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Steel Catenary Riser Design Based On Prescribed Motions from Coupled Analysis Methodology

M. V. Rodrigues, V. L. Hansen, R. A. Bahiense, and C. V. Raposo, Det Norske Veritas.

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Abstract

In a riser design, the assessment traditionally adopted by the industry for the attainment of platform motions applied to the top of the riser consists in the use of de-coupled methodologies. Those formulations consider the static environmental loads over the platform (current and wind) through a static offset and the dynamic environmental loads due to wave through imposition of top riser displacement calculated from cross spectral response of sea spectrum and vessel’s RAOs (Response Amplitude Operators).

Nowadays due to shift of oil and gas exploitation to deeper waters more accurate methodologies, based on coupled analysis, have been introduced. The coupled analysis considers the interaction between the hydrodynamic behavior of the hull and the structural behavior of mooring lines and risers submitted to environmental loads. For deep waters the coupling effects of lines over platform motions can be especially significant and it is expected a reduction of the amplification of platform motions if compared to the platform motions obtained from de-coupled analysis.

This paper presents a typical Steel Catenary Riser design, connected to a semi-submersible platform, where the motions applied to the top of riser are obtained from the “traditional” way (de-coupled) and from the coupled analysis. A numerical application will be presented in order to assess the comparison of the two presented methods in terms of SCR results.

The coupled model studied herein is composed of approximately 80 lines connected to the platform, which requires an excessive computational effort. In order to reduce the CPU time some additional studies are performed considering the variation of line mesh discretization and time step size. The objective of this study is the adoption of an optimized model keeping the required accuracy of platform motions results to be applied on top of SCR. The CPU time consuming and platform motions are presented.

The significance of this work is the conclusion that a Steel Catenary Riser design adopting prescribed displacements from coupled analyses will provide more realistic and optimum results.

Introduction

Offshore oil exploitation activities have been advancing towards deeper waters, reaching new frontiers so far not conceivable. For the new deep and ultra-deep water scenarios, the use of moored floating production systems – FPS (based for instance on moored ships or semi-submersible platforms) is the current trend, instead of the fixed jacket structures that had been employed in shallow waters.

In this context, research in numerical methods can contribute to build innovative and efficient computational tools. Such tools should be mostly oriented towards nonlinear dynamic time-domain analysis, which are required to simulate and analyze the behavior of FPS to be employed in those new deep-water scenarios.

The numerical tools used in the traditional design practice of FPS are based on de-coupled formulations, in which the hydrodynamic behavior of the hull is not influenced by the nonlinear dynamic behavior of the mooring lines and risers. In such “classic” approach, the hydrodynamic analysis of the hull is performed with the mooring lines represented by simplified scalar models, and without consideration of the risers. That analysis leads to the motions of the hull, and to the design of the mooring lines complying with specified limit values for the motions. In a subsequent design step, the motions are prescribed at the top of finite-element models of the risers, for nonlinear dynamic analysis of the risers to determine their structural behavior and to perform the design of the risers.