Safety analysis of platform operation in the ice area of Bohai sea

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ABSTRACT

When an offshore nuclear-powered platform operates in the Bohai Sea area, it faces a threat from floating ice in winter. Therefore, for the sake of safety, it is necessary to analyze the collision process between the floating ice and the platform. The finite element numerical simulation method is used to simulate the collision process between floating ice and an offshore nuclear-powered platform. Comparing the resistance-displacement curve of numerical simulation process with the data of the ice cone compression experiment, the feasibility of the numerical simulation method is verified. Based on the ice conditions in the Bohai Sea, a typical floating ice model is established, and structural response is analyzed by the impact process between the floating ice and the platform. The bearing capacity of the platform for floating ice is then analyzed by changing the size of the floating ice with fixed ice thickness and fixed ice speed respectively. The results show that during the collision, the strength of the aggregate has a great influence on the bearing capacity of the platform, and the impact force increases with the continuous extrusion of the floating ice until the floating ice rebounds. With the increase in the size and thickness of the floating ice, the size of the floating ice that the platform can withstand a collision with reduces accordingly. Studies have shown that the strength of the aggregate at the collision site between the platform and the floating ice directly affects its own bearing capacity. This analysis finds that the speed of the floating ice has a greater impact on the bearing capacity of a platform than its thickness.

KEY WORDS: Bohai floating ice; Offshore nuclear-powered platform; Numerical simulation; Bearing capacity

INTRODUCTION

Oil and natural gas are known as “industrial blood”, which is not only an important energy source but also a crucial strategic material (Liu F, 2009). China’s Bohai Sea is rich in oil and gas resources and can be exploited and utilized. As a kind of mobile marine platform, offshore nuclear-powered platform combines ship and nuclear reactor, which can effectively reduce the cost of exploiting oil and gas resources. The freezing time in Bohai Bay in winter is from mid-to-late December to mid-February or mid-March of the next year, with an ice period of two to four months, which has a great impact on the production and operation of the drilling platform in Bohai Bay, and will pose a serious threat to the safety of the nuclear-powered platform, or even cause a nuclear leak. Therefore, studying the interaction between sea ice and nuclear-powered platform in Bohai Bay is particularly important for their safety analysis. In recent years, people have developed various methods to calculate the ice-structure interaction, such as experimental method, finite element method, discrete element method, and probability method (Xu Y, Hu Z Q, Chen G, 2019). Ye and Wang (2018) established a calculation model of submarine floating ice-breaking process based on near-field dynamics method. The simulation of dynamic fracture process of sea ice was consistent with the test results, which verified the feasibility of using particles to simulate the performance of sea ice. Huang and Sun (2015) tested the resistance model of polar ships moving in the floating ice zone, finding that the ship’s sailing resistance changed significantly under different ice coverage. Myhre (2010) analyzed the influence of the inner wall structure due to the dynamic ice load by the means of finite element simulation to simulate the collision between the cargo hold area of LNG ship and the sea ice. Ehlers and Kujala (2014) conducted a series of four-point bending tests to verify the sea-ice material parameters required for numerical simulation. It showed that the numerical simulation results of force, failure time, and displacement obtained were in good agreement with the experimental results. Nowadays, the mainstream analysis method used by scholars is to simulate the ice-breaking process with finite element method. However, the mechanical properties of selected sea ice materials are rarely analyzed to verify whether the material model conforms to the actual situation. At the same time, the ship-ice collision currently studied is mainly aimed at ordinary icebreakers, and few studies have been conducted on such special structures as offshore nuclear-powered platforms.

In this paper, LS-DYNA finite element software is used for numerical analysis of the collision process between floating ice and platform, and the numerical simulation method will be verified by comparing with the experimental data of ice cone compression. Since the midship part of the offshore nuclear-powered platform is a large cabin without transverse bulkhead, it is selected as the typical working condition of platform-ice collision to analyze the deformation of the platform structure in the collision area during the collision. Since the safety of the nuclear-powered platform is of vital significance, this paper will also analyze the bearing capacity of the platform against floating ice.