Study on Global Fatigue Analysis for Deep-water Tension-Leg Platform Based on Simplified Spectral Method

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ABSTRACT

This paper focuses on global fatigue analysis for deep-water Tension-Leg Platform based on simplified spectral method. TLP serve as a production facility for the Field, the hull is a stiffened plate and shell structure consisting of internal longitudinal stiffeners, girders, web frames, bulkheads, and flats, and the structure of the hull and upper deck are very complicated. The purpose of this analysis is to validate the TLP for fatigue and identify fatigue sensitive areas for further local analysis. These global fatigue results are also later used to extract results for other local fatigue analysis. The load case considered for the global stochastic fatigue analysis is the operating condition. The stochastic fatigue evaluation is based on the ABS guide (2003-2007) for fatigue assessment of offshore structures. The load for the analysis was based on the normal operating condition and the wave scatter diagram was obtained. The analysis was carried out using SESAM suite of programs using its sub-modeling technique i.e. using displacements derived from global spectral fatigue analysis onto the sub-model boundaries. The radiation/diffraction theory is used to calculate wave load acting on TLP. The 3D FEA model of the rig is made using shell element, beam element, and mass element. According to long-term wave distribution of South China Sea, stress response of the global structure is calculated. The results from the detailed FE-models are used to calculate the fatigue life using STOFAT. The fine FEA model of typical joint is made, the result of global FEA is taken as the load boundary condition, the hotspot stress transfer functions are calculated accounting for hydrodynamic load and gravity load. The objective of this study is making a suggestion of a new simplified fatigue analysis method. Based on the Miner's rule, the fatigue life of the typical joint are calculated using a simplified fatigue assessment method, and the results are compared with the results of the spectral-based fatigue assessment method, the simplified fatigue assessment method is verified at last.

KEY WORDS: Tension-Leg Platform; South China Sea; long term forecast; FEA; fatigue life; Simplified fatigue assessment method.

INTRODUCTION

Deep-water Tension-Leg Platform has small water plane area compared to ship structures with same dimension. TLP has short natural period in heave motion and has a merit that can avoid from resonance with wave period range. As projected area subjected by wave is small and pontoon with relatively large volume is under water, tension-leg platform rig has small wave load and the heave motion compared to ship's heave. Because tension-leg platform can be used under more severe sea states, regardless of shallow water or deepwater, and it has favorable motion characteristic. A large number of tension-leg platforms used in offshore oil and gas exploitation. Because the structure of TLP suffered from cyclic wave load during operation, the fatigue failure caused by cyclic stress will be dominating mode of structural damage. Therefore, fatigue strength is one of the most important factors should be consider in design(Yuren Hu,1996; Haixia Liu, 2003; Gang Liu,2002). The typical TLP hull studied in this paper consists of the following structural components: Pontoon, Node, and Column. The Pontoon structure is a rectangular cross-sectioned structure. The Pontoon height is 9.5 m and the width is 12.35 m. The Pontoon structure is connected to the four columns through four Node structures. The Node structure is the connection region of the Pontoon and the Column. The Node structure is cylindrical with a diameter of 23.75 m and the same height as the Pontoon. The Column is the column portion on top of the Node, spanning to the Top of the Column (TOC) at an elevation 57.45 m. Each Column has an access shaft at the center with a diameter of 9.25 m. The platform has a mean waterline (MLW) draft of 30 m. Tanks in hull structure are divided into three types based on their functions: permanent ballast tank, temporary ballast tank, and void tank. In addition, diesel oil tanks are designed in the southwest (SE) Upper Column. Potable water tanks and fresh water tanks are designed in the northeast (NE) Upper Column. Fig.1 shows the typical TLP terminology.

In this paper, according to long-term wave distribution of South China Sea (SCSIO,2006), based on Miner's rule, by using the the calculated Weibull distribution parameter, this paper describes a simplified fatigue analysis method of the typical joint fatigue life of the typical TLP. At last, some comparisons of simplified fatigue analysis method and spectrum fatigue analysis are discussed in this paper.