Analysis of the Mechanism of Slamming on the Bow Flare Region of a Container Ship Using RaNS CFD Method

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ABSTRACT

The steady increase of demand in global container traffic leads to increase the size and capacity of container carriers with large bow flare. Due to large flare, container carriers experience more non-linear ship motions and wave induced load which is termed as slamming in actual seas. RaNS based motion simulator developed at The University of Tokyo, which has the capability of handling 6(six) degrees of freedom (DOF) is used in analysis. Numerical method is validated for a modern container ship model named KCS in regular head waves and mechanism of slamming on the bow flare region is analyzed based on visualization of flow field i.e. velocity contour, surface vector below the free surface etc. near the bow flare region. Present numerical method predicts ship motions accurately and phenomena of slamming can be described by visualization technique.

KEY WORDS: Container ship; slamming; bow flare; visualization.

INTRODUCTION

Slamming can be classified based on the region of the hull surface where it occurs as bottom slamming, green water loading, breaking water impact and bow flare slamming. Among these kinds of slamming, evaluation of hydrodynamic loading due to bow-flare slamming is still a challenging task. It is because of:

- Bow flare slamming occurs only in particular types of ship like container ships and car carriers. Therefore, it is comparatively new kinds of slamming phenomena.
- Since bottom of the hull has high structural strength, preparing for the bottom slamming does not require many tasks.
- Extensive researches were carried out for green water loading and now-a-days practically applicable analytical and numerical methods are available to predict the loading because of it during design stage.

However, flare part of the hull surface is not prepared to withstand high pressure load and it is not practical to add high strength around entire flare part. Therefore, a method to predict flare slamming is needed for safety and total economy of the vessels.

Traditionally, strength requirements in the bow flare region are evaluated based on the empirical formula proposed by various classification societies. Study reveals that there is a sizeable difference occurs in evaluated strength requirements by using classification society’s empirical formula. Therefore, a direct calculation method is needed for evaluating the strength in the flare region in the design stage of hull surface. Inviscid potential-flow based numerical methods are used widely for evaluating wave resistance because of its’ robustness and less computational time requirements. However, flow separation, generation of vortex and non-linear wake filed are occurred in real conditions, which is due to viscous effects. Therefore, improvement is necessary in numerical calculation methods. The possible candidate is the Reynolds averaged Navier-Stokes (RaNS) based computational fluid dynamics method (CFD).

Slamming has challenged many researchers since von Karman’s work (1929). He idealized the impact as 2D wedge entry problem on calm water surface to estimate the water impact load on a seaplane during landing with small deadrise angle. Here, deadrise angle means the angle between the body surface and the impacting still water plane. Zhao et. al. (1996) presented fully non-linear numerical method based on Generalized Wagner’s method for 30 degree dead rise and flared ship section by considering the flow separation from knuckles. Gravity was neglected in their studies. They compared numerical results with their experimental drop tests. Satisfactory agreement of vertical slamming force was documented at initial stage of impact but larger at later stage. They mentioned that it was because of three-dimensional effects which cause 20 percent underestimation in the vertical force at the stage when the spray roots reach the knuckles. Arial et. al. (1989) used finite difference method (FDM) for discretization of the Euler equations and volume of fluid (VOF) method for free surface evolution...