Application of a New Method for Spectral Fatigue Analysis of Minimal Jacket Platform

Qin Feng1**, Liang Wang1,2*, Fengjun Yao1, Wenxue Zhang1, Juan Liu1, Qing Wang1, Wenge Li2
1. SINOPEC Shanghai Offshore Oil & Gas Company
2. Shanghai Maritime University
Shanghai, China

ABSTRACT

Minimal structures of jacket platforms are commonly applied in development of marginal offshore oil and gas fields. It is subjected to continuous cyclic wave loads during services, causing fatigue damage to the platform structures. In design of this kind of structures, assessments of fatigue damage become particularly important. Spectral fatigue analysis approach is a computationally efficient method to describe the random nature of environmental ocean wave conditions during calculating wave loads on the offshore jacket structures and subsequently structural responses. However, its fundamental theory is based on the assumption of linearity of both structural system and wave loading mechanism, but it has still been widely utilized for the design and assessment of shallow water jacket platforms with strong nonlinear mechanism. Therefore, the paper focuses on the studies on the improvement of the accuracies of the fatigue calculations by a new technical approach that can reduce the errors in the spectral fatigue analysis of shallow water platforms. This new approach can reasonably reflect the individually local sea state data by using wave height-period joint probability density function, the discussions of comparisons between the improved approach and the design code oriented method carry out by means of the analysis results. In addition, the wave probability density function which is employed for computing the fatigue damage in the existing design software is only effective for the narrow band spectra, and it causes additional errors for the broadband spectra during the computation of the fatigue damage. The appraisal on improving the calculation of the fatigue damage for the broadband spectra also carries out in the paper.

KEY WORDS: Jacket platform, Spectral fatigue, Nonlinearity, Narrow band; Broadband, Fatigue damage, Transfer function.

INTRODUCTION

Fatigue analysis plays an important role and has become compulsory in the design of offshore jacket platforms since fatigue failure is one of the major reasons causing the welding joint defects of offshore jacket platforms(Bishop, Sherratt, 1989). According to the international authoritative institutions in offshore platform, joint damage of the structures, about 70% above is caused by fatigue. The spectral fatigue analysis method has many advantages compared with other fatigue analysis methods, such as deterministic fatigue analysis and time history fatigue analysis etc(Pierseen, Mosskowitz, 1964). The major reason that the spectral fatigue analysis method is recommended is computationally efficient, assessing structures where the response can be assumed to be linear, Gaussian, stationary and random.

The main characteristic of the spectral fatigue analysis method is that the transfer function is obtained deterministically by using a series of regular waves with different periods and wave heights. These series of regular waves are defined as base wave cases. The traditional determination method of regular waves is to select a fixed steepness, such as 1/15, 1/20, or 1/25, and calculate the corresponding wave height based on the steepness of wave height to wavelength. The stress response spectrum is then obtained by multiplying the transfer function by the relevant sea state spectrum. Finally, the fatigue life of the structures is calculated.

The spectral fatigue analysis is only suitable for the deep sea where the nonlinear relationship is not obvious. It should be noted that the wave force versus structural stress response relationship is actually nonlinear, then the transfer function will depend rather critically on the choice of the wave heights and wave periods for the base wave cases. When it is used for the design and evaluation of shallow water platforms, the error caused by the nonlinearity cannot be ignored. In theory, spectral techniques should not be used very much for the fatigue analysis of such platforms, partly because of the nonlinearities present for such systems and because of the lack of suitable deterministic techniques for establishing transfer functions. When nonlinear response becomes significant, or if the random nature of the sea state is not properly dealt with using a deterministic approach, a more rigorous methodology for choosing the regular waves is required for securing reasonable results(Bishop, 1988).

In recent years, Sinopec has made great achievements in the exploration of Beibu Gulf and discovered Weizhou oilfield. The oil field is located in Beibu Gulf, South China Sea with water depth of 50 meters. It is considered to build integrated jacket platforms for oil field development, and a minimal jacket platform is planned as one of the platforms for the production of the surrounding block and marginal oil field. This paper presents a proposed approach that is developed by the authors, for improving the results of fatigue calculations of shallow water platforms, and practical fatigue assessment cases for a typical shallow water minimal platform designed for the recent Sinopec's offshore project.