Large Amplitude Ship Motions and Capsizing in Severe Sea Conditions

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Jean Otto de Kat

ABSTRACT

A numerical model has been developed to determine the large amplitude motions of a vessel subjected to severe wave conditions, including those that may lead to capsizing. The aim was to numerically identify different modes of capsizing, and to study relevant mechanisms and conditions. The theory is based on a combination of potential and viscous flow approaches in the time domain, where large displacements, the instantaneous free surface and memory effects are considered.

Reasonable agreement was found between predicted motions and experimental results for a variety of wave conditions. A number of capsizes, observed experimentally, were simulated successfully using the numerical model.

An investigation has been carried out to determine the sensitivity of the roll response to changes in the force components. The Froude-Krylov forces were found to be always of importance, irrespective of the wave conditions. Generally, the relative importance of the various components depends strongly on the ship and wave conditions.

Special attention has been paid to random following seas, which tend to have an important effect on capsizing. Wave statistics have been obtained for an observer in a random following seaway, represented by the superposition of a finite number of wave components. It was found that the mean square wave elevation observed at a fixed point, and from a reference point moving at an angle with the waves, can be different, suggesting that care must be taken when conducting simulations.

In random following seas, any point on the ship may be subjected to a quasi regular excitation, while the motion behavior is affected simultaneously by the spatial and temporal characteristics of the seaway. Also, for a short term simulation of an extreme event, it is shown that the random following sea may be replaced by an equivalent wave system, consisting of only two components. Several modes of capsizing in following to beam seas have been identified by simulation: low cycle resonance, loss of transverse static stability, broaching and resonant excitation. An analysis has been made of the behavior of the roll moment components associated with these capsize modes.

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