MEC-E4001 Winter Navigation

EXAMINE 09.02.2018, K326

(Answers either in Finnish or English)

Question 1:

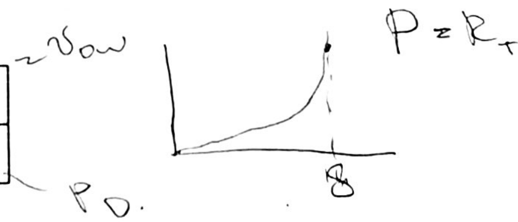
You are designing a product tanker with an icebreaking bow and enough power to operate independently in moderate ice conditions: 2 knots in 60 cm ice. The hull is 150 metres long at the waterline and the vessel is propelled by a single 4-metre controllable-pitch propeller.

Lindqvist's level ice resistance components:

Ice thickness [m]	**Crushing** [kN]	**Bending** [kN]	**Submersion** [kN]
0.2	10	22	74
0.4	40	63	149
0.6	90	115	223
0.8	160	178	297
1.0	250	248	371

Speed-power curve for open water:

Speed [knots]	8	10	12	14	16
Propulsion power [kW]	2090	4520	8378	13988	21674



Determine the minimum installed propulsion power required to meet the desired icebreaking capability (2 points) and plot the vessel's h-v-curve (4 points).

$$T_B = 0.78 \cdot (P_D \cdot D)^{\frac{2}{3}}$$

$$T_{NET}(v) = T_B\left(1 - \frac{1}{3}\frac{v}{v_{ow}} - \frac{2}{3}\left(\frac{v}{v_{ow}}\right)^2\right)$$

$$R_{ice}(v) = (R_c + R_b)\left(1 + 1.4\frac{v}{\sqrt{g \cdot H}}\right) + R_s\left(1 + 9.4\frac{v}{\sqrt{g \cdot L}}\right)$$

$$\frac{y - y_0}{x - x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$ or graphic interpolation

Question 2:

The design work for the Arctic product tanker from the previous question continues. Your team has designed the hull structure according to IACS Polar Class 6 requirements as per client requirements ("I'm mostly sailing in the marginal ice zone anyway"), but you are concerned about hull strength because multi-year ice floes are regularly observed in the operational area where the client's transit analysis is based on a service speed of 8 knots. You have asked your structural engineer to calculate the design ice loads (normal force against shell) in the bow region for a number of ice classes and include a reasonable safety factor. He has also calculated the increase in displacement due to additional steel weight for the higher ice classes compared to the baseline design.

Ice class	Steel weight increase	Design ice load
PC 6		6500 kN
PC 5	+ 500 tons	8500 kN
PC 4	+1000 tons	12500 kN

Consider a design scenario where the vessel, which has a design displacement of 15000 tons, experiences a glancing impact in the bow. Use the energy-based ice forces method and assume a simple impact where all kinetic energy is expended in crushing. Mass reduction coefficient for this impact scenario is 2.0, ice crushing strength for 1 m² reference area can be taken as 2500 kPa, and force-area relationship exponent as -0.5. From the hull lines drawing, you have measured that the waterline opening angle at the impact point is 30 degrees and frame angle is 63.435" from vertical.
What ice class would you recommend for the client?

$$IE = \frac{p_0}{3+2\times ex} \times \left(\frac{1}{\sin\alpha \times \cos\alpha \times \sin\beta' \times \cos^2\beta'}\right)^{1+ex} \times \zeta_n^{3+2\times ex}$$

$$\tan(\beta') = \tan(\beta) \times \cos(\alpha)$$

$$KE_e = \frac{1}{2} \times \frac{M}{Co} \times V_n^2$$

$$F_n = p_0 \times \left(\frac{1}{\sin\alpha \times \cos\alpha \times \sin\beta' \times \cos^2\beta'}\right)^{1+ex} \times \zeta_n^{2+2\times ex}$$

Question 3:

What is meant by double acting ship in ice and why it is so widely used principle for ships navigating in ice (6P)

Question 4:

Why model scale tests and full scale trials are so important for the development of good ice-going ships (6P)

Question 5:

Desribe the background and basic principles of the engine power requirements used in the Finnish-Swedish ice class rules. (6P)