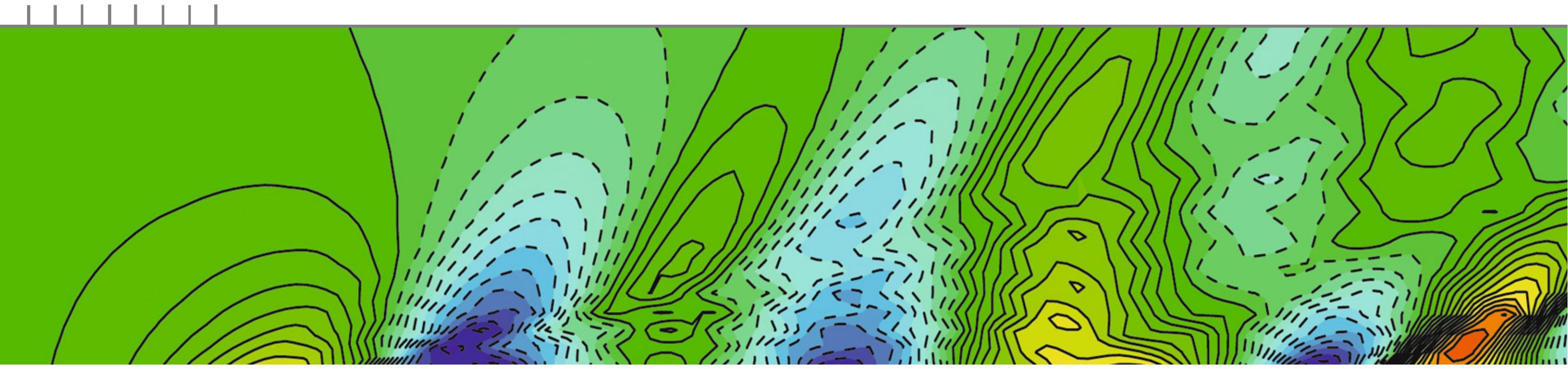


RAPID

Calculation of wave resistance and potential flow

The computer program RAPID calculates the steady inviscid flow around a ship hull, the wave pattern and the wave resistance. It solves the exact, fully non-linear potential flow problem by an iterative procedure, based on a raised-panel method.
Since its initial development, RAPID has been routinely applied in practical ship hull design. Continuous further development has extended the applicability and improved the efficiency and accuracy. Today it is one of the best known codes worldwide in the field of resistance and flow. RAPID forms an integral part of MARIN's consultancy services related to hull form improvements.

Restrictions

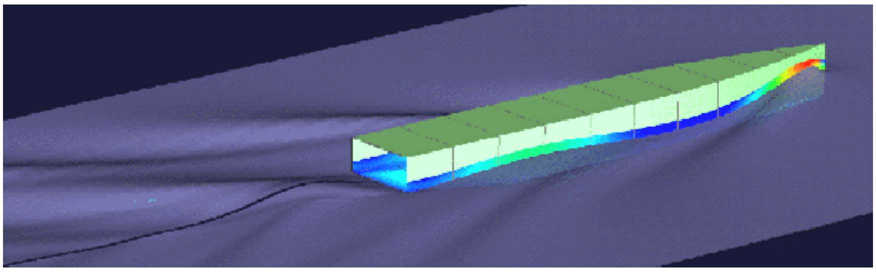
The method is based on inviscid flow theory, which excludes the effect of boundary layers, dead water zones behind a transom, or flow separation. Consequently, the amplitude of the stern wave system is usually overestimated; very little for slender transom stern vessels, more for fuller hull forms. The wave resistance prediction is affected by this, and therefore, not fully accurate for the fuller hull forms. However, the wave resistance is good for ranking different hull form designs in an optimisation process. Wave breaking or spray are not modelled.

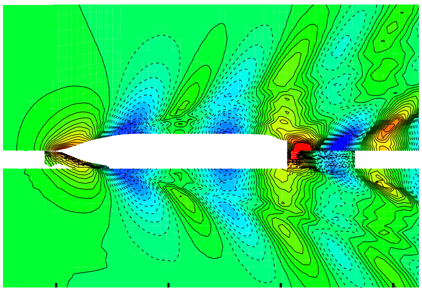
Applications

RAPID is used for the minimisation of wave making and wave resistance, primarily. All features of the wave pattern, hull pressure distribution and streamline direction over the hull can be visualised.
RAPID is applicable to the great majority of vessels, varying from tankers and frigates to sailing yachts, and ferries; ships in deep or shallow water, or even in channels. Extensions have been developed for ships with lifting surfaces (e.g. keel or rudder), and asymmetric cases.

Accuracy

RAPID has been validated extensively against test results from MARIN's model test basins. The predicted flow and wave pattern have been found to be accurate, and to indicate consistently the quality of a design and possible improvements. Compared to linearised methods, RAPID predicts the bow wave height and diverging waves far more accurately. The predicted wave resistance is generally used in a relative way for the comparison of two hull forms in a hull form optimisation process.





Wave pattern of a container ship.
Top half: RAPID prediction. Bottom half: experiment (KRISO)

Input

RAPID comes standard with a Graphical User Interface which helps the user preparing the input, running the code and analysing the results. Calculations are made for the speeds, displacements, LCG positions, water depths, and channel widths specified by the user.

The input consists of a hull panel distribution and a free surface panelling. The hull panel distribution can be generated from a digitised body plan or from a hull surface representation in a CAD system. Interfaces exist for generating RAPID input files directly from e.g. NAPA, TID and GMS. A free-0surface panelling is generated automatically.

Output

The output consists of the velocity and pressure distribution on the hull, the wave pattern, wave profile along the hull, wave resistance, dynamic sinkage and trim, actual wetted surface area at speed, far-field wave spectrum, etc. A visualisation tool gives detailed insight in the character of the flow, the origin of dominant wave components and possible hull form improvements.

Expert judgement of the results will indicate which hull form modifications will reduce the wave making. Hereafter, RAPID can be used again to verify the modified design. In a few steps a hull form can efficiently and quickly be optimised, and thus model testing can be limited.

Additionally, the pressure distribution may indicate possible improvements of the viscous flow (e.g. reducing flow separation). Flow directions on the hull are used for aligning bilge keels or knuckle lines with the local flow. Predicted far-field wave heights are relevant for wash.

Computational approach

The solution of the non-linear free-surface problem is found in an iterative procedure. The flow field and wave surface are repeatedly updated until all boundary conditions are met. The dynamic trim and sinkage of the hull are adapted to balance the hydrodynamic forces and moments.

Each iteration solves a linearised intermediate problem using a panel method. Source panels are distributed over the hull and at a small distance above the wave surface. The hull and free-surface boundary conditions lead to a large system of equations that is solved using an efficient iterative algorithm.

References

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