HSVA NewsWave

The Hamburg Ship Model Basin Newsletter 2004/2

Rudder Cavitation - An Increasing Problem with Fast and Highly Powered Ships

by Christian Johannsen

**Since decades propeller cavitation tests in model scale are a must for sea-going ships to avoid erosion or vibration problems due to unfavorable propeller cavitation phenomena.
This still holds true, even if numerical tools are very efficient meanwhile to optimize the propeller geometry and to avoid time consuming testing of various intermediate optimization steps.**

Nevertheless, almost always these model tests are focused on the cavitation behavior of the propeller alone. Conventional cavitation tunnels with their small test sections did not even allow the investigation of the rudder cavitation behavior at significant rudder angles and in the complicated three-dimensional flow field behind the ship hull. With increased ship speeds of ferries and container vessels, the price to be paid for these omissions is severe rudder damages, which are frequently reported from ship owners (Fig. 1).

Fig. 1 Full Scale Rudder Cavitation Damages

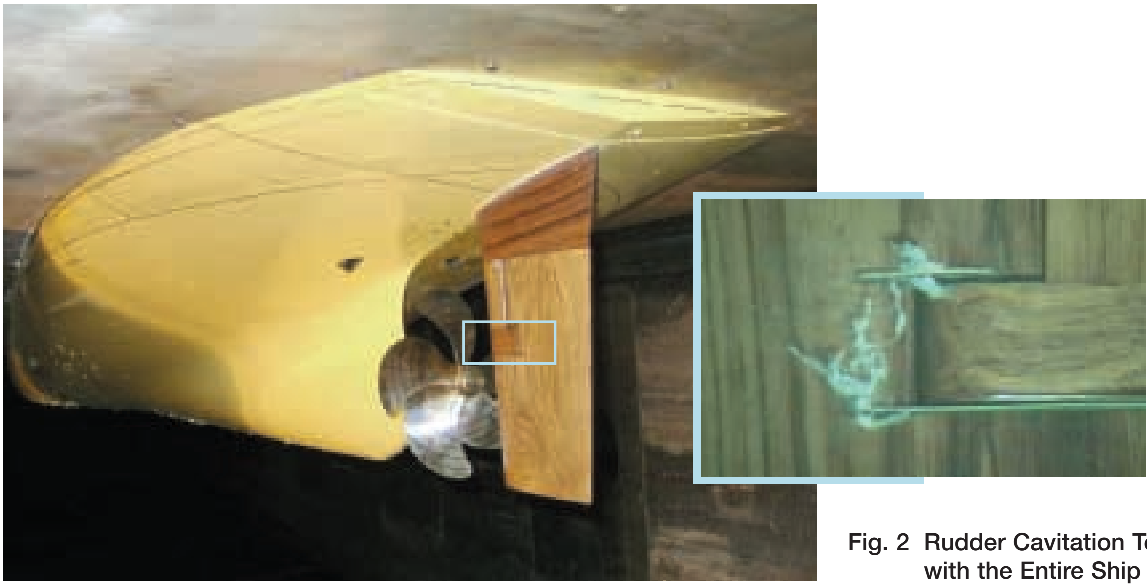


Fig. 2 Rudder Cavitation Test with the Entire Ship Model in HYKAT

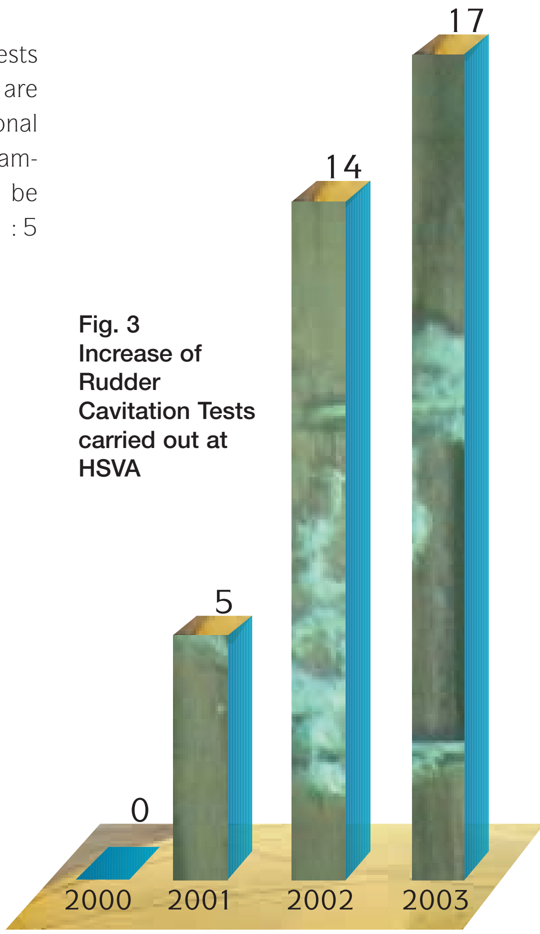
These upcoming problems in combination with the availability of the HYKAT facility for cavitation tests with entire ship models (Fig. 2) have led to an increasing demand for rudder cavitation investigations at model scale. Such as hull pressure measurements are a standard when doing propeller cavitation observations, it is an increasing share of clients asking for simultaneous rudder cavitation tests as well (Fig. 3). The additional effort is small but the increase of knowledge immense. A remotely controlled rudder engine inside the ship model in HYKAT allows rudder angle variation at any time. The high Reynolds Number achieved by high tunnel water speeds in HYKAT ensures good full scale similarity of the cavitation occurrence. The latter has been proven by several full scale rudder observations carried out within the well known EROCAV project or on clients demand within the last years. Promising remedies and alternative rudder arrangements have been investigated successfully.

For detail studies additional tests with large scale part rudder models are possible in HSVA's large conventional high speed water tunnel. Here for example gap cavitation phenomena can be investigated at scale ratios less than 1 : 5 (Fig. 4). A large variety of highly sophisticated numerical methods complete HSVA's toolkit to prevent rudder cavitation damages in full scale.

So there is no need to accept rudder cavitation damages as bad fortune. The helping tools are available - waiting for frequent use.

Fig. 4 Investigation of Gap Cavitation Phenomena Using a 1 : 5 Part Model in the High Speed Tunnel

Fig. 3 Increase of Rudder Cavitation Tests carried out at HSVA



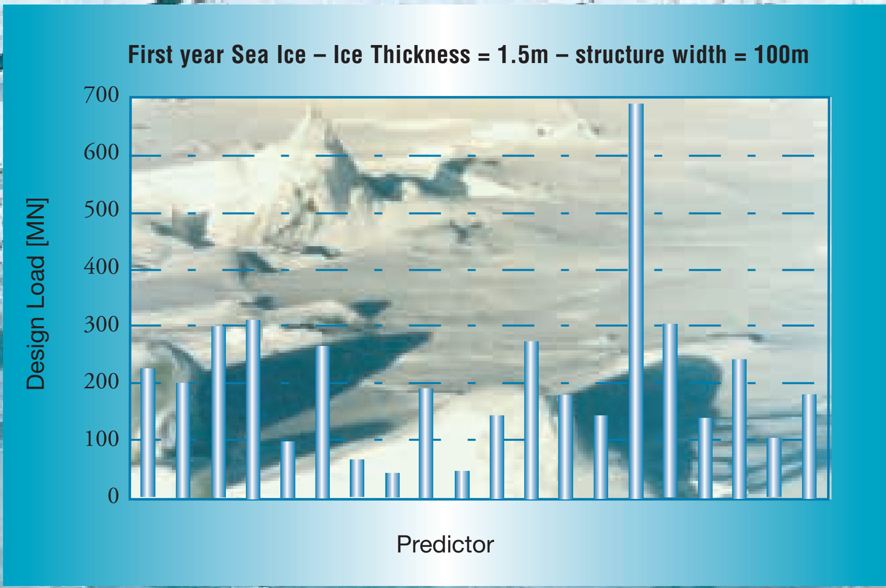


Fig.1 Comparison of Ice Load Predictions from different Experts (source K. Croasdale)

The engineering society is in trouble when they have to design structures for ice covered waters, because the various world wide available predictions of ice forces on structures scatter by a good factor of 10.

STRICE PROJECT

Measurements on Structures in Ice

successfully completed

by Peter Jochmann and Walter Kuehnlein

For several years research groups in Japan, Canada, USA and Europe are working on this problem in order to elucidate the controversies. So far the various groups of researchers have different opinions on the mechanisms and failure processes of ice interacting with structures and on the question which kind of failure leads to the most critical load conditions. This insufficient understanding results from difficult combinations of ice effects and impacts on the structure. Model tests which have been used to develop empirical ice force prediction formulae may also mislead due to incomplete similarity of the mechanical properties of the model ice.

In this situation, facing the wide scatter of ice force predictions, the STRICE researchers intended to go out into nature and study the phenomena of the various ice failure modes and measure the force and its effecting parameters under real conditions and in full scale. The STRICE Consortium - a group of scientists from six countries in Europe, coordinated by HSVA - initiated the STRICE project in order to significantly contribute to the solution of the aforementioned problems and to intensive, trans-European and multidisciplinary research reliable data, information and results for optimised and safe design of structures in ice.

During more than three years of measurement activities, data evaluation, interpretation, numerical modelling and documentation the STRICE project has achieved large amounts of versatile data and results. Excerpts of these results are made available to the general public and the interested science and engineering communities through the STRICE web site: www.strice.org (see Fig. 3).

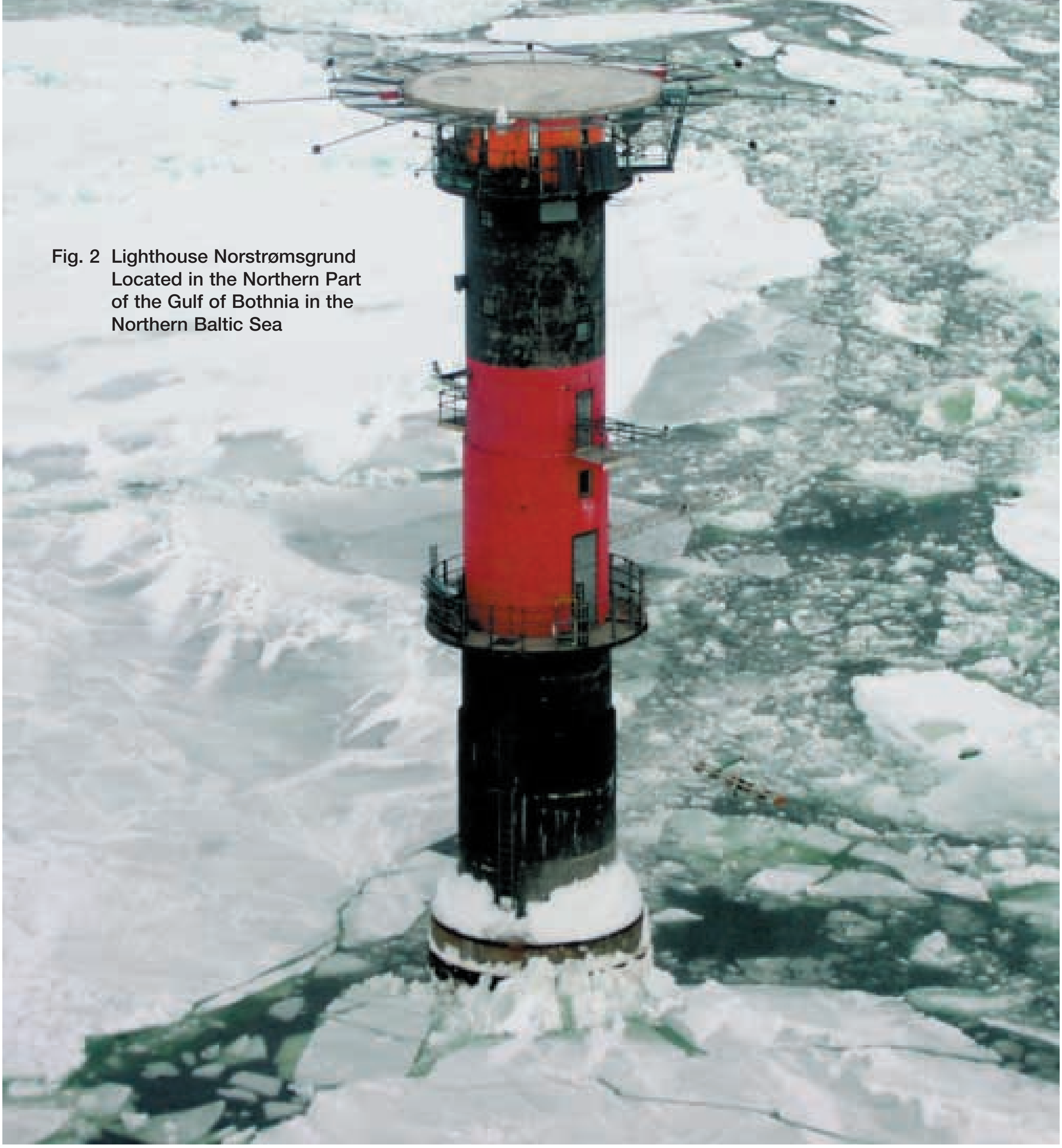


Fig. 2 Lighthouse Norstrømsgrund Located in the Northern Part of the Gulf of Bothnia in the Northern Baltic Sea

THE FOLLOWING RESEARCH PROGRAM WAS EXECUTED:

The central part of the project has been full scale measurements of forces caused by level ice and ridges using an existing device and field laboratory – the Lighthouse Norstrømsgrund (see Fig. 2) located in the Northern part of the Gulf of Bothnia in the Northern Baltic Sea. Ice forces are measured by mounted load cells at different pressure areas. This included accurate and complete characterisation of ice features (level ice and ridges) interacting with the lighthouse by means of ice sampling and subsequent laboratory tests as well as optical / video monitoring. In this conjunction the fracture toughness of level ice, the strength of consolidated and unconsolidated parts of ridges and the documentation of the ice failure process were also obtained.

Development of ice load spectra from various ice conditions as input information for probability predictions, study ice - structure contact and ice failure processes in order to establish the theoretical prediction models on the basis of realistic failure conditions.

Intensive analysis of newly acquired data as well as consistent merging and combined / comparative evaluation of the new data with historic ones.

THE ACHIEVEMENTS OF THE STRICE PROJECT ARE

- a fundamental insight into the problem of ice structure interaction based on full scale measurements of real ice and not on model tests with model ice,
- comprehensive and extended data sets of ice load measurements conducted on full scale under real natural conditions,
- improved ice force prediction models and probability statistics based on most extensive field and laboratory studies,
- the elucidation of the controversy on ice forces,
- validation of low ice force levels for the case of ice breaking against vertical structures.

THE RESULTS

- provide governmental authorities and classification societies with substantial information on ice forces on coastal, offshore and structures on inland waters (estuaries, rivers, lakes),
- provide the basis for the development of an ISO Code for ice forces,
- drastically reduce the costs for structures to withstand ice loads in future designs,
- open new possibilities for technical and scientific developments.

The results of the STRICE project will have a strong impact on the formulation and implementation of a new ISO Standard for in ice Offshore Structures. The European Commission funds a project to foster this process. STRICE participants and partners are substantially involved in this process through their engagement in the ISO Technical Panel on Ice (ISO TC67 SC7 TG8 Techn. Panel TP2b_Ice).

However, the main part of the results and data remain confidential property and for exclusive use of the STRICE consortium and partners, who provided considerable amounts of own funds and research grants to achieve the project's goals. Interested parties from the arctic cold regions and research communities who want to achieve and use more complete results are referred to the STRICE web site or you may contact the STRICE coordinator Walter Kuehnlein directly, Email: Kuehnlein@hsva.de.

Also the project's executive summary report may be downloaded from the web site for a condensed overview on the final research results and a list of scientific publications resulting from the STRICE project. The project partners and participants intend to compile more public information than originally required and agreed by the project's research contract, on a public CD-ROM once the consortium has decided on the specific contents.

This CD intends to feature following contents:

- Extended commented photo series,
- re-prints of publications (as allowed by applicable publishers' copyrights),
- re-prints of posters and other information material,
- extended samples of data and results,
- an inventory and extended abstracts of the confidential STRICE report,
- an inventory of the confidential data acquired in the STRICE project,
- other material and information permitted for disclosure to the general public.

When this electronic publication is available an announcement will be circulated to the scientific and engineering communities as well as to applicable end-users and media. The CD will be dispatched for a small fee covering the efforts for compilation, maintenance

Fig. 3 STRICE web site – main page www.strice.org

and dispatching through the project's data and information management service. Further details will be announced and order forms will be made available on the web page www.strice.org .

In conclusion the STRICE project achieved a much better understanding of ice forces acting on structures including the involved ice parameters. Beside the ice force data which have been measured for the first time in history (together with the former research project LOLEIF) in full conjunction with the related ice parameters, as mentioned above. Very useful empirical and numerical tools have been developed in order to predict ice forces and ice dynamics. Therefore this research project was a major step forward in order to predict ice loads on structures in ice.

The authors would also like to use this opportunity to say thank you very much to all sponsors of the STRICE project and to all our partners for a very fruitful and successful cooperation.

Fig. 1
The "BERKANE" Approaching Tanger Prior to the Conversion

In mid December of 2003 HSVA was contracted by the Moroccan ship owner Comarit to perform a model testing program in conjunction with the modification of the passenger and vehicle ferry MV "BERKANE".

Hull Form Optimisation for the "BERKANE" Conversion

by John Richards

The "BERKANE" was built by Chantiers Dubigeon S.A. of Nantes, France and was originally put into service in 1976 under the name of 'Napoleon' for SNCM. Since 2002 the "BERKANE" is owned by Comarit, and is sailing on a daily basis between the Spanish city of Almeria and Nador in Morocco.

The hull modification consisted of the addition of a ducktail sponson for improving the damage stability and survivability of the "BERKANE". In the past few years this type of modification is common for older ferries which, in order to stay in service, are required to meet the SOLAS 90 standard regarding stability and survivability. In the case of the "BERKANE" the modification allows the lifetime of the vessel to be extended beyond 2005.

The hull modification design work was done by the Finnish marine consultant firm Deltamarin Ltd., and the target of the optimisation was to have the performance improvement due to the optimised ducktail compensate as much as possible for the negative effect on the speed of adding about 200 tonnes displacement and increasing the breadth of the transom. The purpose of the model tests was to check a number of ducktail variants in order to quantify the effect of the modification on the calm water performance of the vessel. A reference test with the ship in the 'as is' condition was also performed, the result of which was to serve as a basis for comparison of the modification variants.

As is often the case for commercial projects, the time available for model preparation and testing was less than extravagant. In fact, as the tentative date for docking the vessel was already set, and thus also the deadline for completion of the steel drawings, it was necessary to begin model manufacturing concurrently with Deltamarin's design work. All sponson ducktail components were manufactured and fitted as removable parts for easy exchange in order to make optimal use of the time slot in the towing tank. The information flow including the provision and clarification of the original shipyard appendages drawings by Comarit was extremely effective, which helped to minimise the overall throughput time for the project.

The model tests demonstrated that with the best ducktail variant, the reduction in speed due to the required modification could be limited to about 0.2 knots. Following the ship's conversion at Blohm + Voss Repair in Hamburg this spring, this result has been substantiated by Comarit, who have confirmed that the performance of the "BERKANE" since the conversion is very much the same as before. She can easily manage 22 knots under normal service conditions and 24 knots at full power.

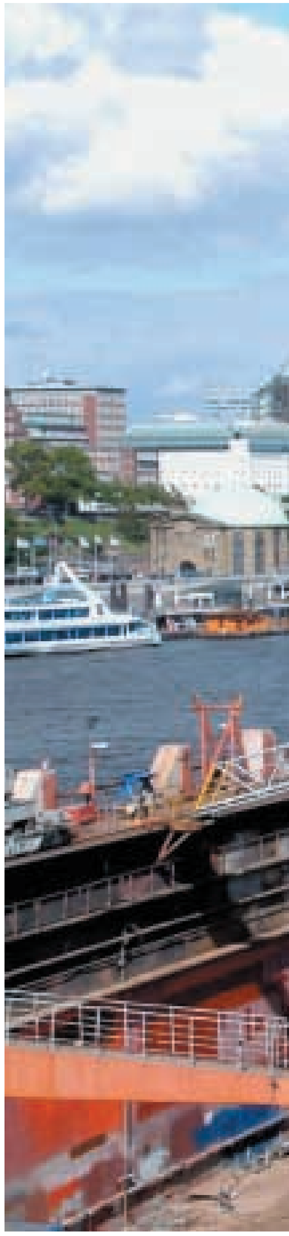


Fig. 2
The Model of the "BERKANE" Approaching HSVA's Large Towing Tank with Ducktail 'Variant 3'

Fig. 3
The "BERKANE" during Conversion in Dock 10 of Blohm + Voss Repair in Hamburg

THE COMPONENTS OF THE FLOWGRID ARCHITECTURE

by Scott Gatchel

HSVA is working together with three other industrial partners and two technology providers to provide a platform for on-demand computing resources for CFD applications without the enormous costs of building and maintaining a computing cluster.

Simulations involving free surface computations, fully modeled rotating propellers, cavitation, and more complex geometry require extensive computing resources. Until recently, these simulations were the subject of long-term, well-funded research projects. Today, customers ask for these kind of analysis as standard services during consultation projects, thus, requiring short response time and competitive costs. In addition, the results from these simulations must meet the quality standards customers have come to expect from HSVA. These requirements can only be met using the "Grid computing" approach.

Decreasing time and costs, while increasing complexity and quality are conflicting issues. HSVA is working together with three other industrial partners and two technology providers to provide a platform for on-demand computing resources for CFD applications without the enormous costs of building and maintaining a computing cluster. The FlowGrid project presents an architecture for Computational Fluid Dynamics (CFD) applications that revolutionizes the way CFD simulations are set up, executed and monitored. In this project, several 'Grid Computing' centers across Europe develop and validate their software for Grid-based CFD computations. The 'CFD Virtual Organization' of FlowGrid provides industrial end users easy and flexible access to CFD resources.

HSVA, together with Skoda VYZKUM (Czech Republic), CERTH/CPERI (Greece) and the Fluid Mechanics Group at the University of Zaragoza (Spain), provided industrial test cases for the new Grid Computing platform which is established by Symban Power Systems Ltd (UK) and the Computer Science Research department at the Zuse Institute (Germany).

HSVA has provided typical test cases from ship hydrodynamics for the FlowGrid system, e.g. wake flow predictions. The results of the exercises performed in FlowGrid are compared with results from other CFD software, as well as experimental measurements. Over the course of the FlowGrid project, these problems are expanded beyond the limits of the industrial partner's own computational resources. This demonstrates the advantages of the FlowGrid system.

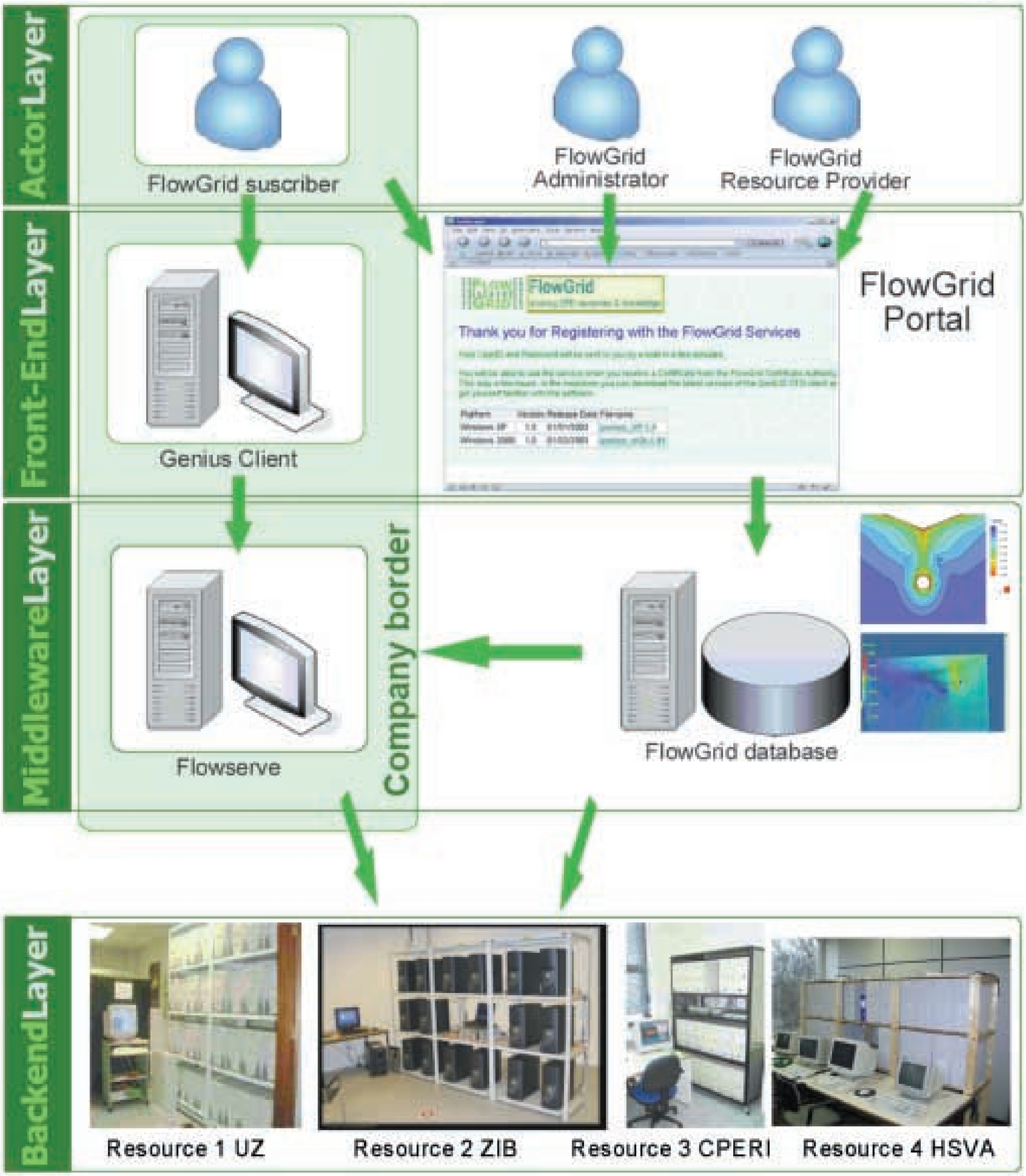
The components of the FlowGrid architecture are organized into four layers: actor, front-end, middleware and backend. The Figure depicts these layers and the distribution of the components. The dependencies and interactions between the components are also shown. The actor layer consists of actual persons taking different roles in the interaction with FlowGrid:

- **resource providers**
- **administrators**
- **subscribers**

The front-end layer consists of two graphical user interfaces – the client interface called and a web portal. In the middleware layer, the FlowServe system manages the jobs on behalf of the user. At the bottom, the backend layer contains the resource managers for the different clusters. This architecture allows for a user friendly problem set-up and definition as well as a most transparent submission of actual computing jobs on remote machines, the "Grid".

The official project for development and testing of the FlowGrid system continues until November 2004. Present evaluations of the system show promising results. Significant speed ups have been obtained when dealing with large scale problems, typically involving grid sizes of several million cells already. Future problems and applications are expected to exceed these model sizes even further, thus making it almost impossible to address them by typical in-house hardware available. The "Grid Computing" approach for the first time ever allows to address today's large scale problems in an efficient – with respect to time and cost – way. Based on the promising results obtained with test cases so far, HSVA expects to fully utilize the "Grid" for CFD analysis for their customers in the near future, after the FlowGrid project has been completed.

How does FlowGrid work?



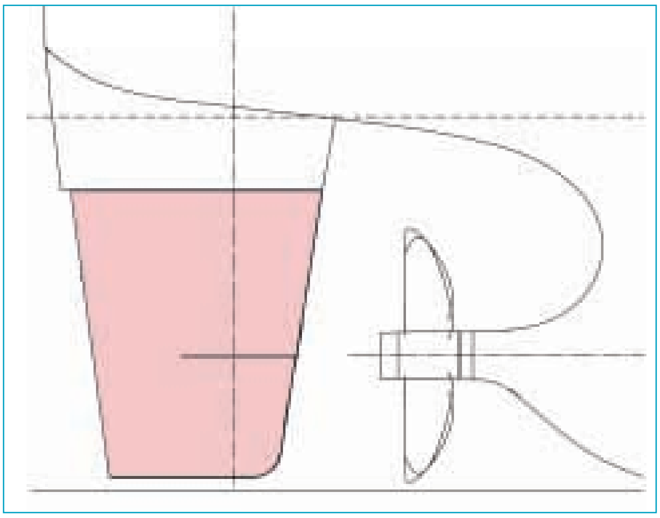


Fig. 1 Twisted Spade Rudder

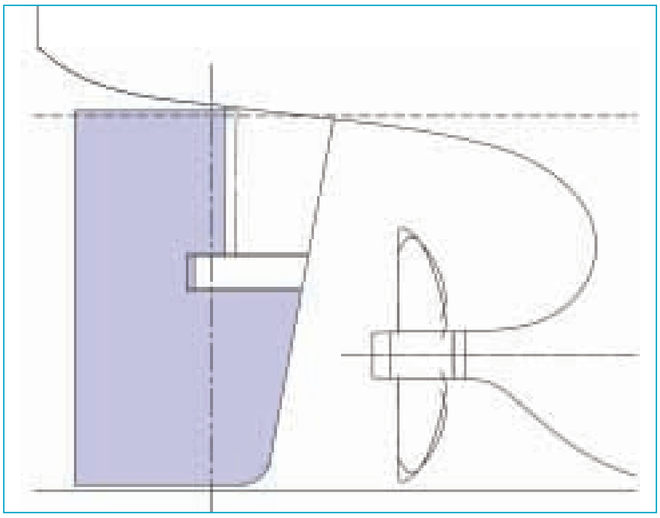


Fig. 2 Semi-balanced Rudder

Comparative Rudder Force Measurements with a semi-balanced Rudder and a Twisted Spade Rudder

by Henning Weede

Rudder forces on a twisted spade rudder have been recorded during manoeuvring tests with a model of an 8400 TEU container vessel. The results have been compared to those of a similarly sized conventional semi-balanced rudder.

A rudder is exposed to a twisted inflow due to propeller rotation. In case of a twisted rudder, both parts above and below the propeller axis are oriented into the twisted inflow individually, whereas in case of a symmetrical rudder both parts can be considered two rudders acting against each other. A semi-balanced rudder is characterized by gaps, sharp edges and a complicated geometry at larger rudder angles because the rudder horn supports the rudder blade with the lower bearing. This can cause local high-velocity low-pressure regions with subsequent cavitation, whereas a spade rudder keeps its smooth geometry at all rudder angles.

Figs. 1 and 2 show both rudders and their arrangement behind the propeller.

To compare both rudder types not only with respect to their manoeuvring behaviour, but also the forces responsible for it, the rudder shaft was clamped into HSVA's force gauge to measure the lateral and longitudinal force and the torque about the rudder shaft. Only the loads on the movable part were measured. The semi-balanced model rudder was not connected to the rudder horn by any bearing.

Fig. 3 shows the lateral force coefficient versus the angle of attack (rudder angle minus propeller slipstream). A force coefficient cy expresses the ratio of mean pressure to the square of inflow velocity. In case of a rudder, there are two different inflows: The outer region, which more or less corresponds to the surge, sway and yaw motion of the manoeuvring vessel and the inner region, where the propeller slipstream is much faster and less declined. This coefficient refers only to the propeller slipstream. As reference area to make the coefficient non-dimensional the movable rudder area was taken, i.e. the part attached to the force gauge. As reference velocity the velocity in the propeller slipstream was taken.

The lateral force is the one that makes the ship manoeuvre, and the diagram of the lateral force coefficient shows that it's generally larger in case of the twisted spade rudder (red). The conventional semi-balanced rudder (blue) loses its effectiveness strongly beyond about thirty degrees especially if it is put to starboard. The sense of rotation of the propeller is right-handed (clockwise), so the lateral component of the twisted inflow is to port in the lower half, where the edge of the twisted rudder is deflected not so far away from the inflow than the one of the symmetrical rudder.

Fig. 4 shows a 35/5 zig-zag test. Evidently, the manoeuvring behaviour is similar with both rudders.

The advantages of the twisted spade rudder mainly focus on avoiding cavitation damage and on improved propulsion properties on a straight course. In this case, the reduction of required power amounts to 2-3%.

With the help of comparative model test investigations it has been shown that the advantages of the twisted spade rudder can be achieved for a large container vessel, keeping the manoeuvring properties comparable to those with a conventional semi-balanced rudder.

Fig. 3 Comparison of the Lateral Rudder Force Coefficients

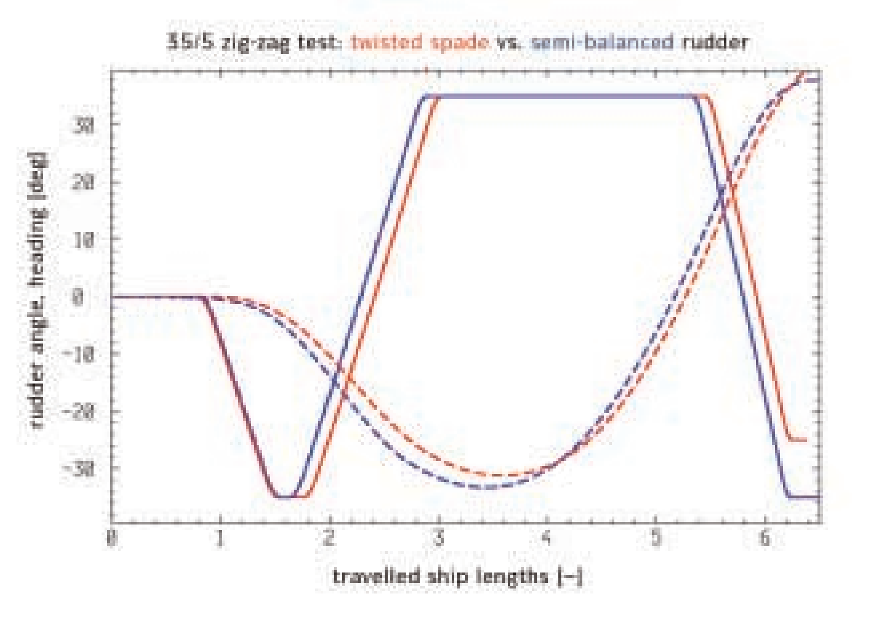


Fig. 4 Comparison of the Zig-Zag - Test Results

notes

sept. 28 – oct. 2, 2004

SMM 2004

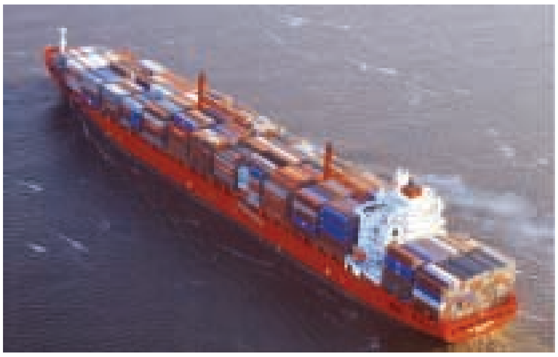
Visit us at our new place:

Halle 12, Stand 220

The next **HSVA-Seminar** for Ship Owners and Operators

will be held on **February 24th, 2005**.

The seminar will focus on economic and safe ship operation from the technical point of view. Aspects, such as propeller cavitation, vibration, seakeeping, manoeuvring and performance of ships in ice will be tackled!



MEMBER OF STAFF

JUERGEN OELLERS

Juergen Oellers joined HSVA in 1979. Before he worked for 5 years as scientific fellow at the Technical University of Aachen, where he had received his degree Dipl.-Ing. in electrical engineering in 1974.

At HSVA he first worked for the seakeeping department, mainly involved in full scale tests within the research project "North Sea Platform".

After that he worked at HSVA's large towing carriage. In March 2004 Juergen Oellers was nominated as head of the tank operation department. He is responsible for the whole towing tank operation including outfitting of models for the tests.

Juergen Oellers is married and has two daughters. In his spare time he enjoys the time with his family and skiing in the Dolomites.

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