Ship Hydrodynamics

MidTerm - I Oct. 23, 2014

1) If Froude's law of similarity is valid, then Moment coefficients should be equal : $C_{M_m} = C_{M_s}$, that is ; $\dfrac{M_m}{\frac{\rho_m}{2} S_m V_m^2 L_m} = \dfrac{M_s}{\frac{\rho_s}{2} S_s V_s^2 L_s}$ 5

$$\therefore \frac{M_s}{M_m} = \left(\frac{\rho_s}{\rho_m}\right)\left(\frac{S_s}{S_m}\right)\left(\frac{V_s}{V_m}\right)^2\left(\frac{L_s}{L_m}\right) = \frac{\rho_s}{\rho_m}(\lambda^2)(\sqrt{\lambda})^2(\lambda) = \frac{\rho_s}{\rho_m}\lambda^4$$ 10

$$\therefore M_s = M_m\left(\frac{\rho_s}{\rho_m}\right)\lambda^4 = 39.5\left(\frac{1025}{1000}\right)(30)^4 = \underline{32794.9 \text{ kN}\cdot\text{m}}$$ 5

2) If the two ships are in the same medium

$$\alpha^3 = \frac{\nabla_B}{\nabla_A} = \frac{\cancel{\rho_B}\,12000}{\cancel{\rho_A}\,8000} = 1.5 \Rightarrow \alpha = 1.145 .$$

$$V_A = 12 \text{ kn} = 6.173 \text{ m/s} \Rightarrow V_B = \sqrt{\alpha}\, V_A = 6.605 \text{ m/s} = 12.84 \text{ kn}$$ 5

Since $\dfrac{C_F}{C_R} = 1.2$ in both ships ; $C_F = 1.2\, C_R$, or ;

$$C_T = 0.6\, C_T + C_R$$

Ship A : $(C_T \, \rho/2 \, S V^2)_A = 147.5 \text{ kN}$ @ 12 kn $\Rightarrow C_{T_A} = 2.85 \times 10^{-3}$

$$C_{T_A} = 0.6\, C_{T_A} + C_R \Rightarrow C_{R_A} = 0.4\, C_{T_A} = 1.140 \times 10^{-3}$$ 5

Ship B : $C_{T_B} = 0.6\, C_{T_B} + C_R$. Since at the corresponding speeds;

$$C_{R_A} = C_{R_B} \quad ; \quad C_{T_B} = \frac{C_R}{0.4} = 2.85 \times 10^{-3}$$ 5

$$\therefore R_{R_B} = C_R \frac{\rho}{2} S_B V_B^2 = 1.140 \times 10^{-3}\left(\frac{1.025}{2}\right)(\alpha^2 S_A)(\alpha V_A^2)$$

$$= 88.56 \text{ kN}$$

and $R_{T_B} = \dfrac{R_{R_B}}{0.4} = 221.4 \text{ kN}$ 5

Finally; $P_{E_B} = V_B \cdot R_{T_B} = 1462 \text{ kW}$ @ 12.84 kn. 5

3) $$Re_s = \left(\frac{VL}{\nu}\right)_s = \frac{\sqrt{\alpha}\, V_m L_s}{\nu_s} = \frac{(10.29)(154.6)}{1.18732 \times 10^{-6}} = 1.339 \times 10^9$$

$$C_{F_s} = \frac{0.075}{[\log(Re)_s - 2]^2} = \frac{0.075}{[\log(1.339\times 10^9) - 2]^2} = 1.4766 \times 10^{-3}$$ 5

$$C_A = \left[105\left(\frac{k_s}{L_s}\right)^{1/3} - 0.64\right]\times 10^{-3} = \left[105\left(\frac{150\times 10^{-6}}{154.6}\right)^{1/3} - 0.64\right]\times 10^{-3} = 0.3995 \times 10^{-3}$$

Model scale wave resistance ; $C_W = C_{T_m} - (1+k)\, C_{F_m}$

$$L_m = \frac{L_s}{\alpha} = \frac{154.6}{26} = 5.95 \text{ m} , \quad S_m = \frac{S_s}{\alpha^2} = \frac{5670}{(26)^2} = 8.388 \text{ m}^2$$

$$Re_m = \frac{V_m L_m}{\nu_m} = \frac{(2.018)(5.95)}{1.02333 \times 10^{-6}} = 1.173 \times 10^7$$

$$\therefore\ C_{F_m} = \frac{0.075}{[\log(1.173\times10^7) - 2]^2} = 2.919\times10^{-3}$$

$$C_{T_M} = \frac{R_{T_M}}{\rho/2\ S_m\ V_m^2} = \frac{75.9}{\frac{1000}{2}\times 8.388\times(2.018)^2} = 4.444\times10^{-3}$$

$$\therefore\ C_W = C_{T_m} - (1+k)C_{F_m} = [4.444 - (1.280)(2.919)]\times10^{-3} = 0.708\times10^{-3}\ \ 5$$

Total ship resistance:

$$C_{T_s} = (1+k)C_{F_S} + C_W + C_A = [(1.280)(1.4766) + 0.708 + 0.3995]\times10^{-3}$$

$$= 2.998\times10^{-3}\ \ 5$$

Finally; $R_{T_s} = (\frac{\rho}{2} S V^2)_s C_{T_s} = \frac{1025}{2}\times 5670\times(10.29)^2\times 2.998\times10^{-3}$

$$= 922.4\ \text{kN}\ \ 5$$

1HP 0.746 kW

$$P_{E_s} = R_{T_s}\cdot V_s = 922.4\times 10.29 = 9491.5\ \text{kW} = 12723\ \text{HP}$$

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4. a) Two methods employing series (family) of ships can be
10 cited: "İTÜ Balıkçı Gemisi Serisi" and UBC trawler series.
Ortmerssen's statistical/empirical method may also be used.

10 b) No. Because thin-ship theory does not account for the viscosity.

c) Adverse pressure gradient means positive gradient in pressure
10 which causes separation by retarding the flow.