

Prediction of Slamming Loads and Extreme Structural Response for Large Twin Hull Vessels

Ole David Økland and Torgeir Moan
Norwegian University of Science and Technology
Trondheim, Norway

ABSTRACT

This paper is concerned with wave impact against the wet deck of large twin hull vessels. Slamming loads and corresponding structural response are studied, at zero forward speed. A numerical model is used to investigate the nature of the extreme structural response caused by slamming. The numerical model is validated by an experimental investigation. It is found that wave impact against wet deck may lead to considerable global shear forces and moments in the hull, compared e. g. to the extreme effect of continuous wave loading. Slam induced rigid body motions and global elasticity of the hull seems to be important for the impact load. It is found that the extreme structural response in short term sea-states can be described by a Weibull-distribution.

KEY WORDS : Calculations, experiments, wave-impact, hydro-elasticity, structural response

INTRODUCTION

During the last decade many large catamarans and SWATH vessels have been built. Development of larger vessels requires investigations of global strength. Wet deck slamming in combination with continuous wave loads, may lead to large structural responses in twin hulls. For extreme cases of wet deck slamming, the ship master will reduce the speed of the ship. This means that the very extreme responses should be investigated for zero or low forward speed. This is especially the case if the vessel has to be operated in an accidental condition, like for instance a SES in an off cushion condition. Slamming against the wet deck is also of interest for semi submersible platforms.

Ochi (1958) found that the slamming pressure on an immersing ship bottom, was proportional to the squared relative velocity between ship bottom and water surface. Based on this relationship, it can be shown that maximum slamming pressure follows an exponential probability law (Ochi, 1964). This approach has later been used by many investigators, and shows good agreement with measurements.

Investigations carried out by Kvålsvold and Faltinsen (1993), indicate that interaction between water and deformation of the local deck structure may influence the slamming pressure. Later investigations (Kvålsvold et al, 1995), show that hydro-elastic effects are important for structural response in the wet deck. According to Kvålsvold (1993), wet deck slamming have a negligible effect on global rigid body motions for high speed twin hull vessel. This is explained by the short duration of the impact. For severe impacts on large vessels with small freeboard and zero forward speed however, the duration of the slam is longer, and slam induced rigid body motions can be important. Global flexible modes of the vessel will be excited by wave impacts as well, and this structural response may influence the slamming load.

Kaplan (1987), presented a method for time series investigation of wet deck slamming on twin hulls. Kaplan used rigid body modes, found by a linear strip theory, to describe vessel motions. Slamming loads were determined from a fluid momentum consideration, and structural response were found by integrating contributing forces along the hull.

The authors have recently developed a new numerical method for investigation of slamming loads and structural response in twin hull vessels, Økland et al (1998). By including flexible modes, dynamics in the structural response, as well as hydro-elasticity due to whipping can be accounted for. Slamming force is found by solving a boundary value problem, and structural response is determined from the excitation of flexible modes. An experimental investigation has also been carried out. A flexible test model was used, and slamming loads, motions of the vessel and structural responses in the hull were measured.

In this paper the numerical method is used to investigate structural response caused by wave impact against the wet deck, for a vessel at zero forward speed. Predictions of slamming force and structural response are shown, and compared to measured results. A probability distribution of maximum response due to wave impact alone is found, and values of characteristic largest impact responses are estimated. Characteristic largest responses due to continuous wave-loading are also established, and compared to slamming responses.