Waves and Current Influence in the FPSO Dynamics

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ABSTRACT

Partial results of an experimental test program developed by Petrobras at the Brazilian Towing Tank of IPT, including the towing test with a fixed yaw angles and the stability test proposed by Leite (1997), are used to identify the polynomial form of the fluid reaction force and estimate some of the coefficients. The use of a second order polynomial is proposed.

First and second order hydrodynamic properties as wave damping, exciting forces and quadratic transfer function are obtained using the panel code WAMIT.

The \( T - l \) map proposed by Fernandes and Sphaier (1997) is used in conjunction with a nonlinear time domain simulation code to analyse the effects of waves.

KEY WORDS: FPSO, dynamic stability, maneuvering, model test.

INTRODUCTION

Motivated by the introduction of FPSO systems in deep waters offshore Brazil, Petrobras has been developing a joint research work with Brazilian Universities and Laboratories to analyse the behaviour of these systems. One of the aspects includes the determination of the hydrodynamic coefficients to simulate the approach of a shuttle ship to perform the offloading operation. Other aspects are the motion of the storage ship alone and also the offloading operation both of the ship in tandem. This is fundamentally a low speed movement with possibly large encounter angles relative to the currents. A part of the research program comprises the development of mathematical model and three different kind of captive tests. The classical towing test with a fixed yaw angle, the yaw rotating test and the stability test (Leite, 1997).

Inserted in the Petrobras effort Fernandes and Sphaier (1997) have presented a study about the stability of such a system in the presence of the current. They linearized the equations of motion and, decoupling the surge from the sway and yaw equations, developed the \( T - l \) maps (Tension X hawser length), a tool for the assessment of the stability level for the choice of the hawser and the connection point at the preliminary design stage. Further, a complete nonlinear simulation model has been used to verify the simplified model. The classical polynomial formulation introduced by Edd and Crane, Jr. (1965) with a cubic form has been used with the coefficient obtained by Ackowitz (1980) for the Esso Osaka tanker.

The behaviour of SPM systems have been studied by many authors with different approaches. Papoulas and Berntesas (1988) have presented a comprehensive study of the problem using the third order polynomial approach with the coefficients obtained by Ackowitz to represent the hydrodynamic forces. Using Cross Flow Principle ideas Wichers (1986) has developed a intensive experimental work trying to find a formulation for the forces due to the currents in a ship hull. A very important contribution of his work concerns the different decay behaviours of surge motion in waves and in still waters, introducing the wave drift damping concept. Sharma and others (see Jiang and Sharma, 1993) have used a mathematical maneuvering model identified by captive model tests to analyse the stability of a tanker moored in a single point.

In the continuity, recent experimental results (IPT (1997)), have lead to the review of the model to account for the relative fluid-hull motion. The stability test defines the bifurcation curve relating the yaw angle and the distance between the center of gravity and the connection point. The experimental curve behaves like a straight line when the connection position is close to the bifurcation point. As the distance decreases a parabolic behaviour picks up. Close to the center a hyperbolic behaviour is expected. These aspects are again addressed below.

The consideration of first and second order waves introduces damping and excitation forces. Although the first order damping factor is given by a convolution, it represents a structural modification in the differential equations of motion. The same