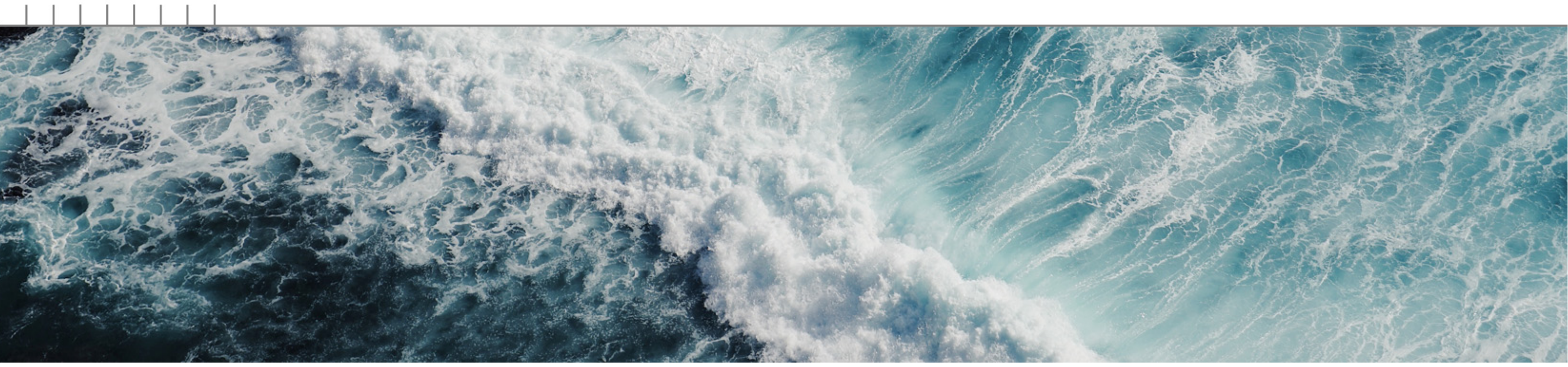


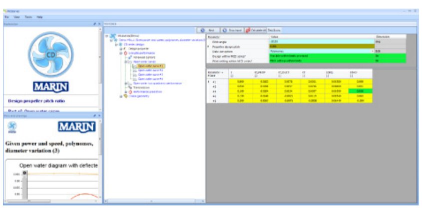
The Wageningen C- and D-propeller Series

The MCD software

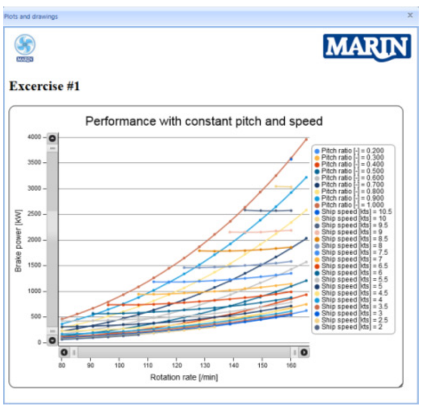
Two standard series of controllable-pitch propellers (CPPs) have been developed in the framework of a Joint Industry Project (JIP), which represent the best achievable designs of open and ducted CP propellers at present. Complete two-quadrant open water characteristics of the series are made available at all pitch settings from full ahead to full astern. The series have already become a new industry standard a short while after the JIP was finished in 2014. The data has been implemented into a software tool called MCD.

Software is relevant for

- Propeller designers
- Ship designers
- Ship owners
- Ship operators
- Classification societies
- Research institutes
- Universities



Software interface (MS Windows® system based)

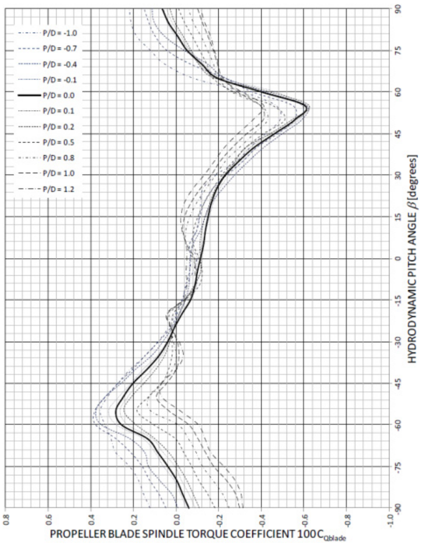


Pitch/Speed curves for combinatory

Hydrodynamic data sets

The C-series contains both 4-bladed and 5-bladed propellers with blade area ratios from 40% to 75% and design pitch ratios from 0.8 to 1.6. The D-series contains 4-bladed propellers in the same ranges for the blade area ratios and pitch ratios, in combination with both Wageningen No. 19A and No. 37 ducts. All propellers were tested for the two-quadrant open water characteristics in pitch ratios from -1.4 to +1.8, as shown in the following table.

Tested pitch settings $P_{0.7R}/D$	Propeller design pitch ratio $P_{0.7R}/D$																	
	C4-40 C4-55 C4-70				C5-60 C5-75				D4-40 D4-55 D4-70 in No. 19A duct					D4-40 D4-55 D4-70 in No. 37 duct				
	0.8	1.0	1.2	1.4	1.0	1.2	1.4	1.6	0.0	0.8	1.0	1.2	1.4	0.0	0.8	1.0	1.2	1.4
-1.4	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
-1.2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
-1.0	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
-0.7	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
-0.4	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
-0.1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
0.0	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
0.1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
0.2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
0.5	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
0.8	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
1.0	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
1.2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
1.4	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
1.6	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
1.8	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x



2-quadrant blade spindle torque

The data sets contain the propeller thrust and torque coefficients as conventional propeller series, as well as the propeller blade spindle torque coefficients, at all pitch settings and for the complete two-quadrant operations.

Propeller geometry

The propeller geometry of all series is parameterised, fitted and smoothened into polynomials, before the series propeller models were manufactured and tested. The propeller geometry is included in the software.

Software

The software has three functions:

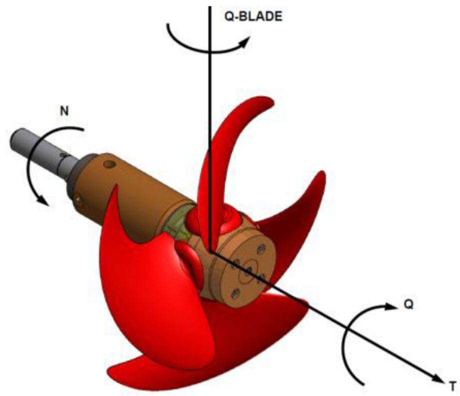
- **Selection and/or design of a propeller from the series:** In this function, the software searches the optimal propeller diameter or propeller shaft rotation rate at given ship operation condition, which can be sailing ahead or bollard pulling ahead, in order to balance the available power or needed thrust. Constraints such as the criteria on cavitation performance are taken into account.
- **Generate propeller geometry:** When a propeller is selected or designed, the software will generate the propeller geometry according to the geometry polynomials.
- **Hydrodynamic analysis and scenario studies:** With the selected or designed propeller, the software can predict hydrodynamic performance, such as the ship speed power relations, the bollard ability, the crash stop, the astern operations, the combinatory curves, and any predefined operation scenario studies.

The MCD software contains a computation core (written in C# and compiled into a .DLL) and a graphic interface based on Quaestor environment for the MS Windows® system. The computation core contains all hydrodynamic data sets and takes care of the interpolation and extrapolation of the hydrodynamic data to any geometric and operational conditions.

The graphic interface takes care of input and output, the ship operation conditions, the engine and the mechanical drives. It also balances power or thrust during the selection of the propeller and optimises the propeller diameter or shaft rotation rate. Hydrodynamic analysis like scenario studies for speed power, for bollard pull, for combinatory curves, etc. have all been taken care of by the interface.

Furthermore, the interface presents the input for the software tools orderly and well structured. All input and (intermediate) output is managed in folders, each being part of a project. Data consistency is maintained by Quaestor, so if you make any change in one of the inputs, the framework will re-execute all dependent calculations.

The software is a must-have for designers, shipyards, operators and classes.



Definition of T, Q and Qblade

References

- J. Dang, J. Brouwer, R. Bosman and C. Pouw (2012) 'Quasi-Steady Two-Quadrant Open Water Tests for the Wageningen Propeller C- and D-Series', proceedings of the 29th ONR, Gothenburg, Sweden, 26-31 August.
- J. Dang, H. van der Boom and J.Th. Ligtelijn (2013), "The Wageningen C- and D-Series Propellers", Proceedings of FAST'13, Amsterdam, December.

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