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Damage detection of jacket type offshore platforms using rate of signal energy using wavelet packet transform

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ABSTRACT

Steel jacket type offshore platforms are highly susceptible to damage because of the severe environmental condition, therefore ensuring its proper performance and detection of probable damage is very important and undeniable. In this paper, by studying on experimental results of a prototype scaled offshore platform subjected to dynamic loading for different damage conditions, efficiency of Rate of Signal Energy using Wavelet Packet Transform for damage detection of this kind of structures has been carried out. Experiments results of two support conditions including hinge based and pile supported cases have been used. Wavelet packet analysis was used to determine the location of damage for different damage scenarios. The results demonstrate that proposed method can predict location of damage accurately. It can be concluded that this method can be used for prediction of damages similar to damages considered in this paper by using a continuous measurements and monitoring of platform responses.

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1. Introduction

Integrity assessment of existing offshore platforms is necessary to ensure fitness for purpose of the structure in view of severe environment of sea, fatigue, high corrosive zone, scouring and vessels impact. Result of structural health monitoring of offshore platforms can be integrated into integrity assessment process of structures based on reliable and unbiased information. Objective data from continuous monitoring of offshore platforms increases quality of decisions and improve maintenance and repair strategies. By using structural health monitoring of offshore platforms, prediction of possible damages and determination of structure's health can be achieved which is valuable for such an important structures. Several structural health monitoring techniques have been used in the past for offshore platforms.

Kim and Stubbs (1995) [1] presented an algorithm to detect and locate damage in jacket-type offshore structures which only post-damage modal parameters was available for few modes of vibration. Researcher formulated a theory of damage localization and severity estimation and a method to identify baseline modal parameters of jacket-type offshore structures. They demonstrated the feasibility of the damage detection algorithm by using a numerical example of a jacket-type offshore platform with limited modal information. Nichols (2003) [2] explored the role of ambient excitation and empirical modeling in detecting damage in offshore structure. They excited two models of an articulated offshore structure. The resulting prediction error was increased when damage incurred. They concluded that this technique was effective for diagnosing the presence. Yang et al. (2004) [3] presented a newly developed damage localization method. This method was based on decomposing the modal strain energy. The method needed a small number of mode shapes identified from damaged and undamaged offshore platforms. They demonstrated that this method was capable of localizing damage for template offshore structures. Shi et al. (2007) [4] proposed a damage detection algorithm based on partial measurement of vibration for offshore jacket platforms. They demonstrated that presented algorithm was feasible and robust against identification error of baseline structure.

Yuan-sheng and Zhen (2008) [5] used time-domain data for detecting damage in offshore platform structures. They presented a new method that used time-domain response data under random loading. They concluded that the use of a few sensors' acceleration history data was capable of detecting damage efficiently and increasing in the number of sensors improved the diagnosis success rate. Elshafey et al. (2010) [6] investigated a combined method of random decrement signature and neural networks to detecting damage in offshore jacket platform subjected to random loads. They concluded that this method can be used to discover any changes in the shape of damage index. Mojtahedi et al. (2011) [7] developed a robust SHM method for offshore jacket platform using model updating and fuzzy logic system. They demonstrated that this technique was shown to be effective for diagnosing the presence of degradation and quantify it. Agrarian et al. (2009) [8] predicted damage location of jacket type offshore platforms by using change in modal strain energy ratio (MSER) of the elements. Compare to the method used in this paper, the accuracy of MSER is reduced when damage rates are low or several damaged elements exist at various locations of structure. Moreover application of this method for existing structures due to insufficient information about its elements properties may be limited.

In this paper by using experimental results of dynamic response of prototype offshore platform, suitability of "rate of signal energy using wavelet packet transform method" was studied for predicting damage location. Wavelet analysis is one of the most important methods used in structural damage detection. Signal analysis using wavelet derived from structural response can characterize the heterogeneity of the signal. Typical wavelet analysis has some disadvantages which has no benefit in the analysis of structural signals. Wavelet transform is capable of detecting location and time of occurrence with highlighting abnormal vibration in signal. Hence, wavelet analysis can detect structural damages by creating disturbance in the vibration signal. However, sensitivity of such an analysis to structural connections and boundary conditions can create disturbance in signals which makes problem to diagnose the damage.

Wavelet Packet Transform (WPT) is a kind of wavelet transform eliminates disadvantages of simple wavelet transform. Wavelet packet transform is a developed state of simple wavelet transform that makes complete separation level of the signal. This transform is composed of a linear combination of simple wavelet function. Therefore, wavelet packet transform can be expressed as steady and unsteady