MMG NEWS
Research and Innovation
MMG The Propeller
Efficiency by MMG | Mecklenburger Metallguß GmbH | **November 2015**

Virtual options but real savings

By analyzing today's shipbuilding and conversion projects, it is obvious that we are facing design options and configurations with much larger differences than in the past. For example, the number of different available engine options cover a broad range of engine speeds. Furthermore the operational demand may change during the early project phase several times as the shipping companies are much more focused on the optimum vessel adapted to their specific transportation task.

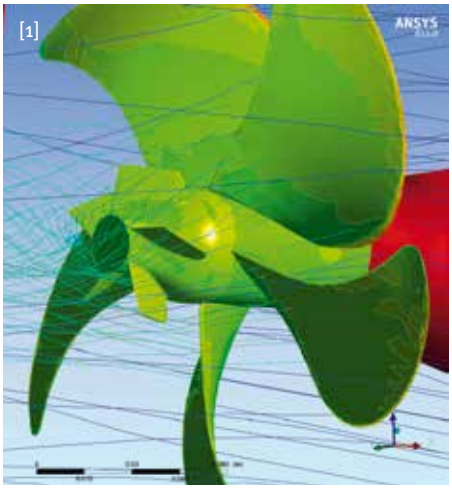
This gives us two challenging design tasks. On the one hand it is necessary to obtain the specifics of the transportation task within the propeller design more or less as a global and at the same time sophisticated criterion. Thus we have to handle the incidence of each single design demand as an impact on the propeller main dimensions. On the other hand the hydrodynamic interaction between propeller and hull is of special interest. Here the detailed blade design influences the propulsive efficiency of this complex hydrodynamic systems. And in order to ensure maximum efficiency ratios the minimisation of possible interaction losses is one of the important duties.

Both design requirements are to be based on a proper data base and from a numerical perspective on direct hydrodynamic calculations. As ship design in general and the layout of propulsion drives in particular have a long history of experience based, semi-empirical calculation methods, the reorientation to a more direct way of hydrodynamic design is quite demanding but also highly promising.

The freshest development of CFD software and especially the increasing affordable numerical capacities give a clear statement on the usability of these methods in daily propeller design. Nowadays the simulation of a propulsion test can be computed with available or even leasable numerical capacity in less than real-time at much lower costs. However, beside the costs the analysis of today's retrofit projects indicates that time pressure is the more important reason to use the numerical propulsion simulation as a design and verification instrument.

In contrast to this close insight into the ship flow, the question of operational based design demands a statistical usage of the direct calculations. In order to ensure the flexibility of the design routines to obtain many different operating situations the individual design responses have to be identified by fast but accurate computations. These requirements nowadays lead to intensified development activities in the field of CFD methods based on the potential flow theory. The algorithms are fast and robust but accurate enough. As usual, the right mixture is decisive.

Thus, MMG combines the benefits of different in-house and external Open-source as well as commercial software tools to support the propeller design and construction processes time-efficient and reliably.



[1] CFD simulation of high efficiency arrangement

More Innovation. Lower Costs.

As a clear statement to the requirement of most efficient propeller drives MMG set up the world's unique and innovative design and manufacturing standard "5D Propulsion". It covers the use of five high-tech digital technologies, recent findings and latest research in combination with more than 65 years expertise in the field of ship propellers.

Herewith MMG ensures highest efficiency in design and in full scale. Based on consequent data handling and processing the detailed design information will not be reduced in their resolution. Whether setting up the CAM files or checking the final geometry the process always keeps the highest geometrical precision.

The standard 5D Propulsion is based on the following five key technologies for design and manufacturing, developed in cooperation with universities and research institutes:

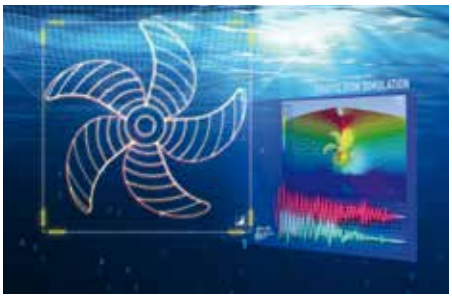
[1]

5D MDC
Multidata Design Concept

In order to obtain the vessel's operational profile within the hydrodynamic design of the propeller the Multidata Design Concept (MDC) uses operation specific data, such as load and draughts, drift angle, running speed, current, wind and swell within the evaluation process of optimum propeller main dimensions. This procedure ensures a propeller design which is optimised for the desired transportation task of the vessel. By this method the propeller is no longer limited to the standard parameters and a static specification point.

Classic calculation methods cannot cope with these new requirements. However, MMG has developed an innovative algorithm in collaboration with the Hamburg University of Technology (TUHH), which gives the opportunity to incorporate more than 2,000 operating points in every calculation. This density of information ensures best coverage of the real ship operation conditions by this simulation. Here especially propeller rudder interactions based on realistic operating conditions can be transferred from vessel operation towards design of propeller and rudder.

5D NPS
Numerical Propulsion Simulation

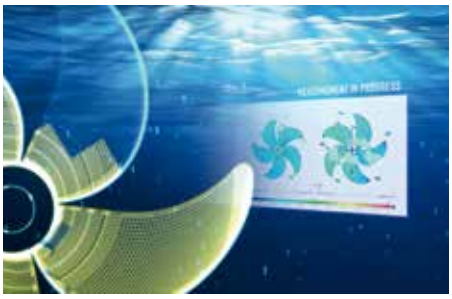


MMG developed Numerical Propulsion Simulation (NPS) as a precise but sufficiently rapid tool for recalculating propulsion data for desired hull-propeller-configurations. The technique is based on modern CFD methods considering the necessary influences like viscous effects as well as the unsteadiness and the detailed 3D geometry. This gives reliable results for possible interaction losses between propeller and hull and supports the optimisation process towards an increased overall efficiency. Finally, NPS can be compared with the classical propulsion test, whereas the virtual test gives more freedom in changing the configurations from one design step to another.

Starting with pilot project MSC Flaminia, which was retrofitted with a new energy saving propeller designed only based on NPS so far twenty further projects were finished successfully. Since the introduction of MMG 5D propulsion NPS is inherent part of the MMG design procedure and is able to give strong support in all design projects. Beside the evaluation of efficiency differences between individual designs especially the precise prognosis of resulting propeller speeds for perfect propeller engine matching is useful outcome of these simulations.

[1] MMG 5D Propulsion products

5D OPM
Optical Precision Measurement

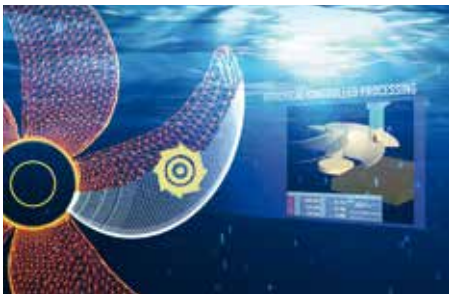


In order to ensure that all benefits of the propeller design can be kept during the manufacturing process MMG uses the Optical Precision Measurements (OPM) as a geometrical check. Since the introduction of MMG 5D propulsion the standard geometry check at MMG is made based on OPM. Whether for casting patterns, directly after casting or as the final acceptance test. OPM always gives highest density of geometrical information to these evaluation procedures.

Another application of OPM is the accuracy check of model propellers. An example is the propeller model of a 20k dwt multi-purpose vessel. During model tests the measured open water characteristics of mentioned propeller clearly deviated from the previously calculated performance indicating an error. Hence, the model basin and MMG checked their test or calculation methods for irregularities. Finally, OPM revealed significant inaccuracies of the blade geometry. The model basin measured the open water characteristics of the model propeller variants in the towing tank. Repeated tests showed not only an increase of maximum propeller efficiency by about 3.5 per cent but also an increase in achievable ship speed. This example shows the effectiveness of OPM even before the start of propeller manufacturing.

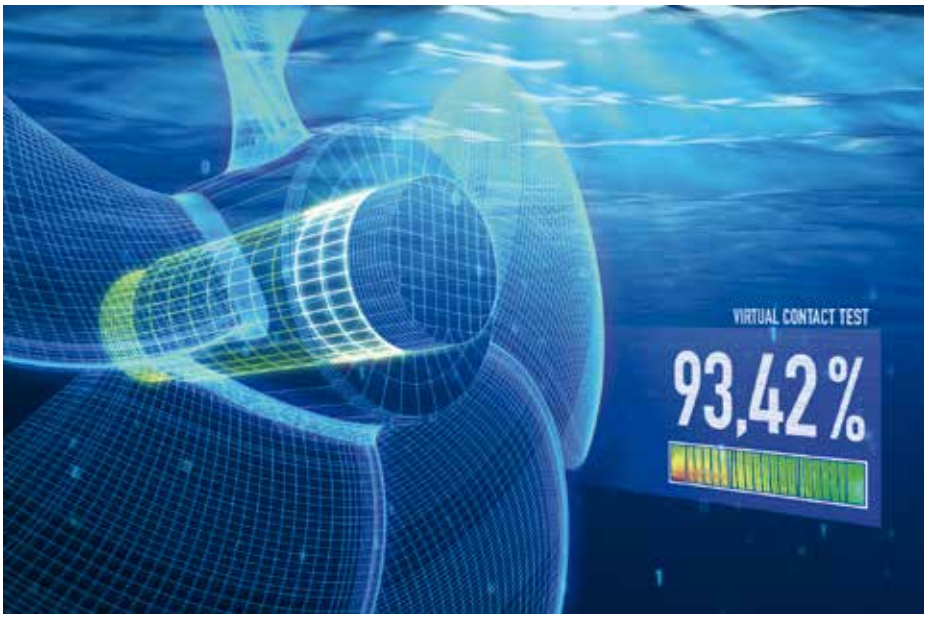
The propeller is scanned with an accuracy of up to 1/100 mm using fringe pattern projection and an optical sensor. The propeller only is awarded the “Efficiency by MMG” certificate when the results of the OPM are in perfect alignment with the design geometry.

5D NCP
Numerical Controlled Processing



Numerical Controlled Processing (NCP) involves all numerical processes during MMG’s construction and manufacturing procedure. With the most accurate free formed surfaces using modern CAD software the basis is set for all geometrical evaluation – whether for best fit algorithm just after casting, as a basis for CAM works or as a rule for the final quality check. This ensures proper geometry and data handling at every step of the process. With our CAD tools we have high flexibility to quickly explore various design concepts. The powerful shape analysis features allow us to ensure the quality of freeform blade design from the beginning of the design process to the final acceptance test.

The direct interface to powerful CAM software tools ensures the loss-free data transfer to all CNC-controlled machine tools. This allows an increase of surface accuracy of all MMG propellers. Therefore, the minimum targets requested by the ISO standards can be beaten reliably.



5D VCT
Virtual Contact Test

MMG has developed the Virtual Contact Test (VCT) as a key technology for propeller replacement for vessels in service. But the procedure reduces the expenditure on propeller assembly even for Newbuilding projects.

With VCT the conical hub bore of the new propeller is measured precisely down to a hundredth of a millimetre and aligned with the design data of the existing shaft while still in the MMG workshop. Based on these measurements the propeller is supplied ready for fitting. The MMG engineers will test the dimensions of the ship‘s shaft using a mobile measuring unit for final check.

As the VCT is already recognised and approved by the leading classification societies, the traditional blue bedding test is outdated – in both redesign programmes and on new ships.

Since its establishment MMG’s VCT over 60 measurements have been carried out. Part of which within vessel conversion VCT has become increasingly popular during regular dry-docking as means of preparation for future retrofitting.

Mecklenburger Metallguß GmbH
Teterower Str. 1 · 17192 Waren (Müritz) · Germany
Phone +49 3991 736 0 · Fax +49 3991 736 210
research@mmg-propeller.de · www.mmg-propeller.de

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Recent projects – ultra large and not less efficient

Following the increased demand for efficient ultra large box ships and the improvement of the existing fleet ship-owners recently requested MMG to take part in several new-building projects as well as efficiency improvement programs.

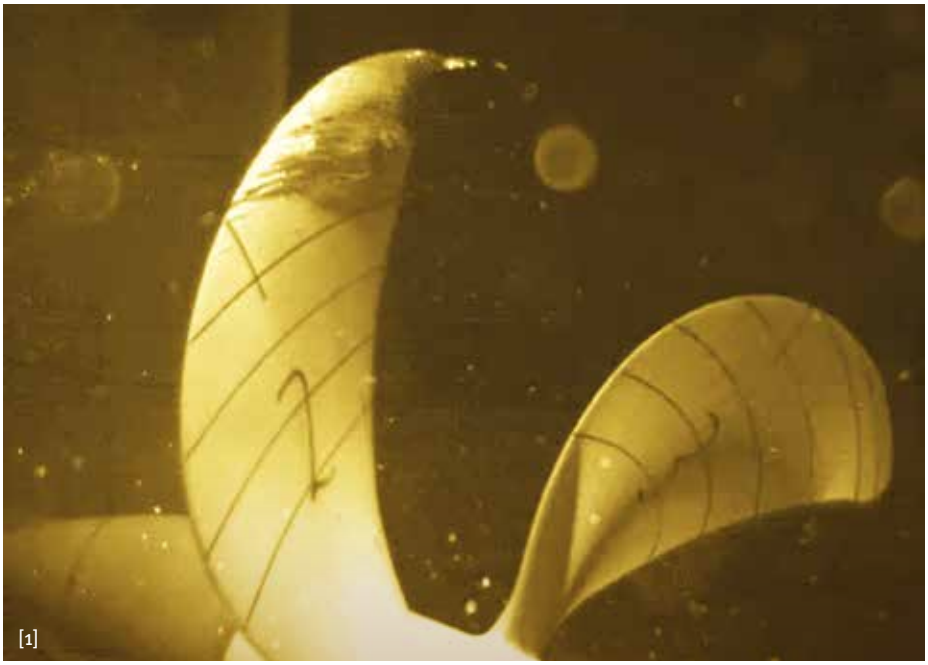
Focusing new container vessels, several projects successfully could be finished resulting in more than 30 orders for container ship propellers with capacity larger than 18,000 TEU. Despite the generally lowered achievable speeds and engine sizes, these propellers again stand for new superlatives in propeller design and manufacturing.

In parallel ship-owners enhanced their fleets by different efficiency improving measures. This includes the exchange of the existing high-speed propellers with especially slow steaming adapted new high efficiency propellers. MMG was able to acquire more than 170 retrofit propeller orders for different vessel sizes. Manufacturing quality as well as design capabilities could convince ship-owners to trust MMG within these challenging efficiency improvement projects. Depending on vessel size and design quality of the original arrangement MMG was able to achieve economically relevant savings.

Vessel Size (TEU)	No. of Ships	Saving
3,000 – 6,000 TEU	30	4 – 7 %
6,000 – 8,000 TEU	36	5 – 9 %
8,000 – 10,000 TEU	38	6 – 15 %
10,000 – 12,000 TEU	4	5 – 10 %
12,000 – 14,000 TEU	58	6 – 11 %
› 14,000 TEU	8	6 – 9 %

KONKAV – Research on Cavitation

Together in a consortium of partners at universities and research institutes MMG investigates the mechanism of cavitation induced erosion on ship propellers. Beside the numerical effect of cavitation and the related erosion risk the simulation of the structural-mechanical process is of special interest. This demands extensive investigations of static and dynamic material parameters in order to calibrate and evaluate the computer simulations. Based on this research MMG improves the analysis of possible erosion damages. This leads to a more accurate prediction of the remaining duration of riskless operation. The research enhances the understanding of the difference between harmless and harmful cavitation phenomena and therefore is to be seen as a basic research for all design and optimisation works. The projects lasted three years and covered the development of hydrodynamic simulation tools as well as the improvement of several prediction methods.


[1]

[1] Suction side cavitation

Publications

Erfahrungen mit Propeller-Re-designs für Slow Steaming
STG Sprechtag – Intelligente Nachrüstung von Schiffen zur Verbesserung des Schiffsbetriebs

Numerical Self-Propulsion Tests with ANSYS CFX
CADFEM User's Meeting 2014

Das MMG Re-Design Programm
Hanse-Sail Business Forum 2014

Development and Verification of an Open Source Overset Grid Library
Numerical Towing Tank Symposium 2015