Fig. 30  Effect of $t$ on $\alpha$ and $Q_D/Q_T$

Fig. 31  The value of $\alpha$ in low $d/(D_B + H_I)$

Fig. 32  The value of $\alpha$ in high $d/(D_B + H_I)$ comparing with prediction
Fig. 32  The value of $\alpha$ in high $d/(D_y+H_y)$ comparing with prediction

Fig. 33  Effect of double bottom height on $Q_d/Q_T$

Fig. 34  Effect of $S_o$ on $Q_d/Q_T$
Fig. 35 Effect of rupture diameter on $Q_0/Q_T$

Fig. 36 Effect of $\Delta$ on $Q_0/Q_T$

Fig. 37 Effects of $t$ on $Q_0/Q_T$ and $Q_0/(Q_0+Q_w)$

Fig. 38 Effect of $D_p$ on $Q_0/(Q_0+Q_w)$
Fig. 39 Effect of $S_0$ on $Q_D/(Q_D+Q_W)$

Fig. 40 Effect of rupture diameter on $Q_D/(Q_D+Q_W)$

Fig. 41 Effect of $\Delta$ on $Q_D/(Q_D+Q_W)$

Fig. 42 Effect of $D_8$ on $\eta$
Fig. 43 Effect of \( S_0 \) on \( \eta \)

\[
\eta_s = 1 - \frac{\tau_w}{\tau_0} \frac{d}{H_1}
\]

(single hull)

\( D_B = 0.04 \text{m} \)
\( D_T = D_B = 71 \text{mm} \phi \)

Fig. 44 Effect of rupture diameter on \( \eta \)

\[
\eta_s = 1 - \frac{\tau_w}{\tau_0} \frac{d}{H_1}
\]

(single hull)

\( D_B = 0.06 \text{m} \)

Fig. 45 Effect of \( \Delta \) on \( \eta \)

\[
\eta_s = 1 - \frac{\tau_w}{\tau_0} \frac{d}{H_1}
\]

\( D_B = 0.04 \text{m} \)
\( D_T = D_B = 71 \text{mm} \phi \)

Fig. 46 Effect of \( t_i \) on \( \eta \)

\[
\frac{\eta_s}{\eta_s} = \frac{d}{H_1}
\]

\( H_1 = 0.5 \text{m} \)

Initial Water Layer Thickness \( t_i(\text{m}) \)
9. CONCLUSIONS

Oil spills and oil-water mixing were investigated by using ruptured ship tank model with double hull for various accident scenarios, tank configurations and cargo loading conditions. The effects of various parameters on oil spills were found. Methods for predicting the oil spills and for interpreting experimental results are presented.

The principal conclusions are as follow.

For groundings:
(1) Oil spills decrease with a decrease in the difference of oil and water levels.
(2) Oil containment in double hull space increases remarkably with an increase in double hull space and with a decrease in cross-sectional area of cargo oil tank, resulting decrease in oil spills.
(3) Oil spills can be predicted by introducing the non-dimensional thickness of water layer $\alpha$.
(4) $\alpha$ is a function of tank configuration, tank dimension, rupture area and liquid level.

For collisions:
(1) All amount of oil below the rupture spills.

Further experimental work is required to study the variation of $\alpha$ with actual accident data or the full-scale test for the grounding accidents.

NOMENCLATURE

$A_0$: area of rupture
$D_L$: diameter of inner hull plating rupture
d: draft
$D_O$: diameter of outer hull plating rupture
$D_B$: double bottom height
$D_S$: double side width
$H$: height of oil level after oil spills
$H_i$: initial height of oil level
$K$: parameter denoting the configuration of the double bottom $K=1$; J type, $K=2$; U type
$\ell$: longitudinal length of oil tank
$L_O$: oil tank breadth
$N$: number of division of oil tank
$Q_T$: quantity of oil leaving from oil tank
$Q_w$: quantity of water flows into double hull space
$S_o$: cross-sectional area of oil tank
$t_o$: thickness of water layer in double hull after oil spills
$t_i$: initial thickness of water layer in double hull
$V_O$: volume of oil tank
$V_D$: volume of double hull space
$\alpha$: non-dimensional thickness of water layer ($= t_o/D_o$)
$\gamma_o$: density of oil
$\gamma_w$: density of water
$\Delta$: offset value of inner and outer shell plating rupture
$\eta_o$: oil spill fraction ($= Q_o/H_i S_o$)
$\eta_T$: oil leaving fraction ($= Q_T/H_i S_o$)
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APPENDIX

Graphical presentation of the experimental data correlated by $d/H_1$ and $(d-D_w)/H_1$