ABSTRACT

To conduct a ship structural response analysis, it is very important to estimate correctly the wave force in strong nonlinear phenomena. Therefore, a method for a ship structural response analysis is proposed. The pressure distribution making the large ship motion with slamming is directly simulated by computational fluid dynamics, and the ship structural analysis is calculated using this pressure distribution. This paper reports the calculation method of the pressure acting on a hull as the first report. The proposed calculation method is validated by simulation of a forced oscillation test in waves.

KEY WORDS: ship structural response analysis, pressure distribution, nonlinear phenomenon, CIP method, C-CUP method

INTRODUCTION

In recent years, the marine transportation volume has been significantly increasing. Ships are upsized to handle the massive quantity of maritime transportation. To meet this trend, large container ships, which are capable of carrying in excess of 10,000 TEU, have appeared. Such container ships generally have a large bow flare. As a result, the stiffness of large container ships coming into service has become relatively low. It is a concern that whipping or springing from slamming loads on the bow flare has an effect on the ship structural response. Therefore, to conduct an accurate ship structural analysis, it is very important to estimate correctly the wave force in strong nonlinear phenomena. As the calculation method of the hydroelastic response in nonlinear problems, the nonlinear strip method was extended to deal with the non linearity of the time domain. Proposed by Yamamoto, Fujino and Fukasawa (1978a, 1978b, 1979), the nonlinear strip method is also useful for the hydroelastic response in a strong nonlinear phenomenon such as slamming. The ship motion and the wave load can be calculated to be accurate with the nonlinear strip method. However, the nonlinear strip method cannot calculate the pressure distribution acting on a hull.

The proposed method of the ship structural response analysis for the strong nonlinear phenomenon due to slamming is as follows. First, the ship motion is calculated with the nonlinear strip method. Next, the data of this ship motion is used as input data, and the pressure distribution acting on the hull is directly calculated by computational fluid dynamics (CFD). Finally, the pressure distribution is used to analyze the ship structural response by the finite element method (FEM). However, in the application of this procedure to ship structural design, three-dimensional CFD calculations consume an immense amount of time and so are not realistic. Therefore, the calculation area is sliced into two-dimensional sections, as shown in Fig. 1 for calculation cost saving. By setting the calculation area in two dimensions, no information is available on the longitudinal direction, which means the head sea cannot be simulated correctly. As the first report, this paper studies the calculation method of the pressure distribution acting on a hull in waves. In addition, this paper studies the modeling of the ship boundary condition to solve this problem.

CALCULATION METHOD

The Constrained Interpolation Profile (CIP) - Combined Unified Procedure (C-CUP) method is used for the CFD calculation code in this research to calculate a strong nonlinear phenomenon. The C-CUP method, developed by Yabe and Wang (1991), is known as a technique capable of treating liquid, gas, and solid simultaneously. However, the three-dimensional numerical computation in the time domain takes an