ABSTRACT

Risers are very important component of deep sea-bed mining. Unfortunately, risers have high risks of damage because they are exposed to harsh environmental conditions such as a current, pressure, high tension and vortex induced vibration. Therefore, it is very significant to retain riser's performance and to detect damage before the riser failure is occurred. A main objective of this paper is to propose a structural health monitoring technique to detect damage of a top-tensioned riser. In this paper, the top-tensioned finite element (FE) model is considered as an analytical model of the riser, and a vibration-based damage detection method with responses from damaged model is proposed. The present method consists of a FE model updating and damage index method. In order to accomplish the goal of this study, first, a sensitivity-based FE model updating method using the natural frequencies and the zero frequencies is introduced. Second, modal parameters of the top-tensioned riser are estimated by eigenvalue analysis. Finally, the locations and severities of the damages are estimated from the damage index method. Five numerical examples are considered to verify the performance of the proposed method.

KEY WORDS: Top-tensioned riser; structural health monitoring; damage detection; FE model updating.

INTRODUCTION

Recently, many investigations on the deep-sea-bed mining were carried out to develop plentiful marine mineral resources like manganese nodules (Chung, 1996; Deepak et al., 2007; Hong et al., 2007). Risers are very important component of deep-sea-bed mining because risers are used to lift nodules from the deep-sea-bed to offshore facilities. Unfortunately, risers have high risks of damage because they are exposed to harsh environmental conditions such as a current, pressure, high tension and vortex induced vibration. Therefore, it is very significant to retain riser’s performance and to detect damage before the riser failure is occurred. For these reasons, an accurate health monitoring method for marine risers must be developed to detect and localize the damages. This paper deals with the development of a health monitoring method for vertical rigid risers, i.e., top-tensioned riser.

Vibration-based damage detection methods have been widely used to detect damages in various engineering fields. Many researchers have focused on the changes of natural frequencies or/and mode shapes between undamaged structures and damaged structures (Vandiver, 1977; Stubbs et al., 1992; Riverios et al., 2007). Some investigations have focused on utilizing zero frequencies to improve the accuracy of damage detection methods (Dilena and Morassi, 2004; Nam et al., 2005).

The main objective of this paper is to propose a new damage detection method for top-tensioned risers with modal parameters of the damaged model. To achieve the stated goal, a sensitivity-based FE updating method with natural frequencies and zero frequencies is applied to update the stiffness matrix of the FE model, and a damage index method is also adopted to detect and locate the damages of top-tensioned risers. Five numerical examples are considered to verify the proposed method.

TOP-TENSIONED RISER

Finite element method

The finite element (FE) structural model (Rustad et al., 2008) is used to obtain the solution for the eigenvalue problem and to evaluate the natural frequencies and the zero frequencies of the top-tensioned riser. This FE model consists of bar elements, and each bar element can be described with four degrees of freedom (DOF), that is two translational DOFs in both ends of the element [see Rustad et al., (2008) for details]. All four DOF are shown in Fig.1. $x$ is transverse DOF, and $z$ is axial DOF.

![Fig. 1 Bar element with four DOFs](image-url)