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Technical Note

Roll performance of a small fishing vessel with live fish tank

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Abstract

The concept of live fish tanks in trawlers is to use the catch in a better condition and to reduce marine pollution. It also reduces the infrastructure meant to freeze the catch to preserve it for longer period. But the presence of additional free surface in the vessel challenges the stability of the vessel. This is besides the sloshing effect due to the moving liquid mass in the tank. Roll motions are initiated due to various factors related to the hull characteristics of the vessel, loading and operating conditions and its interaction with the environment. Location of fish tank, its orientation, arrangement of baffles inside the tank to reduce the free surface affects and careful design of tank opening are to be given priority during the design, manufacturing and tank testing. The results obtained from tank test of model are compared with that of analytical method. The non-linear roll performance become further complicated due to the free surface and sloshing effects of the mass in the live fish tank. Wave makers are used for generating waves under laboratory conditions compatible with the scaled down model of the trawler model. The tests are conducted in the towing tank of Pusan National University.

Keywords: Live fish tank; Non-linear roll motion; Righting arm stability; Parametric resonance; Righting arm curve; Sloshing

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1. Introduction

Many authors have studied about ship motion as per environmental conditions. There are interesting literature on the stability of ship in dynamic environment. These are available in the form of linear models based on strip theory, ordinary differential equations to solve linear and nonlinear models for numerical simulation and tank tests. There are also studies available on the oscillations and performance of a liquid filled tank. These are all in the form of numerical simulations using numerical tanks, fluid motion simulation using CFD packages, experiments using liquid filled tanks in laboratory, etc. Some work is available in the form study on anti-rolling tank installed across a ship. When such tanks are there onboard a moving vessel we have to find out the extent of the advantages or disadvantages. The coupling between the internal flow in a tank onboard a ship and the flow external to the ship have also been studied by many authors. A tank used to keep the catch alive and its influence on the roll performance of the vessel is discussed in this paper.

The capsize of a vessel is due to excessive motions. The GZ curve of the vessel shows the measure of energy after the vessel is heeled due to an external moment. Free surface effects in tanks are to be minimized to a level as low as possible. The movement of the masses in the tank may lead to excitations level challenging the stability. Roll motion is a complicated phenomena due to the non-linear aspects of damping, restoring and exciting forces and hence moments. GM value is reduced due to the free surface levels and movements in significantly sized tanks onboard.

Excessive heave and pitch motions are usually regarded as problem of seaworthiness, not a problem of stability. It is well known that heave and pitch motions may affect the roll motions in some cases. In view of the possibility of parametric oscillations, the hull form characteristics are also said to be responsible for the roll stability of the vessel.

Bhattacharyya (1978) discussed the basic theory behind the linear, nonlinear and coupled motions of ships including roll motion. Neves et al. (1999) concentrated on the stability of small fishing vessels in longitudinal waves. The authors developed mathematical models and conducted experiments. They concluded that the shape of stern is the reason for instability in roll motion. They also discussed resonance using well known Mathew diagram. Rakhmanin and Zhivitsa (2000) concentrated on the influence of liquid cargo dynamics on ship stability. They proposed closed form solution for GM reduction in a compartment due to free surface. Corrections to be made on the initial GM are possible using such approaches. An extensive work was done previously (1994) by the authors mentioned above. They have discussed correction to both GM and damping coefficients.

Lee (2000) discussed the capsizing phenomena of an initially inclined ship a following sea using Mathew-type equations. The author concluded that the stable zone in longitudinal motion could be assessed. It is to be emphasized that parametric rolling has been of practical concern for smaller vessels of low or marginal stability in following seas. Taylan (2000) paid attention to the roll response of ships due to non-linear damping and response. Journee (1992) proposed the methodology to handle various contributions for damping. This has been developed in connection with the method for quick strip theory calculations in ship design.