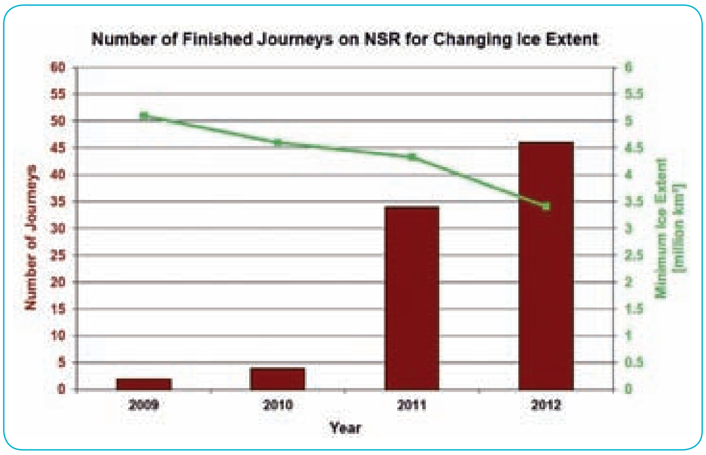


Fig. 1: Number of finished journeys

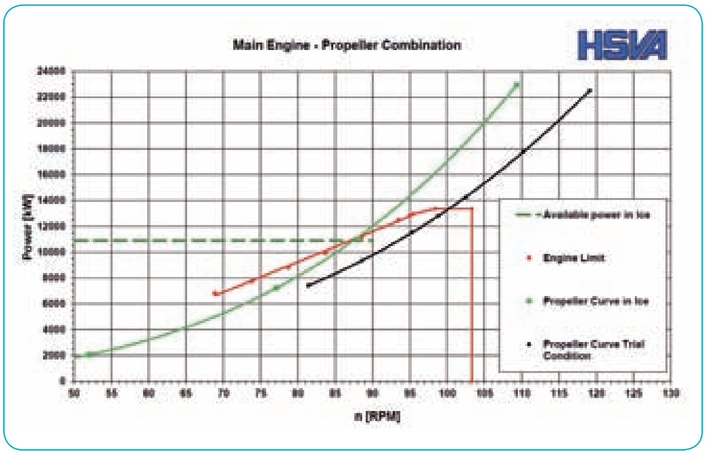


Fig. 2: Main engine propeller combination

by Nils Reimer & Quang-Tan Duong

Due to the significant decrease of ice extent in the Arctic within the summer and autumn periods, in recent years the number of transit journeys on The Northern Sea Route (NSR) has increased rapidly (see Figure 1). Thereby the profitability of transit on NSR depends on factors like the required travelling time, operational costs and attainable freight rates. In order to predict the profitability reliable, simulation tools are required which are able to predict factors with high cost impact based on early available input data. The input quantities which are known in an early planning stage are thereby restricted. Additionally the operation along the NSR will be restricted by navigational rules and guidelines including emission reduction regulations which might contradict to a minimum required engine output needed for a profitable average speed.

Recently HSVA has enhanced an existing travelling simulation program for ice covered waters by including a module for calculation of fuel consumption and exhaust gas emission within a master thesis [1]. The travelling simulation is based on resistance prediction methods for different ice conditions. The methods are based on theoretic approaches and have been adapted using model test results. The program is able to include the actual propulsion arrangement and maximum engine output to interpolate the maximum attainable speed in ice.

For the new fuel consumption and exhaust gas module the behaviour of the actual propulsion arrangement is of major concern as the fuel consumption will be directly related to the power consumption and thereby to the operation profile of the ship.

A distinction is made between diesel electric and diesel mechanic propulsion with fixed pitch propeller (FPP). For diesel mechanic arrangements with FPP the available power delivered to the propeller will be restricted for ice conditions in which the ship speed is reduced but high thrust is required at the same time. A diesel electric (or diesel mechanic with CPP) arrangement will provide its power for heavy running propeller conditions with only small losses.

The available power will determine the maximum attainable speed of the ship and at the same time influence the fuel consumption and exhaust gas emission per time. In order to assess the total amount of exhaust emissions for one passage both, operation profile and the total required travel time need to be determined.

For a first simulation four different route options along the NSR were investigated (see Figure 2, Table 1) The route options differed in their course either close to the Russian coastline or north of Novaya Zemlya (NZ) and Novosibirskiye Island (NI) and were therefore covered by different ice formations. The simulations are based on ice conditions of the year 2007.

Track	Route no.	distance
south NZ south NI	1	3017.76 nm
south NZ north NI	2	2976.94 nm
north NZ south NI	3	2842.60 nm
north NZ north NI	4	2801.78 nm

Table 1: Route options along NSR

For all routes a bulk carrier (ice class IA) with diesel mechanic and a panmax sized tanker (ice class IAS) with diesel electric propulsion were investigated. The routes were divided into legs of a certain distance while the end-points of each leg were adjusted according to the change of ice conditions.

the Northern Sea Route

The results included the resistance and attainable speed in each leg as well as the engine output which the fuel consumption was related to by the load depending nominal specific fuel consumption and an operational margin. The exhaust gas emissions are included by constant factors shown in Table 2.

Emission Factors	g/kg fuel	g/kWh	%
CO	7.4	1.30	0.015
NO_X	78.0	13.65	0.157
SO_X	54.0	12.90	0.109
HC	1.42	0.25	0.003
PM	5.3	0.93	0.011
CO_2	3206.0	561.05	6.467

Table 2: Emission factors for a low speed diesel engine

The results of the simulation show that the travelling time in freezing period (November) is roughly twice the required sailing time in September (see Figure 4).

Further it can be read that for the Bulk Carrier with a conventional diesel propulsion the fuel consumption is higher in November compared to September for all route options while for the diesel electric driven tanker the fuel consumption is the same or even less in November (Figure 5). Comapring the different propulsion arrangements it can be seen that even if the travelling time for the Bulk Carrier is much higher especially in November the fuel consumption is lower due to the mentioned restriction of available power. This leads to a lower total amount of consumed fuel and related emissions in moderate ice conditions. As an example the total amount of NO_X emission is presented in Figure 6.

Assuming that the ship will use its individual, maximum power in different ice conditions there might be periods with reduced fuel consumption for ships with conventional diesel mechanic propulsion and fixed pitch propeller. Ships with diesel electric or diesel mechanic and CPP arrangement will always use their full power to reduce their sailing time. If the fuel consumption per day exceeds a certain threshold the total amount of emission impact for one journey will be higher than for low speed operation in moderate ice. Therefore the impact of ship emissions for a whole season might show strong variation.
The first investigation focused on the impact of ship and engine operation profile related to varying ice conditions and is therefore based on rather simple approaches for the fuel consumption and exhaust gas emissions.

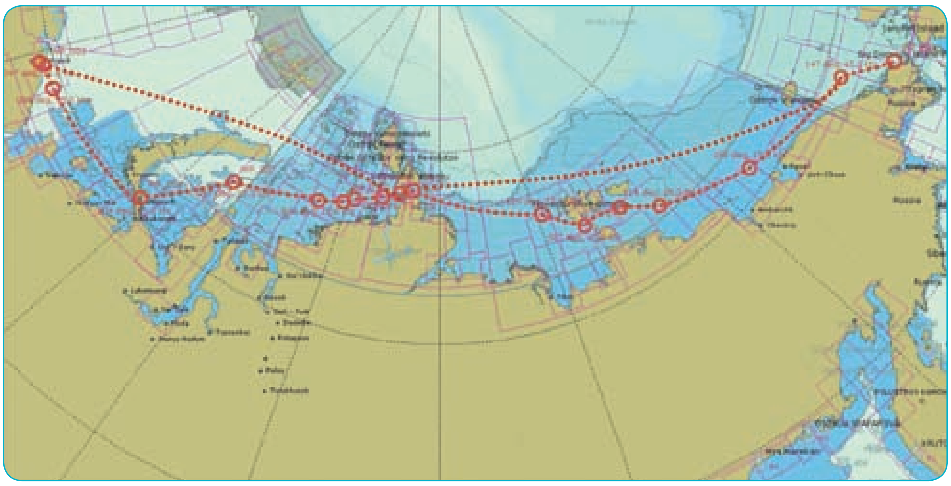


Fig. 3: Total amount of NO_X

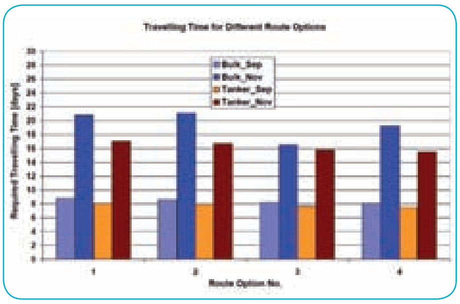


Fig. 4: Traveling time

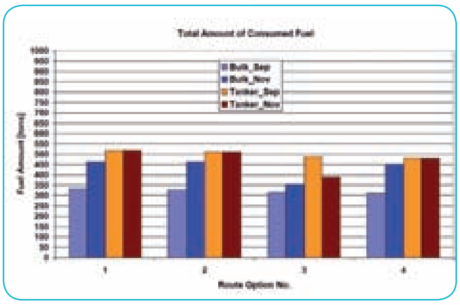


Fig. 5: Total amount of fuel

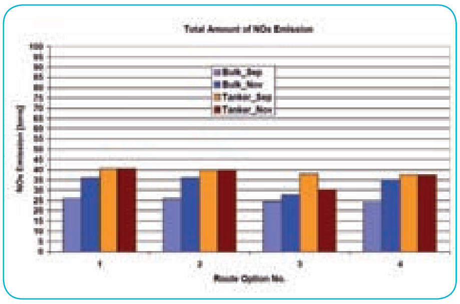


Fig. 6: Total amount of NO_X

In order to enhance the accuracy of simulation it is planned to include effects like low ambient temperature and detailed behaviour of the actual engine propeller combination like the efficiency loss of non design pitch conditions for CPP.

References:
[1] Duong, Q.T.: Calculation of Fuel Consumption and Exhaust gas Emissions from Ships in Ice Conditions, master Thesis, EMShip, 2013

Member of Staff

Oliver Reinholz joined the Resistance and Propulsion Department of HSVA in May 2008 as a Project Manager. In this position he manages diversified commercial projects covering the planning phase, the conduction and evaluation of model tests as well as customer support and consulting.
He is mainly involved in projects related to the Cruise & Ferry, Yacht and Special Purpose Vessel sectors, with his customers coming primarily from Europe. However, Oliver Reinholz is also HSVA's contact person for clients from South America.

After getting his degree in Naval Architecture in Kiel, Oliver Reinholz worked for the Aker MTW Shipyard in Wismar (now Nordic Yards) in the hydrodynamics section of the Project Design Department.
Travelling is one of Oliver's favorite activities when time is available.
In his spare time at home he enjoys cycling, jogging and seeing friends for a good evening of live sports broadcast. Oliver lives in Kiel, a perfect place for enjoying the Baltic seaside with family and friends.

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Since last year HSVA uses CONTURA G2® for measuring and monitoring data of all manufactured pieces such as propellers, shaft bracket arms and propulsion improving devices. The machine is ideal because it has all the benefits of high-speed scanning. The VAST® scanning technology enables form inspections at maximum speed with high-quality measuring results. Process deviations are detected at an early stage, high production quality is ensured and the number of rejected parts is reduced. It is a robust machine design with ceramic guide ways in X and Z direction which provides rigidity and protection against production-related environmental influences and with air bearings on all axes for high stability at high travel speeds. It is possible to scan features in all angular positions.
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