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CFD validation of a controllable pitch marine propeller using a truly autonomous mesh generation with adaptive mesh refinement

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The design of propellers for maritime propulsion systems has a long history of using Computational Fluid Dynamics (CFD) as result of the constant desire to improve efficiency. The complex physics in addition with the motion of the propellers pose several challenges to CFD investigation, in particular with regards to mesh generation. In order to achieve an adequate accuracy of results, one needs to ensure a high grid quality while meshing the propellers, which can be an expensive process. Additionally, the investigation can be more convoluted by the transient nature of certain phenomena that needs to account for the propeller motion, resulting in a bottleneck for the design process. In view of addressing these challenges, the present work proposes an alternative approach, which employs an autonomous mesh generation based on a modified Cartesian cut-cell methodology, which locally retains a high quality purely orthogonal and unskewed mesh. This allows the boundary motion to be directly imposed and enables on-the-fly adaptive mesh refinement (AMR) based on local velocity gradients, together with a dynamic near-wall refinement relying on the estimation of a non-dimensional wall distance y*.

This approach is validated against the extensive open measurement data of the Potsdam Propeller Test Case (PPTC) [1 and 2] from SVA Potsdam. The results of these comparisons are presented and discussed in this work. More specifically, a.) thrust, torque and efficiency are numerically computed in a steady open-water configuration for various advance coefficients and compared with experimental data, and b.) detailed velocity field, computed in a transient manner, are compared to Laser Doppler Velocimetry (LDV) measurements. Additionally, benefits of both steady-state and fully-moving transient approaches for propeller numerical analyses are discussed, together with a future outlook on cavitation phenomena within the presented framework.

REFERENCES

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