Applicability analysis of jacket platform in marine resources development in extremely cold regions

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ABSTRACT

With the development of technology and the influence of global warming, the marine resources development is possible in extremely cold regions, such as polar and subpolar regions. The jacket platform which is widely used in oil and gas exploitation all over the world, has expansive application prospects in the future, as it is technology matures. In order to verify the applicability of the jacket structure in extreme cold such as in polar and subpolar regions, the structural responses of the jacket structure under the action of severe sea ice are analyzed using a finite element method. The results show that traditional jacket structure doesn’t meet the requirements of the specification. The wall thicknesses of pile legs need to be increased to improve the ice-resist performance of the jacket structure. The results show that the ice-resist performance can be improved effectively by this method. However, the effects of improving the ice-resist performance are gradually weakened with the increase of wall thickness, and the cost is also increasing dramatically. Therefore the structural cost and the ice-resist performance should be considered comprehensively in the practical application.

KEY WORDS: Jacket structure; extremely cold regions; marine resources development; ice force; ice-resist performance.

INTRODUCTION

The extremely cold locations such as Polar and subpolar regions, contain abundant mineral, oil, gas, and wind energy resources. It is a fatal attraction to all countries in the world because of the short supply of global resource (Gautier et al., 2009). It is hard to develop marine resources in these regions, as they are usually underpopulated, travel is difficult and ice conditions are severe. But, it is possible to develop it in the future, as the freezing time becomes shorter and the temperature becomes higher with the global warming. More and more countries are working on developing the polar resources, such as, the opening of the Arctic Route (Ellis et al., 2009; Wang et al., 2015)and the exploration of polar oil and gas resources (Wassink et al., 2013). Beside the Polar Regions, some marine resources development projects have also been carried out in the subpolar region (Denney, 2009). For example, Russia has exploited oil and gas resources on the continental shelf near Sakhalin island in the subpolar region. Offshore oil and gas resources are exploited using the bottom-supported platforms, gravity concrete platforms and subsea equipment in the sea (Wang, 2016). But these development patterns are costly. The reason for choose those methods is that the sea ice is severe in the winter in Sakhalin Sea. In addition, there are considerable marginal oil fields in the Sakhalin sea area. The existing oil and gas resources exploitation methods are too expensive for marginal oil fields exploitation. Meanwhile, these sea areas are rich of wind energy resources. The existing structural forms are obviously unable to meet the economic requirements of wind energy development. Hence, a structure with good economy and mature technology is needed for the marine resources development in these regions. As the most common structure, the jacket structure has a good application prospect in marginal offshore oilfield exploitation, as it is technology mature and economical (Wei, 2010). It had been widely used in oil and gas production in Bohai Bay of China. The ice forces and ice-resist design problems of the jacket structure were solved by researchers through field monitoring, numerical simulation and model test methods (Wang et al, 2015; Wang and Ji, 2017; Zhang et al, 2017). The jacket structure was also widely used in the marginal oil fields production in Cook Inlet (Liu et al, 2015). Jacket structures will be used in more and more marine resources development in cold region with the technology developing and global warming. However, at present, it is not suitable for marine resources development in some extremely cold regions.

In summary, the jacket structure is mature in technology and good in economy, and will play an important role in the development of marine resources in cold regions in the future. Therefore, the applicability of the jacket structure under the action of sea ice in the extremely cold regions is discussed through the structural safety and human comfort analysis. Firstly, the finite element model (FEM) of the jacket structure is established based on the parameters of a real jacket platform, and the correctness of the model is verified. Secondly, the ice force calculation methods of vertical and conical jacket structures under the action of severe sea ice are introduced. Finally, the static and dynamic responses of the jacket structure under the action of sea ice are calculated by the FEM. And the influence of wall thickness on the structural ice-resist performance is analyzed. The objective of this paper is to provide a reference for the application of the jacket structure in marine resources.