Influence of DOF on manoeuvring Prediction by direct CFD Zig-Zag Simulations

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ABSTRACT

Recently, major liner companies are speeding up to place orders of Mega Container Ships (MCS) with the capacity over 20,000 TEUs so as to provide a more competitive freight rate. For instance, CMA CGM has ordered a group of nine container carriers each with a capacity of 22,000 TEUs. However, this type of vessel is usually characterised by 400 metres long and 60 metres wide, which in turn can challenge ship manoeuvring performance, especially in the heavy traffic areas. Conventional manoeuvring predictions are limited to 3 DOF or 4 DOF considering the complexity of mesh strategy in ship motion and numerical discretization errors. Whether full 6 DOF can contribute to the increase of prediction accuracy for current ship type is still not quite clear. In this paper, direct zig-zag simulations for 10°/10° and 20°/20° are performed under the consideration of degrees of freedom, namely 3 DOF, 4 DOF and 6 DOF, to evaluate their influence on the manoeuvring prediction. A modern container ship KCS is chosen as the benchmark model. All simulations are performed in the numerical environment FINE™/Marine, whose flow solver is based on the widespread ISIS-CFD code. It solves impressible unsteady RANS equations in full hexahedral unstructured meshes and couples with the motion equations of rigid body in 6 DOF. Current direct manoeuvring simulations are achieved by means of overlapping grid technique. The Propeller effect is modelled by a simple prescribed body force model to reduce the computational effort. Straightforward trajectories are recorded without any further treatment to extract the hydrodynamic derivatives. The prediction accuracy is evaluated by comparing derived parameters i.e. overshoot angles and corresponding time as well as peak yaw rate, etc. against the experimental data of MARIN. In conclusion, for small rudder angle such as 10°, 4 DOF concept has behaven accurate enough for current ship type. With the increasing rudder angle to 20°, 6 DOF concept can only provide more accurate predictions for the second overshoot angle. On the contrary, 3 DOF concept underestimates all overshoot angles in each test group. The reason for this behavior can be explained by the change of side projected area under the waterplane in different DOFs, which affects the distribution of hydrodynamic forces and moments indirectly. Additionally, more kinematic parameters obtained by increasing number of DOF can be useful to analyze other ship motion, for instance, roll or pitch motion.[1-4]

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