Static Equilibrium Configuration of Deepwater Steel Lazy-Wave Riser

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ABSTRACT

Steel lazy-wave risers (SLWR) have gained popularity as a viable solution to improve fatigue and strength performance at the touchdown zone of a simple catenary riser. With the objective to provide technical reference for a lazy-wave shaped riser, this paper focuses on the study of lazy-wave configurations. The static equilibrium configuration of SLWR is of great importance on the basic design and dynamic analysis of the riser. Previous work by models is often used a small deformation beam or catenary theory, and some finite element analysis software can provide nonlinear large deformation solutions. In this paper, the riser is modeled used the non-linear large-deflection beams accurately as a result of its inclination angle’s rapid changes. And the seabed is simplified as rigid. Using the finite difference method to write the program in MATLAB, the numerical solutions are obtained. The result is proved to be reasonable and practicable. Finally the influences of water depth, top inclination angle, buoyance catenary length on the maximum tension and moment of pipelines have been studied by this method and the conclusions are drawn. And it can provide a significant and basic reference for the dynamic analysis of the deepwater riser.

KEY WORDS: SLWR, Elastic, Finite differences, static configuration

INTRODUCTION

In recent years, exploration and production activities have increased dramatically in deepwater oil and gas development (Yang H Z, 2011). The steel catenary riser (SCR) was adopted by Petrobras as a cost-effective alternative for oil and gas export (Huang W P, 2006). The use of SCR is often the preferred solution as it is by far the least expensive concept. But, it is generally considered a great challenge to suspend SCR from vessels with relative higher motions, such as semi-submersibles and FPSO (Zhang H Q, 2009). Since the SCR dynamic response is sensitive to porch motions, new concept and/or technologies are needed to improve its performance (Bin Y, 2010). Compared with the free hanging catenary configuration, the steel lazy wave catenary risers (SLWR) can isolate TDP motion from porch motions, reduce the top loads and improve the fatigue life (B. Thomas, A. Benirschke, et al. 2010).

SLWR achieves this goal by installing buoyancy to the riser creating a subsea “arch”. A typical SLWR (Fig 1) consists of three segments, each segment a catenary, namely the upper catenary, buoyancy catenary and the lower catenary. There are a sag bend and an arch bend in the configuration of SLWR.

ANALYTICAL FORMULATION

A lot of workers have studied the extensive parametric study of risers including the dynamic of the SLWR. And other studies on the current related problem of vortex-induced vibrations (VIV) have been conducted. A static analysis is made here as a foundation for a more thorough dynamic (S. T. Santillan, 2011). This paper presents a more accurate method to obtain the static configuration. The bending stiffness and large deformation of the riser are taken into consideration.