Springing Responses and Springing Effects on Design Bending Moments of a Large Container Ship

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ABSTRACT

In this study Fluid Structure Interaction (FSI) models are used to investigate nonlinear wave actions and wave induced global loads acting on a large container ship. This paper introduces some methods to predict values of dynamic bending moments considering the effects due to springing suitable for design application. Further this paper presents a design guidance to determine springing induced fatigue loads. Examples of the use of these methods are also presented. A 13,000 TEU container ship has been used for the study on springing responses and springing effects on design bending moments.

KEY WORDS: Nonlinear ship motion; hydroelasticity; Fluid Structure Interaction; springing; structural vibration; wave induced bending moment; container ship.

INTRODUCTION

The demand for larger container ships has increased dramatically in the last few years as world trade continues to grow and with the marine industry requirement for more energy efficient ships. Currently the largest of these ships have capacities of 14,000 TEU and designs of 18,000 TEU or more are currently being prepared. Due to the large deck openings of these ships springing and whipping phenomena can be critical for the design and operation of large container ships.

Springing of a ship is the continual hull girder vibration as a consequence of the waves exciting resonant hull girder frequencies. The flexing of the hull girder due to springing may continue for a significant period once initiated. Springing is an issue for ships which have low natural vibration frequencies of bending or torsion modes and the ship operation speed is above 20 knots. This is the case for large container ships due to their high speed and open cross sections. The magnitude of the springing moments (stresses) is usually low and hence springing is not normally a strength issue but as the number of cycles is very large springing is important with regard to the fatigue life of a structure (Lloyd's Register, 2011).

Ships that have hull girder natural frequencies close to the frequencies of the wave energy region are therefore potentially prone to springing. In addition springing may be excited after a wave impact as there is little damping resistance of the hull girder natural vibrations. Full scale measurements of the amidships vertical wave induced bending moment of an 8,100 TEU container ship are shown in Figures 1 and 2. A typical hull girder response due to bow slamming impact measured by a long base strain gauge is given in Figure 1. The hull girder natural frequency response has been extracted from the total response in Figure 1 and is shown in Figure 2. A whipping event is shown by the sudden amplitude increase at 418 seconds caused by the slamming impact, the initial high response decreases quite quickly due to hydrodynamic and structural damping effects. This time trace also shows a continuous springing hull girder vibration (Bakkers, 2009).