

Design of Anti-Rolling Tank for 500-Ton Class Coast Guard Ship

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ABSTRACT

Coast Guard vessels are to satisfy not only the speed and stability for missions but also the comfortable ride for crew members as well. In the study, a 500 ton class coast guard ship is investigated for its stability in various sea conditions. Due to its specific function, the comfort is not considered significantly in this type of ship. To improve its stability and comfort, an anti rolling tank (A.R.T.) device is applied to the ship and the effects to the stability were studied and compared.

KEY WORDS: Anti Rolling, Rolling Device, Rolling Motion, Roll Reduction

INTRODUCTION

The stability of vessel is very important to accomplish the tasks and missions in every sea state for Navy and Coast Guard vessels. For the stability and the safety, A.R.T. device has been proven its effect improving in these two areas. The Coast Guard vessels are to have the working capability in severe surge condition to enforce their tasks and to conduct rescue operations. The device design and selection are to be carefully decided according to the vessel size and type.

To calculate the dynamic behavior of the vessel, a numerical approach by Chadwick was applied. In the motion equation, the presence of A.R.T. was added. Two motion equations, without and with A.R.T., were developed and the motions of two cases for two different sea states were analyzed. The significant wave heights of 2.19 meter and 3.57 meter were applied in the study.

THEORY EXPANSION

The dynamic equation for ships with tank can be expressed as below according to the paper by Chadwick (1955).

$$\begin{aligned} J_s \ddot{\theta} + B_s \dot{\theta} + K_s \theta + J_{st} \ddot{\Phi} + K_{st} \Phi &= M_w \\ J_{st} \ddot{\theta} + K_{st} \theta + J_t \ddot{\Phi} + B_t \dot{\Phi} + K_t \Phi &= 0 \end{aligned} \quad (1)$$

From the characteristic of two tank motions, $K_{st} = K_t$ and in the variable of J_{st} the characteristic of the position in the tank is included. The solution of equation (1) is as below:

$$\begin{aligned} \theta &= \bar{\theta} e^{i(\omega t - \epsilon_s)} \\ \Phi &= \bar{\Phi} e^{i(\omega t - \epsilon_t)} \end{aligned} \quad (2)$$

where θ = ship transverse angle
 Φ = fluid transverse angle in A.R.T.
 ϵ_s, ϵ_t = angle difference of θ and Φ

Applying equation (2) to equation (1),

$$\begin{aligned} (-J_s \omega^2 + iB_s \omega + K_s) \theta + K_t (1 - \omega^2 \frac{J_{st}}{K_t}) \Phi &= M_w \\ (-J_t \omega^2 + iB_t \omega + K_t) \Phi + K_t (1 - \omega^2 \frac{J_{st}}{K_t}) \theta &= 0 \end{aligned} \quad (3)$$

and,

$$1 - \omega^2 \frac{J_{st}}{K_t} = 1 - \frac{\omega^2}{\omega_{st}^2} \equiv a_{st} \quad (4)$$

Then the a_{st} expresses the position variation of tank and the frequency is $\omega_{st} = (K_t/J_{st})^{1/2}$. If the tank locates in the middle position, the ω_{st} becomes ∞ and $a_{st} = 1$.