Hydrodynamic Studies on Hull-Propeller-Rudder Interaction

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Paper Outline

➢Introduction

➢Numerical Approach

➢Grid Generation

➢Results and Discussions

➢Concluding Remarks

Introduction

➢ Investigation of the hydrodynamic performance of a modern benchmark container ship hull is presented in the paper

➢ Numerical simulations is performed for the flow around the bare hull at first, then around the hull with propeller, hull with rudder and finally around the whole ensemble, so taking into consideration the effect of propeller – rudder as a whole.

Introduction

➤ Configurations like propeller Open Water test, Self Propulsion test and deflected rudder are studied as well.

Numerical Approach

➢ Efficient potential flow panel method is used to predict important quantities like waves and wave resistance

➢ All the viscous flow computation, is made by means of the XCHAP module of the SHIPFLOW CFD code, which is a finite volume RANS solver.

Numerical Approach

➢One point closure turbulence approach is attained trough the EASM model

➢The propeller is modeled by lifting line method
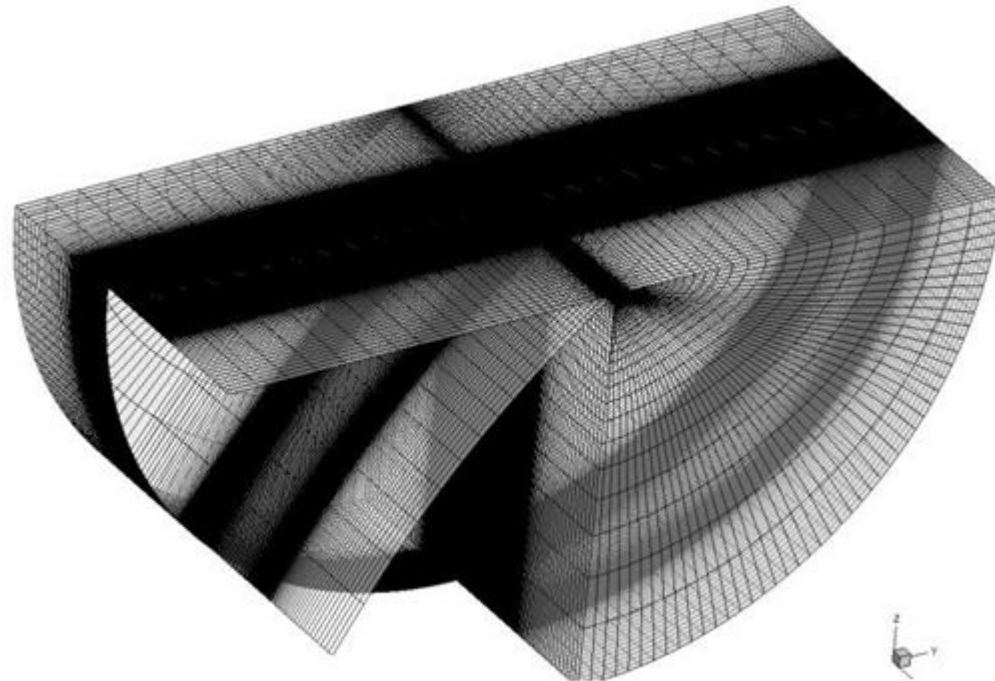
Numerical Approach
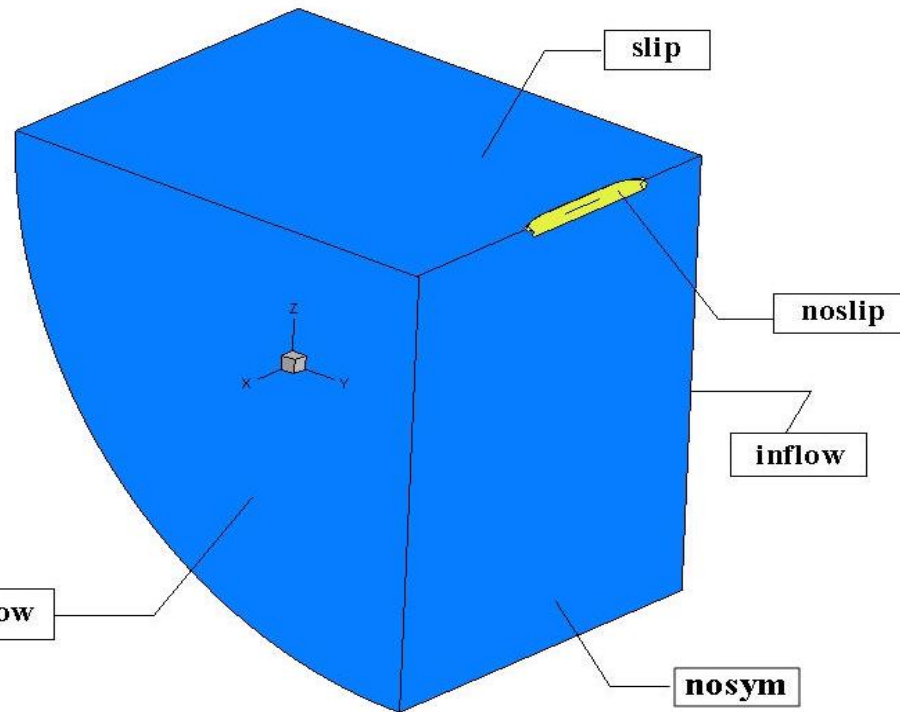
➢ Boundary conditions

➢The boundary conditions are formulated in terms of pressure, velocity, turbulent kinetic energy, and turbulent frequency.
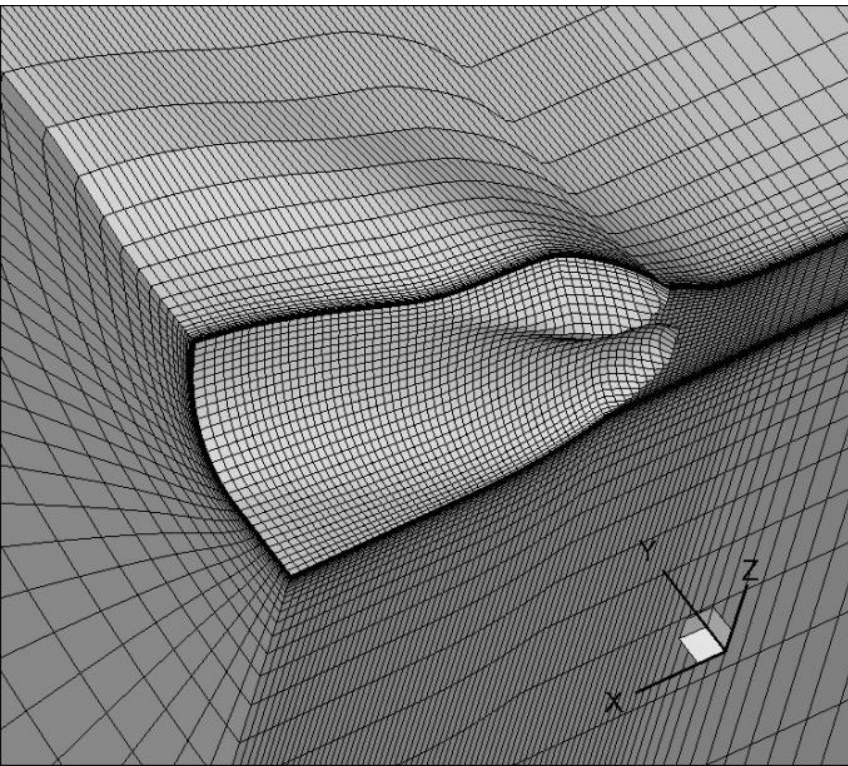
Grid Generation

➢An H - O type, structured grid of 2.2 million cells is created to cover the entire computational domain along the bare hull
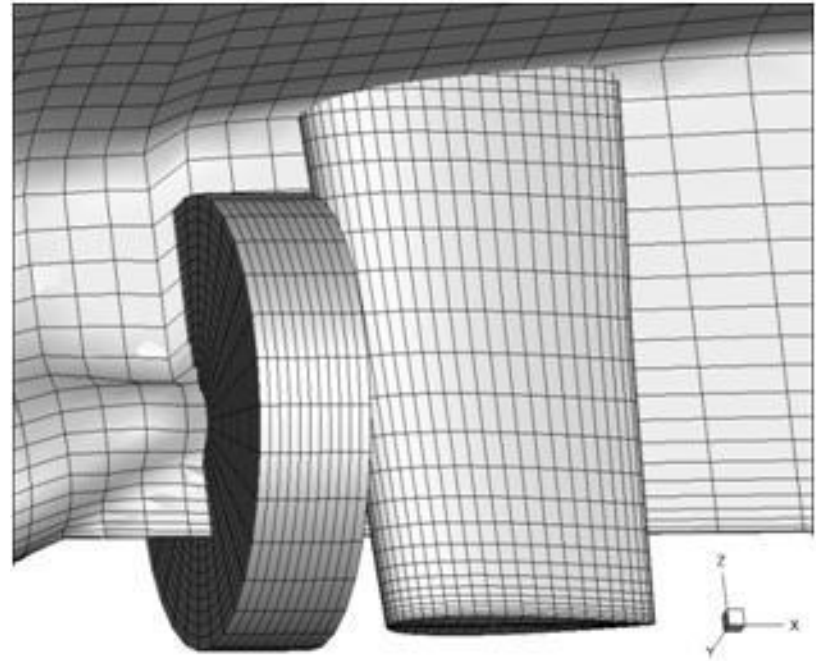
Grid Generation

➢ Computational grid

- The computational grid is clustered longitudinally, radially and vertically near the ship hull
- The clustering is made appropriate for accurate numerical solution
- y+=1

Grid Generation

➤ Overlapping grid

• Chimera technique was used – the additional grids for the propeller and the rudder can be fitted together and overlap at the junction points.

Results and Discussions

The objective of the present study is:

➤ To provide the specific knowledge to simulate and analyze numerically the viscous interaction that appears and develops between hull, propeller and/or rudder

Validation is provided for:

➤ Wave pattern of bare hull

➤ Axial velocity distribution

➤ Total resistance for bare hull

➤ Propeller Open Water Characteristics
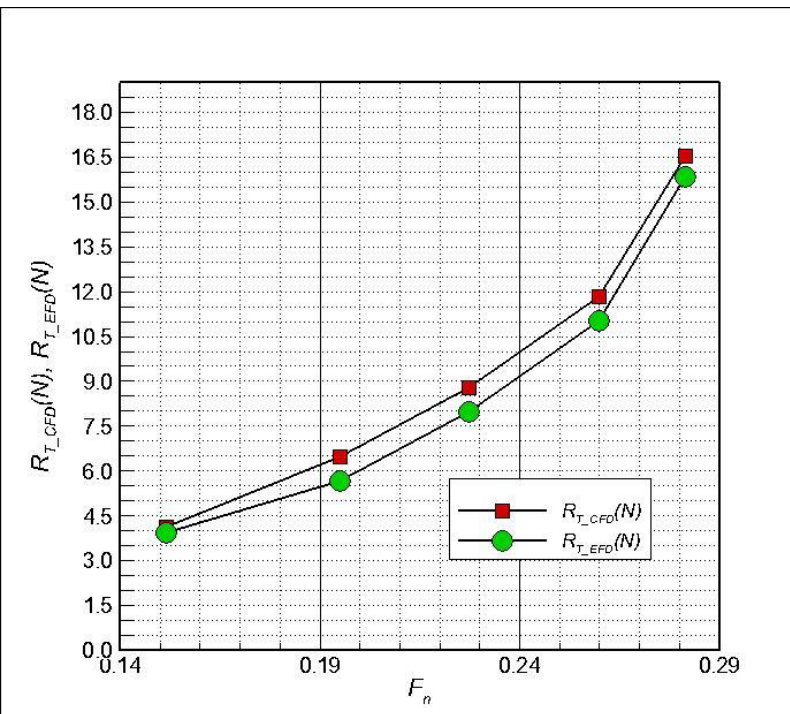
➤ Total resistance for Hull with rudder

Results and Discussions

➤ Wave pattern
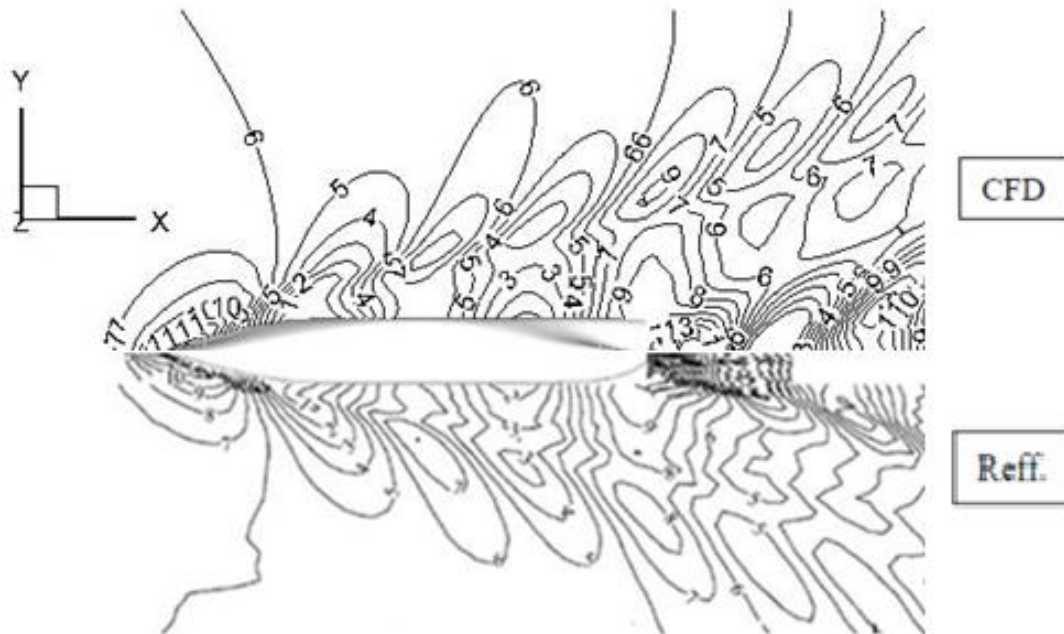
• The shape and the contours are in very good match with the reference result

Results and Discussions

➢ Axial velocity bare hull

- The comparison shows very good agreement with the reference result

Results and Discussions
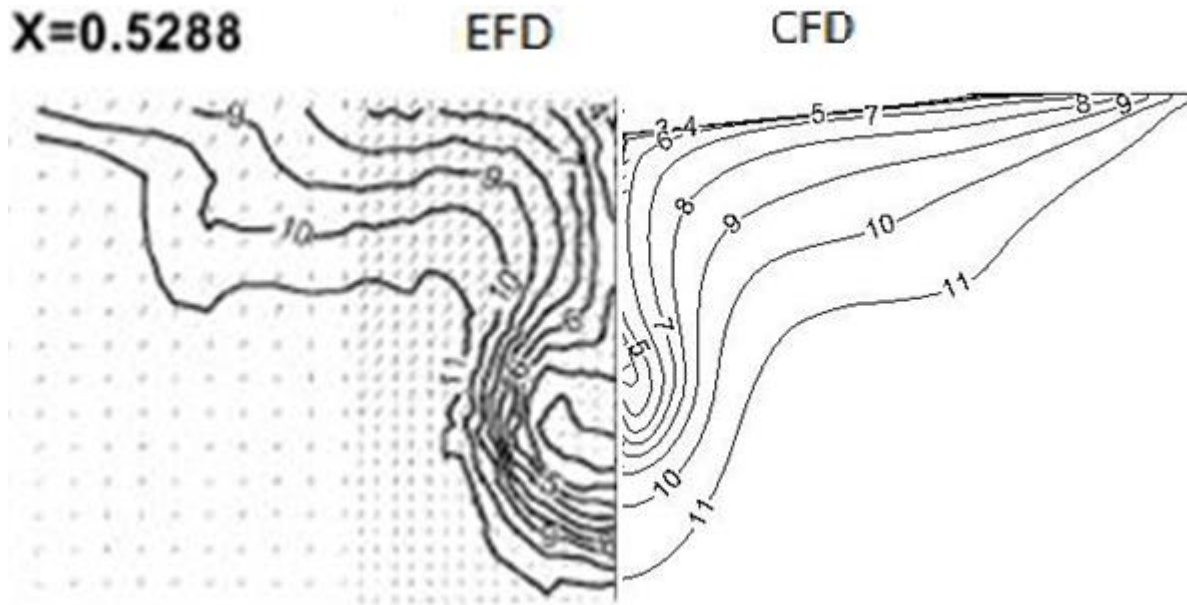
➤ Total resistance validation for bare hull

Fn	Error %
0,1516	-4,364
0,1949	-14,75
0,2274	-10,066
0,2599	-7,35
0,2816	-4,382

• The error at the design speed is satisfactory

Results and Discussions

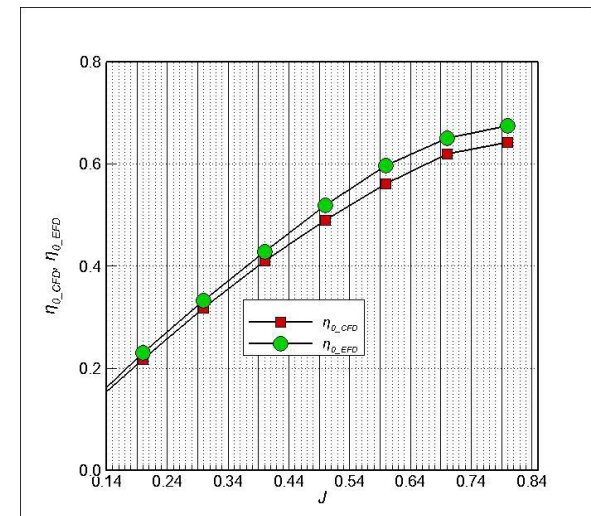➤ Propeller Open Water validation
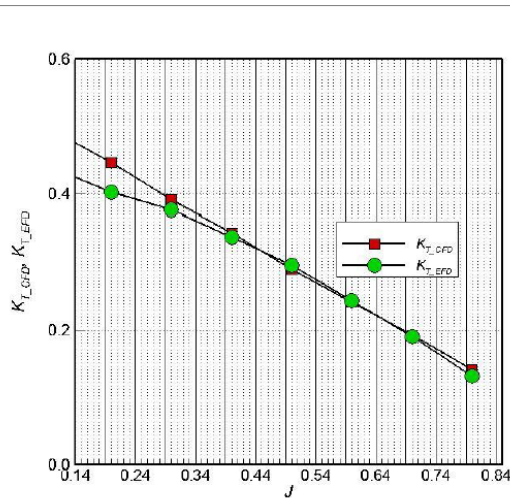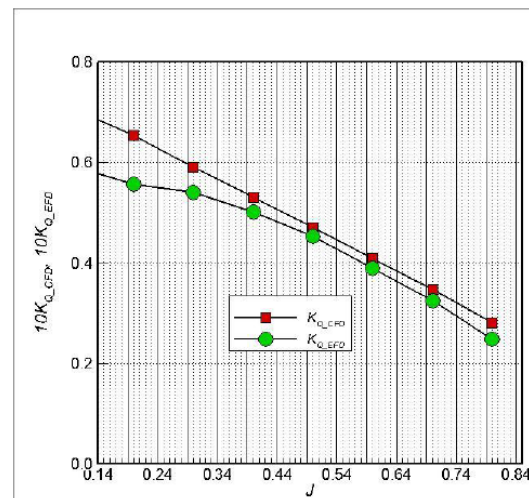
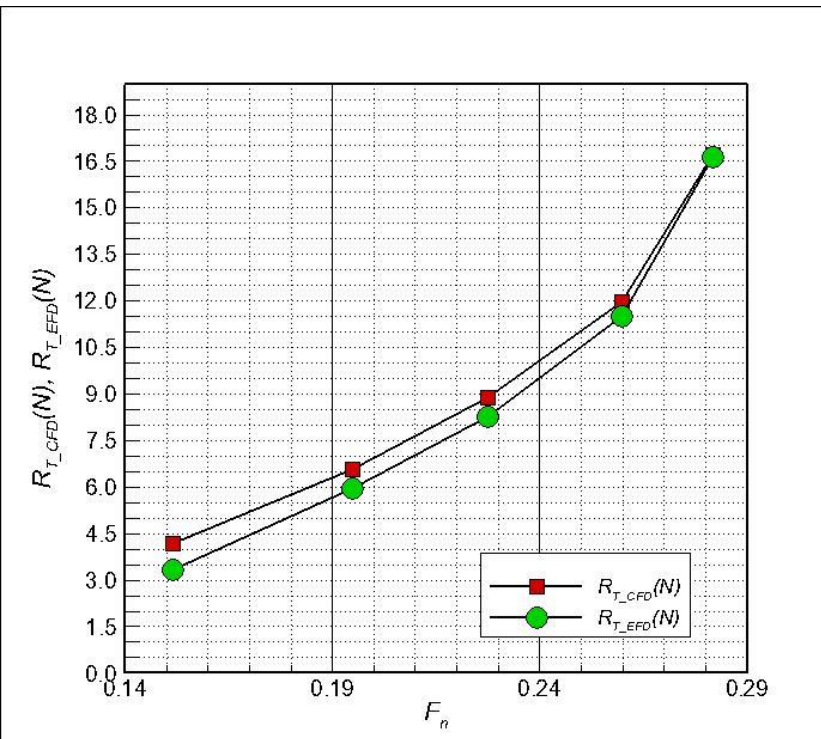Kt diagram   Kq diagram   η0 diagram

➤ The minor inconsistencies that appear in the figures can be explained by the fact that the method does not consider the surface of blade
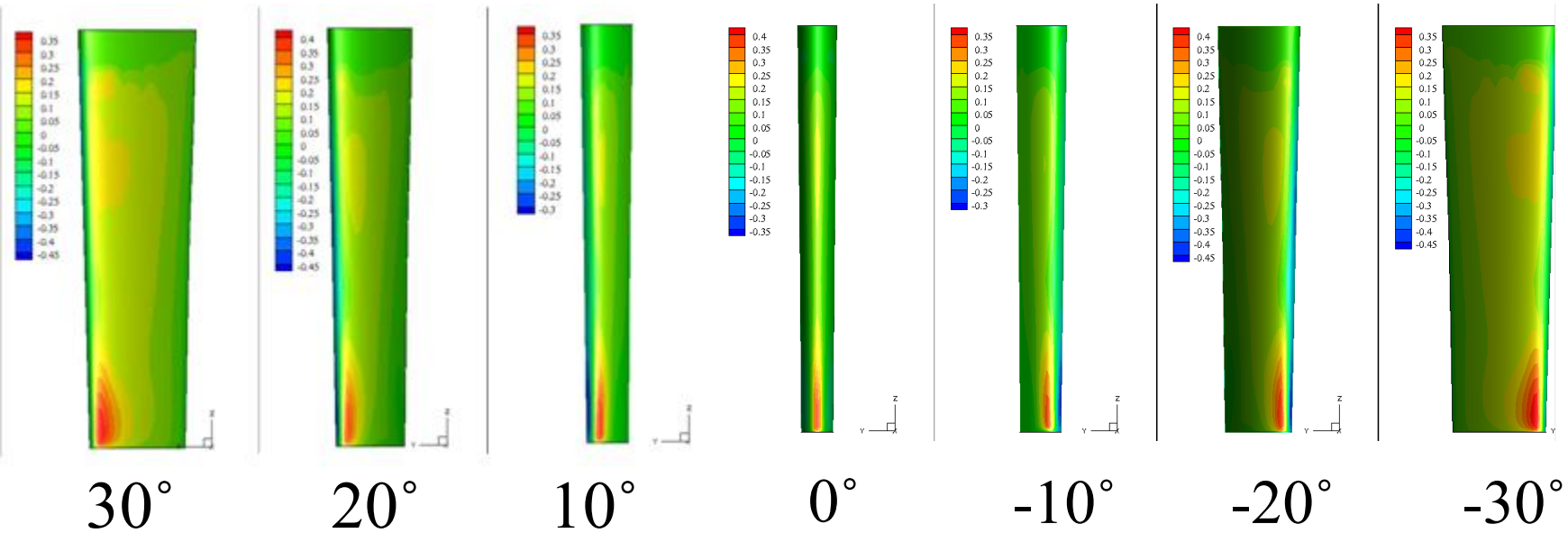
Results and Discussions

➤ Total resistance validation for hull with rudder

- The method used shows very good agreement at the design speed.

Results and Discussions

➤ deflected rudder
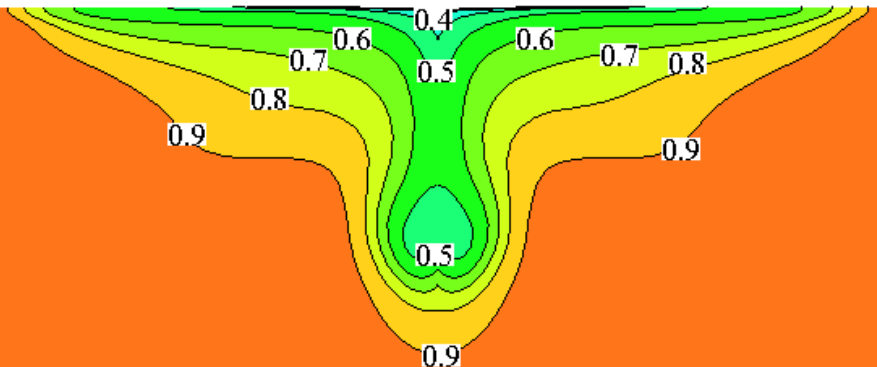
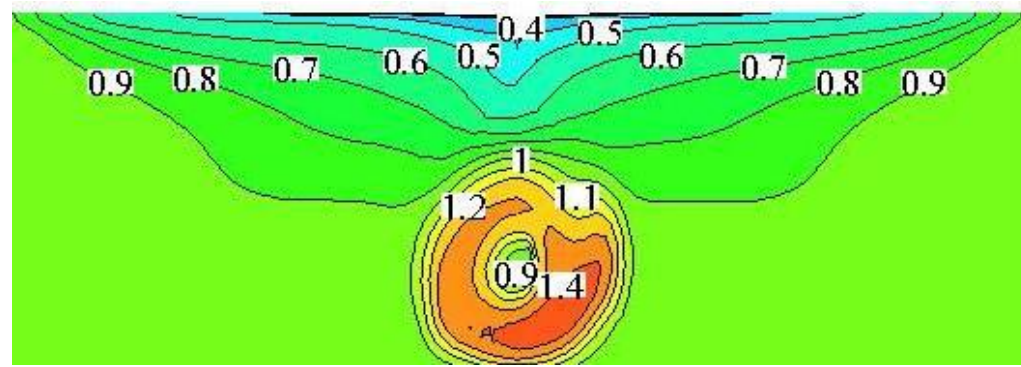PS   STB

30°   20°   10°   0°   -10°   -20°   -30°

- The difference of the pressure between -30° and +30° due to the right handed propeller, is obvious

Results and Discussions

➤ Axial velocity comparison

Bare hull

Hull with propeller

Hull with rudder

Hull with propeller and rudder
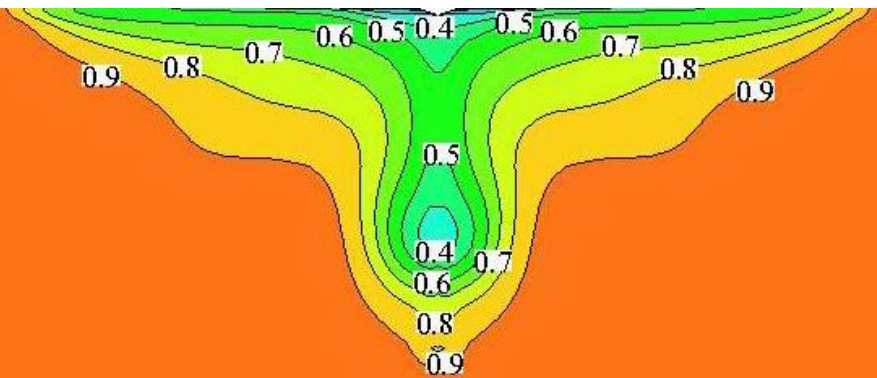
Results and Discussions
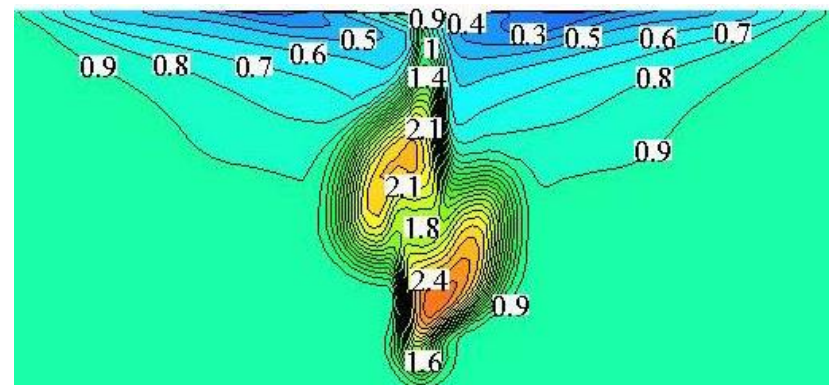
➢ Pressure distribution comparison

Bare hull

Hull with propeller

Hull with rudder

Hull with propeller and rudder

Concluding Remarks

➢Study of Hull – Propeller - Rudder interaction is performed

➢Validation for wave pattern, total resistance for bare hull, axial velocities for bare hull, propeller open water characteristics, total resistance for hull with rudder

➢The influence caused by the presence of propeller and rudder is clearly shown

➢The method allows including of a drift angle as well as combination with different rudder angle

Thank you for your attention