Hydrodynamics of Dry Tree Semisubmersibles

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ABSTRACT

This paper presents a hydrodynamics analysis of a conceptual dry tree semisubmersible for drilling and production platforms. Computational analysis shows that the hull form of the dry tree semisubmersible can be optimized to control the cancellation period, magnitude of the heave RAO below the cancellation period and the heave natural period. The relative areas of the column and pontoon are varied to demonstrate the global effects on the hydrodynamic forces acting in these structural components while the area of the heave plate is kept constant. Results show that by keeping the displaced volume of the hull constant the relative areas of the column and pontoon can be varied to affect the magnitude of the hydrodynamic forces on the columns and pontoon and thus the shape of the heave RAO.

KEY WORDS: Dry tree semisubmersible; hydrodynamic forces; cancellation period; heave RAO.

INTRODUCTION

Top Tensioned Risers (TTRs) with dry trees allow direct vertical access to production wells and thereby offer a number of attractions for well completions and interventions. The two traditional deepwater hull forms to support TTRs are the Spar and the Tension Leg Platform (TLP). For production depths exceeding 5,000 ft the TLP may have its own challenges with tendon design, making the Spar the sole candidate (Murray et al., 2006).

Semisubmersibles are in use in some of the deeper developments using Steel catenary Risers (SCRs) to tie-back to subsea wet trees. In their traditional forms, with drafts less than 100 ft, the motions of the tradit semisubmersible are not amenable to supporting TTRs. Recent designs have increased drafts up to approximately 120 ft to improve their motions and reduce damage to SCRs but these motions are not low enough to practically support dry trees. Nonetheless, the semisubmersible has a number of functional advantages over the Spar. For example, the Spar is installed by horizontally towing and up-righting at the installation site. A heavy lift vessel must be mobilized to install the topsides using single or multiple module lifts and hook-up and commissioning is completed at sea. The semisubmersible can have its topside modules installed and commissioned at the quayside which offers a large cost saving. The Spar has a number of stacked decks because of its single column form, whereas the semi submersible offers a large open deck area which has a number of operational advantages. The semisubmersible can be vertically wet towed in shallower water but the Spar draft of approximately 500 ft to 600 ft restricts the depths in which it can be towed.

An improved deepwater floater design is one which has the motions of the Spar and the functionality of a semisubmersible. To this end, a number of design variations, which involve combining semisubmersibles with heave plates, have been proposed. The strategy is to retract the heave plate allowing semisubmersible’s draft to be shallow enough for quayside integration. The two main design considerations for these configurations are 1) to have minimum heave response at periods where wave energy is applied, particularly at the wave energy spectrum peak period, and 2) to ensure that the natural heave period is sufficiently high such that the additional vertical stiffness caused by riser tensioners does not reduce this period to a value near the wave energy periods.

To a certain extent, the magnitude of the heave RAO below the cancellation period can be manipulated by designing the relative sizes of the pontoons and columns such that the sum of the forces on the respective structural components are minimized thereby minimizing the heave motion while keeping the draft of the semisubmersible to a minimum. The natural period can be increased by means of a heave plate supported below the hull. The hydrodynamic force interaction among the columns, pontoons and heave plate can be optimized to minimize hull draft and heave performance.

This paper presents and discusses the hydrodynamic interaction among these structural components. Computations using basic geometric shapes and dimensions are used to illustrate the interactions among structural components and how they can be optimized in designs.

NUMERICAL ANALYSIS

The analysis takes a systematic approach individually analyzing the