Performance prediction of KP505 propeller using Lifting Line Theory and RANS

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ABSTRACT

Lifting line theory was developed over a century ago by Prandtl and has been employed to predict thrust and torque in various working conditions including lift of a wing, or as in this case, the thrust and torque produced by a propeller. Lifting line theory belongs to panel methods which are quick to converge as compared to CFD simulations. In lifting line theory, the actual blade geometry is replaced by span-wise panels of constant line circulation, which generates lift when it experiences an inflow. The method assumes the propeller blade sections to be replaced by a single line vortex that varies in strength from section to section.

CFD (Computational Fluid Dynamic) is one of the most popular and prolific technique used to solve hydrodynamic related problems nowadays. RANS (Reynolds-averaged Navier–Stokes) solver predicts the values of different performance indicators (Thrust, Torque, Efficiency) for the propeller and also give us valuable information about the flow field around the propeller.

Propeller open water characteristics are useful indicators of the performance for propellers in undisturbed uniform flows with steady loads. The thrust and torque, T and Q, can be normalized as

$$K_T = \frac{T}{\rho n^2 D^4} \qquad K_Q = \frac{Q}{\rho n^2 D^5}$$

The thrust and torque coefficients, K_T and K_Q, are generally plotted against a range of advance coefficient, J, which is defined as

$$J = \frac{V_A}{nD}$$

Jarle V. Kramer, John Martin K. Godø, Sverre Steen compared results from lifting line method and CFD for a hydrofoil.[1] They concluded that lifting line method is both simple to implement and faster to execute on a computer as compared to CFD. Brenden P. Epps and Richard W. Kimball presented a unified lifting line method for the design and analysis of axial flow propellers and turbines. The method incorporates significant improvements to the classical lifting line methods for propeller design to extend the method to the design of turbines.[2][3]

The propeller being studied is KP505. The KP505 was designed by Korea Research Institute of Ships and Ocean Engineering (KRISO) to be used for the KRISO Container Ship (KCS). This study aims to study the current trends in lifting line theory and CFD for propeller performance prediction and see how they compare to experimental results in accuracy and time to solution.

Historically CFD has shown greater consistency with experimental results, but with new techniques being added to improve the accuracy of panel methods, the divide between the two methodologies might be small enough to bridge now.

REFERENCES

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