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Navigational Simulation Using Tidal Simulation and Tidal Effects on Sailing Ship

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ABSTRACT

The final object of this research is to develop a weather routing system for small vessels in coastal water. As a first step, we researched the effects of tidal currents on the maneuverability of a ship by numerical simulations and on-board experiments. Ship positions of within a tidal current were estimated by navigational simulation and compared with the experimental results obtained with the use of an actual small ship. The simulated rhumb lines of a ship showed reasonably good agreement with the experimental ones. We concluded that this simulation method for the ship positioning was effective for a weather routing system. As a second step of this study, the methodology used in the computer simulation of tidal currents in the bay was explained. Simulation of tidal currents and navigation were carried out in Osaka Bay in Japan. The effects of tidal currents on the navigation of a small vessel were examined. As a result, it was recognized that the effects of tidal currents on navigation are very large and that tidal simulation is very effective for the weather routing system of a small vessel.

KEY WORDS: Weather routing; ship maneuverability; tidal effects; tidal simulation.

INTRODUCTION

The wind, tidal current and waves are the most important elements affecting a ship's navigation. Many studies on ship navigation for large transoceanic vessels have been conducted relative to weather routing, and most of them have focused on minimizing the transit time or quantity of petroleum oil required for a voyage. However, few studies have focused on weather routing for navigation of small vessels, including cargo, a passenger, and fishing ships operating in narrow coastal waters, have been conducted(Shiotani,2000, 2002). In fact, even with short-voyages, the cumulative sailing time deserves a great economic consideration. Furthermore, because of the diminishing petroleum oil reserves and the development of powerful high-speed engines, it is likely that the cost of fuel will be very high in the near future.

With such considerations, the final objective of this study is to develop a weather routing system for the navigation of a small vessel in coastal waters.

We first studied the effects of tidal currents on a ship's maneuverability with the use of numerical simulations and on-board experiments. Simulated ship positions in a tidal current were compared with the field experiment results using an actual small ship.

As a second step in this study, the methodology used in the computer simulation of tidal currents in the bay was described. The simulation of navigation in the bay was carried out, and the effects of tidal currents on small vessel navigation were examined.

It was concluded that effects of tidal currents on navigation were significant and the tidal simulation for the weather routing of small vessel was very effective.

SHIP MANEUVERING SIMULATION

Accurate estimates of a ship's position are key to the optimum routing of ships. Such estimates can be obtained when hydrodynamic forces and moments affecting the hull are known in advance. In consideration of the above, the MMG mathematical model, which is widely used for describing a ship's maneuvering motion, was adopted for the simulation(Xia, 2005, 2006). The main feature of the MMG model is to divide all hydrodynamic forces and moments working on the vessel into the hull, rudder, propeller and others and their interaction.

The coordinate system is denoted in Fig. 1. Two coordinate systems are used in ship maneuverability research: space-fixed and body-fixed. The latter, G-x,y,z, moves together with the ship and is adopted in the MMG model. In this coordinate system, G is the center of gravity of the ship, the x-axis is in the direction of the ship's heading, the y-axis is perpendicular to the x-axis on the right-hand side, and the z-axis is vertically downwards through G.

Therefore, the equation of the ship's motion in the body-fixed coordinate system adopted in the MMG is written as