Response of Moored Ship in the Waves Generated by Passing Ship

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ABSTRACT

Ships have significantly increased in size, number and velocity over the last decades. Ports and waterways are accommodating these ships. In restricted water, waves generated by ships have potential adverse impacts on the environment (beach erosion, ecological disturbance, structures damage) and other waterway users (navigations, moored ships). This paper was conducted to find a fast numerical model to investigate the effects on moored ship and to validate this model. A coupled method is used in this paper to simulate the washes and its effects on moored ship. The wave patterns are calculated by a generalized boundary element method that based on NURBS. Rankine source is used as the Green function, which is simple and can be easily applied to solve the non-linear problems. It is convenient to generate grids on hull surface by using the NURBS to express the surfaces and source strength. The continuity of the panels and source strength can also be guaranteed by this method. Waves generated by passing ship are translated into frequency components by Fourier transform, hydrodynamic coefficients and forces are calculated for each frequency based on the linear potential theory, motions and forces of the moored ship in ship waves are simulated based on Cummins's indirect time domain theory. The comparison between simulated results and experimental results showed that the methods adopted in this paper are feasible. The effects of the velocity of passing ship, water depth and the distance between two ships on moored ship are discussed.

KEY WORDS: coupled method; wash wave; moored ship; indirect time domain.

INTRODUCTION

Waves generated by passing ships especially high speed ships and large ships always cause a lot of problems particularly in shallow water. The generated waves may have large effects on moored ship, the amplitudes of washes that generated by passing ship are much smaller than primary wave, but the longer periods may make their effects on banks and nearby environments more serious. Finding a quick and convenient method to predict and control the ship waves attracts more and more concerns. This paper is conducted to find a fast numerical model to investigate the effects of wash waves on moored ship and to validate this model.

The researches on the effects of passing ship are more and more in recent years. Liu(2007)calculated waves by emperical equations, and modeled the effects of waves on other ships. Wang(2010)introduced an algorithm to calculate the forces and moments on moored ship in waves generated by passing ships, and discussed the characteristics of the forces and moments. Xu(2013)numerized the researches of ship waves, and discussed the measurements of bank protection for ship waves. Lu(2009)studied the effects of displacement, the angle between mooring cables and wharf, wave angle and wave period on the mooring force, ship motion and impact energy by experiments. Wang and Zou (2014)calculated the interactions between passing ship and moored ship when passing ship passed the lock using RANS method, and analyzed the effects of velocity, water depth and the distance between passing ship and moored ship. Pinkster and Bhawsinka (2013)applied the procedure Delpass (based on potential theory)that predicting the interaction between ships and between ship and wharfs on the maneuvering simulator of MARIN to provide real time prediction. Pinkster(2004,2009), A.van der Hout et.al(2011)adopted a coupled method to calculate the motions of moored ship in wash waves of passing ship, but nonlinear features of mooring system were not considered. Bunnik(2009)calculated the motions of moored ship in wash waves by RANS, and discussed the effects of navigation angle. The effect of viscous was considered, but the mooring systems were not considered in the paper. Luth(2011)studied the effects of passing ship on moored ship from the point of human comfortableness by real ship tests, but plenty of manpower and material were needed.

In recent years, a NURBS based generalized higher order panel method for the problems of ship waves are validated to be applicable for displacement ships(Zhou,2012,2013), which is adopted in this paper to calculate the wash waves of passing ship. The calculated wash waves are used as the input data to simulate the responses of moored ship by an indirect time domain method.

NUMERICAL METHOD

A NURBS based generalized boundary element method

Non-uniform rational B-splines method is one of the successfully used tools for surface generation. Considering its excellent features and widespread application, STEP (Standard for the Exchange of Product Model Data) chooses NURBS as the main method for geometric description. The introduction of a NURBS based higher-order boundary method for the calculation of ship fluid mechanics problem serves as a link for CFD and CAD.

In this paper, NURBS is adopted to express ship surface, the unknown wave pattern of free surface and the unknown source strength on ship surface and free surface. Weight factor is set as 1 when expressing the source distributed surfaces by NURBS, but the weight factors change everywhere for the description of object surface, which makes the expression of complicated object surfaces more accuracy and more