Study on the Structural Strengthening Design under the Ship-ice Collision Load

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ABSTRACT: In order to investigate the water media effect on Structure response under ship-ice collision load. This paper presents a study on ship-ice collision considering the effect of water media for the first time. The ship-ice collision is simulated in aqueous medium and the coupling behaviors between the ship, water and ice was considered. The calculation model is applied to various working conditions of ship-ice collision calculation. The parametric study on the thickness of shell and transverse diaphragm and the spacing of the frames is then conducted. The damage deformations, collision forces, structural energy absorptions varying with thickness of shell plate, thickness of the transverse diaphragm and different spacing of frame are discussed. The capability and contribution of each major component in the shoulder of the ship on the resistance of ice loads is analyzed. The conclusions are of great significance in improving anti-ice load ability of ship structure.

KEY WORDS: Ship-ice collision in water media; Ice model; Structure response; strengthening design

INTRODUCTION

In the recent years, with the discovery and exploitation of oil and gas resources in arctic area as well as the development of Northern Sea Route (NSR), more and more attentions has been paid to the study on ship-ice collision in the field of naval architecture and ocean engineering. Ship-ice collision has been a topic of interest among researchers especially those from Canada, Norway, America. Gagnon (2006) investigated the ship-ice collision through both the experimental and numerical methods. However, the structural damage was not reported. Wang and Yu (2008) used a coupled model to simulate ice-LNG collision. The floating ice model with inducted ice failure model, Liu, Amdahl and Løset (2010; 2011) systematically studied the external and internal dynamics of a ship collision. They got the pattern of the energy dissipation during the collision by using a simplified method. They also simulated the ship-ice collision by a numerical method. Lee and Lee (2009) conducted a collision test between a cylindrical ice a and grillage structure. Special efforts were put on the failure law of the ice model. Zhang, Wan and Chen (2014) used both numerical and experimental methods to investigate the collision between the side grillage and ice to validate the feasibility of the ice material model, as well as the numerical method.

This paper based on finite element software, numerical simulation of ship-ice collision is conducted in the water media, The discussions are highlighted on the reinforcement of the structures in ice area. The conclusions are of great significance in improving anti-ice load ability of ship structure.

ICE NUMERICAL MODEL

The accuracy of the numerical simulation depends on two aspects: the material model of both sides during the collision and method of numerical simulation. There are two kinds of materials mainly involving in ship collision: the steel hull and the ice. The material of hull is very mature already. However, The mechanical property of the ice is very complicated. One example is that ice fails in different modes under different strain rates (Liu, Amdahl and Løset , 2011). At a low strain rate, the deformation of ice can be stimulated by the elastic-plastic theory and the non-recoverable stage of deformation is dominated by the nonlinear properties. At a high strain rate, the ice deformation tends to be smaller. The stress-strain curve is linear to a large degree and the fragility of the ice takes the dominate role when the ice is fractured, the failure mode (e.g. large scale and partly fragmentation and bending failure) varies. A transitional zone appears between the ductile zone and brittle zone and is characterized by plastic deformation, many cracks shear failure and partly fragmentation. Schulson (2011) investigated this strain rate effect, as shown in Fig.1 and suggested that ice stress tends to rise along with the strain rate until brittle failure appears.