Analysis of the Blade Boundary-Layer Flow of a Marine Propeller With RANSE

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ABSTRACT

In order to improve the prediction of the propeller performance at model-scale, the $k-\omega$ SST turbulence model [1] and the $\gamma-\tilde{\mathrm{Re}}_{\theta_t}$ transition model [2] were applied with a RANSE solver for two marine propellers for which paint-tests have been conducted and experimental open-water data is available [3]. The analysis of the numerical simulations focussed on a qualitative comparison between the predicted limiting streamlines and paint-tests observations, and propeller forces in open-water conditions. From this study, an improvement in the blade boundary-layer flow is obtained with the transition model, whereas the simulations with the turbulence model predict a too large turbulent region on the blade.

As an alternative, the experimental study of the laminar/turbulent flow in the vicinity of a rotating propeller blade conducted by Jessup [4] can be used for a better quantitative comparison and understanding of the blade boundary-layer flow. This investigation was carried out in the DTMB 24 inch water tunnel for marine propeller P4119, where two blades were applied with leading-edge roughness and the remaining was smooth. The experiments comprehended three-dimensional velocity component measurements of the blade boundary-layer and wake using a LDV system in uniform inflow conditions.

From these experimental measurements, an extensive comparison with the numerical results obtained from the turbulence [1] and $\gamma-\tilde{\mathrm{Re}}_{\theta_t}$ transition [2] models is presented in this paper. The present work comprehend the analysis of the chordwise and radial components of the boundary layer velocities, estimation of the boundary-layer characteristics, comparison of the blade wake flow and prediction of the open-water performance. From this study and depending on the turbulence inlet parameters, the transition model is able to predict the extent of laminar and turbulent regions observed in the experiments.

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