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Numerical Simulation of an Oblique Towed Ship by naoe-FOAM-SJTU Solver

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ABSTRACT

The present work is focused on the numerical simulation of an oblique towed ship using Unsteady Reynolds Averaged Naver-Stokes(URANS) method. The numerical computations are carried out by using the solver naoe-FOAM-SJTU, which is developed for ship and ocean engineering based on the open source code OpenFOAM. A new 6DOF module has been extended to the solver to accurately simulate the static drift test (oblique towing test). The main purpose of this research is to investigate the capability of our solver for ship maneuvering prediction especially for steady oblique tow. During the process, a series of simulations are carried out due to different drift angles. The computations are performed for a bare ship hull model free to sink and trim at Froude number 0.24. The hydrodynamic forces and moments acting on the ship as well as the hydrodynamic derivatives are obtained for further analysis. All the above numerical results have been compared to those of the oblique towing test with a Planar Motion Mechanism (PMM) system performed at Marine Design & Research Institute of China. Taking free surface into consideration and using viscos-flow simulation, the results are satisfactory and finally we draw the conclusion that the CFD simulation of the oblique towing test is applicable.

KEY WORDS: static drift; URANS; PMM; numerical simulation; naoe-FOAM-SJTU solver.

INTRODUCTION

In the past few years, ship maneuverability has become more and more important for navigational safety, thus an accurate estimation of a ship's maneuvering ability at the design stage is essential to comply with the IMO standards. Up to the present, the main method for predicting ship maneuverability is model scale experiments, among which a static and dynamic Planar Motion Mechanism (PMM) system in a conventional towing tank is popularly applied to determine the hydrodynamic coefficients in the experiments. Static drift test or say oblique towing test controlled by PMM system is one of the most commonly used approaches for maneuvering prediction. Despite its feasibility in motion generation, the PMM tests still have many disadvantages: the cost of facilities is very expensive and the workload of duplicate operation is heavy due to different conditions; it also has limitations in obtaining the information of flow fields around a ship in corresponding motions.

In recent years, tremendous advances have been made in the development of Computational Fluid Dynamics (CFD) for ship hydrodynamics, including ship resistance, propulsion, seakeeping and maneuvering. Numerical simulation method based on CFD for ship maneuvering prediction significantly helps to compensate the disadvantages in physical experiments. Ohmori (1998) has developed a finite-volume method of computing the viscous flow field about a ship in maneuvering motion, and emphasizes that the only accurate way to obtain the hydrodynamic forces and moments acting on a hull should has the ability of resolving the details of the flow field. Turnock et al. (2008) employ CFX to investigate the global forces and moments acting on the KVLCC2 hull form under going straight line, drift and pure sway PMM tests, and shallow water results are also presented. The URANS simulations of static and dynamic maneuvering for surface combatant and the forces, moments, and hydrodynamic derivatives acting on the ship have been investigated by Sakamoto et al. (2012). Carrica et al. (2013) have shown the URANS computations of steady turn and zigzag for a surface combatant at both model and full scale, the results in which indicate that URANS computations of standard maneuvers are feasible. Stern et al. (2011) have given an overview of the benchmark cases for the prediction capabilities of different ship maneuvering simulation methods on SIMMAN 2008 workshop and the conclusion that finer grids and detached eddy simulation (DES) can be more accurate is also presented.

The objective of the present work is to investigate the hydrodynamic forces and moments of a ship scaled model in oblique towing conditions. In this paper, the numerical results of the hydrodynamic forces and moments as well as the hydrodynamic derivatives are presented and compared with physical experiments performed at Marine Design & Research Institute of China. The existing solver, naoe-FOAM-SJTU, developed for ship and ocean engineering based on the open source code OpenFOAM has been applied to simulate the static drift in the numerical towing tank. A new 6DOF module has been further extended to the solver to accurately simulate ship motions in the oblique towing test. The physical experiment is conducted by a static planar motion mechanism system free to sink and trim and the ship is subjected to static drift under different drift angles, namely 0, 2, 4, 6, 8, 10, 12. Based on the full viscous-flow calculation and free surface