issue 2-19

HSVA newswave

The Hamburg Ship Model Basin Newsletter

The perfect crush

An approach to improve model ice

Full Scale Correlation @ Sea

Rearch Project "HYKOPS"

Lifting Spirits by Testing a Depressor

editorial

Dear reader,

Recently, we were able to finalise the new roof of our large towing tank. Everyone who is familiar with the dimensions of model testing facilities recognizes immediately that such projects can be considered relatively large – our roof is about 300 m long. We are very proud that we were able to finalise the project at lower cost and within a reduce timeframe than initially budgeted! Due to the improved insulation characteristics of the roof material, we are saving energy cost and improve the temperature stability in the tank which in consequence reduces the uncertainty of our test results noticeably.

Reducing uncertainty at increasing accuracy and efficiency is our daily goal to even more provide best value for money to our clients. For all our services, it is very important for us to learn, gain insights and become even better experts to serve you at our best continuously improving our level of expertise.

This issue of NewsWave is displaying our broad range of services – design, model testing, calculations and full scale investigations, the strength being the ability to verify and to validate predictions by both measured full scale and model scale data, as presented in our correlation article.

Speaking about validation, this has also been key to several projects such as HYKOPS-MOVE: Results of newly developed parts of the propeller analysis program QCM have been validated against on-board measurement data, up to the nominal wake field.

Our design services are of growing interest within the maritime industry. Together with our longstanding experience and a broad portfolio of competences under one roof as well as a huge database, we are proud to provide our customers with the best design solution tailor-made for your vessels' purpose. The service ranges from first rough estimates at a very low budget to detailed design optimisations.

Coming from the "basin wave generation" in hydrodynamic model testing, I am still very fascinated by the modelling of frozen water and its ever challenging complexity with respect to the sorts of ice nature is providing us with as well as its different effects on the structures exposed to arctic waters. As such, the research project FATICE is dealing with ice crushing scenarios in the tank.

As usually, you can meet us at the MARINTEC in China, and it would be great to see you there!

Best wishes,

Dr. Janou Hennig

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FATICE

Development of alternative model ice for ice crushing scenarios

HSVA's current model ice origins from developments in the 1990s and was designed mainly for the correct representation of flexural failure against sloping ship hulls. Results from ice model tests have been validated against full scale measurements from sea trials with ships throughout the past decades and prove good applicability. However, growing interest from the offshore industry demands for tests with different structures: monopiles, artificial islands, giant floaters, etc. Those structures often have vertical side walls, which initiate ice crushing rather than flexural failure. ►

Figure 1: Photograph of ice crushing against Norströmsgrund lighthouse (top, STRICE project) and its replication in the model basin (bottom, BRICE project)

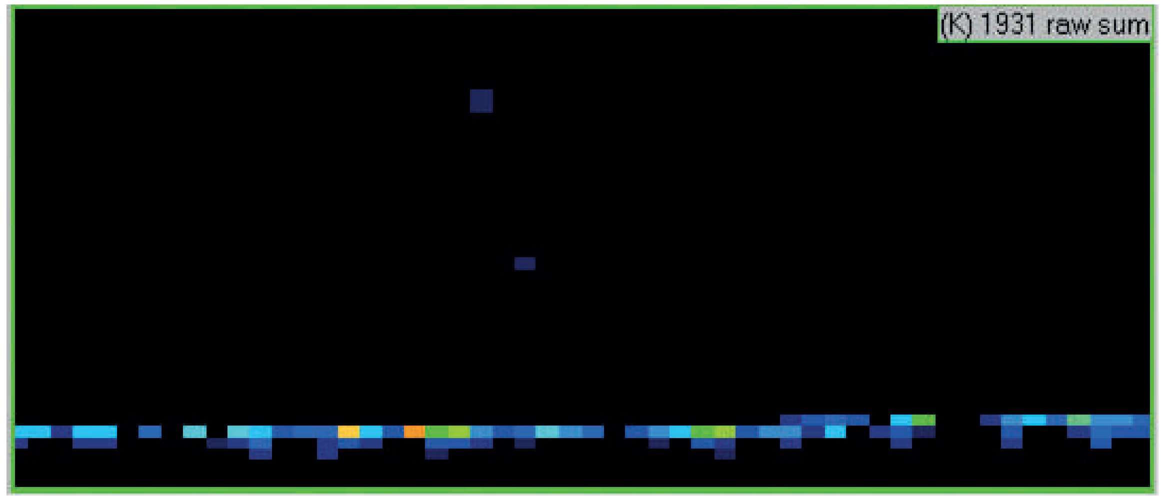

Figure 2: Snapshot from tactile sensor measurement showing the local ice pressure over the whole ice-structure interaction area for a cylinder with 200 mm diameter in current model ice

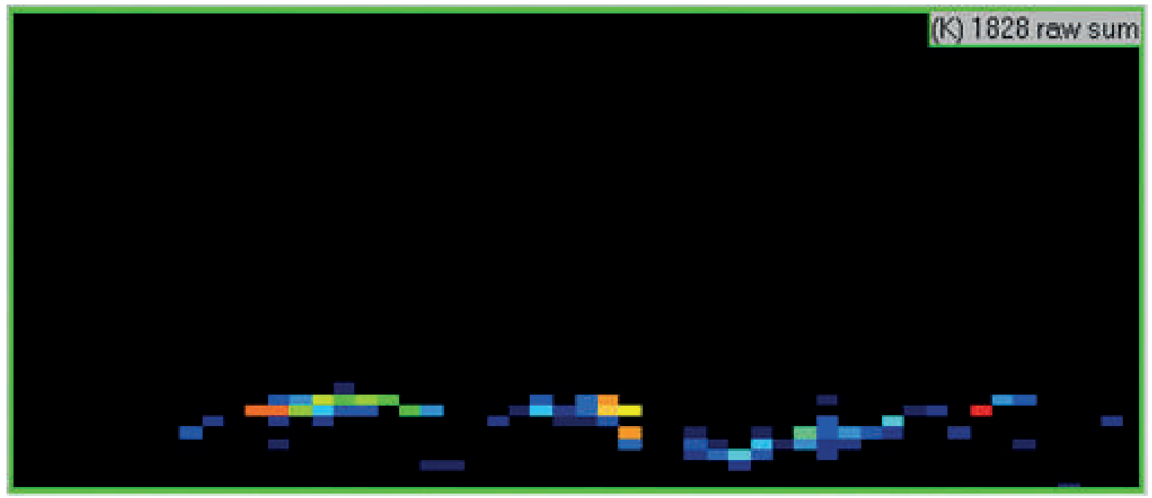

Figure 4: Snapshot from tactile sensor measurement showing the local ice pressure over the whole ice-structure interaction area for a cylinder with 200 mm diameter in new model ice

by Gesa Ziemer

Although past tests have shown that the load level in ice crushing is represented well with the current model ice, visual observation of the failure process indicates that HSVA's current model ice is not sufficiently suited to replicate interaction of ice with vertical structures. The out-of-plane deformation of the ice sheet is highly overestimated, and the transportation of crushed ice around the structure is not realistic. **Figure 1** shows a comparison of ice crushing observed on a full scale structure (Norströmsgrund lighthouse) with a model test of the same structure at scale 1: 8.7 performed at HSVA in 2012.

In the MarTERA ERA-NET COFUND project FATICE (Fatigue Damage from Dynamic Ice Action), HSVA approaches this issue by dedicated model tests and further development of an alternative model ice. Project partners in FATICE are the Norwegian University of Science and Technology, Hamburg University of Technology, DIMB Engineering, and Siemens Wind Power B.V. The German part of the consortium is funded through BMWi. FATICE deals with the assessment of fatigue damage of fixed offshore structures exposed to drifting sea ice. As one aspect of the project, HSVA conducts three series of model tests to improve the model ice and ultimately to provide high quality measurement data that project partners can use as input for their respective works. The overall project goal is to develop new methods to assess fatigue life of structures to design them more cost-efficiently.

The second FATICE model test phase has been conducted in July 2019. In this phase, two cylindrical structures were comparatively tested in HSVA model ice and in an alternative model ice. HSVA's current model ice is frozen from a 0.7% sodium chloride solution. The ice sheet preparation starts with a seeding procedure in which fresh water is sprayed into the cold air, forming small ice crystals before settling on the water surface. These crystals initiate the growth of fine-grained ice of primarily columnar structure below them. The resulting model ice sheet is composed of a thin fresh ice top layer with similar thickness regardless of total ice thickness, and a thicker bottom layer that provides the target thickness. In the first FATICE tests, tactile sensors were attached to the test cylinders to monitor the contact area and local pressure distribution over the entire ice-structure interaction area. These measurements indicate that most ice load was transferred to the structure from the top layer as shown in **Figure 2**. However, it is known from full scale measurements that the highest pressures should appear in individual zones roughly at middle height of the ice sheet.

After trying different approaches of alternative ways to create model ice, the most promising solution was repeated for the latest model test series. Therein, the ice formation is started by cooling down the room temperature, removing all ice from the surface, and proceeding with cooling while wavemakers keep the water in motion with regular waves. The waves prevent growth of a solid ice sheet, but single crystals start to form. These replace the tiny fresh water crystals from the standard spraying procedure. When the wavemakers are stopped, the ice grows in a more natural way. Model tests with cylinders reveal that the crushing process looks more similar to reality. Local loads appear less uniform, and the highest pressures are transferred at middle height just as expected from full scale measurements. The out-of-plane deformation observed in tests with conventional model ice is cancelled. The loads scale linearly with geometric lengths of model and ice. These promising results will be investigated further in the on-going test analysis, and the ice preparation procedure will be further improved in the next FATICE model test phases. ■

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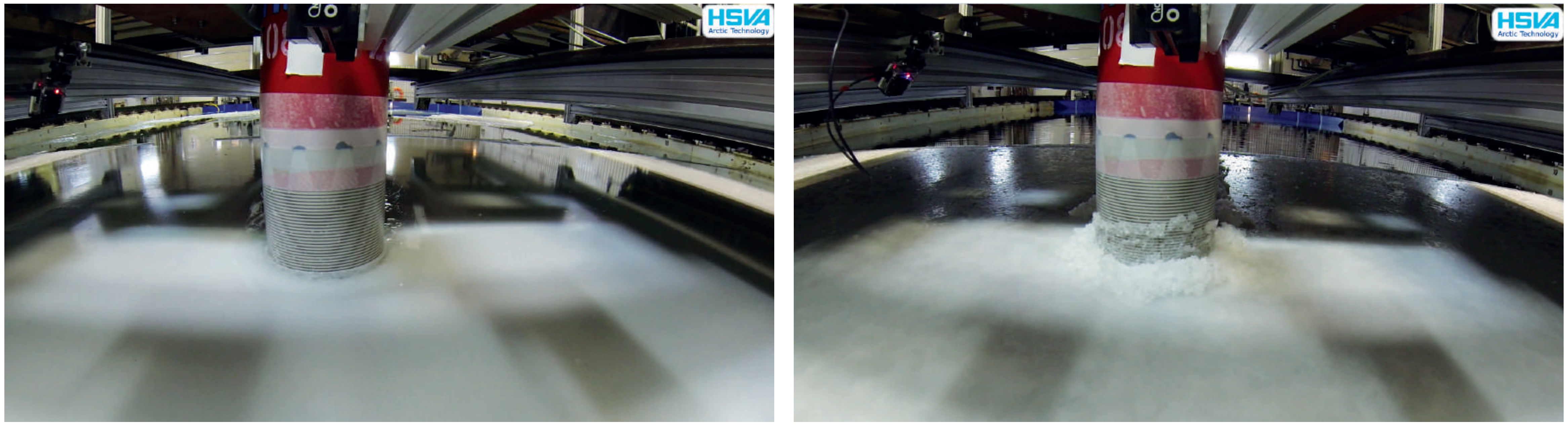

Figure 3: Cylindrical model crushing through current model ice (left) and new model ice (right) during FATICE tests

Investigating Full Scale Correlation @ Sea

Figure 1:28 m SAR Cruiser delivered to the German Maritime Search and Rescue Association by Fr. Fassmer Werft (Photo courtesy of DGzRS/Die Seenotretter)

The recent months saw a large number of newbuilding deliveries in which HSVA took a major role during the hydrodynamic optimisation and the model test verification phase.

by Oliver Reinholz

The great variety of ship types included cruise ships, yachts and fast rescue vessels. Among those also three identical Offshore Patrol Vessels (OPVs) were handed over to the owner in short succession. Within the projects all typical propulsion concepts – conventional propeller as well as pod arrangements – were covered. Ship sizes ranged from 30 to 300 m – representing a typical selection of vessels in HSVA's project portfolio.

Thankfully, HSVA had the opportunity to be on board during quite a large number of pre-delivery sea trials in order to witness procedures and to record measurement data. This data are not only used for thorough and dedicated sea trial reports but also contribute to extend our database for long-term statistics, ensuring the accuracy of HSVA's model to full scale correlation.

Especially the series of the three identical OPVs provided valuable insight into the functionality of the individual correction methods for environmental impacts such as wind and waves. The trials for the fast SAR vessels allowed a detailed study of the powering aspects both in deep and in shallow water. Most importantly and of immediate interest to our customers the trial results confirmed HSVA's correlation method with exquisitely satisfying accuracy. Nevertheless, HSVA will remain committed to continuously monitor our model to full scale correlation method in order to maintain the quality of our services and reliability of our ship powering predictions.

Figure 2:86 m Offshore Patrol Vessel delivered to the German Federal Police by Fr. Fassmer Werft (Photo courtesy of Hans-Uwe Schnoor)

For any vessel that has been numerically or experimentally investigated at HSVA, we offer to evaluate trial results including reporting and consultation free of charge. The underlying measurement data can easily be submitted directly to the responsible Project Manager in HSVA's Resistance & Propulsion Department. HSVA also offers a one-stop service including sea trial attendance and conduct of measurements on board as well as the independent witnessing of trials. We are also happy to offer the assessment of on-board monitoring data which can be provided upon request.

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The 40th MARINTEC CHINA 2019 will take place from 3 to 6 December 2019 in Shanghai.

HSVA has its own small stand in the German Pavilion. Our stand number is N2B6A-04 in hall N2.

Dr. Yan Xing-Kaeding and Hilmar Klug will be on site for HSVA. Michael Waechter will be in Shanghai for SDC.

Website of the German Pavilion:
https://marintec.german-pavilion.com

MOVE – Modeltests and Development of Numerical Methods for the Research Project "HYKOPS"

Recently the joined research project "HYKOPS"– a frame work to describe unconventional propeller geometries" has been finished successfully. HYKOPS was a national research project, financed by the Federal Ministry for Economic Affairs and Energy (BMWi) under the funding code 03SX401D with several partners linking maritime industry and research:

- **Flensburger Schiffbau-Gesellschaft mbH & Co. KG (FSG, project coordination)**
- **Entwicklungszentrum für Schiffstechnik und Transportsysteme (DST)**
- **Schiffbau-Versuchsanstalt Potsdam GmbH (SVA)**
- **Technische Universität Hamburg-Harburg, Inst. für Fluiddynamik und Schiffstheorie (TUHH)**
- **Universität Rostock, Fakultät für Elektrotechnik und Informatik (URO)**
- **ISA Propulsion GmbH & Co. KG (ISA)**
- **Mecklenburger Metallguss GmbH (MMG)**
- **Friendship Systems AG (FSYS)**

by Tom Luecke and Heinrich Streckwall

Within this framework HSVA was involved in theoretical and practical topics. Firstly, in the enhancement of the propeller analysis program QCM, in order to improve the prognosis of the hydrodynamic characteristics of unconventional tip-raked propellers. Secondly, these hydrodynamic characteristics have been investigated by means of cavitation observations together with power measuring campaign and wake measurements on board of the LOCH SEAFORTH as well as their corresponding model tests. Power measurements have been made by the project partner FSG, and the total – and nominal (!) wake fields have been measured by URO.

This article presents some topics of the investigations carried out at HSVA, which are:

Propeller Code QCM, Geometry Description

The propeller analysis program QCM used at HSVA allows for fast computations and results processing as well as for an efficient pre-processing of the propeller geometry. Classical propeller geometries are described by a natural cylindrical coordinate system, using the radius as one independent coordinate, where the profile sections are defined along each radius. For tip-raked propellers a radius, dependent on the axial coordinate, is an appropriate choice, where the profile sections can be located on an individual cone with an additional angle of orientation related to the slope of the cone. **Figure 1** shows the cylindrical and the conical orientation of a blade section. As a consequence, profile camber and thickness have to be measured based on the local orientation rather than on the classical global cylindrical orientation. This difference is depicted in **Figure 2**, where the global cylinder definition is shown in red and the appropriate local oriented definition is shown in black.

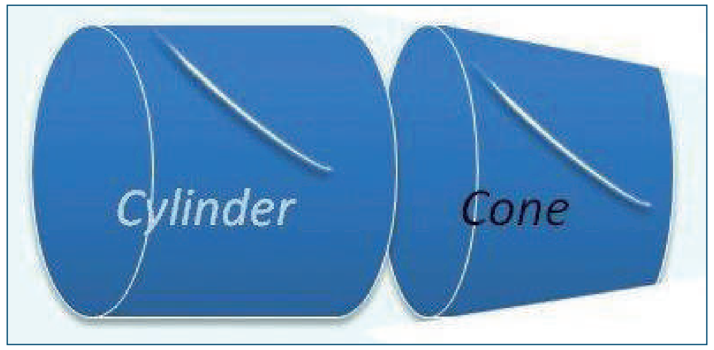

Figure 1: Two reference planes for a profile section orientation, left global cylindrical and right local cone

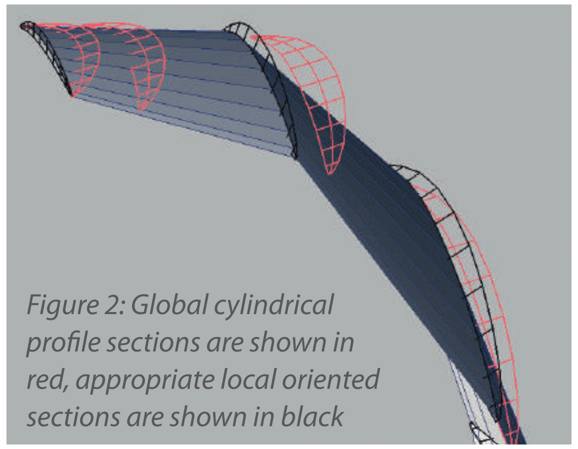

Figure 2: Global cylindrical profile sections are shown in red, appropriate local oriented sections are shown in black

Figure 3: The LOCH SEAFORTH in the harbour of Stornoway (Outer Hebrides)

In order to invoke the analysis of tip-raked propellers, it was necessary to review this pre-processing. The transformation of the geometry could be validated using two examples (LOCH SEAFORTH-propeller and the Potsdam Test Case propeller P1727).

The results are already promising, nevertheless the application will be extended in the daily practice to gain as much confidence as for conventional propellers.

Wake Field in Model- and Full Scale

Measurements of local wake field components in full scale as well as in model scale in the HYKAT, HSVA's large Hydrodynamic and Cavitation Tunnel, could be performed by the project partner URO. Due to the suppressed free surface in the HYKAT the tests could be carried out at much higher speed as classically in the towing tank. The measurements were performed by means of PIV (Particle Image Velocimetry) in a plane upstream of the propeller. **Figure 3** shows the LOCH SEAFORTH in the harbour of Stornoway (Outer Hebrides), built by the project partner FSG. Both, the total as well as the nominal wake fields have been measured. Especially the nominal wake field is a challenge to determine in full scale due to the presence of a working propeller. The specific choice of this twin screw vessel and the excellent collaboration of the ship crew from Caledonian MacBrayne made it possible to sail the ship in single shaft mode for a certain period. While the port side shaft was driven, the starboard shaft was idling as low as possible, allowing the measurements of the nominal wake field.

Figure 4 shows the axial nominal wake fractions in model as well as in full scale looking downstream. Since the real ship speed through water at each instant is difficult to determine, the axial velocity component in an outermost located reference point (No. 71) has been used to normalise the results. As a main finding the axial wake components differ in the mean sense only marginally between both scales. This can be regarded as a further supporting reference for the good model – full scale correlation of the cavitation test results obtained in the HYKAT. The combination of the full scale wake- as well as power-measuring campaign is further used to

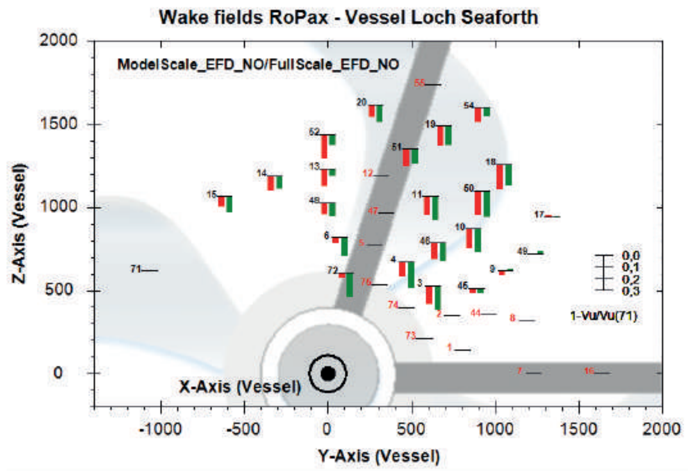

Figure 4: Comparison of the local nominal wake fraction, measured in HYKAT (red) and in full scale (green). (Source: University of Rostock)

calibrate the full scale CFD wake predictions with special focus on modelling hull roughness.

The collected wake data in model- and full scale and the developed methods represent an important element for the understanding of ship-propeller interaction in general and the design of unconventional propellers in particular. The financial support by the national funding is gratefully acknowledged.

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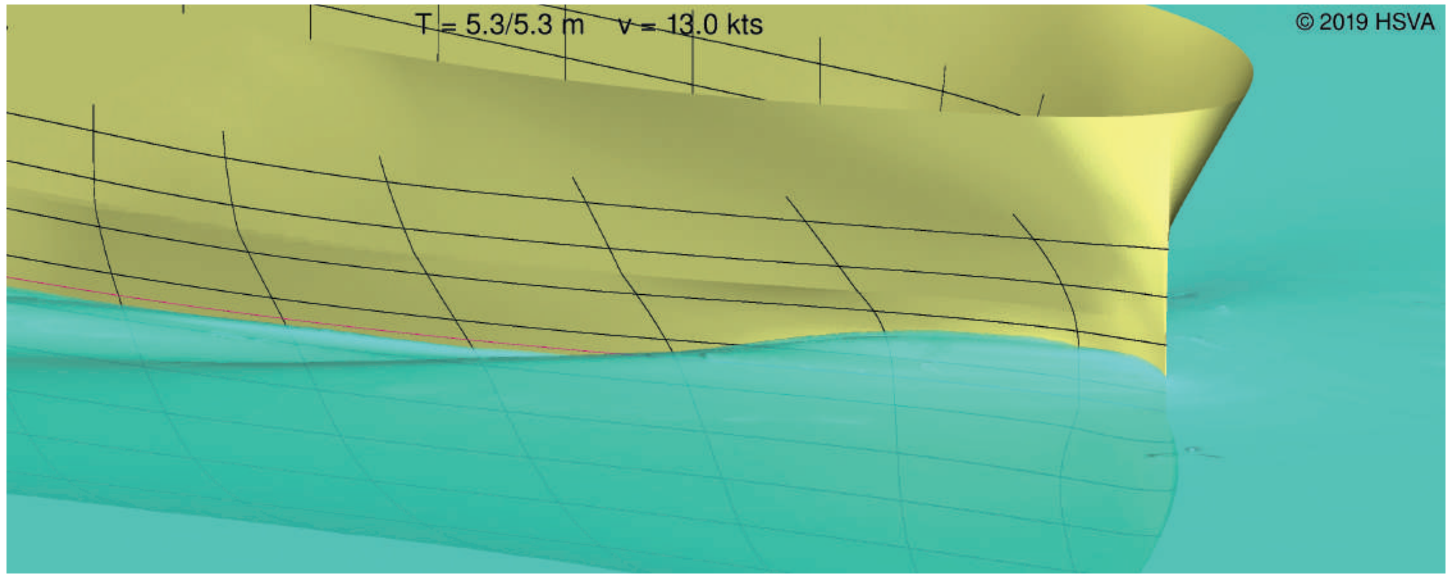


Considerations on Vertical Stems

Starting off from the middle of the 20th century ships have been equipped with bulbous bows aiming to reduce bow wave making. Being at the beginning an experienced-based, empirical game of trial and error the evolution of computational tools providing insight into flow field details have led to a more rational assessment and design of bulbs and related bow shapes.

by Florian Kluwe and Henning Grashorn

The bulb in front of the stem evidently represents an efficient way of reducing the height of the bow wave, especially for Froude numbers above 0.2. The underlying principle mainly relies on counteracting the stagnation pressure at the bow (leading to the build-up of a bow wave) by accelerating the flow prior to reaching the stem. According to Bernoulli's equation this reduces the pressure in the flow. Furthermore the bulb design gives the possibility to influence the wave interaction not only at the stem, but also along the hull (e.g. forward shoulder). A positive side effect is the resulting more slender waterline in case a bulb is added.

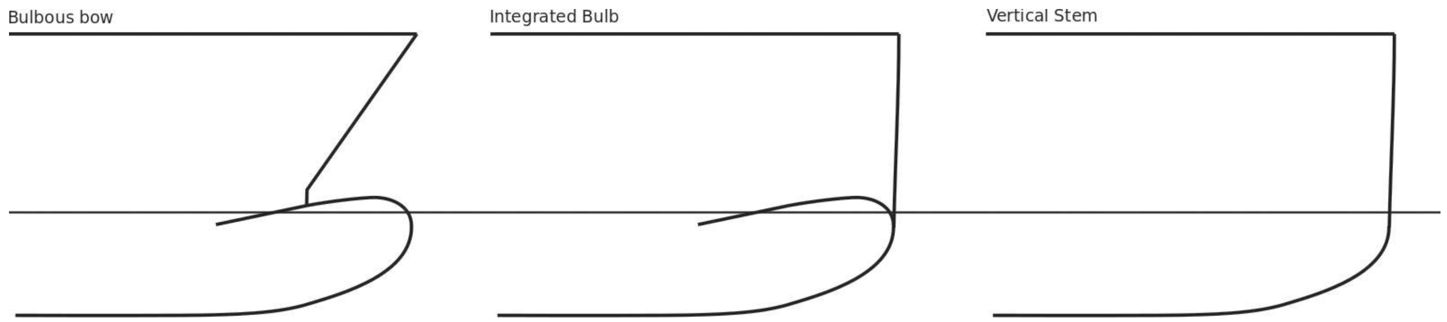
The articulated downstream bulbs that were common practice in the first decade of the 21st century showed excellent performance in the vicinity of their design point (draught/speed). However, the upcoming trend for slow-steaming quickly revealed that these bulbs had the tendency to add significant extra power demand on low speeds. Investigations show that these voluminous bulbs virtually "turn" the speed-power curve with the fix-point often located at Froude numbers around 0.2. Secondly the performance of these vessels proved to be very poor in some cases when they were operated on partial loaded draughts when the bulb is partly emerged. Sometimes the power demand on ballast draught is then even higher than on design draught despite the much smaller wetted surface. Furthermore, tests carried out at HSVA show that the added resistance in waves can be more than 50% higher for vessels with bulbs having face normal with large longitudinal component.

Nowadays ship-owners take much more effort in analysing the in-service performance of their vessels. This has raised awareness not to focus on single design points but to take into account realistic operating profiles when judging upon the performance of vessels. Taking the aforesaid into account the hull form optimisation today in most cases does no longer focus on a single design point but takes into account these operating profiles comprising various draft-speed combinations. In consequence bulbs have become much more slender than in the past reducing their effect in design conditions slightly but gaining significant better performance in other conditions. Most recently many designs feature a vertical stem contour either without any bulb or with a bulb-like shape integrated below the waterline (see sketch in Figure 1) reminiscent of the classical liner silhouettes from the beginning of the 20th century.

Does this represent primarily a visual design element or is there a real advantage of this kind of design?

The design requirements and constraints have changed remarkably due to the already mentioned reduction in ship speeds (slow steaming), the broader focus on operating profiles and additionally due to the trend for wider ships leading to smaller L/B ratios. The latter leads to increased waterline entrance angles. Above certain waterline angles a bulb is no longer able to significantly influence the flow regime around the stem. In such cases fitting a bulb becomes redundant. In this respect the vertical stem can be considered as logical evolution of displacement bulbs known from slow full block vessels for many years. They do not follow the flow acceleration principle but take advantage from providing additional buoyancy making waterline more slender, reducing the waterline entrance angle and providing a softer forward shoulder. As both, the speed and the waterline entrance angle of a vessel have a direct impact on the height of the bow wave and the position of the bow wave crest, these parameters need a different tuning when implementing a straight stem.

Figure 1: Comparison of bow concepts



Care needs to be taken also when comparing designs and when making speed-power prediction. The larger length between perpendiculars (Lpp) results in a (calculatory) lower block coefficient (CB) – but this is just a virtual change. More reliably the assessment should be based on the length over surface (Los) in these cases.

Figure 2 shows generic resistance curves illustrating the general relation between bulbous bow and a vertical stem solution. Fundamentally the decision on the concept to use needs to be made based on the speed range covered by the operating profile.

In practice the decision on which design variant to choose is governed by more complex considerations which need to elaborate which design has the highest potential for optimisation. ▶

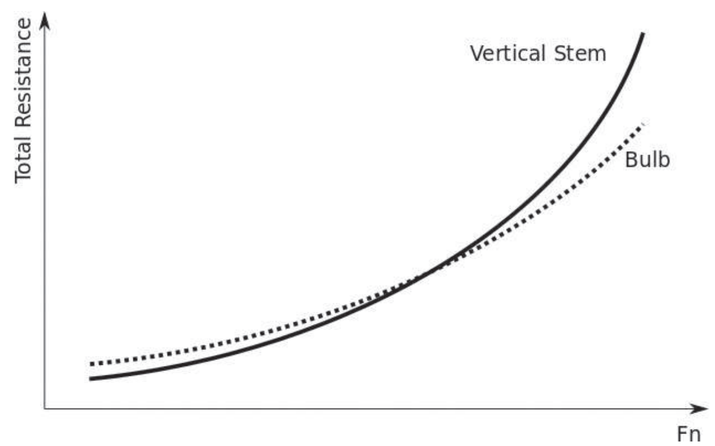


Figure 2: Generic resistance curves showing the fundamental effect observed for the different bow concepts

The following list summarizes the influencing factors for the decision on vertical stem (inter alia):

- **Block coefficient CB**
- **L/B ratio (i.e. waterline angle)**
- **Operating profile (speed range, draft range)**
- **Area of operation (added resistance in waves)**
- **Wave interference between bow wave system(s) and wave generated at forward shoulder**

HSVA gained experience within several projects where both bow variants have been put into competition for the most efficient design. The results confirm the statements made above in principle but conclusions need to be drawn carefully due to the complex interaction of other hull design elements.

For example for vessels with similar fullness in a comparable speed range our assessment revealed contrary results in favour and against vertical stem. The interaction with the forward shoulder and the shape of the waterline play a role here. Generally the decision in most cases is a trade-off between the reduction of the bow wave by a low pressure generating bulb and a reduction of bow wave height by increase slenderness of the waterline. Figure 4 shows a comparison of the two bow concepts, bulbous bow and vertical stem. In the example the design locally takes advantage of stretching pressure gradients leading to a longer but smaller elevation of

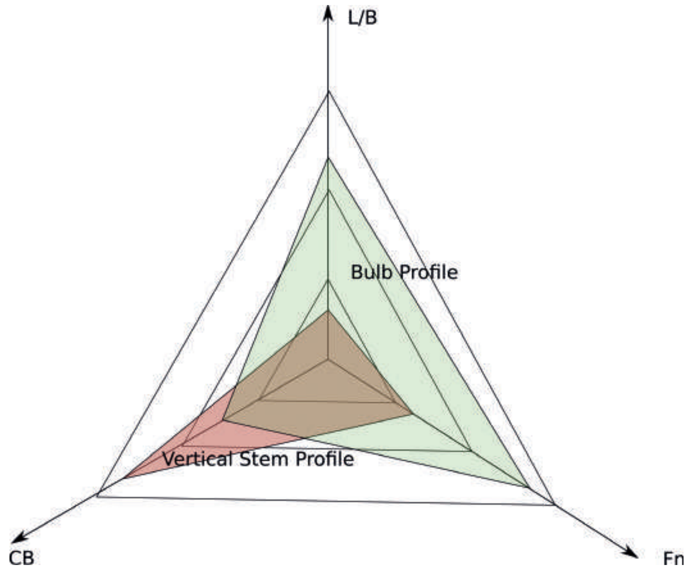


Figure 3: Decision-profiles for the application of vertical stem concepts

the water surface along the bow. This has a positive effect on the secondary wave system but needs to be tuned with the forward shoulder wave system.

Finally when making the decision for a vertical stem comes with some side effects as it always increases the length between perpendiculars (Lpp) and consequently may also influence the concept design also in non-hydrodynamic terms, e.g. position of the collision bulkhead. ■

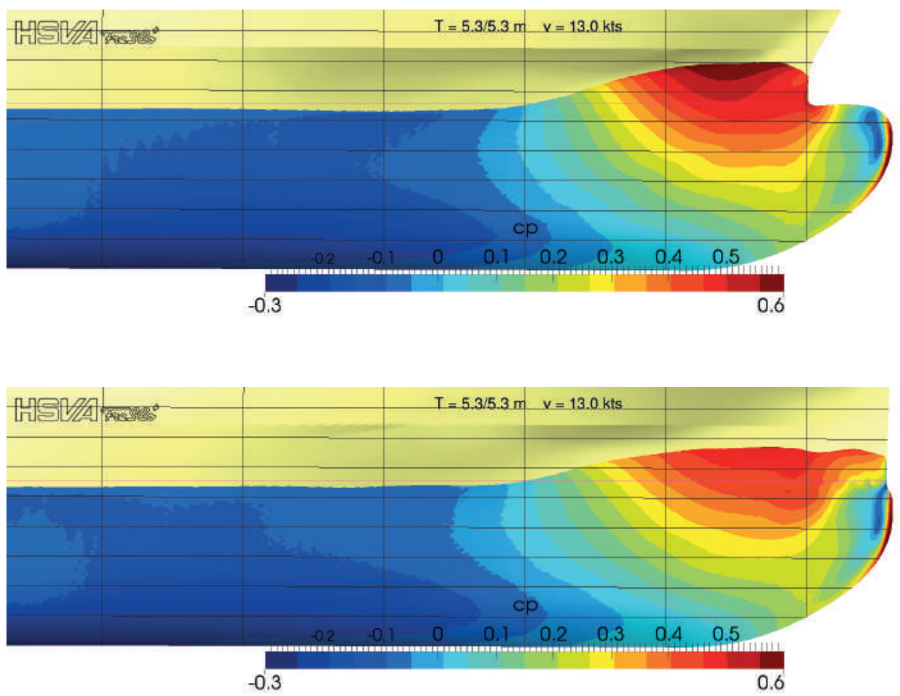


Figure 4: Comparison of bow concepts

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HSVA Services

- **Review of hull / bow forms, incl. viscous flow CFD and suggestions for improvements**
- **Preparation of an alternative (bow) design**
- **Design of specialised bow and bulb forms – e.g. for the operation in ice**
- **Partial (e.g. bow) or full optimisation of vessel**

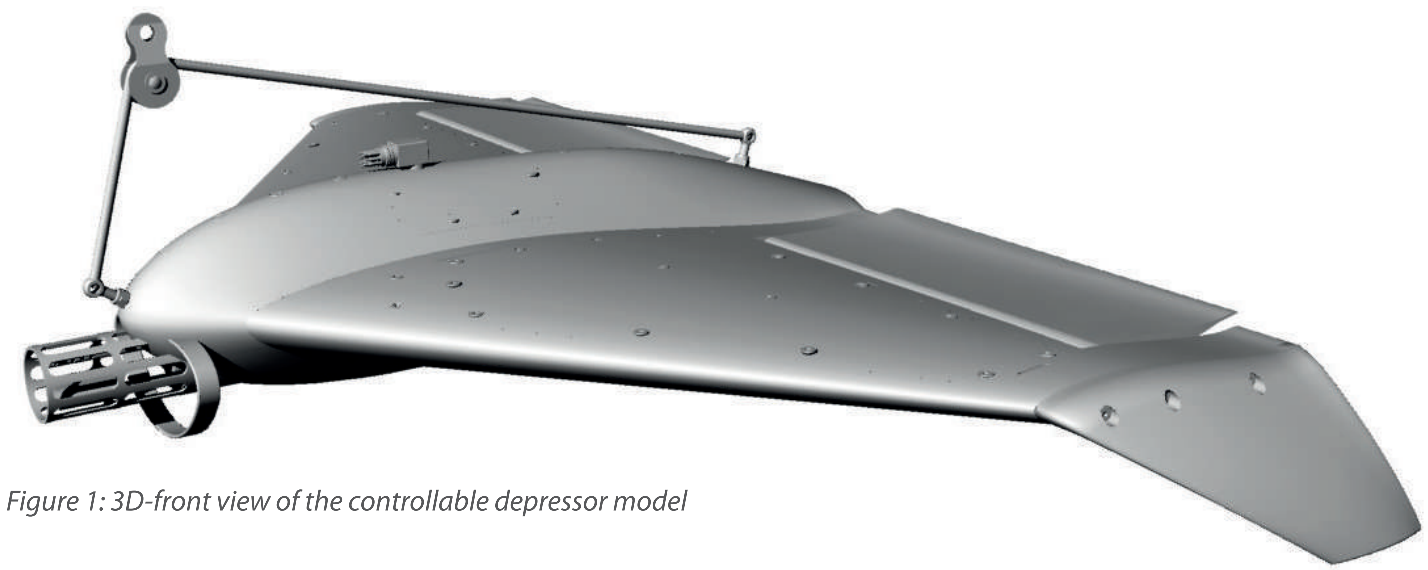

Figure 1: 3D-front view of the controllable depressor model

Lifting Spirits by Testing a Depressor

Recently HSVA tested the hydrodynamic characteristics of a depressor for the scientific research project MOSES (Modular Observation Solutions for Earth Systems) (www.ufz.de/moses), analysing vortices and measuring temperature, salinity, oxygen concentrations and chlorophyll in the oceans.

by Soeren Bruens

On behalf of the innovative water probe manufacturer **Sea & Sun Technology GmbH** (www.sea-sun-tech.com) together with the **Research Centre Helmholtz-Zentrum Geesthacht** (www.HZG.de), HSVA has carried out submerged towing tests for a "Controllable Depressor". The depressor is intended for pulling down a measurement cable with multiple sensors attached to it while being towed behind a research vessel. A 3D-model is shown in **Figure 1**. The depressor is self-controlling its depth and thereby the sensors along the instrumentation chain keep a defined submergence. The system is then able to send real-time measurement data for the different environmental parameters at different layers of the oceans. The possibility for online-monitoring of the measurements is a new feature which is realised by an innovative inductive coupling system of the sensors to the measurement cable. There is no need for plugged or fixed connections that always incorporate the risk of water ingress. The sensors in the depressor and along the cable all communicate via a bus system and can be placed at arbitrary positions.

The test object was supplied by the customer representing the first prototype of a low-drag and high ▶

Figure 2: Depressor submerged and connected to the towing carriage in free towing mode

"inverse" lift generating depressor. The concept features "flying wing" design and is equipped with two ailerons for adjusting the pitch angle and for controlling the orientation. Its operation profile is defined for submerging the instrumentation chain to depths of about 50 m to 100 m and speeds of up to 10 knots.

In order to determine the relevant hydrodynamic characteristics for further simulations and to assess the dynamic behaviour, HSVA carried out tests in two different setups: Fully submerged resistance tests in a captive condition as well as tests in a free towing condition, comparable to the intended use in operation. From the captive test the basic hydrodynamic properties of the depressor at different angles of attack, various speeds and in combination with different aileron angles could be determined. With second series of tests with the depressor being towed in free-moving condition, its behaviour in the intended working condition has been gathered.

For the captive towing test the controllable depressor was attached to HSVA's deep towing device R39 – a stainless steel foil fitted to the main towing carriage. It has a length of about 5 m to assure that the test object operates in sufficiently deep water in order to avoid any influences of the free water surface. For a strong and stiff connection HSVA designed and built a custom-made mounting adapter made from brass. The streamlined body does not only form the foundation for the depressor but also incorporates a 6-component force sensor. On the top side it has been connected to the flange of HSVA's deep towing device. The deep towing device can be tilted in order to realise pitch angles of ± 5°. The system, ready for installation, is shown in **Figure 3**.

In the free towing condition the depressor was connected to the main towing rope via a steel cable with a two-point mounting on the object: One point close to the nose and one at the rear side. In order to keep the object free in its pitch a pulley was used to connect the main towing rope with the steel cable. **Figure 2** shows the depressor being towed under water.

All tests have been conducted successfully and showed very promising results. With the obtained hydrodynamic characteristics the simulation model will be enhanced. The results are input to the next stage of the system development enabling design improvements related in particular to lift to drag performance and controllability of the vehicle. On HSVA's side we have added valuable equipment to our toolset for underwater experiments that is ready for use in future projects. ■

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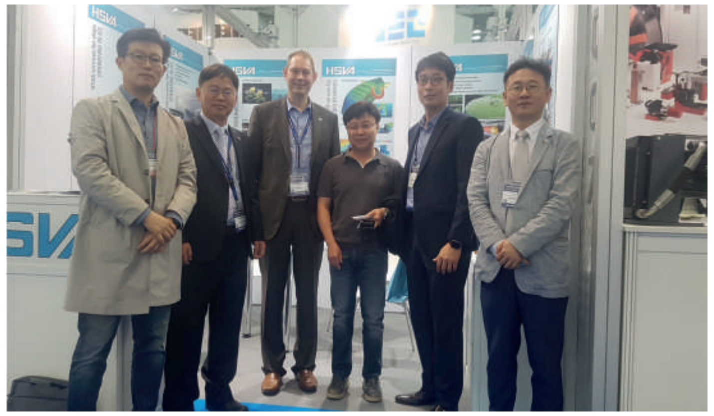
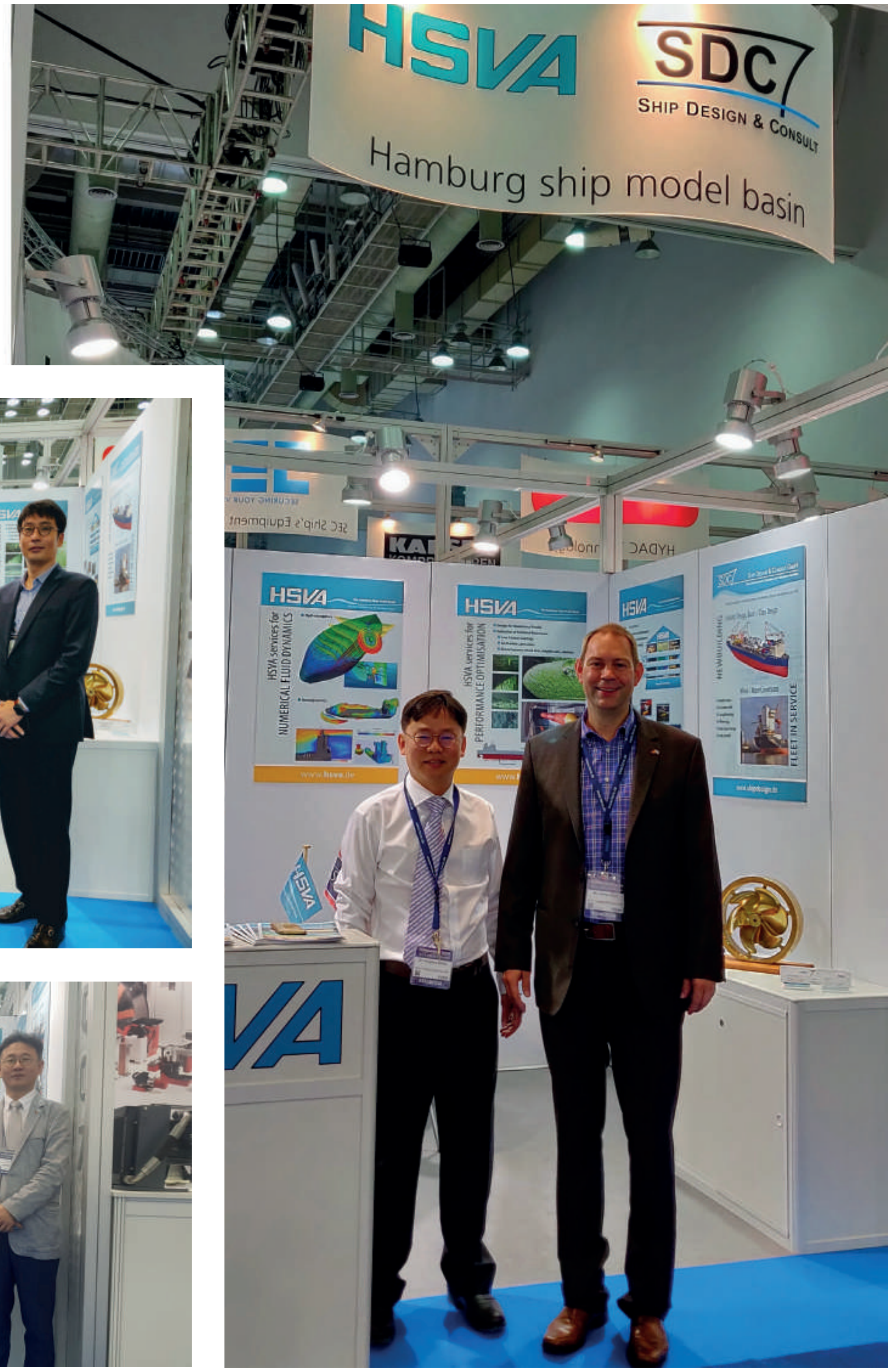
Figure 3: Depressor mounted at the „R39" deep towing device – ready for installation on the towing carriage





KORMARINE 2019

International Marine, Shipbuilding, Offshore, Oil & Gas Exhibition

OCT 22 (TUE) – 25 (FRI), BEXCO, BUSAN, KOREA

After the successful round trip to our customers, partners and friends in South Korea last year, HSVA took part in the KORMARINE exhibition in Busan in October this year.

Dr. YongPyo Hong and Hilmar Klug represented HSVA in the German Pavilion and we thank all our visitors for the very interesting discussions and talks. We are looking forward to continuing our long lasting cooperation with you. ■

Member of staff Christian Schroeder

Christian Schroeder joined the Arctic Technology Department at HSVA as a project manager in September 2013 after receiving his Master's Degree in Naval Architecture at Hamburg University of Technology.

Since that time Christian has been involved in numerous model testing projects for ice breaking ships including a high number of polar research and expedition vessels. Many of those projects included design assistance with special focus on ice breaking and sea keeping performance. Furthermore, Christian enjoyed participating in technically challenging, special projects for the offshore industry. One of the highlights in his work is to frequently take part in arctic sea trials with different types of vessels. The trials include work on board as well as field work on the ice.

In his spare time Christian, together with his wife, enjoys long-distance travels to various places around the world. He also likes to spend time in sporting activities, craft work and meeting with family and friends. ■

in brief

HSVA proudly congratulates its employee Daniela Myland for achieving her PhD degree!

Congratulations to Daniela Myland, Deputy Head of Arctic Technology Department, for achieving her PhD degree at NTNU with her thesis on "Experimental and Theoretical Investigations on the Ship Resistance in Level Ice". The thesis focused on the resistance of icebreaking ships advancing continuously in level ice, whereby different aspects of the ice resistance were analysed on the basis of ice model tests. Newly developed methods and techniques were used in the course of the model tests, and a semi-empirical resistance prediction method was improved with the gained insight. The work allows an enhanced analysis of the ice breaking process in model and full scale and can be seen as a basis for a refined ice resistance prediction in the future. ■