Hydrodynamic Analysis for Side-by-Side Offloading

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ABSTRACT

In this paper a comparison between model basin experiments and results of linear diffraction computations on side-by-side moored LNG carriers is presented. The computations are based on a variation of the damping lid method in diffraction codes to suppress non-realistic high wave elevations between two floating objects in close proximity. The damping lid method was originally formulated by Chen (2005). In the original method damping is added to the free surface between the vessels. In this paper, an alternative approach is used, in which damping is also applied to the free-surface inside the vessels, instead of the traditional rigid-lid approach. This method reduces the grid dependency and provides a better comparison with model tests results.

KEY WORDS: Diffraction, side-by-side, damping, lid method, model tests, experiments.

INTRODUCTION

Liquefied Natural Gas (LNG) is becoming a more important source of energy. LNG carriers can be used to transport the cargo from the offshore production platform to the shore or from terminal to terminal. Offshore floating LNG systems become a more and more economic viable solution.

Due to the cryogenic nature of the LNG the offloading is not yet done with floating hoses. Loading arms with a short reach are currently used on jetties. The short reach of those loading arms requires the LNG carrier to moor side-by-side to the LNG terminal or production platform during offloading operations.

The economics of a terminal or production platform are directly related to its availability; the percentage of time the approach of the LNG carrier, berthing, on- or offloading and sail away can take place successfully. A thorough understanding of the hydrodynamics of the two floating bodies in close proximity is necessary to identify if criteria of successful operation can be met.

Linear diffraction analysis, based on potential theory, can be used to calculate vessel response in waves. Discrepancies are observed in results of diffraction analysis of two floating bodies in close proximity. Conventional near field calculations result in unrealistic wave elevation in the gap between the side-by-side moored vessels. Resonance behavior of the wave in the gap tends to be overestimated using standard diffraction programs. Viscous effects, neglected in diffraction theory, may be more dominantly present at the bilges of the keel due to resonant flow between the bodies.

The gap kinematics, such as wave elevations at the waterline and water velocities at the hull, are used to calculate the wave drift force quadratic transfer functions (QTF’s) using a pressure integration scheme. As a consequence of the unrealistic wave motions the drift forces are largely over predicted as well.

Different methods to reduce the spikes in the QTF’s have been reported.

• A simplistic approach to suppress the unrealistic wave motions was presented by Huijsmans et al. (2001) where a rigid lid was applied to the free surface between the two vessels. The formulation of this rigid lid approach is similar to the formulation to suppress irregular frequencies.

• A suppression method based on the damping of generalized wave modes was given by Newman (2003).

• A first attempt in applying the ‘epsilon’ damping lid method on the wave in the gap between two vessels (Chen, 2005) was presented by Fournier et al. (2006). These studies showed that the lid method was effective in reducing the relative wave elevation and consequently in reducing the wave drift forces at the resonance peaks. One unique value for the damping was obtained for the first order quantities as well as the second order wave drift forces. The gap between the bodies was 25m.

• That no unique value of epsilon does fully cover the comparison with measurements at a 4 meter gap between the vessels was presented in Pauw et al. (2007). Results presented showed a frequency shift in wave elevations and vessel motions, between the measurements and diffraction results.

This paper shows an improved comparison with experimental results using a different way to suppress the irregular frequencies inside the bodies. The results of a grid sensitivity study are shown and the wave motions in the gap and resulting drift forces are discussed.