SVA items

SCHIFFBAU-VERSUCHSANSTALT POTSDAM GmbH

No. 3, August 1997

Theoria cum praxi

Research, development and work for clients are an inseparable unity in the work of the Potsdam Model Basin. Under inclusion of recent results of basic research of universities, other institutions and the own research results the SVA Potsdam contributes to the development of new products of their customers. In the last year more than 70 % of our proceeds class with research and development. The rest of our work class with standard services.

The main part of our research work lies in the field of numerical ship hydrodynamics. Computational fluid dynamics is a powerful tool for the estimation of the flow and the velocity distribution around the ship hull, bodies and other profils, the optimization of the hull form, the estimation of the velocity distribution in the propeller plane. The estimation of the infuence of the flow on hydraulic structures and soles of waterways is done by the program TASCflow in the Potsdam Model Basin. These results are used for industrial orders. In this way the influx to the propeller was optimized for a fast monohull vessel, the entrance channel of a waterjet was optimized, the wake distribution for a yacht and other ships was estimated and the stress on the sole was estimated by higher motorization for example.

Another special field of our research work is the investigation on propulsion systems. New propulsion systems were developed in cooperation with partners in the industry and used at new types of ships. For instance the SCHOTTEL Twin Propeller, developed by the SCHOTTEL Werft in Spay together with the SVA, was investigated for special types of ships, like double ended ferries and cruise liners. But last but not least also numerical simulations implemented in the research work. The results of the research program „Propeller design by inverse methods" are in use for the propeller design now.

Palace Schloß Cecilienhof

Research work for clients in the cavitation tunnel

In recent years the SVA has done new practical research in propulsion systems in the cavitation tunnel, like the LINEAR Jet, overlapping propellers, trochoidal propellers, selfadjusting propellers.

The cooperation with our clients plays an important role in our work, for instance with the SCHOTTEL Werft in Spay and the AIR Technology GmbH in Rostock. Results of the common R & D work are the SCHOTTEL Twin Propeller and the TIP-Vortex-Vane (TVV) propeller. In the future the SVA will investigate the so called SCHOTTEL-SIEMENS- Propeller for an electrical propulsion system. In the last years we have tested the AIR - Propeller made out of carbon fibre reinforced materials in relation to a conventional metal propeller. In the next years we have a strong collaboration in the research of propeller with flexible blades.

Hans-Jürgen Heinke
Head of Cavitation Tunnel

Calculation of viscous flow around conventional and high-skew marine propellers

Introduction

The interaction between propeller and hull should be considered during optimization of marine propellers. The interaction is largely influenced by viscous effects and only viscous flow computations will be able to treat these problems successfully. The boundary layer from the hull has a strong effect on the flow conditions at the location of the propeller and vice versa. As a result, the numerical simulation of propeller flows based on the solution of the Reynolds averaged Navier-Stokes equations is receiving increased attention.

In order to have an useful tool for calculation of the propeller performance, it is necessary to develop strategies for the efficient generation of grids around a wide range of propeller shapes. In addition, efficient numerical methods must be available to allow the solution of the equations in a matter of hours in a workstation environment.

As mentioned in the SVA items No. 2, the numerical calculation of viscous flow around marine propellers is a subject of a research project at the Potsdam Model Basin. This project was started two years ago in collaboration with Advanced Scientific Computing (ASC), in Otterfing, Germany. Thanks the support of the German Ministry of Education, Research and Technology it was possible to do extensive numerical calculations for different propeller geometries.

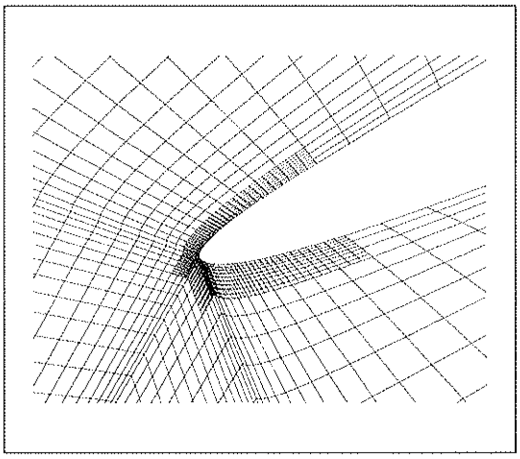


Figure 1: Grid refinement in leading edge region

Results

Because the results of the research project will be published soon, only few results of the numerical simulations for three propellers will be shown here, see figures.

The open water test for the propellers VP 4020 and VP 4021 have been done in the cavitation water tunnel of SVA GmbH. The two propellers have an outer diameter of 250 mm and are mounted on a hub with a diameter of 70 mm. The test-section is rectangular and has been approximated by a cylinder of diameter 310 mm. During the tests, the propellers where operating at a constant number of 25 revolutions per second. Off-design conditions were achieved by changing the speed of the water in the tunnel. The experimental data of the open water test for the propeller P 2133 have been obtained from the towing tank of HSVA.

The outer boundary for the computation is therefore not as well defined and an outer radius of 310 mm was used, as in the previous computations. The outer diameter of the propeller was 260 mm and the hub diameter 47 mm. The computations were performed at = 25 rps.

The computations have been performed with ASC's fluid dynamics software TASCflow Version 2.6 (ASC, 1995). The method is based on a conservative second order finite volume scheme with co-located variables. An algebraic multi-grid algorithm is employed to accelerate the convergence of the linear solver. Turbulence is modelled by the k-ε model.

The following boundary conditions were specified:

- Inflow: Velocity vector specified
- Outlet: Pressure specified at one face. All other variables extrapolated.
- Propeller and hub: Wall function boundary conditions.

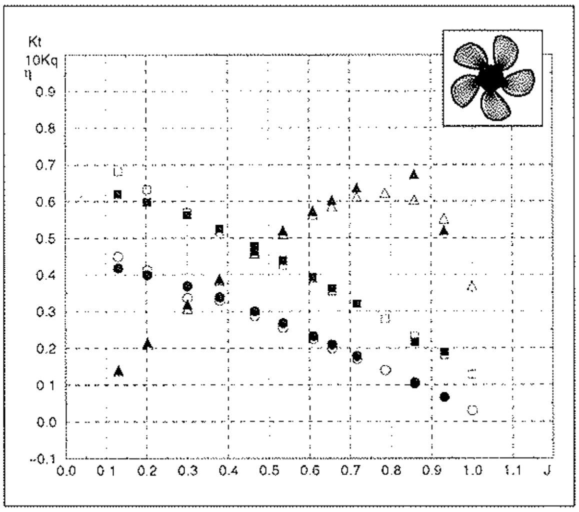


Figure 2: Comparison of thrust parameter K_t and torque parameter K_q for the conventional marine propeller VP 4020 in comparison with experimental data.

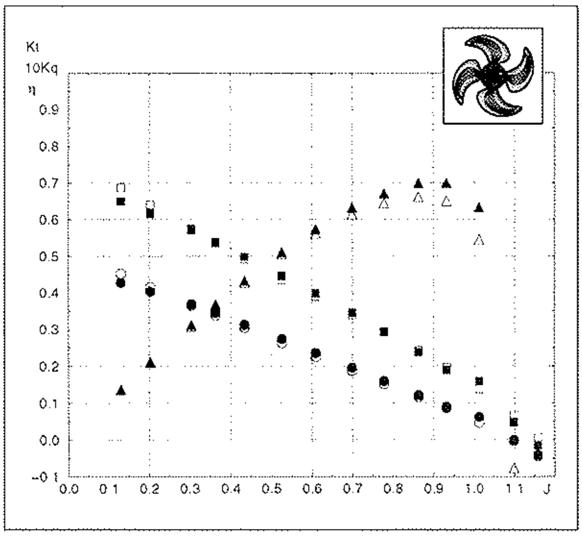


Figure 3: Comparison of thrust parameter K_t and torque parameter K_q for the skew marine propeller VP 4021 in comparison with experimental data.

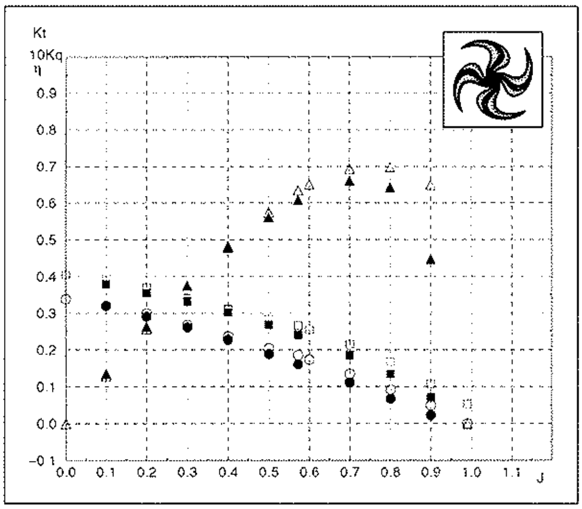


Figure 4 Comparison of thrust parameter K_t and torque parameter K_q for the high-skew marine propeller P 2133 in comparison with experimental data.

- Tunnel walls: Slip condition.
- Side boundaries: Periodicity on all variables.

The number of grid points used to obtain the following results was 261072. In the leading edge region a local grid refinement (grid embedding) was performed, as shown in Fig. 1. Figures 2, 3 and 4 show the results of the open water tests. The integration of the forces is carried out over the surface of the blade and the hub (which is also included in the force measurements). The abscissa in Figs. 2, 3 and 4 is the advance ratio:

The design points for the propellers are at J = 0.656 (VP 4020), J = 0.699 (VP 4021) and J = 0.6 (P 2133). It can be seen from Figs. 2 and 3 that the numerical results are in very good agreement with the experimental data for the propellers VP 4020 and VP 4021. There are only slight differences between the results at the extreme off-design conditions. The differences might be a result of still insufficient grid resolution, shortcomings in the turbulence model for separated flows or experimental deficiencies. Especially at low flow speeds (small J), there is an influence of the propeller induced flow on the flow speed in the circulating water tunnel.

For the propeller P 2133 the agreement between the simulations and the experimental data is still good, although there are larger differences than for the other two cases, Fig. 4. This might largely be due to differences between the discretized and the real geometry specially in the tip region, which was not well known as in the other two cases. For example, the stagnation point of the hub was upstream of the propeller in the experiments, but downstream in the simulations, which might account for some of the differences. Considering these difficulties, the agreement between the numerical results and the data is still surprisingly good.

Detailed comparison of the numerical results and the experimental data from flow field measurements also have been done. In addition, a detailed grid refinement and tests with an alternative turbulence model are planned for the future. Grid refinement studies for these three-dimensional flow problems will be done using the parallel version of TASCflow.

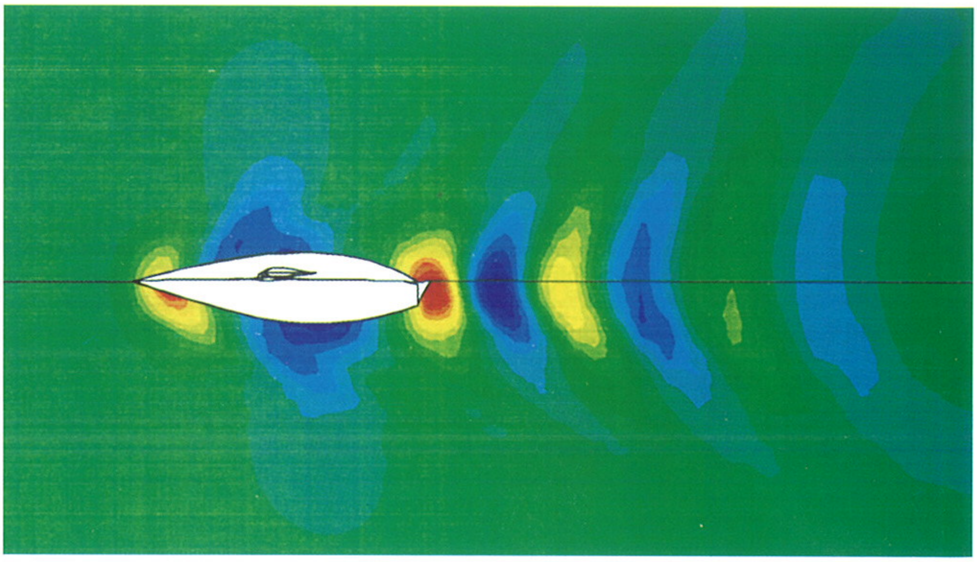


Figure 1: Potential flow calculation - wave contours for flat keel for 12 degree roll angle and 4 degree drift

Optimization of keels inclusive body for sailing yachts on the base of numerical viscous calculations

Within a research work project the viscous flow around the keels of sailing yachts were estimated. RANSE investigations were carried out with two different codes, TASCflow and Comet. The numerical calculations with Comet are carry out in closed cooperation with Prof. Perić (Institut of shipbuilding, Hamburg). During the investigations drift and roll angles were varied. Model tests were executed for validation of the calculations. For that reason a wooden model was manufactured with a scale of 1:2. In addition to an ordinary keel a flat keel and a keel with wings were investigated. The lines of the sailing yacht including the keels were delivered by Prof. Brandt (TU Berlin). For the tests the development of a special measuring technique was necessary. The main problem was the relation between the small longitudinal forces and the comparable great transverse forces and moments. A solution was found in compact sensors for 6 components which were ordered on purpose of these tests.

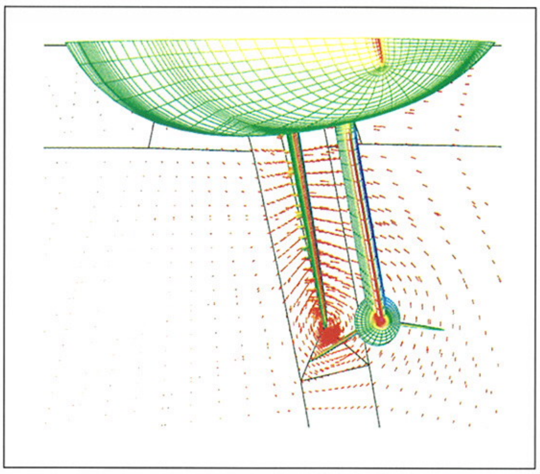


Figure 2: Viscous flow calculation - tip vortex, wing keel

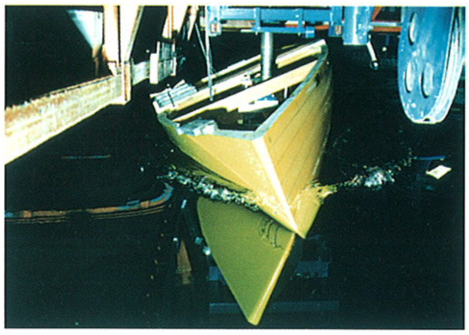


Figure 3: Model test

The test program enclosed 33 different sailing conditions for every keel, that means a totality of 99 runs, which were carried out in the towing tank of the Potsdam Model Basin. Beside the usual parameters resistance and drift force of the model, the forces and moments on the keel and the rudder in all main directions were measured. The results of that research work shall be used in an other research work, which comprises the development and manufacture of a full scale „sailing dynamometer". The aim of that work is to reach a further progress for the yacht industry in Germany.

Members of the staff

Moustafa Abdel-Maksoud

Moustafa studied Naval Architecture at the Alexandria University, where he obtained his BSc. and MSc. Ship Hydrodynamics at the Berlin University of Technology was his further educational choice. After working in a varity of research projects at the Institute of Ship and Offshore Technology (ISM) of the Berlin University of Technology he earned his Dr.-Ing. degree in May 1992 on the subject of application of RANSE-Solvers for the investigation of interaction between hull and propeller.

Moustafa continued his activities as a research assistant for more than one year at ISM. He has been employed at the Potsdam Model Basin in April 1994. He has mainly engaged in the application of modern CFD-methods for hull form development. Since March 1996 Moustafa is the head of the Numerical Simulation Department. He is also a member of the 22nd ITTC Resistance and flow committee.

He is married. His hobbies are reading and playing squash in spare time.

Impressum
SVA items
2. Jahrgang (1997) Nr. 3
SCHIFFBAU-VERSUCHSANSTALT
POTSDAM GmbH
Marquardter Chaussee 100
D-14469 Potsdam
Phone + 49 - (3 31) 56 71 20
Fax + 49 - (3 31) 5 67 12 49

Layout und Satz:
Knoll- Verlags-, Werbe- und Informationsagentur

Inland navigation forum in Brandenburg and Berlin

The Potsdam Model Basin is moderator and coordinator of this forum.

Inland navigation can be an important factor for the efficient development in industry and trade especially in the region of Berlin and Brandenburg. Under this slogan representatives from shipyards, shipping companies, loading companies, forwarding agencies, research institutes and policy have had an opening meeting in January in Potsdam.

Under the protectorate of the ministry of traffic in Brandenburg and the senate of traffic in Berlin this forum declares for the improvement of the competitiveness between the different traffic carrier like road and railway in the future. Under the aspects of lowering of cost and nonpollution the inland navigation must include intensively in closed transportation lines. New transport products and lines must be find for the inland navigation.

Now two workgroups, workgroup 1 „Public relation / Marketing" and workgroup 2 „Infrastructure", find out the problems in the use of inland navigation and in the inland navigation themself and and forced for solution of this problems in policy and industry. The possibilities and demands to industry, local and federal policy will be presented in a final forum in November of this year.

The ship model No. 1000 in the Potsdam Model Basin

The completion of the 1000th ship model was celebrated in middle of April in Potsdam Model Basin. That means 1000 basic models and more than 2.500 hull form variants have been investigated.

It is a model of a hydrografic survey ship with a length of 60 m and a breadth of 12.5 m for the Bundesamt für Seeschiffahrt und Hydrographie (BSH). It will be apply in the Baltic and North Sea. In the SVA there have been done resistance and propulsion tests for speed prognosis and tests for estimation of the manoeuvring characteristics of this ship. The ship will built by the Kröger Werft in Germany and finished in October 1998.

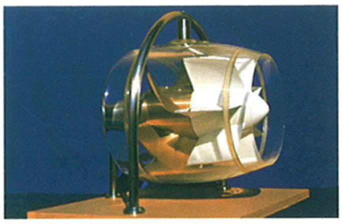
LINEAR-Jet: A powerful propulsor for fast ships

JAFO-Technology Hamburg and the Potsdam Model Basin (SVA) have developed and investigated a propulsor for fast and unconventional ships. The propulsor called LINEAR-Jet.

The propulsor works similar to a water jet. It consists of a rotor, guide vane and a de acceleration nozzle. The position is the same like a ducted propeller.

The propulsion system LINEAR -Jet has a couple of advantages especially for fast and flat going ships.

- The velocity in the area of the rotor is less then the velocity at the trailing edge of the duct. For that the cavitation starts at higher velocities.
- The cavitation behaviour was investigated in oblique flow in a range up to 5 deg. The cavitation behaviour is nearly independent from the angle of attack in this range.
- The maximum efficiency of the LINEAR-Jet is about $\eta_0=70$ %.
- The thrust loading coefficient of a LINEAR-Jet can be up to ten times higher then the thrust loading coefficient of a ducted propeller, without cavitation problems.



Model of LINEAR - Jet

For that reason it is possible to

- reduce the diameter, compared with an open propeller.
- reduce the noise by reduction of the revolutions.

Further advantages are:

- The stream of the propulsor is nearly spin free.
- If the LINEAR-Jet is powered by a Z-drive, the shaft covers by a blade of the guide vane.
- By shaft-powered LINEAR-Jets working with a rudder, the danger of rudder cavitation is low. The reason of that is the spin free stream.

Model tests for the patrol boat have shown the advantages of this system.

The LINEAR-Jet is an attractive alternative for fast ships; especially for ships with a design velocity between 20 and 30 knots and for ships with a high thrust loading coefficient.