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The Dynamic Effects of Water Column Inside the Turret of an FPSO

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Abstract

Thanks to the evolution of hardware and software, the direct computation of dynamic loads is becoming a common practice on the design of offshore floating units for both extreme and fatigue assessments. In the specific case of FPSOs, usually the loads prescribed by Classification Societies for oil tankers are adopted. Nevertheless, the direct computation may be used in order to adapt those prescribed extreme loads to consider the specific operational profile of FPSOs. Also the performance of spectral fatigue analysis is commonly accepted in lieu of the Rules prescriptions. The state-of-the-art is to employ potential theory for the hydrodynamic calculations. In this theory, the fluid is considered ideal and therefore no viscous dissipation is included. In spite of the reasonable accuracy of that theory for the computation of large bodies' behavior, in the case of FPSOs with internal turret it may overpredict the free surface elevation inside the turret around resonance frequencies, which may impact both global and local loads acting on the hull. In reality, however, it is expected that a lot of dissipation is generated by the turret structure and components which would bring the wave elevation to much lower levels. In this paper, the relevance of the phenomenon for the structural assessment of an FPSO is evidenced and the effects of dissipation are discussed based on modified potential theory results and CFD RANS analysis.

Nomenclature

FPSO Floating Production Storage and Offloading
CFD Computational Fluid Dynamics
RANS Reynolds-Averaged Navier Stokes

Introduction

For the structural assessment of the FPSO hull, direct hydrodynamic computations of loads may be used either to adapt the extreme loads prescribed by Class Societies or for spectral fatigue analysis. For that purpose, the state-of-the-art is to use the 3D potential theory which is demonstrated to provide reasonably accurate results in case of large bodies. With an increase of water depth and the need to accommodate a large number of risers, an increase on the size of turret moonpool is observed. In de Vries *et al* [1], the trend to increase turret dimensions is demonstrated based on a track record of 15 years of the turret designer, and it is observed that "*latest turret designs are today 3 to 4 times more massive than the systems designed fifteen years ago*". Therefore an understanding of the effects of the turret moonpool on the FPSO structure is important for the definition of appropriate models and design procedures.

The issue with entrapped water-induced resonance has been the object of many publications as the phenomenon may be observed in several practical applications like side-by-side offloading operation, drillship moonpool, etc. It is well known that close to the resonance frequencies the potential theory, which is based on the assumption of perfect fluid, overpredicts the wave elevations while in reality it is expected that the energy dissipation by viscous effects would play a major role in limiting the elevations in the confined area. Even though the problem is under discussion for a long time, there are only few papers focused on FPSO turret moonpools, among which we have already cited Ref [1], in which the resonance effects are well discussed and results from potential theory as well as from CFD simulations are presented.