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Voith Water Tractor – Improved Manoeuvrability and Seakeeping Behaviour

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SYNOPSIS

The demand for manoeuvrable tugs able to work in exposed conditions is growing. There are more and more offshore activities worldwide, with new LNG terminals opening where tugs have to work under severe conditions, with waves, currents and high wind loads. The requirements of an offshore tug are different from a harbour tug. The tug motion is a limiting factor for operations not only because of unacceptable acceleration for the crew on board, but also for the material, eg the fendering system. There is also the question of the reduction in efficiency of the tug owing to exposed conditions: the motion of the tug and the inflow due to waves and current affects the propulsion system and the ship's hull.[1]

This paper will focus on the way Voith is working to improve the design of Voith Water Tractors. At the previous Tugnology in 2007, Voith presented together with Force[2] the introduction of simulator technology at Voith's premises. The models for the simulator have been created in a traditional way based on model tank tests and full-scale measurements. The model tank tests are mostly based on the so-called PMM method whereby the model ship follows forced manoeuvres and, based on the measured forces, the derivatives are developed and will be used by the simulator. Full-scale methods are only applicable to ships that have been built and are therefore not convenient for future designs.

INTRODUCTION

Voith is now developing a method to actively use the simulator in the design of tugs. There are very often design goals with conflicting interests, such as turning ability and the capability of creating indirect steering forces. The simulator offers a unique way to judge early in the design phase the influence of different elements of the Voith Water Tractor.

The Voith Water Tractor is a unique tug concept, consisting of a comparatively flat ship hull, two Voith Schneider Propellers (VSPs), a propeller guard (thrust plate) and a fin. The two VSPs, the propeller guard and the fin are hydrodynamically active elements because they are creating hydrodynamic lift.

Figure 1: A Voith water tractor in exposed conditions.

During the design phase, it is very important to understand the influence of each part on the total behaviour of the tug, for example an increased fin has a very positive influence on the indirect steering forces, the course stability and the rolling behaviour, but the turning ability is decreased.

This paper will present a computational fluid dynamics -based method (CFD) which, early in the design phase, gives the analysis through the use of the simulator.

THE VOITH WATER TRACTOR AND THE VOITH SCHNEIDER PROPELLER[3]

Figure 2 (*see end of paper*) illustrates when and where assistance from the shiphandling tug may be necessary. The efficiency of a ship's rudder increases approximately in proportion to the square of the speed. Conversely, its steering capacity falls rapidly as the speed of the ship decreases. Depending on the size and type of ship, and on wind and current conditions, or conditions in a particular area, it may be necessary to provide assistance at relatively high speeds of as much as 6-8 knots. The Voith Water Tractor (*see Figures 3 and 4*) covers all the above aspects. Thanks to the two possible methods of operation – direct and indirect – the VWT can assist a ship safely over a wide range of speeds. The introduction of the Voith Turbo Fin (VTF) has further improved the indirect capabilities of the Voith Water Tractor at lower speeds.

The distinguishing feature of the Voith Water Tractor is that the propellers are located in the bow section, where they are protected by an integrated guard plate. Other important elements are the aft stabilising fin with the towing gear mounted above it and the centrally mounted, logical controls (*see Figure 3*).

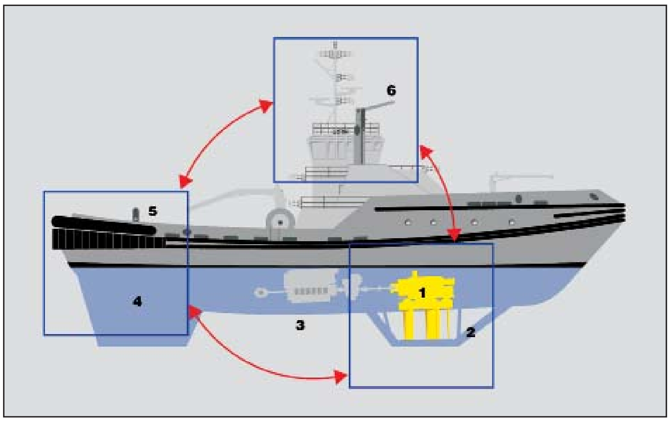

Figure 3: Characteristic features of the Voith Water Tractor.

Figure 4: VWT **Oden** *(Svitzer) in escort mode.*

The Voith Schneider Propeller has the unique facility of steering the thrust in any direction steplessly. The basis is its vertical axis. *Figure 5* shows a sectional drawing of the VSP and *Figure 6* shows the Voith Schneider Propeller installed in a tug boat.

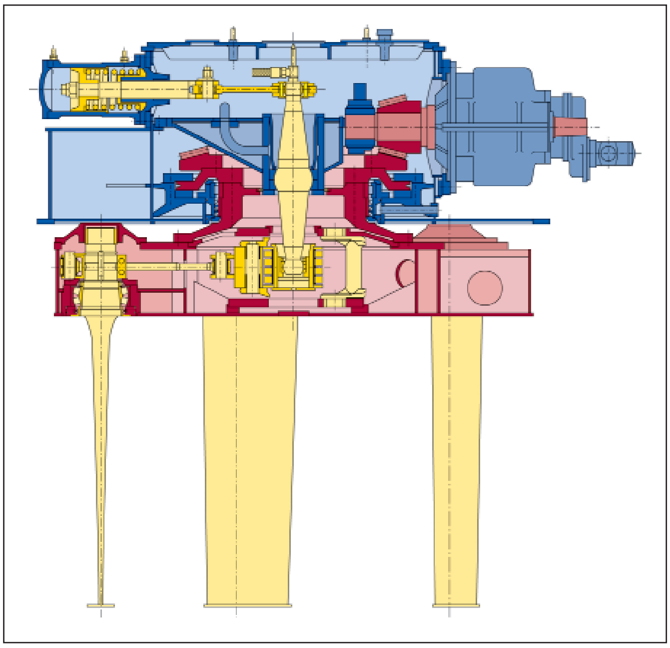

Figure 5: Sectional drawing of a Voith Schneider Propeller.

Figure 6: Installation of two VSPs in a VWT.

NEW APPROACH TO IMPROVING THE MANOEUVRABILITY AND SEAKEEPING OF VOITH WATER TRACTORS

Figure 7 demonstrates the design steps Voith is using to develop on new tug concepts. Based on the requirements of steering forces, bollard pull, main dimensions, seakeeping behaviour etc, a prototype design of a VWT hull is made which is used for a CFD analyses. Firstly a CFD model is created which can be used to calculate the resistance of the vessel and to do the CFD-PMM calculation – to be explained later. The propeller can be included in the CFD calculation and a precise forecast of the propulsion power is also possible.

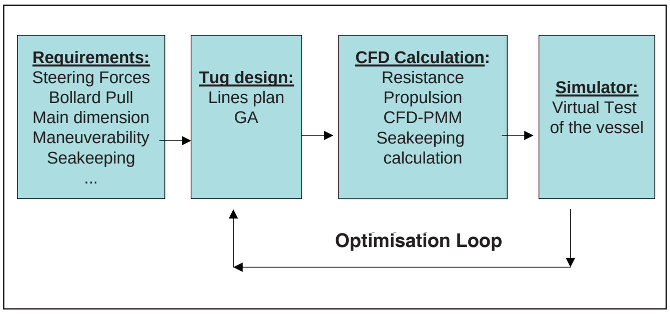

Figure 7: Design loop, based on CFD and simulator.

CFD PMM

It is important to find a method of having the new ship hull in the simulator within a very short time. There it is possible to test the manoeuvring characteristics of the tug either by fast time simulation or by the more time-consuming real-time simulation. The experimental Planar Motion Method (PMM), as used by Force, was exactly the pattern required for the CFD method. This has the advantage that the calculation of the derivatives used for the simulator is straightforward as developed by Force Technology. Selected manoeuvres for the CFD calculation are shown in *Figure 8*.

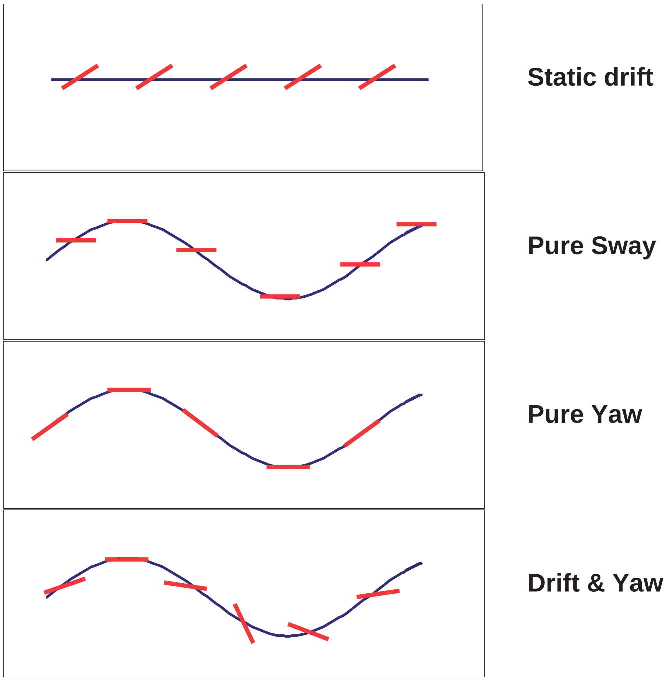

Figure 8: Selected PMM manoeuvres.

Results

All calculations have been carried out by adapting the commercial CFD code COMET[4,5]. The motion of the vessel is considered by a 6 Degree of Freedom (6 DOF) model, which is coupled directly with the RANSE code. The influence of the free surface is also considered *(see Figure 9*).

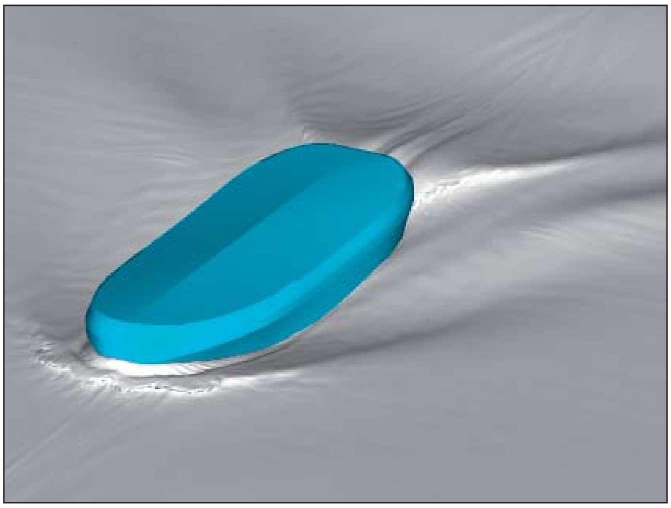

Figure 9: Calculated free surface of manoeuvring VWT.

A comparison of the CFD calculation with the measurements carried out by Force Technology[2] will be given. All calculations have been carried out for the Voith Water Tractor with VSP guard, struts of the guard and fin. The VSPs were not included in this calculation. Measurements had been carried out for the same arrangement.

The resistance and the transversal force of the VWT are shown in *Figure 10* and *Figure 11* demonstrates a low speed situation (two knots) as a function of the yaw angle.

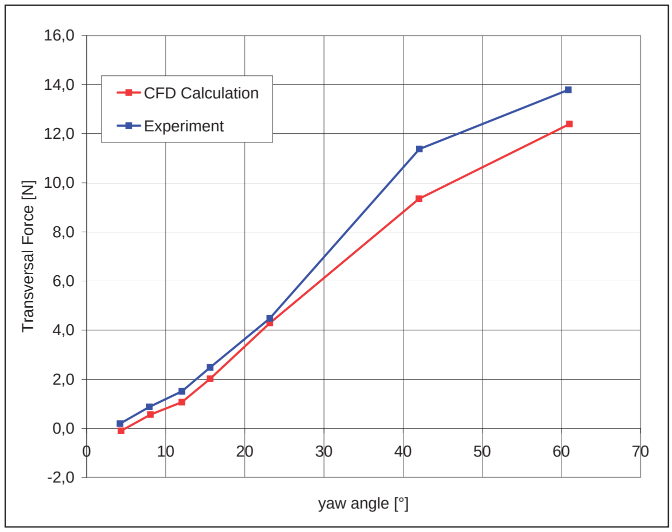

Figure 10: Resistance as a function of the yaw angle, comparison of measurement and calculation, sailing VSP ahead; U = 2 knots.

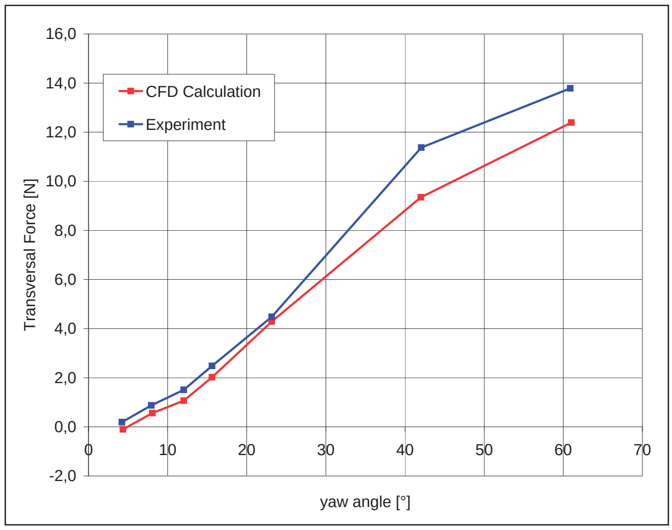

Figure 11: Transversal force as a function of the yaw angle, comparison of measurement and calculation, sailing VSP ahead; U = 2 knots.

The method can also be used to get a deeper insight into the contribution of the individual parts of the VWT on the steering forces. As an example, *Figure 12 (see end of paper)* shows the percentage on the transversal forces of the struts of the guard, fin, hull and guard for a static yaw angle of 16 degrees. There is a remarkable difference if the tug is sailing VSP first or fin first, with the fin forces especially more efficient in creating transversal forces if the tug is sailing fin first.

In total, the steering forces are 25 per cent higher when sailing fin first, ie in the escort mode. In this case the fin has optimal inflow conditions and the leading edge is respectively designed.

Manoeuvring simulation

Based on the CFD calculation, a simulator model can be created which can be used for either fast-time simulations or for real-time simulations. The simulator gives the opportunity to compare turning ability and steering forces for different scenarios. A modification of individual parts of the VWT can also easily be incorporated – a good example is the fin size.

Figure 13: Escort trial in the simulator.

A detailed analysis of all sailed manoeuvres is important, as are the forces of the propeller and the whole system. The simulator technology offers a unique way of getting a deeper insight into the physics of the individual manoeuvre (*see Figure 14 at end of paper*). Here the tug is tested as an LNG terminal tug. The LNG carrier is approaching the harbour and the VWT gives steering assistance.

CONCLUSIONS

The Voith Water Tractor can be improved by using the simulator technology. A new VWT design can be tested in an early phase of development by the simulator.

Important parts of the simulation are the hydrodynamic derivatives for the simulator model. To generate these, Voith has adopted the CFD technology. The method is called CFD-PMM and means that all tests done in past can now be conducted numerically through the use of CFD. A comparison between calculated and measured results tallies for most of the manoeuvres.

The ship design can then be easily tested in the simulator either with fast-time or real-time simulation and any one-off changes, eg the fin size, can be effectively tested.

REFERENCES

[1] *SAFETUG – Tugs Operationg in Waves*, Johan De Jong, Tugnology 2007, Southampton, 11-12 June 2007.

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[4] *Prediction of Resistance of Floating Vessels*, D Jürgens, M Palm, M Schreck Peric, Proceedings of Marine CFD 2008, Southampton, 26.-27. March 2008.

[5] *Matching the Reality of Ship Hydrodynamics through CFD*, M Palm, Second Symposium on Voith Schneider Technology, Heidenheim, 4-6 June 2008.

Figure 2: Speeds at which assistance may be required.

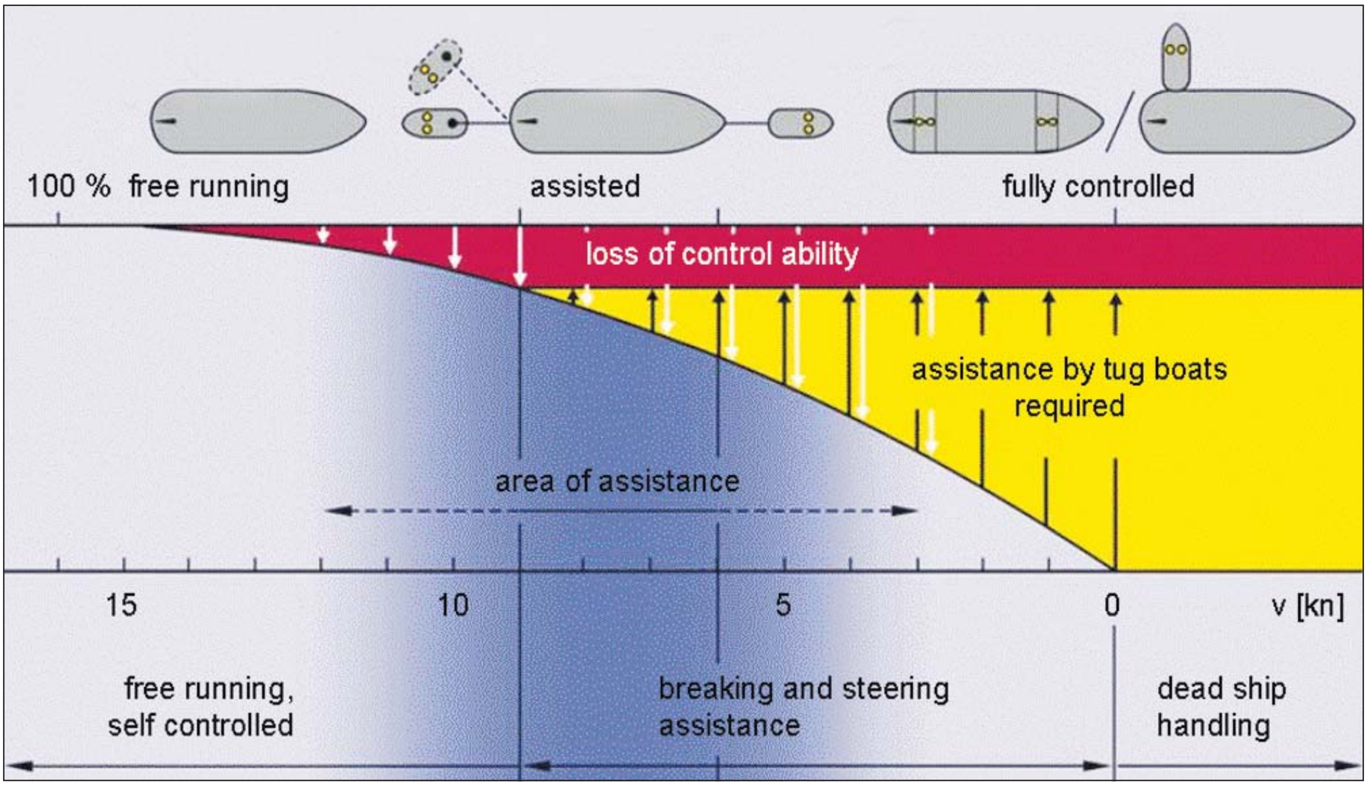

Figure 12: Distribution of the transversal forces for a static yaw angle of 16 degrees.

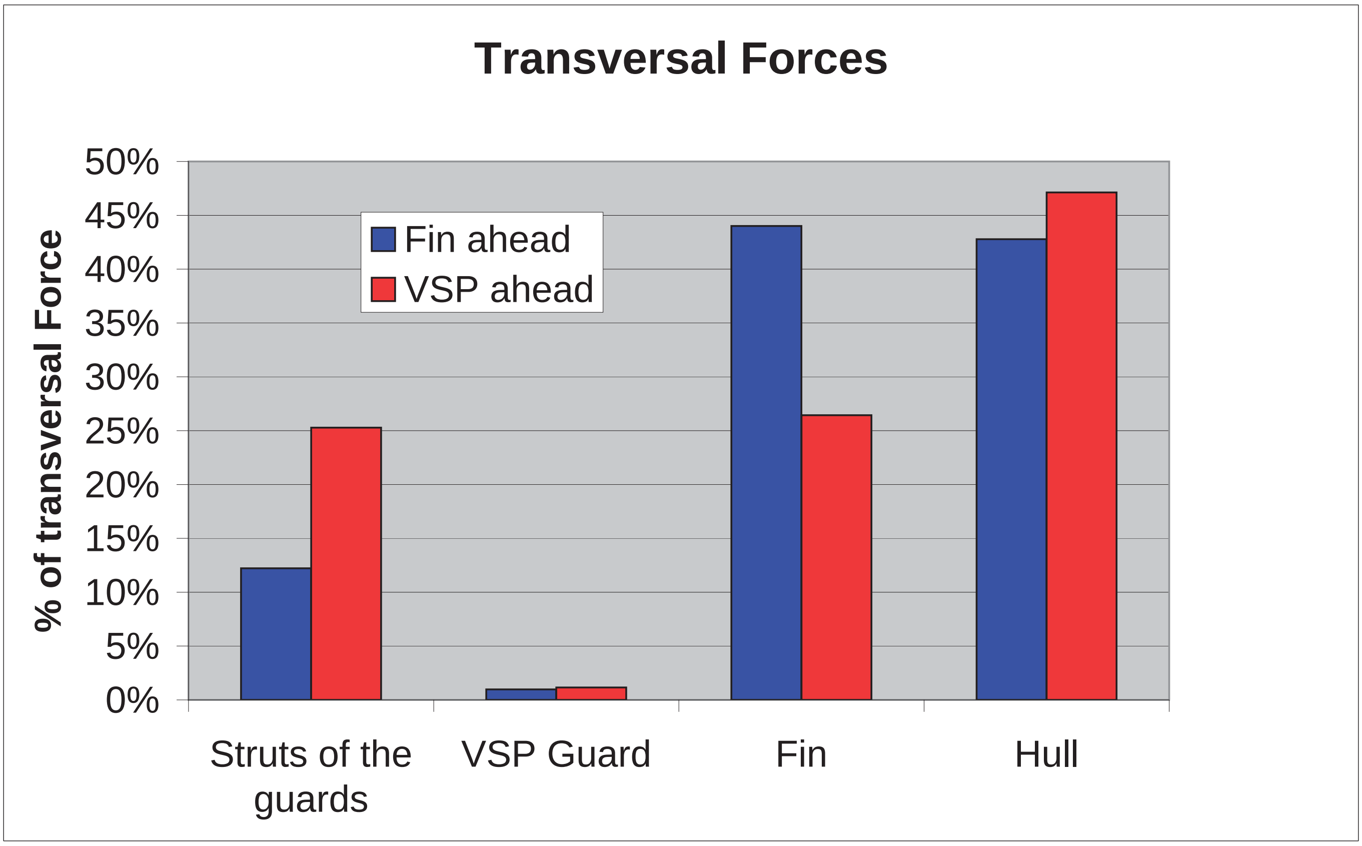

Figure 14: Test of a tug design in a simulator, berthing an LNG carrier.