

## Numerical Simulation of Strongly Nonlinear Wave-Ship Interaction by CIP/Cartesian Grid Method

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### ABSTRACT

A Cartesian grid method for three-dimensional computation of strongly nonlinear wave-body interactions is presented in this paper. The main feature of the method is the use of CIP (Constrained Interpolation Profile) method (Yabe et al., 2001). The free surface is captured by THINC scheme and a newly technique is developed to define a practical ship with complicated shape. The accuracy of the method is shown by a comparable computation with an experiment on a modified Wigley model. The efficiency of the method for practical ships is demonstrated by an numerical example with a container ship model.

**KEY WORDS:** CIP/Cartesian grid method, 3-D computation, practical ship, strongly nonlinear wave-body interaction.

### INTRODUCTION

The numerical method described in this paper is a Cartesian grid approach for computing strongly nonlinear free surface flows such as slamming, water on deck, green-water impact, violent sloshing, etc. The present target of the development is the prediction of both the global ship motions and the local water-on-deck phenomena, and their interactions using one code.

By this method the wave-body interaction problem is treated as a multi-phase problem and the computation is carried out on a Cartesian grid as shown in Fig.1. An important feature of the method is the use of CIP (Constrained Interpolation Profile, Yabe et al., 2001) for the multi-phase computation. The numerical method developed on this framework is called the CIP/Cartesian grid method.

In the ISOPE-2006 conference, we presented main features of the CIP/Cartesian grid method and studied a two-dimensional strongly nonlinear wave-body interaction problem by both computation and experiment (Hu et al., 2006a). The experiment was performed in a two dimensional wave channel (10m long, 0.3m wide and 0.4 m deep) at RIAM, Kyushu University. The floating body model used for the experiment is with length of 0.5m, depth of 0.10m and freeboard of 0.025m. A box type upstructure is installed on the deck. The comparison between the experiment and the 2-D computation was

satisfactory. For the forced oscillation case, the viscous effect on the damping force coefficient can be correctly predicted by the current numerical model. For the wave-body interaction case, strongly nonlinear features of the body motion are found in the experiment for some of the wave periods and can be well simulated in the computation. An analysis based on the numerical result has shown that green water gives very important effect on the body motion.

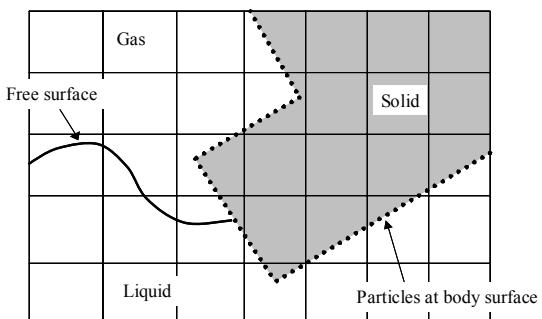


Fig.1 Multi-phase computation model for wave-body interactions in the CIP/Cartesian grid method.

In this paper, the CIP/Cartesian grid method for 3-D computations will be presented. Two new developments, the implementation of THINC (tangent of hyperbola for interface capturing) scheme for efficiently capturing the free surface, and a method for treatment of practical ships with complicated shape, will be described in details. For numerical results, at first a comparable computation with an experiment on a modified Wigley model is shown for validation. Then to demonstrate the efficiency of the proposed method for practical ship calculation, a numerical example with a container ship model is presented.

### NUMERICAL METHOD

The CIP/Cartesian grid method used for the present three-dimensional computation is summarized in this section. Details about the method can be found in previous papers (Hu and Kashiwagi, 2004 and Hu et al., 2006b).