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Effect of Buffer Bow Structure in Ship-Ship Collision

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The purpose of this paper is to investigate the effectiveness of a prototype buffer bulbous bow structure in ship-ship collisions as compared with that of standard bulbous bows. A series of large-scale finite element analyses were carried out using LS-DYNA in the collision scenario where a VLCC in ballast condition collides with the midship of another double-hull VLCC in laden condition. The effect of the equivalent failure strain and the forward velocity of the struck ship on the results of simulation were investigated. Collapse modes, contact forces and energy absorption capabilities of the buffer bows are compared with those of conventional bows. This study found that, in the collision case of 90° without forward velocity of the struck ship, the critical striking velocity for the buffer bow becomes about 77% higher than that for a standard bow. It could be said that the buffer bow is effective in reducing the damage to a struck ship in case of collisions.

INTRODUCTION

In order to prevent oil spillage from a struck tanker, the double-hull system has become the de facto standard as an effective countermeasure. However, it is still a fact that collision accidents involving struck double-hull tankers result in oil spills; one example is the collision accident involving the double-hull oil tanker *Baltic Carrier*. There are good reasons, then, to further minimize the consequences of ship collision accidents. In order to reduce the oil-spill risk from struck oil tankers, the Buffer Bow Project (BBP) has been carried out at NMRI in Japan, sponsored by the Japanese Ministry of Land Infrastructure and Transport (MLIT). The results presented in this paper consist of a part of the results obtained within the BBP. From an environmental point of view, Kitamura et al. (1998) suggested that the bulbous bow of the striking ship is the most threatening part for the struck ship and is thus regarded as a key structural part for buffer bow design; the main focus in the BBP is then laid on the bulbous bow structure. A lot of research has been conducted so far concerning numerical studies of ship-ship collisions. Kitamura et al. (1998, 2000) applied the buffer bow concept to the bulbous bow of large cargo ships in the research project of the Association for Structural Improvement of Shipbuilding Industry (ASIS). They carried out FEM simulations assuming that a Suezmax tanker collides with a double-hull (D/H) VLCC with the purpose of evaluating the effectiveness of buffer bows. In that research project, due to the limitation of computer technology in those days, only one oil tank of the struck tanker was modeled by elastic-plastic elements. Other parts of the struck ship were modeled by rigid elements, where deformation of transverse bulkheads located back and forward of the struck oil tank was not considered. However, this modeling of the VLCC was not sufficient for the case of high-energy collisions The relatively narrow deformable range surrounded by the close rigid boundaries may cause early rupture of the side and inner shell of the struck ship. Subsequently, Kitamura (2002) conducted a series of finite element simulations and pointed out that the effect of the global-hull-girder horizontal bending moment (GHBM) is significant when a ship collides with the midship of a ship and the size of the striking ship is the same or larger as that of the struck ship. Kitamura (2002) analyzed several cases, considering the GHBM of the struck ship where a VLCC collides with a relatively small ship. Using a simplified model, the GHBM effect was demonstrated by Pedersen et al. (2004) to result in significant strains in the ship side. Thus, in this study 3 oil tanks on the port-side and 3 oil tanks on the starboard-side—a total of 6 six oil tanks—are modeled in order to take the GHBM effect into account.

In order to validate the accuracy of the finite element simulation of ship collisions, some large-scale experiments have been conducted. ASIS (1996) conducted full-scale ship-ship collision experiments in The Netherlands. Endo and Yamada (2001A), Endo et al. (2001B) and Yamada and Endo (2003) conducted a series of quasi-static axial crushing experiment with large/small-scaled bulbous bow models assuming right-angle collisions. As a general observation, the usefulness of the finite element analysis was confirmed in estimating the crushing strengths and collapse mechanisms of ship collisions. Further improvements are still needed, however. In this study a series of finite element simulations is conducted using the general-purpose structural analysis code LS-DYNA, assuming a collision scenario where a D/H VLCC is struck midship by a VLCC. Fracture of fillet weld, elastic-plastic material properties, and strain rate effects are taken into account in the simulations. The effect of equivalent plastic strain and forward velocity of the struck ship in relation to energy absorption of the bow of the striking ship are investigated. Collapse modes, contact forces and energy absorption capabilities of the buffer bow are compared with those of similar conventional bows. The effect of critical failure strain (FS) on the initiation of rupture of the outer and inner shell is investigated.

COLLISION SCENARIO

In this study a VLCC is adopted as the striking as well as the struck ship. The reason is that the environmental damage is supposed to be most severe when an oil spill happens from an accident involving a VLCC, and those ships are most likely to collide

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