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NUMERICAL PREDICTION OF FATIGUE DAMAGE IN STEEL CATENARY RISER DUE TO VORTEX-INDUCED VIBRATION*

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Abstract: For studying the characteristics of Steel Catenary Riser (SCR), a simplified pinned-pinned cable model of vibration is established. The natural frequencies, the normalized mode shapes and mode curvatures of the SCR are calculated. The fatigue damage of the SCR can be obtained by applying the modal superposition method combined with the parameters of S - N curve. For analyzing the relation between the current velocity and the SCR's fatigue damage induced by the vortex-induced vibration, ten different current states are evaluated. Then, some useful conclusions are drawn, especially an important phenomenon is revealed that the maximum fatigue damage in the riser usually occurs near the area of the boundary ends.

Key words: vortex-induced vibration, Steel Catenary Riser (SCR), fatigue damage, modal superposition method

Introduction

The Steel Catenary Riser (SCR) is a preferred solution for deepwater oil/gas export. Compared to the Top Tensioned Riser (TTR), the SCR reqiures no top tension and can allow large vessel's drift and heave motions. Compared to the flexible riser, the SCR can bear worse environmental loads, especially, where high temperatures and pressures are involved. The SCR is considered to be a technically feasible and commercially efficient solution in deep water, and finds ever wider applications there. The first SCR was installed on TLP in the Gulf of Mexico for oil and gas export, in a water depth of 2 860 ft using a flexjoint connected to the TLP pontoon, 70 ft below the mean water level. The first SCR installed to a semi-submersible was in the Marlim field, offshore of Brazil, with a water depth of 1 985 ft. Later, more and more SCRs were designed and installed on TTP, Spar and semi-submersible facilities in the world.

To predict the fatigue damage in SCR is one of the key problems in the design of the riser. The SCR in deepwater is very sensitive to the environmental loads. As a current flows toward the leading edge of a riser, the pressure in the fluid rises from the free stream pressure to the stagnation pressure. The high fluid pressure near the leading edge leads to the development of boundary layers about both sides of the riser. However the pressure forces are not sufficient for the development of the boundary layers behind the bluff riser at high Reynolds numbers. Near the widest section of the riser, the boundary layers separate from each side of the riser surface to form two free shear layers in the flow, surrounding the wake. Since the innermost portion of the free shear

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