90 YEARS
HSVA
NEWSWAVE

THE HAMBURG SHIP MODEL BASIN NEWSLETTER 2003/1

EROSION PROBLEMS ON FAST SHIPS

Today, the shipping market shows a strong industrial need for merchant ships of large size with very high efficiency combined with low levels of propeller induced noise and vibrations.

by Jürgen Friesch and Jochen Laudan

FULL SCALE MEASUREMENTS

Together with the increase in ships speed and propeller loading, this leads to an increased danger of cavitation on the propeller and more and more on the appendages like rudders, pods, and struts.

HSVA conducted several full scale observations on semi-balanced rudders, revealing quite dramatical cavitation occurrences and cavitation induced erosion damages (Fig. 1). Rudder cavitation erosion is of interest if it happens within the range of rudder angles $\alpha = \pm 5$ deg. used for course-keeping. There are different types of cavitation occurring on rudders, such as bubble, sole, gap, vortex cavitation and cavitation caused by surface irregularities. Main emphasis must be given to the area around the pintle. There the details of gap size and geometry and additionally exact workmanship are important.

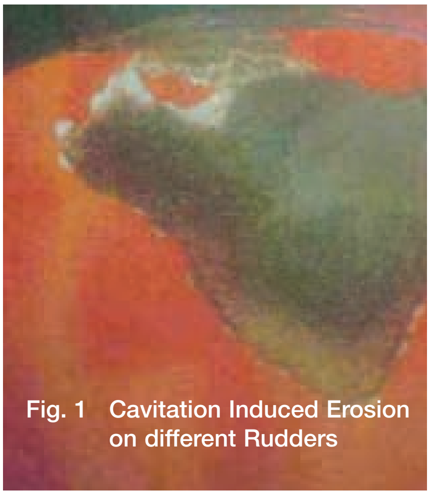


Fig. 1 Cavitation Induced Erosion on different Rudders

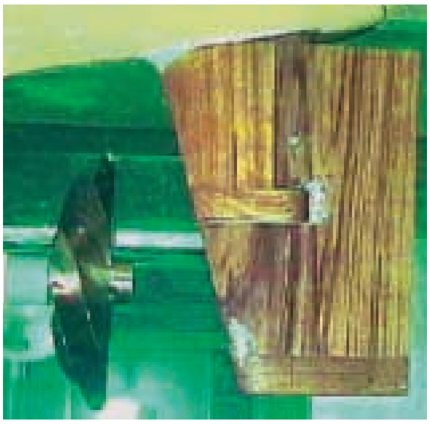


Fig. 2 Rudder Cavitation Test in HYKAT

MODEL TESTS

Can model tests help in a very early design stage? Yes they can, especially when they are performed in an adequate test facilty and with the specific aim to predict that types of cavitation occurrences. Rudder cavitation is not only influenced by the geometry of the rudder but also by the inflow to the rudder and the propeller cavitation. Therefore tests in the three-dimensional inflow, behind the whole ship model which gives the full propeller hull interaction are necessary to get a clear view of the cavitation behaviour (Fig. 2).

If the danger of cavitation induced erosion is large for specific areas like the pintle, additional tests in a smaller tunnel with even higher Reynolds-numbers are recommended.

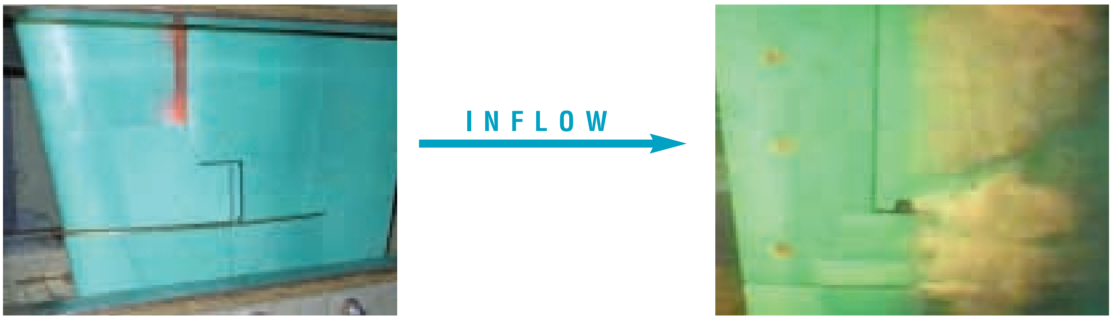


Fig. 3 Partial Rudders in the Test Section of HSVAs Large Cavitation Tunnel

For the case mentioned above, therefore a partial large rudder model was tested in HSVAs Large Cavitation tunnel. The tests could prove that there are mainly two critical areas, where cavitation occurs, the gaps between the moveable part and the fixed part and the areas downstream of the maximum thickness of the rudder sections. Partially, complicated interactions between the flow through the gaps and the cavitation phenomena were observed.

One solutions to improve the cavitation behavior was to keep the cavitation, which cannot be avoided, away from the rudder surface in order to avoid erosion damages at those parts, which are sensitive with respect to strength. To achieve this, use was made of wedge-shaped spoilers (Fig.3). Additionally the final rudder exhibits the following modifications (compared to the original rudder):

- width of horizontal gaps and lower vertical gap reduced in order to obstruct flow through gaps;
- spoiler at the lower end of the upper vertical gap (upstream of medium horizontal gap);
- spoiler on the lower pintle, in order to direct cloud cavitation away from the rudder surface;
- horizontal plate below the lower horizontal gap, extending downstream of the lower vertical gap.

The modified rudders are in use on two ships now for half a year and diver reports showed large improvements concerning the observed erosion damages.

NUMERICAL INVESTIGATIONS

Even before model tests CFD calculations can be used to check the cavitation behavior of different rudder designs. With simple potential theoretical techniques, pressure distributions can be determined for the rudder profiles. Fig. 4 shows the pressure distributions for two different profile geometries. The shown thickening – which is often used because of strength considerations –

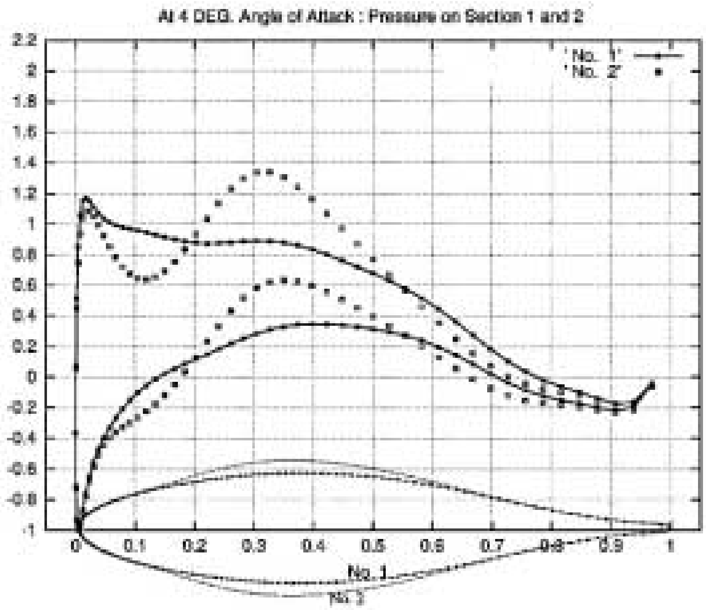


Fig. 4

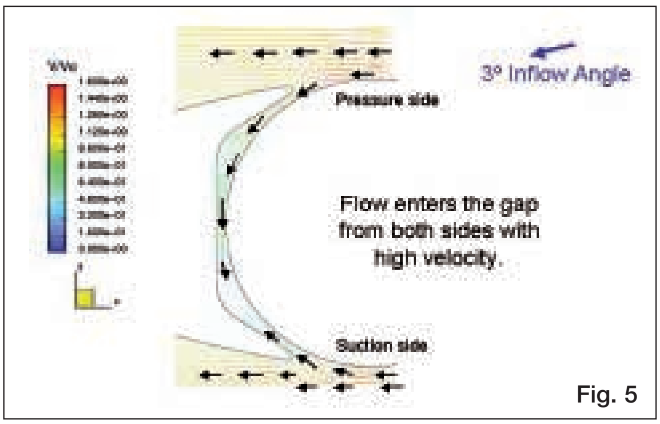


Fig. 5

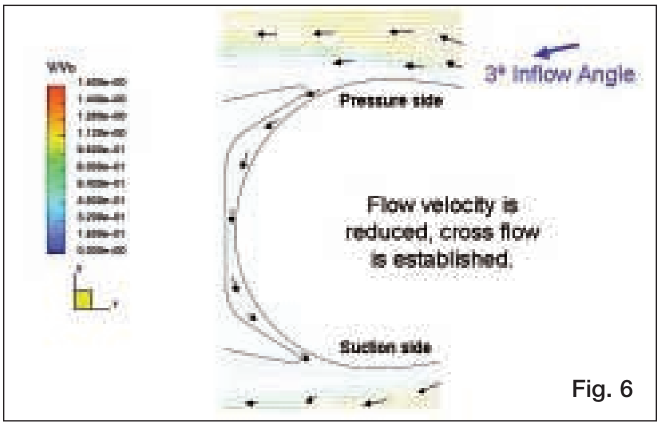


Fig. 6

leads to significant low pressure drops in the region of the pintle bearing. And this is just the most critical area of the rudder as shown above (Fig. 3). Additionally three-dimensional viscous flow calculations revealed a rather complicated flow behavior in this region (Fig. 5). The water is sucked in, comparable to the behavior of a scoop, into the gap between rudder horn and rudder blade. By a change of the geometry in front of the gap, the quantity of water passing through the gap could be reduced (Fig. 6), resulting in an improved pressure distribution and therefore less cavitation danger (Fig.7).

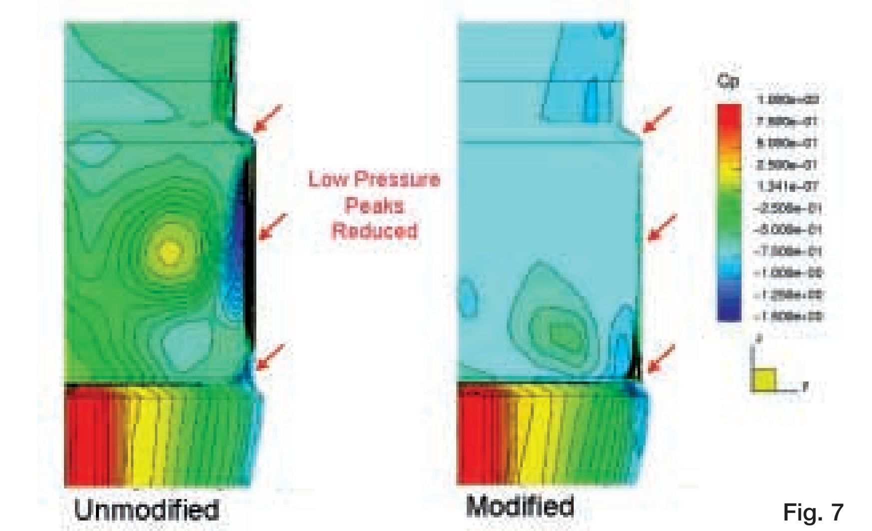


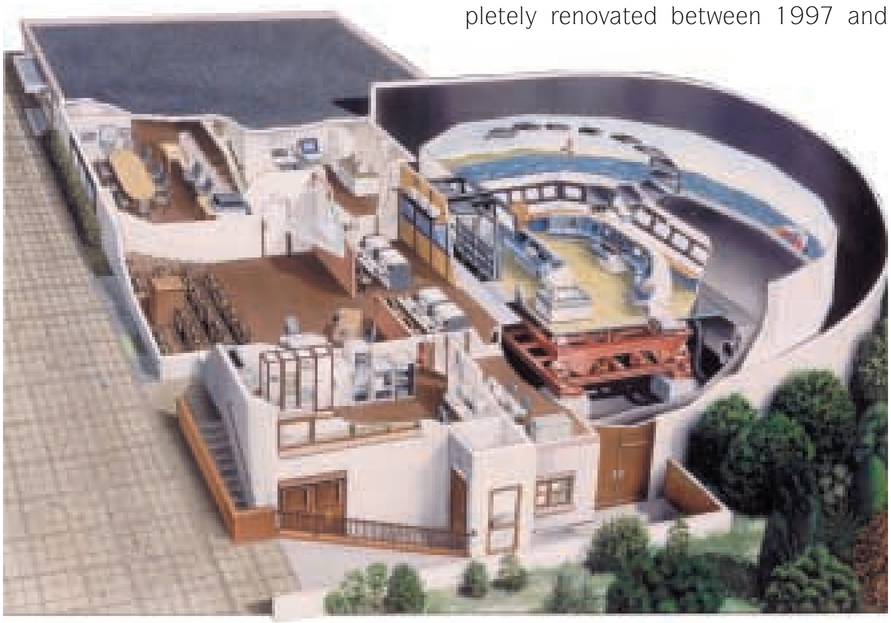
Fig. 7

HSVA AND SUSAN COOPERATING

by Dietrich Wittekind

Increasing needs for complex solution from single sources lead to a co-operation between HSVA and SUSAN (Schiffsführungs- und Simulationsanlage = Ship Handling and Simulation Facility).

The partners are now in a position to offer combined simulation projects based on model tests and CFD together with real time simulation and training. This keeps costs down for tailor-made mathematical models and at the same time allows for extraordinary conditions e.g. asymmetric ships or channel bottom profiles.



SUSAN is a real-time “full mission” simulator, operated by the Hamburg University of Applied Sciences and one of the most modern and effective facilities of its kind in the world. The simulator was installed in 1982 and completely renovated between 1997 and 1999. The constant updating of hardware and software means clients’ needs can always be catered for.

The main features include the basic simulator (STN-Atlas ANS 4000), advanced navigating components, a hydraulic motion bridge, 360° visual scenery, a radar simulator, a VTS simulator and several control and monitoring consoles. With the aid of available software tools, the system’s extensive database can be updated and changed without external assistance and hence immediately meet clients' demands.

The simulation software allows 4 different simulations to run parallel, thereby gaining maximum efficiency from the whole facility by allowing for a wide range of scenarios from multi-ship simulation to Vessel Traffic Service and Search and Rescue Operations.

For more information see
http://issus.susan.fh-hamburg.de
or contact **Wittekind@hsva.de**
or **froese@issus.susan.fh-hamburg.de**

FURTHER DEVELOPMENTS IN POD PROPULSION

by John Richards

Pod propulsion has received much attention in technical publications in the last few years. Numerous pod propelled ships are now in service, and further vessels are under construction.

Scale model testing has played an important role in the hydrodynamic development of pod drives from the very beginning. In the process, model test and evaluation procedures for pod drives have been developed and refined to the point where standard procedures are available for all pod types on the market today. The suitability of the methods is being confirmed by full scale performance data currently being acquired and analyzed.

Now a new type of drive called the Rim-Driven Permanent Magnet Motor Propulsor Pod (RDP) was developed by General Dynamics Electric Boat (EB) of Groton, CT, USA, (numerous patents and patents pending). This drive is more compact, and has several features that differ significantly from other pods available today. The motor of conventional drives is encased within a pod (hence the name) on the same shaft as the propeller(s). The concept of the RDP is completely different: It basically consists of a propeller rotating within a nozzle which has an integrated downstream stator. The rotor shaft and bearing system is supported in the stator hub. The electric motor rotor is integrated onto the hydrodynamic rotor rim and the entire motor is embedded in the nozzle (thus the name 'Rim Drive'). The nozzle is attached via struts to the slewing bearing in the hull (Fig.1).

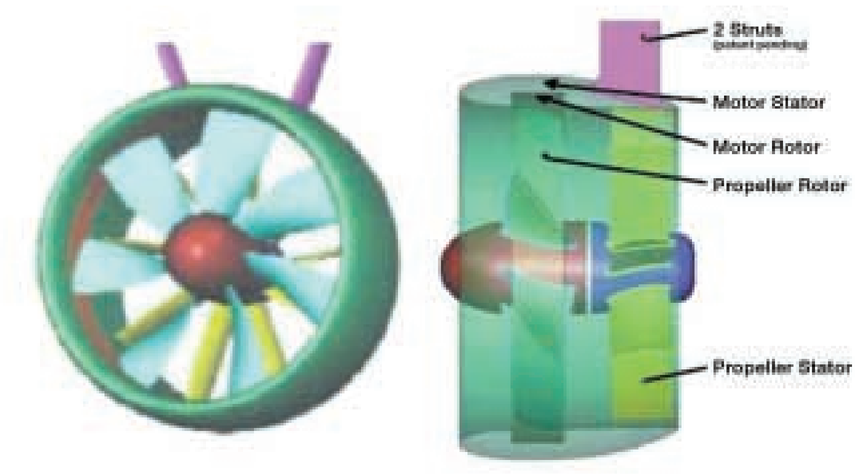


Fig. 1 Rim-Driven Permanent Magnet Motor Propulsor Pod (RDP)

In the spring of 2001 HSVA was contacted by EB regarding the performance of scale model tests for this new RDP drive. Testing was performed in conjunction with Deltamarin of Helsinki, Finland as a consultant, and the hydrodynamic agent for EB was the Applied Research Lab of Pennsylvania State University.

The test scope included open water, propulsion, cavitation breakdown and hull pressure fluctuation testing for the purpose of hydrodynamic design verification for the RDP. Procedures for the required tests were developed in close cooperation with the customer.

The design and manufacture of the RDP model (Fig. 2) was certainly a challenge due to the unique design of the drive. The standard test equipment and procedures available could not be directly employed. This meant that a new propulsion test method and in particular a reliable test evaluation procedure had to be developed (Fig. 3 - 5).

The model of a Panamax cruise vessel was used as a platform for the propulsion testing. In these tests the model was outfitted with a RDP on the port side and a conventional pod on the starboard side. In general the test and evaluation techniques developed here can be applied whenever a direct com-

Fig. 2 Scale model RDP

parison of two different propulsor types on the same hull model is desired.

All phases of the project were carried out in close cooperation with the customer and the excellent communication was the key to making the project a success. The results confirmed that the RDP design goals were met or exceeded in all areas. Several aspects of the project have been presented, in both technical papers and presentations, at the SNAME annual meeting in Boston, MA, USA in September, 2002:

References:

1. Scale Model Testing of a Commercial Rim-Driven Propulsor Pod,
   Michelle Lea, Dr. Donald Thompson, Bill Van Blarcom, Jon Eaton, Jürgen Friesch and John Richards
2. The Commercial Rim-Driven Permanent Magnet Motor Propulsor Pod,
   Bill Van Blarcom, Juha Hanhinen and Friedrich Mewis

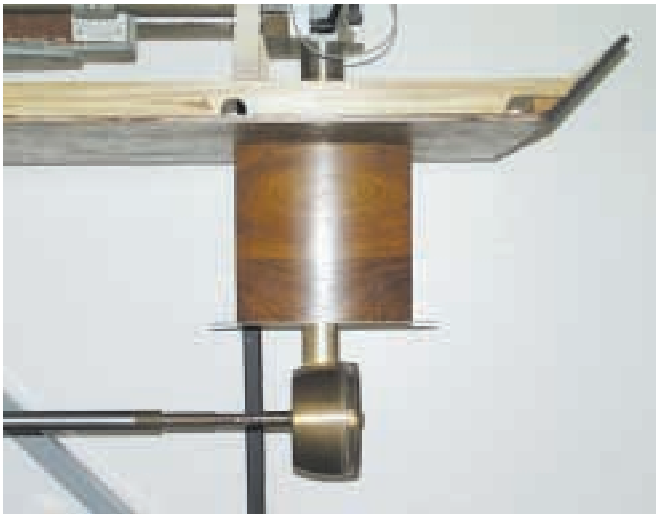


Fig. 3
Open water test setup

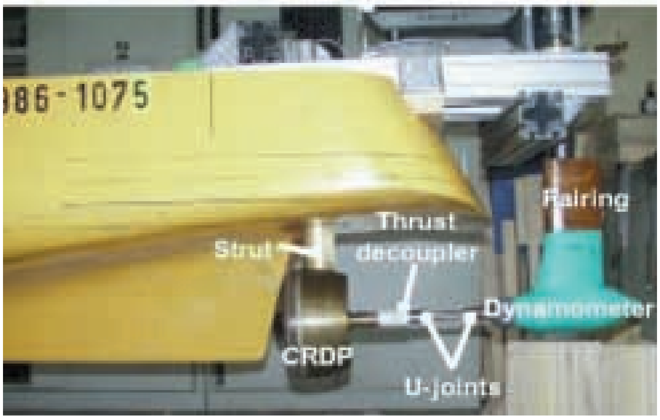


Fig. 4
Self-propulsion test setup

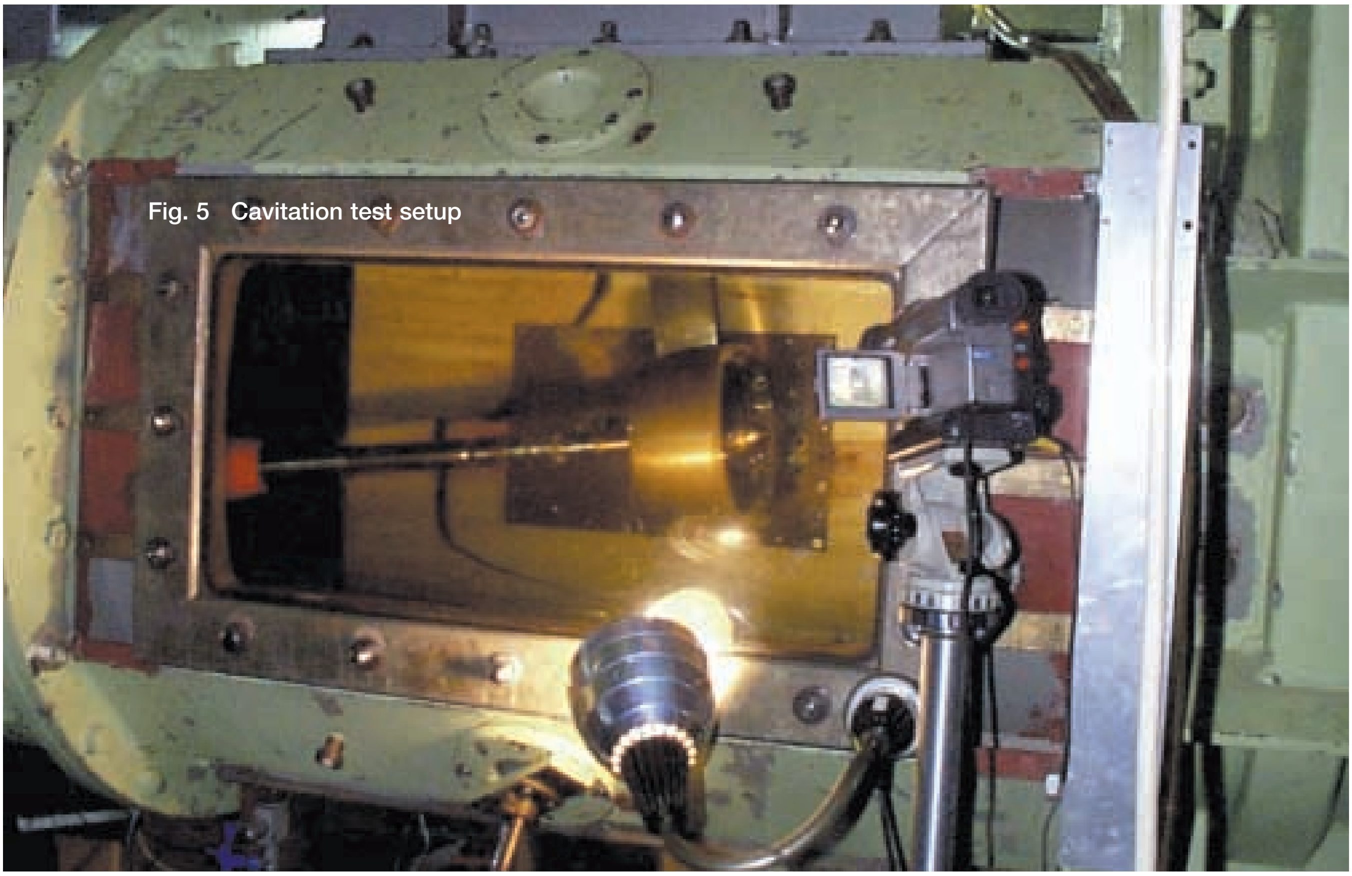


Fig. 5 Cavitation test setup

Investigation of a Sumitomo Integrated Lammeren Duct

by Christian Johannsen

On behalf of Sumitomo Heavy Industries, Japan, extensive model tests are in progress at HSVA for a PanMax Tanker.

Beside the usual optimization of the hull lines, the power saving effect of a so called Sumitomo Integrated Lammeren Duct (SILD) is under special consideration. The SILD is a circular flow accelerating duct as shown in Fig. 1. Its diameter is about 70 % of the propeller diameter and it is mounted non-centric in front of the propeller. Comparative propulsion tests carried out in the towing tank

Fig. 1 SILD-Arrangement

showed power savings due to the duct between 5.6 % and 9.1 % depending on draught and ship speed.

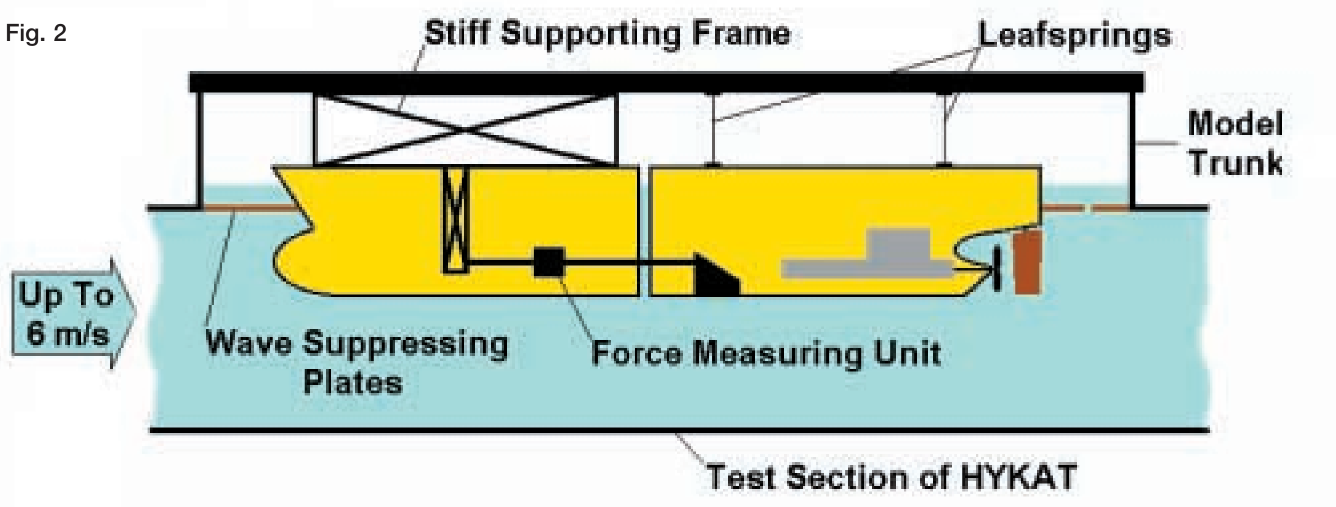
The reliability of those comparative model tests, however, suffers from the small Reynolds number, which results in an exaggeration of viscosity effects, especially around the duct. To get deeper insight in the hydrodynamic working mechanism of the duct, Sumitomo decided to order comparative propulsion tests with and without duct at different Reynolds numbers. These tests will be carried out in HYKAT, HSVA's large Hydrodynamics and Cavitation Tunnel using a special test procedure, developed some years ago for the investigation of a so called Schneekluth duct within the European E3 tanker development.

Basically the installation is the same as for cavitation tests routinely carried out with the complete ship model in HYKAT. The model is installed in a model trunk above the test section in a way that only its underwater body penetrates into the test section. The free surface is replaced by wooden plates suppressing the wave system and this way allowing the violation of Froudes scaling law, i.e. allowing the performance of the test at high tunnel water speeds, resulting in high Reynolds numbers.

Fig. 2 gives a schematic view of the special test set-up for comparative propulsion tests. The ship model is separated by a bulkhead. While its forebody is fixed in the tunnel by a very stiff supporting frame, the afterbody is held by leafsprings, allowing good flexibility in the ships longitudinal direction. The axial movement is avoided by a force measuring unit only, which is located between two abutments attached to the supporting frame and to the afterbody respectively. Of course it is impossible to gain a complete propulsion prediction from those model tests without a free surface. The wave resistance is falsified by the wave suppressing plates and the frictional resistance is falsified by the increased but still too small Reynolds number. Nevertheless, the big advantage of this test procedure is that the difference in the propulsion behavior due to the installation of the SILD (or whatever device is in the focus) can be determined at much higher Reynolds number than in the towing tank.

Sumitomo Heavy Industries has realized within their project that these tests are a very reasonable addition to the conventional towing tank propulsion tests.

Fig. 2



SDC SUBSIDIARY OF HSVA

HSVA has acquired the majority of *SDC* Ship Design & Consult GmbH. The company headed by managing director Dr.-Ing. Harald Jensen is located on HSVA's premises.

Dr. Harald Jensen, managing director of *SDC* and Dr. Dietrich Wittekind, managing director of HSVA with the second out of a series of three very successful 700 TEU container ships currently in service between Hamburg and Canary Islands.

SDC offers the whole range of hydrostatic calculations according to all relevant damage and intact stability regulations and ship design from the first concepts to complete basic design for a wide variety of ship types. SDC serves shipyards, other consultancies as well as ship owners.

In design SDC integrates all aspects as machinery, outfit, stability etc. from the very first concept to the full set of classification drawings with a small group of specialists.

In many projects HSVA's and SDC's specialists co-operate closely resulting in optimised vessels with highly competitive life cycle costs and a large degree of operation flexibility.

For further information see **www.shipdesign.de**
or contact **Jensen@shipdesign.de** and **Wittekind@hsva.de**

SDC's 700 TEU type in HSVA's Large Towing Tank

EXTENDED TEST CAPABILITIES IN THE ICE TANK

by Walter Kühnlein

A new transverse carriage was installed as a subcarriage to the main ice tank carriage (10 m wide).

Both carriages together make it now possible to run offshore structures or floating vessels in a combined and computer-controlled x-y-motion (planar motion) through the ice sheet. The new device gives HSVA the opportunity to simulate, for instance, ice drift scenarios with slow or rapid ice drift direction changes, whereby the model ice sheet is kept stationary.

The new transverse carriage has a maximum static load capacity of 5000 N in any horizontal direction and a load capacity of nearly 10000 N in vertical direction. The horizontal load can be applied on a vertical lever of up to 1.2 m length. A maximum driving force of about 3000 N is applied to the transverse carriage for speeds from 0.002 m/s to 0.5 m/s.

Model Tests in Ice for a Tanker Loading Unit

by Jens-Holger Hellmann

Immense recoverable oil and gas reserves have been assessed in the geological province 1322 North Sakhalin Basin. The oil and gas deposits are situated onshore and offshore of Sakhalin Island in the southern part of the Sea of Okhotsk.

At present there are three major development projects in the north-eastern sector of the Sakhalin shelf. One of these is the Sakhalin–2 project covering the Lunskoye deposit (gas and condensate) and the Piltun-Astokhskoye deposit (oil and associated gas), shown in Fig. 1. The concession of the Sakhalin-2 oil and gas fields is held by Sakhalin Energy Investment Company Ltd (SEIC). SEIC is an international consortium established in 1994. The interests of SEIC are presently held by Royal Dutch/Shell (55%), Mitsui (25%) and Mitsubishi (20%).

Targeting a year-round oil production from the Astokh portion of the Piltun-Astokhskoye field in 2005, SEIC plans to transport the crude oil via pipeline to the south of Sakhalin, where the oil will be loaded into conventional general trading tankers for the transport to the final destination. For this purpose, SEIC intends to deploy a Tanker Loading Unit (TLU) in Aniva Bay about 5 km offshore, in a water depth of about 28 m. The planned TLU will be a single column tower design with a rotating head and loading arm. For the loading process the tanker will be moored at the TLU by a hawser and loaded via a loading hose being suspended from the loading arm.

Aniva Bay is ice-covered for a two to three month period each winter i.e., the TLU and the moored tanker will be exposed to drifting ice. Thin sea ice grows in Aniva Bay, while medium and thick sea ice occasionally drifts into the bay from the south-east side of Sakhalin Island under the influence of winds and currents. It is planned that icebreakers will be employed for ice management duties during the time in which the tanker is connected to the TLU.

In order to investigate for which ice condition the loading operation can be safely performed, a comprehensive ice model test programme was carried out at HSVA's ice model basin on behalf of SEIC.

The main objective of these tests was to determine hawser loads and vessel motions on a 110,000 dwt tanker moored to the TLU in a variety of moving pack ice conditions. Particular

Fig. 1 Sakhalin – 2 Project
Gas and oil fields, pipelines and terminals

interest was focussed on the behaviour of the loading system in the case of ice drift direction changes. Hawser loads, tanker motions, as well as hose and hawser behaviour were investigated for different ice drift, thickness and ice management scenarios.

The behaviour of the tanker loading system was investigated in ice varying from 0.4m to 1.0m in thickness. Ridges with very thin consolidated layers and keel depths of 4m and 8m were also modelled.

Three different ice drift situations were simulated as part of the model test series. They included:

- Unidirectional ice drift cases, representing “straight line” ice movement trajectories,
- Slow change of drift direction cases, representing different curvatures in the ice movement trajectory
- Rapid change of direction cases, representing stationary ice that begins to move at various directions relative to the tanker

Various combinations of the foregoing ice thickness, ice drift and ice management parameters were included in the model test matrix in order to span a wide range of possible ice scenarios.

According to common model test practice the ice drift was simulated in the model basin by moving the TLU and tanker through the stationary ice cover. Thus, for modelling slow ice drift the towing carriage in the ice basin was supplemented by a sub-carriage for the transverse motion (for details please read the separate article in the present News Wave issue), from which the TLU model was suspended (see Fig. 2). In order to realistically model the hawser i.e., with respect to mass distribution and stiffness, a composite model hawser was prepared. An existing tanker model (lent by the Chinese Shipbuilding Corporation (CSBC)) was used for the tests.

The horizontal motions of the tanker and the TLU loading arm were recorded on a video system and subsequently analysed using a video tracking program (see Fig. 3).

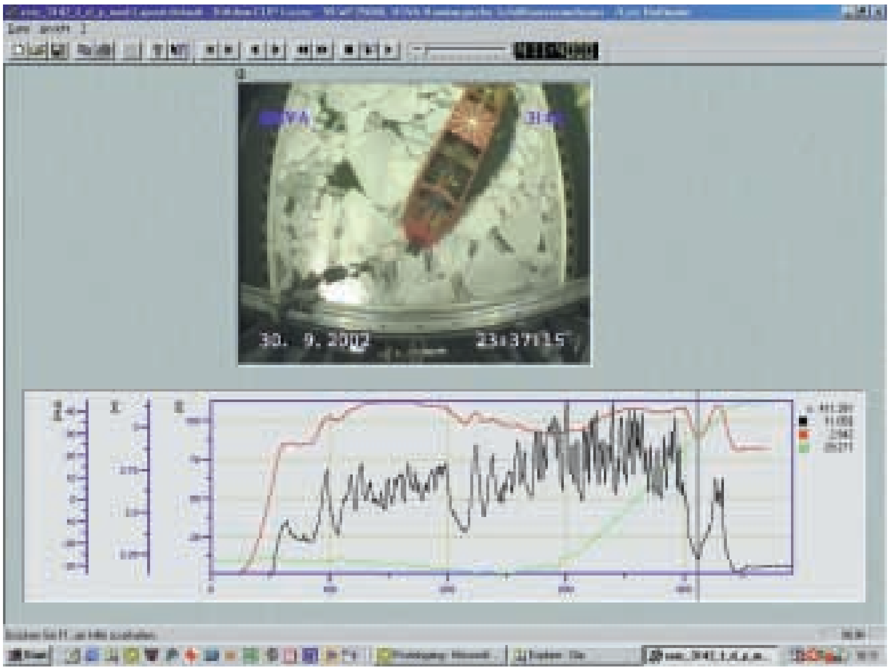


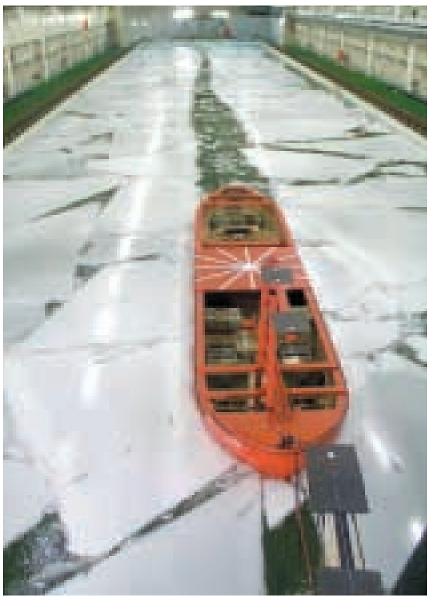
Fig. 3 Slow drift direction change – managed ice

The tests have shown that for ice below a certain thickness, the probability of peak load levels exceeding the safe working load of the proposed hawser is extremely low. Thus, for ice below this thickness, the tanker loading process is viewed as feasible, provided that the oncoming ice is broken up into fairly small floe fragments by an icebreaking support vessel (see Fig. 4).

In an ideal sense, the proposed tanker mooring arrangement at the TLU would be capable of handling unmanaged level ice of this thickness, in unidirectional ice drift situations. However, in reality, there will always be small ridges in unbroken level ice. These features could result in hawser load levels far in excess of acceptable limits, and could “come on” very quickly. Although ice drift changes in level unbroken ice around the TLU and tanker were not the subject of the present investigation, it is clear that the SWL of the hawser will be exceeded in these scenarios. On the other hand, there is practically no risk of overloading the hawser, when slow or rapid ice drift direction changes are experienced in well-broken ice that has been sufficiently managed, particularly with ice clearance assistance from a support icebreaker(s).

Fig. 2 Straight ice drift – level ice

Fig. 4 Straight ice drift – managed ice



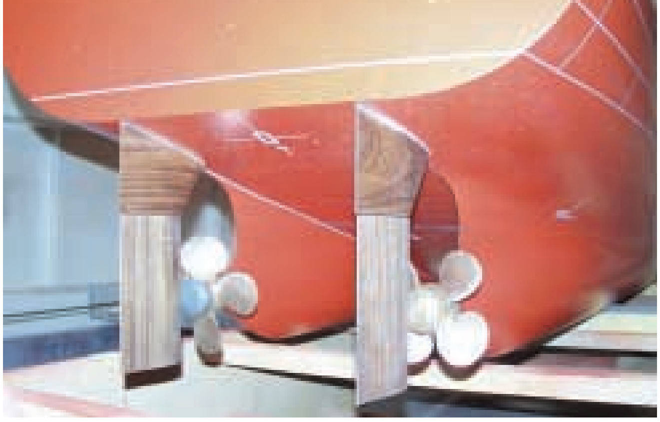


Fig.1 Stern of the wooden model

Fig. 2 SCOT 8000 “Wappen von Hamburg” ready for service (SCOT Safety Chemical Oil Tanker, 8000 DWT)

Redundant Propulsion

by Karl-Heinz Rupp

One part of improving the safety of ships is to improve technical redundancy.

The German Lloyd for example, defined an added notation to the character of classification. This technical redundancy is defined in three levels. For the first level (RP 1) the ship requires redundancy for the ship propulsion system, and for the RP 2 level additional redundancy for the steering of the ship is necessary.

The highest level in safety is the RP 3 notation which requires redundant systems for ship propulsion and for steering. Each redundant system must be separated mechanically and electrically and installed in separate compartments and have to be independent from each other.

An additional index, e.g. 50% denotes which percentage of the main propulsion power of the ship is provided by redundant propulsion. The vessel with RP must be able to sail at least 7 knots under headwind Bft 5 conditions with a significant wave height of 2.8 m. At Bft 8 with 5.4 m height significant waves the vessel must be able to manoeuvre into a position of less resistance against the weather and must maintain this position with the redundant systems.

HSVA was asked to develop the lines and to carry out model tests for a RP 3 50% vessel from the German shipyard Lindenau GmbH Schiffswerft & Maschinenfabrik. The shipyard evaluated the developed lines in a global design context (production, economics).

In order to fulfill the demand of RP3 50%, a full aftbody with two engines relatively far aft motivated a twin-skeg design, Fig. 1. The skegs were developed to accommodate the completely separated engine rooms. Generally, twin-skeg ships feature higher resistance due to the larger wetted surface. This can be compensated in good designs by an increased propulsive efficiency.

The ship hull designs were first investigated and improved using extensive CFD analyses, before model tests in HSVA's large towing tank and ice tank commenced (see News Wave 2002/2 “Hull Form Optimization”).

Fig. 1 shows the aft body of this hull development in model scale and Fig. 2 in full scale.

The tests in calm open water showed that the developed hull shape has the lowest power consumption in comparison to similar twin and single screw vessels investigated at HSVA (Fig. 3). Furthermore, good water flow on the hull between the skegs and a relatively homogeneous wake field leads to an extraordinary silent vessel. Redundancy propulsion tests in seaway showed that the model was able to fulfil the RP 50% requirements of the classification society Germanischer Lloyd, and shows a pleasant behavior in seaway. Furthermore, the manoeuvring performance was good. SCOT 8000 more than fulfils IMO recommendations regarding yaw checking and course keeping ability.

The trial of the first of 6 vessels confirms the above statements.

The SCOT 8000 project is an example where HSVA has supported the yard and the shipping company with design services and a comprehensive model test program to develop an excellent vessel.

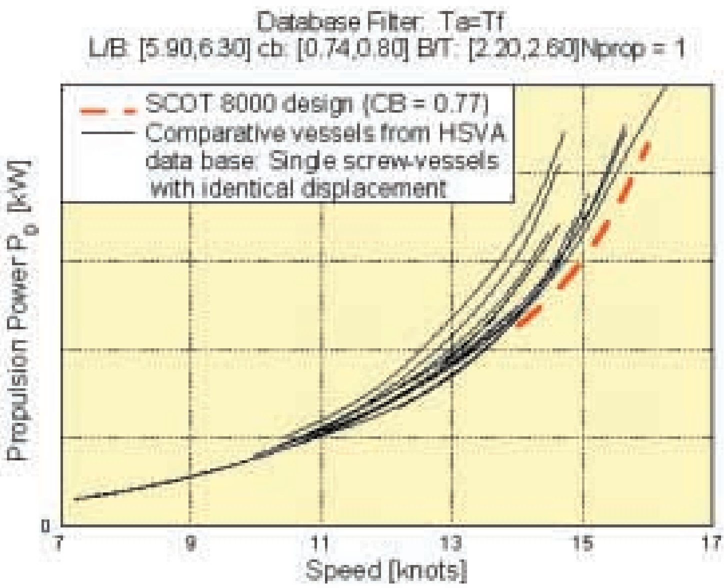


Fig. 3 Comparison of SCOT 8000 with single screw vessels of identical displacement

Predecessor Olga

GOING FISHING

by Hilmar Klug

HSVA was contracted by Diamante Fishing Company, a Peruvian operator of 18 fishing vessels, to optimise the hull lines design for a new 450 m³ fishing vessel for fishing anchovy in the Pacific Ocean.

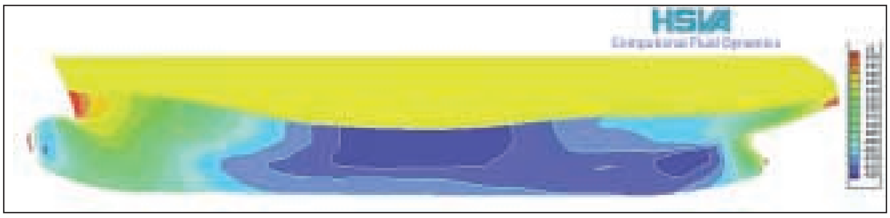
During the fishing period the fishermen leave the harbour early in the morning and sail to the fishing grounds. Upon arrival, the shoals of fish are sought using modern sonar equipment. When a shoal of more than about 200 t of fish is found, the purse net is brought out with the assistance of a small tender. Closing the purse traps the fish and the anchovies are taken onboard. After filling the holds with fish a fast journey back to the coast is essential to achieve a high price for the first and freshest fish on the market.

Following this operation profile it is clear that the new fishing vessel should be optimised for a high speed at both empty and full load draughts. This optimisation was performed prior to model tests using HSVA's potential flow CFD-code ν-SHALLO. Furthermore, the old rudder design was replaced by a modern one featuring a HSVA high lift profile in order to assure good manoeuvring capabilities during trawling.

The results of the CFD-calculations indicated a reduction of the resistance by abt. 5% in relation to the initial hull form. This was mainly gained by the optimised bow and stern bulbs.

The model test program included resistance and self-propulsion tests at two draughts, a 3-dimensional wake survey, a paint flow test as well as trawl pull tests at four speeds including VS = 0 kts (bollard pull condition). Based on the test results further but minor modifications of the hull form were proposed.

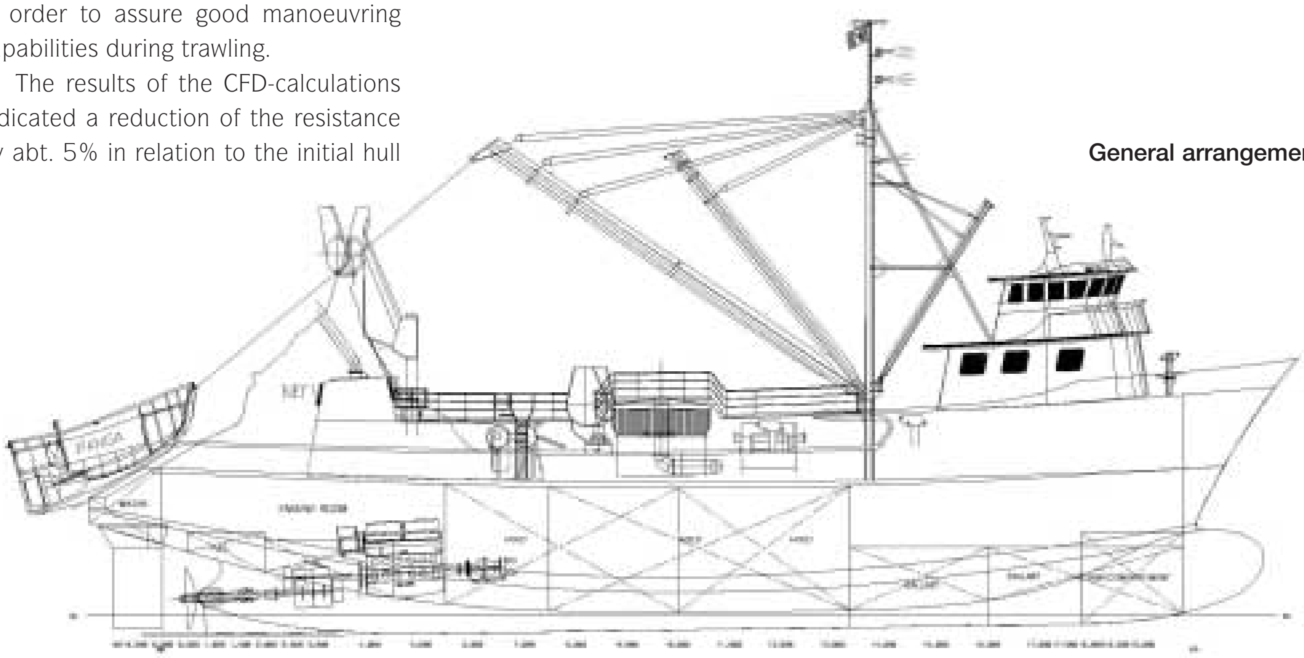
The test results are very satisfying and it is likely that the new vessels will be the fastest in the fleet of Diamante Fishing once they enter service.



Pressure distribution on optimised hull surface (T = 2.8 m; VS = 14 kts; Fn = 0.38)

Sailing to the fishing grounds (Tm = 2.8 m; VS = 14 kts; Fn = 0.38)

General arrangement



HSVA will be carrying out another

SEMINAR FOR SHIP OWNERS AND OPERATORS

on May 8, 2003

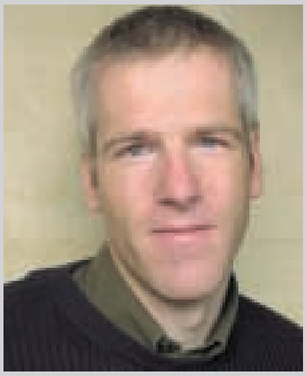
This seminar will be focussed on economic ship operations from the technical point of view, and will include numerous aspects such as propellers and cavitation performance, sea keeping behaviour, manoeuvring and performance in ice.

Technical Presentations:

"The Role of the Model Basin as an Adviser to the Ship Owner"	D. Wittekind, Managing Director, HSVA, Hamburg
"New Developments in Lines Design and Power Optimisation"	F. Mewis, HSVA, Hamburg
"The Optimum Propeller for Ship and Owner"	G. Hilbert, M. Urban, Mecklenburger Metallguss GmbH, Waren
"Cavitation Investigations for Propellers and Rudders – How to detect and cure cavitation related problems - "	J. Friesch, HSVA, Hamburg
"Ship Propulsion under Service Conditions"	K. E. Brink, HSVA, Hamburg
"Maneuverability Predictions"	A. Cura-Hochbaum, M. Vogt, HSVA, Hamburg
"Economic Solutions for Ice related Transportation Problems"	W. Kühnlein, J.-H. Hellmann, HSVA, Hamburg

For further information please contact **mewis@hsva.de**

MEMBER OF STAFF



KAY-ENNO BRINK

Dipl.-Ing. Kay-Enno Brink has recently been awarded as Deputy Head of the Seakeeping and Manoeuvring, Ice & Environmental Technology Department.

Kay-Enno Brink received his diploma in Naval Architecture in 1997 from the Hamburg University of Technology (TUHH). From 1997 until 1999 he worked as a project engineer at a German boat yard.

In 1999 he joined HSVA as a project manager within the Seakeeping and Manoeuvring Department. Until 2001 he worked very closely with Dr. Blume, a world wide recognized authority in the field of seakeeping related topics and safety of vessels in seas.

Since 2001 Kay-Enno Brink is responsible for the performance of seakeeping model tests and related calculations and also for the conception and realisation of special custom-built model tests. Furthermore he is also active in the field of sea trial measurements and analysis.

Kay-Enno Brink has published several articles, among others, about safety of vessels and innovative model testing. In his spare time he is active as a measurer of sailing yachts. He also gives lectures at the Hamburg University of Technology about this topic and enjoys dinghy sailing.

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