Computation of Wave-Making Resistance on High Speed Catamaran Using FINE/Marine

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ABSTRACT

The viscous flow around a M331-based catamaran is simulated based on a computational fluid dynamics (CFD) commercial software FINE/Marine, which is an integrated CFD software environment for numerical simulation of mono-fluid and multi-fluid flows around kinds of vessels. The wave-making resistance on a catamaran and the corresponding wave patterns are studied and illustrated in the present paper. Firstly, convergence studies with respect to computational domain size, ramp function, grid number, and time step are performed by the wave-making resistance problem of the catamaran. Then, waves generated by a M331-based catamaran and the corresponding wave-making resistance on the hull with various traveling speed are simulated. Finally, the ratio of ship-length to its displacement is mainly optimized to obtain a high seakeeping performance with low wave-making resistance and fast advancing speed. It is confirmed that the FINE/Marine has the capability of prediction of wave-making resistance on the catamaran, and it is also considered to be a promising tool to optimize hull form for high seakeeping performance with fast advancing speed.

KEY WORDS: Hydrodynamics, FINE/Marine, catamaran, wave-making resistance.

INTRODUCTION

As a new type of ship, the high-speed catamaran has recently been attracting the world’s attention. More than high-speed, it possesses excellent seakeeping performance, large capacity, beautiful shape, comfortable accommodation space environment, and high cost performance. Fishing boat/yacht is quite popular with people in recreational activities. Spacious deck area and an open cockpit are two important characteristics of the fishing boat. In order to arrive at the inhabit areas of fishes, the mobility and voyage of the fishing boat is crucial, although some large fishing boats also provide cabins to stay overnight which expands fishing areas (Zhu, 2012).

Compared with conventional ship, the prediction of wave-making resistance on the catamaran and the corresponding wave patterns is much more difficult. Physical experiment is considered the most reliable method by far, but it is inconvenient for optimization of ship hull to redo new series of experiments resulted from a slight change of hull form. With continuous development of modern ship, ship forms have been changed significantly, which makes some conventional resistance charts used for ship design inapplicable, especially for the high-speed catamaran which has slender hull, small ratio of width and draft, high speed and high Froude number.

Over the past two decades, numerical calculation method based on CFD in ship hydrodynamics has been rapidly developed with the development of computer science and technology. And it becomes an effective tool for ship design and hull optimization by applying it to hydrodynamic performance analysis and forecast. The numerical method can be divided into two categories, namely the potential-flow-based method and the viscous-flow-based method. Details to forecast the flow field and viscous resistance rely on viscous flow method much more strongly despite the potential flow method can evaluate the wave-making resistance, since viscosity is important for boundary layer around hull and the ship wave. The simulation of viscous flow field around hull and prediction of resistance accurately becomes one of research topics in ship hydrodynamics.

Three-dimensional numerical study of viscous flow has been started in the 70s, and the research was mainly based on the theory of boundary layer. In the 80s, the viscous flow field in the boundary layer separation part has been solved by separate the potential flow and viscous flow. Until the early 90s, solutions of viscous flow field were truly realized. Since the 90s, viscous flow field and hydrodynamic research became more active. Besides, significant progress was made in numerical techniques, such as grid-generation technology, parallel computing technology, multi-grid acceleration, adaptive artificial dissipation, preset system and result-visualization technology. The Mississippi State University united with Pennsylvania State University made some research of ship computer aided design (CAD) by supercomputers (Li, 2008). The Reynolds Average Navier-Stokes (RANS) algorithm with viscous effect considered was adopted in vessel maneuverability calculation of a conceptual submarine. Based on three-dimensional viscous flow, Zhou et al. (1997) calculated the partition/block flow field of submarine with appendage by solving Poisson equation and the k-s RANS equation. Chen (1998) calculated both steady and unsteady seakeeping problems by adopting algebraic method to generate hull grids and selecting the standard turbulence model based on artificial compression. Zhang and Liu (2001) simulated a hull advancing in three-dimensional waves successfully by solving RANS equations and tracking free surface. It adopted surface dynamic grids technology to stick to object surface and free surface, and selected the mixed turbulence combining subnet scale (sGs) with Baldwin Lomax model.

In this paper, the viscous flow around a M331-based catamaran is simulated based on a CFD commercial software FINE/Marine, which is an integrated CFD software environment for the simulation of mono-