MARIN

Challenging wind and waves

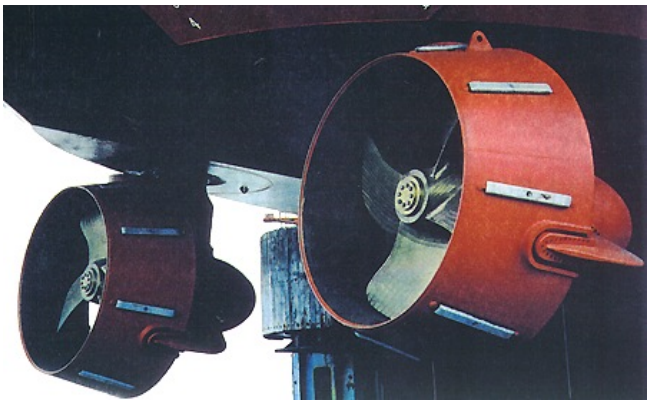
Linking hydrodynamic research to the maritime industry

Hydrodynamics of Thruster Interaction

TRUST JIP

THRUST Hydrodynamics JIP

During DP operations the effective force generated by the thrusters can be significantly smaller than what would be expected based on the thrusters' open water characteristics. This is a result of interactions of the thrusters with current, the vessel hull and the wake of neighbouring thrusters. The main question therefore is "How can you trust the thruster specification?", since it only tells part of the story. The understanding and quantification of thruster-interaction (or: thrust degradation) effects is essential for an accurate evaluation of the stationkeeping capabilities of any DP vessel. The TRUST JIP (Thrust Hydrodynamics JIP) aims at increasing the insight into the physical phenomena, quantifying thruster interaction effects and investigating possibilities for improvement.



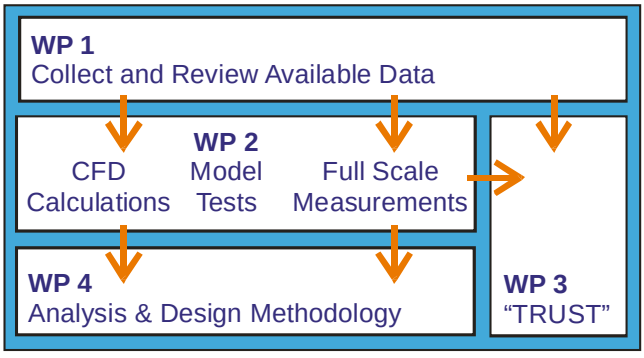
At present, thrust degradation effects can be quantified using data available from literature, or by carrying out dedicated model tests. Unfortunately, published data are often too general or not applicable to the design under consideration. Model tests, on the other hand, do provide detailed results, but are relatively expensive. And test results often become available relatively late in the design process, making it difficult to incorporate the results in the design. CFD calculations could be an alternative option, but these have not yet been developed far enough to be applied as engineering tools.

Past research has provided a lot of information on thruster-interaction effects, but to incorporate this knowledge in the design process is a complex task. The goal of the TRUST JIP is to better understand thrust degradation effects, to develop analysis methods and to apply these tools in the design process and in the analysis of the DP vessel's stationkeeping capabilities in operational conditions. As part of the work in the TRUST JIP, the possible influence of scale effects on the thruster performance, a largely unexplored area, will also be investigated.

The TRUST Joint Industry Project will combine dedicated thruster-interaction model tests and CFD calculations with existing data, available from literature. The objectives of the TRUST JIP are as follows:

- Increase the insight into the physics of thruster interaction;
- Deliver a DP capability and operational analysis tool, including extended and improved thruster-interaction data bases;
- Develop an analysis and design approach, of combined CFD calculations and model tests, to optimise thruster configurations.

The complete project is divided into 4 work packages. The schematical outline of the project is shown in the figure below;



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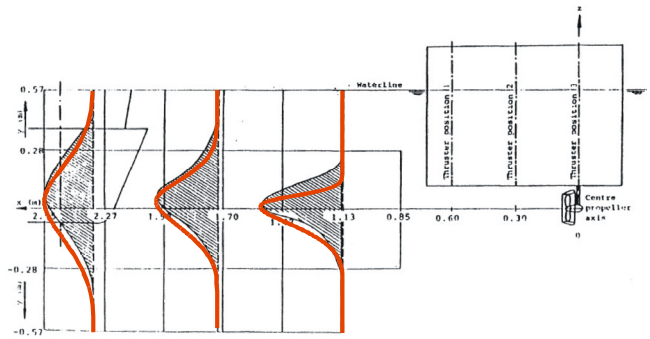
Inventory of Existing Data

In WP1 existing thruster-interaction data will be collected, e.g. published data from previous research projects. This will give an overview of existing knowledge and reveal areas of thruster-interaction that have not been sufficiently investigated in the past ("blank spots"). This inventory of available data can also help to optimise the scope of work of the model tests and CFD calculations in WP2.



Nienhuis's measurements compared with recent CFD calculations

Increase Insight into Physics

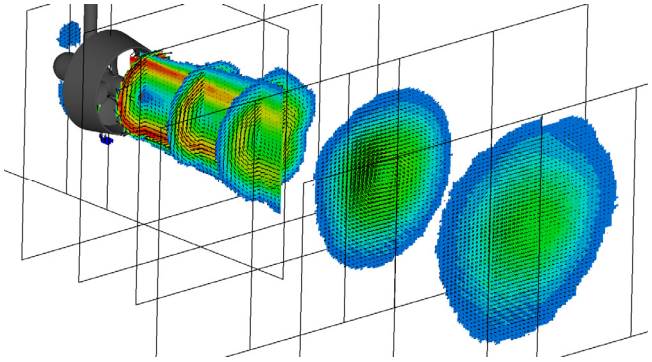
In WP2 model tests and CFD calculations are carried out. The scope of work will include investigations of the thruster-interaction effects on semi-submersibles and mono-hulls. The considered aspects will include the influence of the hull shape and thruster configuration, as well as the presence of current. Furthermore, possible scale effects will be part of the investigations.

Model tests

Thruster interaction tests will be carried out on a large number of different configurations. The following parameters will be varied:

- Ship-type (mono-hull and semi-submersible);
- Hull shape (e.g. bilge radius, semi-submersible pontoon spacing);
- Thruster positions (relative distance, distance to bilge), geometry (e.g. nozzle angle) and settings (RPMs, azimuth angle);
- Presence of current;
- Scale ratio.

Thrust and torque of the thrusters will be measured, as well as the loads on the floater hull. In addition, PIV measurements will be carried out to document in detail the velocities in the thruster wake and around the floater hull.



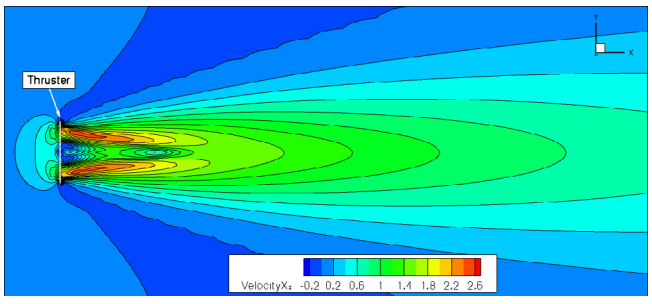
Particle Image Velocimetry (PIV) measurements at MARIN

The model test results will improve the understanding of the hydrodynamic phenomena relevant to thruster-interaction and will provide quantitative results in terms of thruster-interaction coefficients. The scope of work will include model tests at different scale ratios, including tests at a scale of 1:1 (full scale measurements), to help improve the insight into possible scale effects. Examples where scale effects might play a role are friction forces on the vessel keel and the deflection of the thruster wake as it flows past the vessel bilge.

CFD calculations

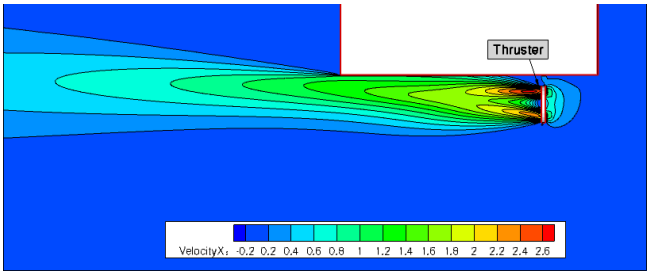
The application of CFD calculations for the analysis of thruster-interaction is still a largely unexplored area. At this moment CFD calculations of a floater, complete with all its thrusters, may seem too complex, but suitable modelling methods will be investigated and developed. Thorough validation of CFD models against measurement results is required and the TRUST JIP will play a role in that.

As a first step, CFD calculations will be performed to determine the velocities in the thruster wake. The accurate calculation of the velocities, especially at larger distances from the thruster, is crucial for an accurate prediction of thruster-interaction effects later on.



CFD calculation of wake axial velocities

Subsequently, increasingly complex configurations are considered. In this manner, the performance of a thruster under a ship hull can be investigated. Another example would be the calculation of the loads caused by the thruster wake on the opposite pontoon of a semi. The effect of current can also be investigated in the CFD calculations.

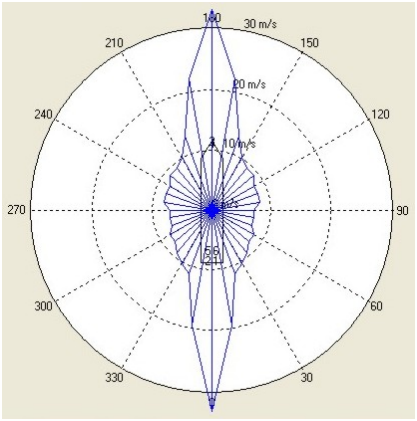


CFD calculation of a thruster wake under a schematical hull

The applicability, accuracy and limitations of CFD for thruster-interaction will be investigated by comparing the model test results with CFD calculations. The CFD results and visualisation of flow patterns might also be useful for interpreting and understanding the model test results.

Delivery of DP Capability Calculation Tool

In WP3 the thruster-interaction results, available from existing data bases (WP1) and new data from the TRUST JIP model tests and CFD calculations (WP2), are incorporated in a new tool for DP capability and operational analysis, suitable to evaluate stationkeeping performance of DP vessels. The data bases will have an open format, so that JIP participants can also include and apply their own model test or calculation results. Besides DP capability calculations, the tool will have an integrated evaluation of other criteria, such as (relative) motions or accelerations, making it a unique tool for early design calculations, as well as operational evaluations. The DP capability and operational analysis program will be called "TRUST".



Analysis and Design Methodology

The objective of WP4 is to define a standard approach for the analysis of thruster-interaction effects and optimisation of the thruster configuration during the vessel design. This unified step-by-step approach will be formulated to serve as a "best practice" description. The analysis and design methodology will typically consist of the following steps:

- Preliminary DP capability analysis static or time-domain DP calculations using thruster-interaction coefficients from a data base or earlier model tests;
- CFD calculations guidelines for grid generation, recommendations for numerical settings, recommendations for calculation scope;
- Model tests definition of the minimum required scope of work, recommendations for modelling and instrumentation.

By following this systematic approach the performance of the vessel's thrusters can be optimised during the design, without carrying out any unnecessary calculations or model tests.

Deliverables

Below an overview is given of the TRUST JIP deliverables:

- DP capability and operational analysis tool TRUST, including a data base of thruster interaction coefficients, for operational analysis and early design calculations;
- Model test report, containing the measurement results, analysed data, time records in ASCII format and discussion of the results;
- CFD calculation report, containing the calculation results, analysed data, applied calculation grids (on CD-ROM) and discussion of the results;
- "Best practice" reference document, analysis and design approach.

Participants

The TRUST JIP aims at the following participants:

- DP operators
- Engineering companies
- DP manufacturers
- Thruster manufacturers

Participant Fee & Schedule

The participation fee for the TRUST JIP is EURO 75,000.= (excl. VAT) for oil companies, EURO 55,000.= (excl. VAT) for other companies and EURO 35,000.= (excl. VAT) for classification societies and small engineering firms (at request only). This is the total participation fee for the complete project. The payment of the participation fees can be divided over 3 years (1/3 each year). A discount is foreseen for participants contributing to the CFD calculations in WP2.

An informative project meeting was organised at the FPSO JIP week in San Francisco in November 2009. The final project plan was made and in October 2010 the project had its kick-off meeting in Houston. The total duration of the project will be 3 years.

References

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[2] Cozijn, J.L., Buchner, B. and Dijk, R.R.T. van; "Hydrodynamic Research Topics for DP Semi-submersibles", OTC1999-10955.

[3] Dijk, R.R.T. van and Aalbers, A.B.; "What Happens in Water - The Use of Hydrodynamics to Improve DP", DP Conference, Houston, 2001.

[4] Oosterveld, M.W.C.; "Wake Adapted Ducted Propellers", PhD-thesis, Delft University of Technology, 1970.

More Information

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