Numerical Simulations of the Motion of Wharf Moored Ship Induced by Passing Ship

Ming Wu, Xiao Wang, Bo Yang, Feng Cai
Department of Navigation, Dalian Naval Academy
Dalian, Liaoning, China

ABSTRACT

The dynamic response of wharf mooring ship induced by passing ship was conducted based on computational fluid dynamic method (CFD). The three-dimensional viscous flow between mooring ship and passing ship was simulated by solving the Reynolds Averaged Navier–Stokes (RANS) equations and shear stress transport (SST) k-ω turbulence model. The motions of ship were predicted by solving the equations of motion of a rigid body, and the overset grid method was used in the simulations. The mooring rope forces were obtained by solving catenary coupling equations. The method was applied to the simulations of motions for a carrier model mooring at the dock, and the simulation results were examined by the comparisons with experiment results, which demonstrate the ability of the present method to compute hydrodynamic force of mooring ship. On this basis, the hydrodynamic force and moment acting on the moored ship was investigated, the effects of passing ship speed and separation distance were illustrated. The conclusions of this paper can provide the reference for setting the restrict speed in port area, and ensure safety of wharf moored ship.

KEY WORDS: Mooring ship; Passing ship; Motions; Force of mooring cable; Computational fluid dynamic (CFD); Overset grid.

INTRODUCTION

Ship wave will be enhanced by the reflection of dock when ship entering or leaving port. The large amplitude ship wave may arouse wharf moored ship significant motion, which make the shipboard operation become difficult, and affect the ship collide the wharf; even cause mooring facility broken accidents in some extreme cases. Therefore, it’s essential to study hydrodynamic interaction between wharf moored ship and passing ship to ensure safety.

The influence of passing ship on moored ship is very complex, since it involves the problems of the evolution of ship waves and the ship’s six degrees of freedom motion with mooring cables. Some researches focus on the physical model test and empirical formula of the hydrodynamic force of mooring ships. Remery (1974) conducted a series model tests, and the hydrodynamic force under different speeds and transverse spacing acting on mooring ships were considered. Flory (2002) proposed an empirical formula to calculate the hydrodynamic forces between the passing ships and mooring ships. Kriebel (2007) conducted model experiments and developed empirical equations based on the measured forces and moments between the passing vessel and the moored vessel. Duffy and Renilson (2011) presented some results of hydrodynamic interaction between a berthed ship and a passing ship from model scale experiments. In recent research, some numerical studies were adopted for mooring analysis. Pinkster (2011) investigated passing vessel forces on the moored vessel using potential flow theory based on panel method using non-deforming free surface assuming the effects of surface waves on forces are negligible. Yuan Zhiming et al. (2015) proposed an uncoupled method using 3-D Rankine source potential flow theory to study the ship–ship interactions in overtaking operations in shallow water. Wang Zhihong et al. (2014) made a numerical analysis on the hydrodynamic interaction between passing ships and berthing ships by using commercial software AYSYS Fluent. V. Nandhini et al. (2019) made a detailed parametric study by using commercial software Star CCM+, and provided a proper insight into the effect of full hull forms of various displacements on the passing vessel forces.

In this paper, the computational fluid dynamics method was used to simulate the three dimensional viscous flow around wharf moored ship induced by passing ship, and the hydrodynamic force action on the moored ship was calculated, the three degree of freedom motion of the moored ship was realized by using overlap grid technology. The calculation results are compared with experiment results, which verify the effectiveness of the numerical method in this paper. On this basis, the influence of passing ship speed and the separation distance were investigated.

NUMERICAL METHODS

Governing equations

The flow around moored ship induced by passing ship can be regarded as incompressible viscous flow, so the governing equations can be represented by continuity equations and unsteady incompressible RANS equations: