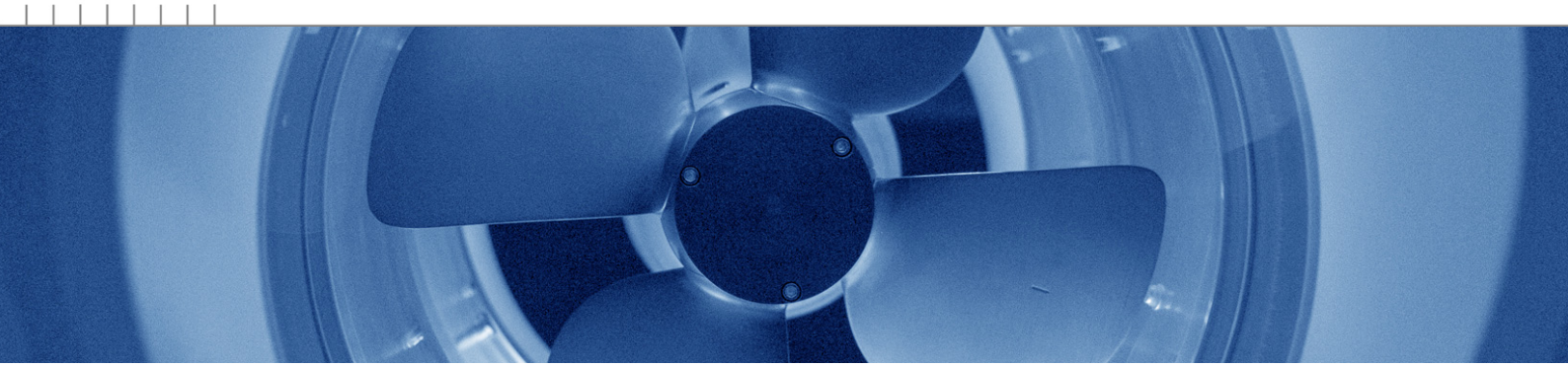
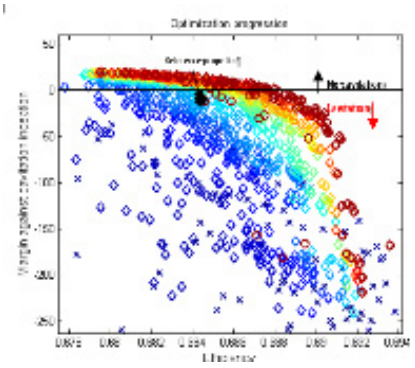
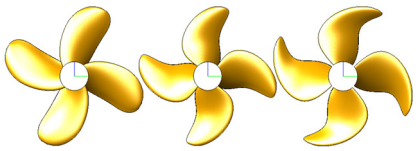


Propeller Design Support & Evaluation

MARIN offers its propulsor services to ship yards, operators, propeller manufacturers and suppliers of marine propulsion components. These services include an independent prediction of the performance of propellers and design support. Propeller design involves finding the right balance between conflicting objectives, for instance between propulsive efficiency and cavitation related nuisances like propeller induced pressure pulses on the ship hull and underwater noise. The hydrodynamic performance is evaluated by computational methods, often followed by model experiments or full scale observations.



Example of optimization case with final Pareto front in red. Both the margin against cavitation and efficiency should be maximized.



Example of propeller candidates within an optimization study

MARIN focuses on a wide-range of propeller designs, e.g. high-end “low-noise” propellers for yachts, naval, research and cruise ships with delayed cavitation inception, propellers with low vibration-excitation and ducted propellers for special purpose vessels such as dredgers, tugs and fishing vessels. Also for merchant ships, MARIN can for instance provide insight into whether the best possible compromise between the propulsive efficiency and cavitation related pressure pulses is achieved or further improvements can be made.

Throughout the years, MARIN developed substantial knowledge of propulsors by means of calculations, model tests and full scale tests. This experience is virtually indispensable for a good propeller design.

Evaluation

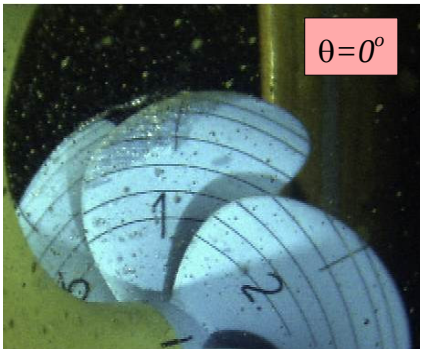
An independent second opinion on a propeller design may for instance be required:

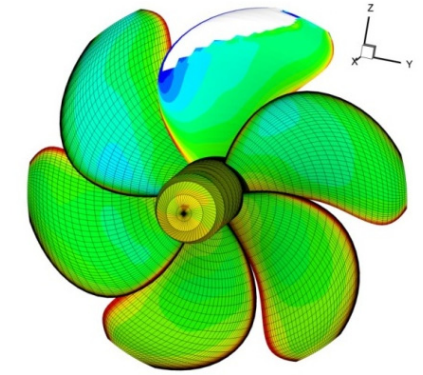
- to provide good understanding of the best possible efficiency within given boundaries;
- before proceeding to more expensive model test experiments or propeller manufacturing;
- after the vessel’s commissioning as trouble shooting, when there are, for example, problems including cavitation erosion or onboard vibrations and noise.

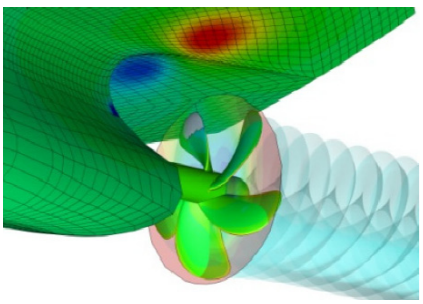
A propeller evaluation will always be tuned to the specific project at hand. MARIN will give expert advice on the performance and draw recommendations to solve possible issues.

Design

By using the latest design techniques and experience within the whole chain of design, model tests and full scale observations, MARIN is able to make a best suited independent propeller design based on the specifications provided by the customer. The MARIN propeller blade design often acts as a reference or counter design for third parties.







Optimization

Multi-objective optimisation techniques allow propeller designers to perform design studies. An optimization gives insight in the different trade-offs between conflicting objectives and indicates the influence of design constraints on the attainable objectives. Possible objectives or constraints are for instance efficiency, avoidance of pressure side cavitation, cavitation volume, pressure pulses, tip vortex nuisance, material stress or weight. The propeller is fully parameterized to allow large design freedom. The optimization either serves as a preliminary investigation of feasible objectives in conceptual design studies or as a choice support tool for the best possible compromise which serves as starting point for further detailed design.

Model experiments

Verification of propulsive performance and cavitation behaviour by model experiments is often desired by ship owners to check whether the design fulfils the expectations and is likely to reach its targets at full scale. Cavitation observations, pressure pulse measurements and noise recordings are performed daily in MARIN's Depressurised Wave Basin (DWB).

Full scale observations

Full scale cavitation observations are indispensable as feedback for propeller design and interpretation and correlation of model tests. MARIN offers a full scale consulting and monitoring service, and has gained considerable experience in a broad field of ship types over the years. Each time, MARIN carefully analyses the propulsor performance which is used to further improve propeller design methodology and model experiments.

Design conditions

For each propeller design study the design conditions such as shaft power, thrust, RPM and ship speed are necessary. Either model tests with stock propellers, CFD studies or empirical methods could be used to determine the design conditions, all of which are offered by MARIN. Furthermore, the wake field in which the propeller operates should be known, preferably the effective wake field at full scale.

Tools

Throughout the years, several systematic series such as the Wageningen B, C & D series were generated and computational tools were developed. Detailed propeller design and prediction of pressure distributions and cavitation patterns are possible with the Boundary Element Method (BEM) PROCAL. Pressure pulses on the hull due to cavitation will be analysed with the BEM code EXCALIBUR. Optimization can be performed using a genetic algorithm which is coupled to a geometry generator and PROCAL. Effective wake fields could be computed with MARIN's RANS codes PARNASSOS or REFRESCO on either model or full scale by coupling them to PROCAL. Nowadays, state of the art full RANS propeller computations are becoming more and more the standard.

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