HSVA
NewsWave
THE HAMBURG SHIP MODEL BASIN NEWSLETTER 2004/1

Reorganisation for better Service!

Starting February this year HSVA new managing directors took responsibility for HSVA.

Professor Gerhard Jensen is the head of the Fluid Dynamics and Ship Theory department at the Technical University Hamburg-Harburg and is acting part time for HSVA. Gerhard Jensen had been managing director of HSVA until September 2000.

Jürgen Friesch works for HSVA since 1979 and has been the head of the Cavitation and Propeller Department until his assignment as deputy managing director.

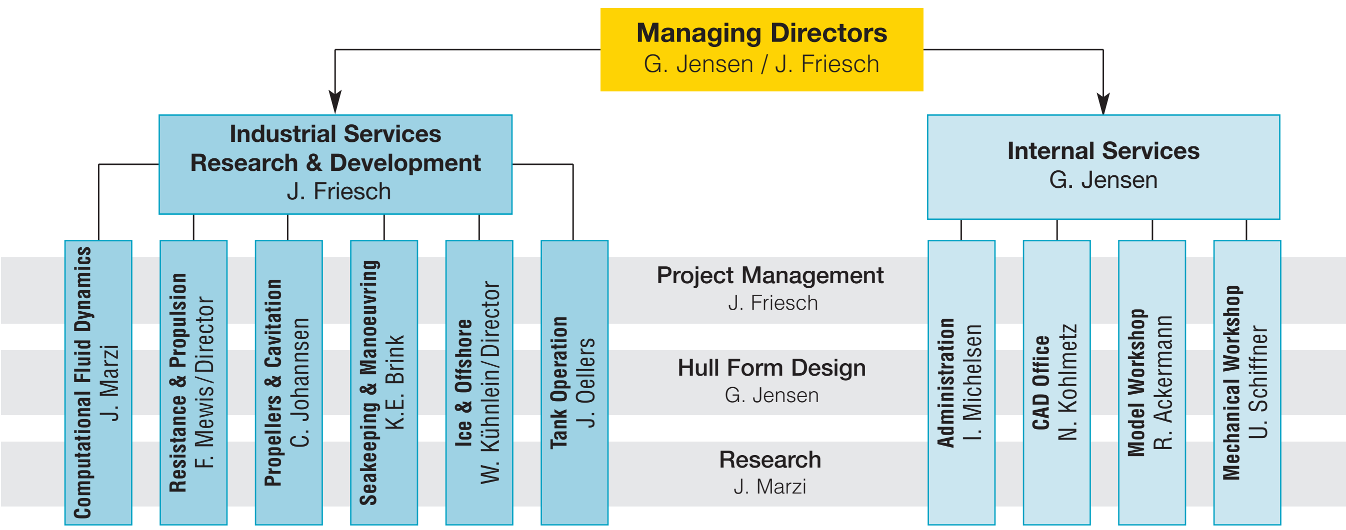
"We will develop HSVA further as one of the leading professional organisations for ship hydrodynamics in open water and in ice", is their common statement. HSVA's main goals are to be a world leader in

- ***Quality***
- ***Efficiency***
- ***Fast Customer Services***

Customer orientated services and research have always been the solid foundation for HSVA's business activities. Research to improve our highly sophisticated facilities, our test methods and procedures is essential to meet the future challenges and to solve the questions of our clients. HSVA shall be the central point for applied research in all areas related to transport systems and ship technologies in open water and in ice. To improve HSVA's efficiency further, among the first thing the new management tackled was a new organisational structure.

Responsibilities are clearly structured along specific technical tasks taking advantage of the highly educated, experienced and motivated staff. This will make sure that the best know-how and quality is available and research and development in specific areas can go directly into customer projects.

HSVA Organisational Structure



Many CFD applications have emerged from HSVA´s research activities and their application is now transferred into the corresponding technical departments, so that experimental and computational investigations complement each other.

The CFD - department will concentrate on more demanding numerical solutions and on the internal CFD-Software development. A special task force is formed for hull form design using specialists from all departments.

Modern hydrodynamic developments require interdisciplinary thinking. Therefore all projects are led by qualified project managers, who coordinate all developments technically as well as organisationally.

Research is the foundation of technical improvements and competent customer services. Interdisciplinary research becomes more and more important. Dr. Jochen Marzi was installed as the coordinator of HSVA´s research activities.

The internal services include an Administration Department the Model Workshop and the Mechanical Work shop, as well as a newly formed CAD-office. The CAD-office will not only prepare the necessary drawings for model manufacturing, but also co-operate with the work shops to improve the already high technological level of Computer Aided Manufacturing in HSVA, in order to produce models to highest quality standards in the shortest possible time.

In future issues of our Newswave we will introduce more details of the work of the departments.

HSVA DISPLAYS CFD – VIRTUES

by Jochen Marzi

Six leading European Marine CFD players have joined forces to address the challenge of the European "The Virtual Basin" Integrated Project.

VIRTUE (The Virtual Tank Utility in Europe) has been initiated in response to the European Commission's 2nd call of the new framework programme (FP6 – Sustainable Growth and Development). Co-ordinated by HSVA, leading European Model Basins – MARIN, SSPA – together with Academia – Univ. of Glasgow/Strathclyde and consultants – Principia, Atkins – collaborate on the preparation of a proposal for this demanding task.

VIRTUE will improve and integrate state-of-the-art CFD tools in a comprehensive simulation environment of ship behaviour at sea aiming to complement real test basins in the provision of marine hydrodynamic services.

STRATEGIC OBJECTIVES:

- To increase the competitiveness of the European shipbuilding and shipping industries through this enhanced system of hydrodynamic analysis and optimisation by improving product quality and lead times.
- To enable improved communication between CFD tools and other sources required to generate and store information for a comprehensive product data model thus facilitating the overall design process.

More specifically, the Virtual Basin intends to

- provide services from four different virtual tanks covering all relevant aspects of hydrodynamic analysis in ship design
  - the Virtual Towing Tank
  - the Virtual Seakeeping Tank
  - the Virtual Manoeuvring Tank
  - the Virtual Cavitation Tank/Tunnel
- integrate these tanks to allow for multi-objective optimisation in an all embracing way, based on common standards for data provision and results presentation
- develop and validate advanced analysis methods for applications beyond present capability to further enhance the range of services to be expected from test basins.

Assembling Europe's leading marine CFD research, development and consulting centres, this approach will assure the best possible, flexible and all-embracing development strategy. VIRTUE's future services will allow the European Maritime Industry to attain and keep a competitive advantage in ship design and production of advanced products.

10 Years CSBC and HSVA

A Long and Enjoyable Cooperation for the Mutual Benefit of the Yard and the Model Basin

by Peter Schenzle and Christian Johannsen

It has been 10 years now that CSBC (China Shipbuilding Corporation) in Taiwan and HSVA are practising a regular cooperation in numerous Container Vessel projects between 1500 and 5500 TEU besides such diverse projects like Bulk Carriers, Tankers, RO-RO Vessels and even Heavy Lift Carriers.

It is the wide experience of HSVA in these fields and particularly in analysis and design of hullforms and propellers for large container vessel projects that suggests this cooperation for a competent design team of a successful shipyard on the global market.

The latest examples of this long and enjoyable cooperation were the container vessel projects CSBC CV1500, CV4050, CV4250 and CV5500.

According to all these propeller designs model propellers were manufactured at HSVA and tested in the large Hydrodynamics and Cavitation Tunnel (HYKAT) together with the respective complete ship models. Beside observation of the cavitation behavior measurements of the propeller induced hull pressure pulses were performed.

Fig. 1 CSBC CV 5500 at Design Draught, 26.5 kts

For all these ships special attention was paid to a low vibration level, i.e. to reduce the excitations resulting from the cavitating propeller to a minimum. For this reason for all ships at least two different propeller designs had been generated by CSBC. These designs featured different radial load and pitch distributions along the propeller blades to achieve smallest possible but nevertheless stable and non-erosive sheet and tip vortex cavitation.

The test loops were arranged in a way, allowing to react with the second design on HSVA's recommendations and the results obtained with the previous one.

This enormous expense paid back in terms of a very satisfying cavitation performance. In all four cases a good compromise could be achieved between a smooth and stable cavitation appearance, a low excitation level and non the less a sufficiently high open water efficiency.

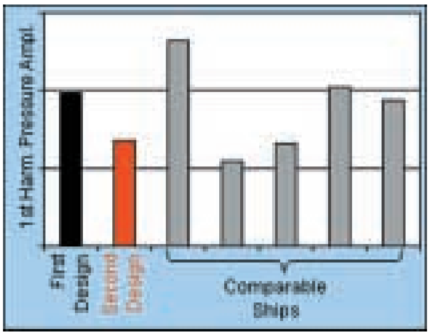


Fig. 2 Hull Pressure Pulses CV 4050

Fig. 2 shows exemplarily the encouragingly low hull pressure pulse level obtained with the second propeller design for the CV 4050. The figure shows both the large improvement from the first to the second design as well as the low amplitudes in comparison to other ships of similar capacity and power. Of course this second design was convincing in all other design aspects as well.

HSVA is looking forward to continue the fruitful cooperation with CSBC in the future.

Model Tests in an Ice Channel with an AFRAMAX Tanker

by Karl-Heinz Rupp

Fig. 1 Close tow

Oil and gas trade in sea areas with seasonal ice coverage are becoming more and more common in Russia in the Sakhalin region (Pacific Ocean), Pechora (Barents Sea) and Kara Sea region as well as from the port of Primorsk through the Baltic Sea. Tankers sailing these routes must be able to sail in ice covered water safely and economically with the help of icebreakers.

It is common practice in many countries to guide ships in ice covered waters using an icebreaker. The cargo vessel is led through the ice by the icebreaker, with the icebreaker breaking the ice and the cargo vessel following in the broken channel. In more difficult ice conditions it can occur that the cargo vessel is not able to follow in the broken channel with its own power. In several countries it is common practice for the icebreaker to take the cargo vessel directly into its stern notch. This contact towing is called “close tow” (Fig. 1). The steering ability of the icebreaker under these conditions is restricted but nonetheless possible when the beam of the icebreaker is larger than the beam of the cargo vessel.

This traditional way of guiding cargo vessels in ice fails when the beam of the cargo vessel, for instance that of a tanker, is larger than the beam of the icebreaker. The waterline beam of large icebreakers is in the range of about 20 to 30.5 m. In the case that the tanker’s beam is larger than that of the icebreaker, the broken channel is not wide enough and the tanker has to widen the channel by breaking ice with its forward shoulders. An AFRAMAX tanker has a beam of about 40m to 46m. Breaking ice with the forward shoulder results in a very high resistance for the tanker because the shape of the forward shoulder is usually disadvantageous for breaking ice as the frames are mostly vertical (see Fig. 2 and Fig. 3).

One way to guide a tanker with a wider beam than the icebreaker is to use two icebreakers, with the first one breaking the channel and the second widening it. The tanker follows in a channel of about 1.4 to 2 times the beam of the tanker. In this ice channel both smaller and larger ice floes contribute to the ice resistance of the following tanker (Fig. 4).

In order to investigate the speed, resistance and power in different ice thicknesses a comprehensive ice model test program was carried out in HSVA’s ice model basin on behalf of HYUNDAI HEAVY INDUSTRIES for an AFRAMAX tanker.

The ice thickness was varied in the range from 0.3m to 1.0m with a flexural ice strength of 500 kPa. The ice channel was prepared using two icebreakers (Fig. 4). The tanker followed in the newly broken ice channel. The bow of the tanker shifted the ice floes aside, submerged and sometimes broke larger ice floes (Fig. 5). The test demonstrated

Fig. 2 Sailing in an ice channel smaller than the beam of the ship

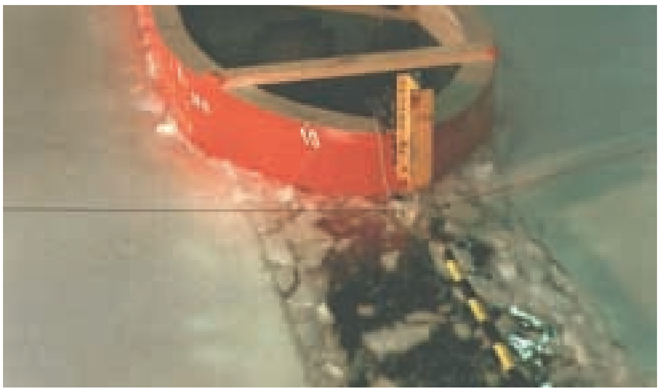


Fig. 3 Sketch of the conditions when sailing in a narrow ice channel

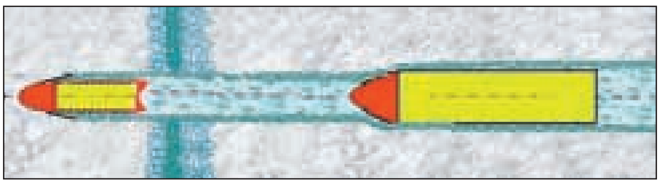


Fig. 4 Preparation of a wide ice channel with the help of two icebreakers in model and full scale

that the tanker is able to follow the two icebreakers at a speed of more than 5 knots in the ice of the target operational area at both design and ballast draft with the available installed power.

Furthermore tests in a channel filled with brash ice (very small ice floes) were carried out in order to determine the ability of the tanker to fulfill the Finnish –Swedish ice rules. Here it was found that the required power was much

Fig. 5 Sailing in a wide ice channel

lower than that predetermined based on the equation in the regulations. An ice channel with brash ice simulates the typical Baltic Sea ice channel where several ships per day use the channel, and through this use the brash ice is kept small (Fig.6).

Model tests in ice are an important tool during the design phase for investigating the performance of the tanker in defined ice conditions.

Fig. 6 Brash ice channel in model and full scale

A THREE YEAR EU PROJECT SUCCESSFULLY COMPLETED!

by Juergen Friesch – Coordinator EROCAV

The main aim of the work within EROCAV was to develop a practical tool to assess the risk of erosion on ship propellers and rudders in an early design stage.

Motivation

The maximum power for single screw ships has grown from 30 to more than 70 MW over the last two decades. The speed of the ships and therefore the loading on the propeller increased. Together with the increase in ship's speed and propeller loading, the inhomogeneous inflow to the propeller leads to an increased danger of cavitation on the propeller and the appendages (rudder and struts). Cavitation can cause erosion resulting in severe material damage with a number of negative consequences like damages to rudders, appendages and propellers (propulsors) which may end even in a total loss of propeller blades, excessive vibrations and loss of efficiency which will increase the impact of emissions on atmospheric pollution. This results in strong costs for the owner.

Although ships have been model tested for decades, there exist no real good prediction methods for cavitation induced erosion. The risk of erosion on a ship propeller or rudder depends on the impact strength of the cavity implosions and on the resistance against erosion of the propeller or rudder material. Therefore within the EROCAV project a systematic analysis of possible erosion mechanisms and the related cavitation patterns was performed, scaling effects were addressed, bubble collapse impact correlation by use of acoustical measures were investigated and the role of cloud cavitation for the occurrence of erosion damages was checked. The main focus of the work was on the identification and the understanding of global as well as more detailed hydrodynamic mechanisms generating erosion. Such knowledge is supposed to be the key to understand the possibilities to simulate erosive cavitation processes by model experiments or by computational methods. And finally it formed the basis for the formulation of guidelines for the design of propellers and rudders. The combination of fundamental studies and well controlled experiments in model as well as full scale result in a unique knowledge concerning the hydrodynamic mechanisms involved.

Fig. 1 Damaged Propeller Blade Tips

FULL SCALE INVESTIGATIONS

The full scale work has been carried out very successfully. The cooperation with the owners was very good. Instead of the planned three ships four ships have been investigated. The results available are a set of fully documented cavitation observations and corresponding erosion data. This is more or less unique. The results show a variety of mechanisms causing erosion on propeller and rudder. Apart from the regular mechanism of cloud cavitation behind a sheet, observations have shown that slight cloudy streaks near the tip can also cause propeller erosion. In particular cavitating vortex structures originating from the propeller leading edge appear to be potentially erosive. Rudder erosion was expected to be caused by tip vortices, but the mechanism seems to be more complicated in that erosion is especially caused when there is breaking up of the cavitating tip vortex upstream of the rudder. The mechanism involving the existence of a cloud of cavitation and the subsequent implosion on the

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Fig. 2 Rudder Damages

rudder have to be investigated further. The observations have shown that there are indeed erosion mechanisms which have not been considered in detail until now. It was found that some types of cavitation which were believed to be harmful might not always be as harmful as expected allowing more space for optimisation of propellers from the efficiency point of view. For example some pressure side cavitation on propellers was occurring frequently without causing erosion damages. Since this type of cavitation has always been considered to be very erosive, more investigations are necessary. The co-operation in EROCAV has already led to a cooperative investigation at full scale by four "ex-EROCAV members" to investigate this phenomenon further.

MECHANISMS OF CAVITATION INDUCED EROSION

The work on the review and implementation of models concerning the mechanism of cavitation induced erosion covers more than what is traditionally meant by "mechanisms". Examples of classical hydrodynamical mechanisms are the formation of a micro jet at the collapse of a spherical cavity close to a solid body and the formation of a small group or cloud of sub-cavities. This micro jet and the shock wave emitted at the collapse of the clouds are supposed to be the main mechanisms of cavitation erosion. It has been the aim of the research in EROCAV to start from these and look for more large scale mechanisms related to erosion that create links between the small scale mechanisms mentioned above and the behaviors observable in ordinary model tests to judge propeller and rudder designs. Therefore the principle of energy focusing by a collapsing cavity is generalized and formulated for practical applications. A conceptual model for the hydrodynamics of erosion is introduced and a handbook for observation and analysis of eroding cavitation was written. This handbook has been elaborated with clear definitions, a categorization of different cavitation types was made and a guideline to judge a certain observed cavitation behavior concerning the danger of erosion was formulated. Due to the wide scope of the project, this handbook has been tested against simplified model tests with a straight wing, model tests with a propeller behind a ship model and the respective full scale observation.

PREDICTION TOOLS

Another main objectives of the research work was to develop and improve erosion prediction methods based on model tests. Three different test techniques have been investigated in detail, the work went well for the paint test technique and the High Speed Video observations. The work related to the impact method shows, however, even if the application seems promising, the interpretation of the signals, both in the fluid and / or the material is so complicated that only an initial application could be obtained. Further research efforts will be necessary to make this method a practical tool for every day work. It must be stated that model experiments are and will continue to be the only reasonable way to make predictions, concerning the influence of cavitation on the occurrence of erosion. Besides the detailed observation of the cavitation phenomena, high speed video observation and paint tests are the most reliable tools at the moment. Unfortunately the paint test method up to now does not give reliable results for the prediction of cavitation induced rudder erosion. Further research is needed to develop an adequate paint. Therefore the only way to judge the danger of erosion on rudders is to observe the cavitation phenomena very carefully.

COMPARATIVE MODEL TESTS

The results of the full scale measurements and the new developed tests techniques have been used in an extensive series of model tests in the different test facilities of the partners. Both methods, the paint test method and high speed video observations were used to compare the model test results with the full scale data. The analysis of the physical behavior of the observed cavities was made, using the rules given in the handbook. The results show that cavitation patterns on propellers can be reproduced quite well in cavitation test facilities mainly behind whole ship models, but also dummy models give quite reliable results. The risk of erosion on the back side of the propellers was reproduced quite satisfactory in all facilities using the paint test technique. High speed video observations appear to be a powerful tool to detect erosive types of cavitation and to improve the knowledge concerning the structures of the cavities further and should therefore be used routinely. The prediction of face side cavitation and its influence on erosion seems to lack sufficient accuracy and needs to be investigated further. The prediction of erosive cavitation on rudders based on model tests is much more difficult, mainly because of very low Reynolds numbers involved and the interaction between vortex structures and the different types of flow across and around the rudder, especially at different angles of attack. The paint test technique does not always give reliable results and therefore detailed observations are the only way to judge the danger of erosion on rudder models. It is suggested to perform additionally detailed investigations with large models in a separate test set-up.

GUIDELINES

One of the aims of the consortium was to develop guidelines based on the results of the work performed and make them available to others. In these guidelines the accumulated knowledge was applied in a practical way and split into three main parts. The first part is related to the design stage before model test results are available, the second part deals with improvements on designs after model test results are available and the third part is related to improvements of existing hardware when damages have been found after some time of operation of the ship. In all three parts, the problems related to propellers and rudders are treated separately.

Fig. 3
Comparison of Damages, Full Scale Observations and Model Tests Results

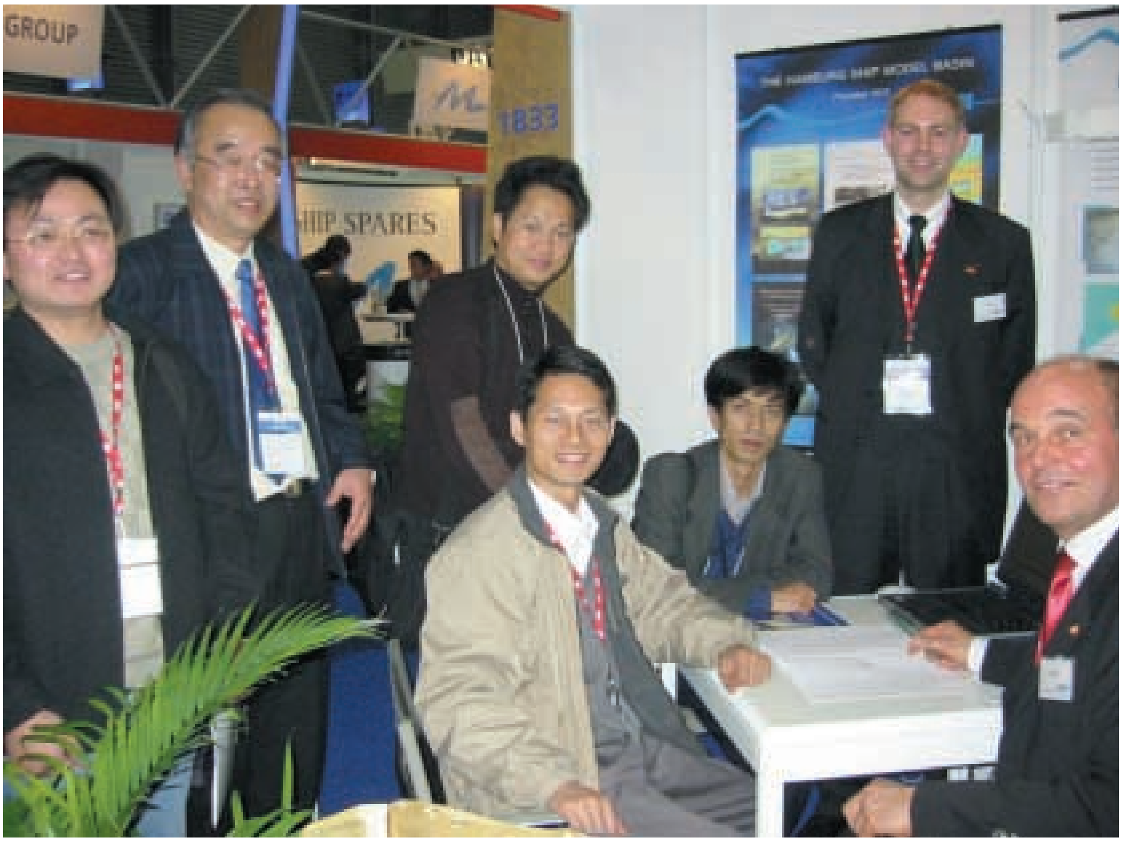
HSVA ON THE MARINTEC CHINA 2003 IN SHANGHAI

by Hilmar Klug

The biannual maritime trade fair **MARINTEC CHINA** was held in Shanghai from 2-5 December 2003 in the Shanghai New International Expo Centre (SNIEC). This fair is the most important maritime event in China. For the first time HSVA participated in this trade show with its own stand located in the German Pavilion in Hall No.1. The two representatives, Mr. Friedrich Mewis (Head of the Resistance and Propulsion Department) and Mr. Hilmar Klug (project manager), were very busy throughout the entire show and welcomed new customers as well as old business friends at the stand. For instance Mr. Lou Dan Ping from Hudong-Zhonghua Shipbuilding (Group) visited HSVA with his colleagues for discussion of current and future projects for which model tests were or will be performed at HSVA.

Beginning on the opening day of the exhibition, HSVA and Becker Marine Systems (BMS) started a close cooperation and announced the instalment of an agency for HSVA's services which will be run by Mrs. Zhang Yong Yin in the Shanghai bureau of BMS.

For HSVA the participation in the **MARINTEC CHINA** was a great success and we will have our own stand in 2005 again.



Mr. Lou Dan Ping (with light brown jacket) and his colleagues from Hudong-Zhonghua Shipbuilding (Group)

Hydrogen Flow Simulation:

an Investigation on Battery Gas Spreading during recharging the Electrical Battery of a Forklift

by Petri Valanto

A modern forklift is often powered by a relatively massive electrical battery located in a closed compartment under the drivers seat. During recharging the battery releases significant amounts of hydrogen and oxygen gases. The mixture of hydrogen with oxygen or with air is highly flammable. The hydrogen/air mixture can burn in relatively wide volume ratios, between 4% and 75% of hydrogen in air. Therefore it is important to make sure that the hydrogen concentration in the forklift interior does not rise over critical limits in any circumstances.

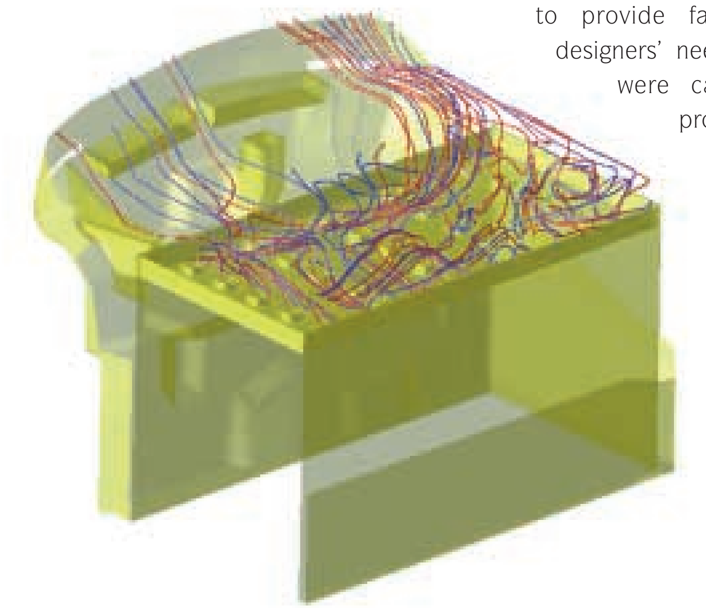
HSVA carried out an investigation of the hydrogen and oxygen concentrations during the charging of the battery of a new forklift design for one of the leading manufacturers of material handling products. The purpose of the investigation was to help to design a battery space with sufficient escape possibilities for the hydrogen gas in order not to exceed critical hydrogen limits in the forklift. Three different cases with the standard geometry and in addition four alternative designs were investigated with the Reynolds-Averaged Navier-Stokes Equations (RANSE) solver Comet.

The problem was modelled as an initial value problem of two gases starting to flow out of the battery cell vents when the recharging starts. In the beginning the forklift spaces are filled with air, the concentration of the hydrogen and oxygen increase until the situation stabilises, that is, the outflow of these gases becomes equal to the inflow from the battery vents into the forklift, and the concentrations level off.

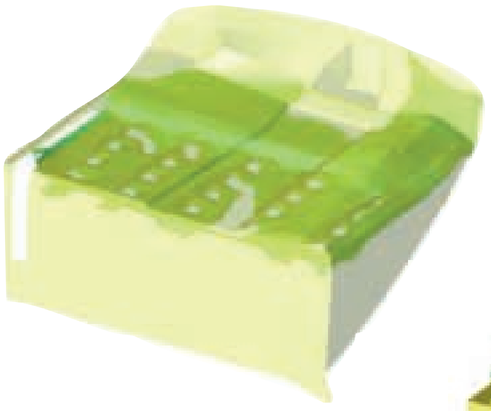
We have used a relatively coarse grid to speed up the computation and to provide fast response to the designers' needs. The computations were carried out using 12 processors of the HSVA's 40-processor PC-cluster. The computed results compare favourably with existing measurements, help to explain the measured results, and provide concentration values corresponding quite well with measurements with a similar, but not identical geometry.

Beside the diffusion of hydrogen and oxygen in the air, the large density difference between hydrogen and the other gases is the most important driving mechanism of the flow. It causes high buoyancy forces, which generate a strong airflow through the battery chamber.

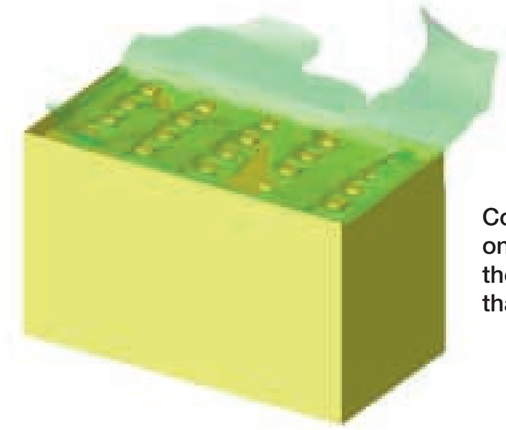
The density difference driven flow inside the complicated geometry of the battery chamber reaches speeds at which the transition between laminar and turbulent flow can take place. As the computations were in general carried out assuming turbulent flow, one steady state computation assuming laminar flow was carried out for comparison. The hydrogen gas distribution computed as a result of turbulent flow yielded slightly higher concentration values and corresponded better with



Modelled spaces of around the battery: The bonnet on top is removed. The streamlines show the movement of hydrogen (red) and that of oxygen (blue). All streamlines start from battery cell vents, where the gases flow out of the battery into the battery compartment.



Computed isosurface of one percent hydrogen concentration shown under the semitransparent bonnet.



Computed isosurface of hydrogen on the battery. Above the isosurface the hydrogen concentration is higher than one percent, below it is lower.

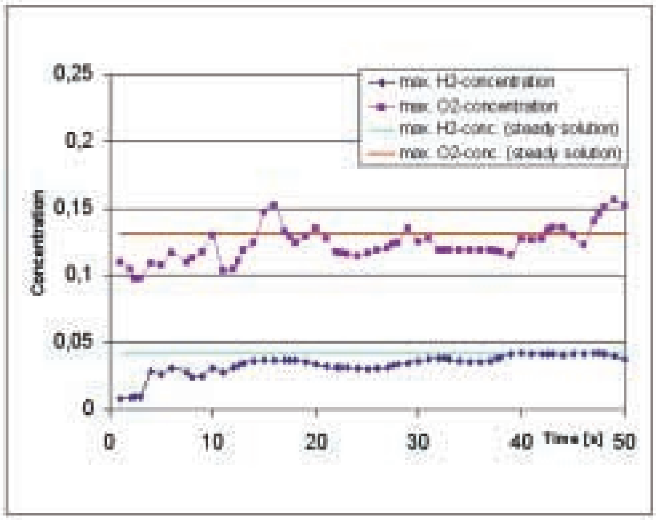
the measurement than the computation with laminar flow. This check showed that the turbulent computations are on the safe side and thus improved the reliability of the results.

In order to check that the unsteady solution converges properly, also a steady solution was computed for some cases. The steady solution does not provide the maximum gas concentration values, which appear relatively soon after the recharging is started, but it gives the concentration values in the equilibrium state, which the system should reach after the initial phase. In all cases the transient maximum gas concentration values of the unsteady solution also approached the maximum steady state values. Thus all the results are very coherent.

The diffusion between the various gases is modelled in the Navier-Stokes solver with Fick's law, which accurately describes the diffusion of one component in case of a binary mixture, and in the case the binary diffusion coefficients have the same value for all pairs of the components in a multi component mixture. The equation of mass conservation is satisfied by Fick's law only if all mass diffusion coefficients are given identical values. As the diffusion coefficient of hydrogen in reality deviates from this common value, one steady case was computed to investigate the effect of this approximation on the computed results. The computation with the diffusion coefficients from the literature showed about 0.7 per cent higher hydrogen values than the computation with the standard values of Comet. The distribution of the hydrogen was, however, very similar to the earlier computations with the standard values of the coefficients.

The computations showed that the hydrogen level was in most cases at acceptable level. The investigation gave light on the various possibilities to reduce the hydrogen concentration, provided practical hints for design and thus helped to make the right design decisions.

With this project HSVA gained further experience in the numerical modelling of gas spreading through diffusion and convection in complicated inside spaces. Considering the use of batteries in submarines and other vehicles and the increasing use of hydrogen related applications, e.g. fuel cells, HSVA is in a good position to provide flow simulations for purposes of design and safety.



Development of the maximum hydrogen and oxygen concentration as function of time. The highest gas concentration is usually reached shortly after the start of the recharging.

notes

Representative in China

Starting December 1, 2003, Becker Marine Systems - China will be the official representative of HSVA in Shanghai, P.R. China.

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MEMBER OF STAFF

HERBERT BRETSCHNEIDER

Herbert Bretschneider joined HSVA in 1999 as scientific employee in the department Propeller/Cavitation/Hydroacoustics. He is one of HSVA's project managers in the fields of acoustic model testing and theorectical investigations such as measurement and prediction of cavitation noise and propeller noise of non-cavitating conditions.

Before he experienced for 8 years acoustics in design, construction and approval for several projects in the naval ship construction department at Nordseewerke GmbH in Emden.

He studied physics in Hamburg and received his Dipl.-Phys. from the University of Hamburg.

In his spare time he enjoys sports by climbing and playing volleyball.

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