Research of deform process and interactive mechanism on typical ship side structure under the quasi-static loading

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ABSTRACT

In order to evaluate the crashworthiness of ship side structures of collision loads, the structure response of typical frame structure of ship side is studied, focusing on deformation and energy dissipation process of the structure under quasi-static bow-shape indenter. In the whole deformation process, the hull plate, girder structure and stiffener have different deformation and energy dissipation modes, which are interacting with each other and resist the penetration of external indenter conjunctly.

First, the deform process of the whole frame structure is analyzed in stages. First stage, plastic tensile deformation occurs in the hull plate. Second stage, plastic buckling and crushing failure occurred in the girder structure, and slight warping and torsional deformation occurred at the boundary of the two ends of the stiffener. Third stage, the center of the girder structure is crushed and folded and interacted with the hull plate. Finally, due to the large tensile force on the hull plate near the girder, the plastic strain in this area exceeds the tensile fracture strain of the material, leading to the tear of the hull plate.

On the basis of the overall analysis, the frame structure is split into three combinations of structure, which are hull plate structure, plate-girder structure and plate-stiffener structure. Each combination is subjected to quasi-static penetration by the same indenter and deform and energy dissipation modes are analyzed. Moreover, deformation and energy dissipation of the frame structure and the split structure under the same penetration depth are compared, and the interactive mechanism of the hull plate, girder and stiffener are simply analyzed.

KEY WORDS: ship collision; deform process; structure response; failure mode

INTRODUCTION

Ship collision is a complex nonlinear process, in which ship structure is subjected to external impact load. Serious damage and deformation occurs on the impacted structure during the process. For metallic structures such as ship structures, the material will go beyond the elastic deformation range of the structure and plastic deformation takes place when it is impacted. According to statistics (Zhu, et al, 2002), the casualties caused by ship grounding and ship collision account for one third of all ship accidents. This makes the research of ship collision to an important position.

Generally, the collision of ship side structure accounts for a large proportion of ship collision problems. Therefore, it is particularly important to study the resistance and energy dissipation process of the ship-side structure subjected to collision load, as well as the anti-impact design strategy of ship side structure. Due to the relatively low ship velocity, the quasi-static method is generally used to study the displacement-force curve of ship structure when it is invaded by external indenter, so as to evaluate the resistant ability of ship structure, and give the displacement-energy curve of ship structure subjected to the impact. Liu et al.(2015) implemented a quasi-static study on the collision and grounding loads of the ship structure with experimental means and compared the numerical simulation to discuss the energy absorption in the collision process(Liu, et al.,2015).

Figure 1 shows a typical collision accident scene (1999). In this scene, the side structure of the ship suffered a significant intrusion from the bow of the other ship, causing serious damage. Moreover, when the center point of impact is located on the transverse frame, it has a great possibility to cause serious damage and deduce the whole strength of the ship. The side structure of the ship will be seriously dented and torn, which easily leads to further damage such as water leakage and electric...