MEC-E4001 Winter Navigation

EXAMINE 21.02.2019
Time: 09-12
Class rooms: K202 (K1), Otakaari 4

(Answers either in Finnish or English)

Question 1:

You are designing an anchor-handling tug-supply (AHTS) vessel with an icebreaking bow and a design icebreaking capability of 4 knots in 1.2 m level ice. The hull is 100 metres long at the waterline and the vessel has two propellers with a diameter of 4.2 metres.
You have previously calculated the following Lindqvist's level ice resistance components:

Ice thickness [m]	Crushing [kN]	Bending [kN]	Submersion [kN]
0.2	6	6	57
0.4	25	18	115
0.6	56	32	172
0.8	99	50	230
1.0	154	70	287
1.2	222	92	344
1.4	302	116	402
1.6	395	141	459

Your hydrodynamic engineer has provided you the following open water speed-power curve:

Speed [knots]	8	11	14	17	20
Propulsion power [kW]	1000	4000	9000	16000	25000

Determine the following:

- minimum installed propulsion power required to meet the desired icebreaking capability (2 points);
- vessel's h-v-curve(3 points); and
- ice thickness where the vessel can achieve a speed of 10 knots.

$$T_B = 0.98 \cdot (P_D \cdot D)^{\frac{2}{3}}$$

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

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

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

Question 2:

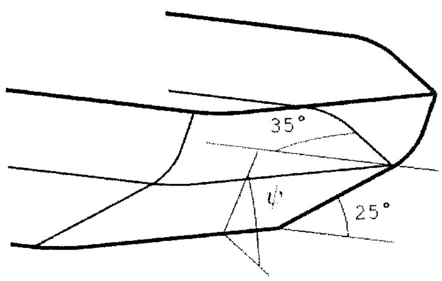
Consider a design scenario where the AHTS vessel from the previous question experiences a glancing impact in the bow. Your structural engineer has calculated the design ice load for different ice classes according to the IACS Polar Class rules. In addition, he has calculated how much extra steel needs to be added to the ice-strengthened regions. If the vessel is designed to ice class PC 6 (baseline), its design displacement would be 10000 tons.

Ice class	Steel weight increase	Design ice load
PC 6	-	6000 kN
PC 5	+ 750 tons	7500 kN
PC 4	+1500 tons	9500 kN
PC 3	+3000 tons	12000 kN

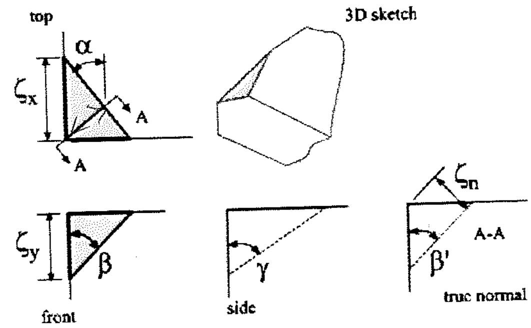
The shipowner is ready to accept an operational speed limit of 9 knots for ice management operations in the marginal ice zone where there is a possibility of encountering multi-year ice floes.

a) What is the lowest ice class that could be considered acceptable for the AHTS based on the operational speed limitation proposed by the shipowner? (50% points)
b) What kind of operational speed limitation(s) could be considered for the lower ice class(es)? (50% points)

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. The hull angles, description of the glancing impact, and necessary equations are given below.



$$\psi = \arctan\left(\frac{\tan\phi}{\sin\alpha}\right)$$



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

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

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

Question 3:

Describe the main elements of the Finnish winter navigation system. The new EEDI requirements will decrease the used power of the ice-strengthened vessels, what kind of effect this can have on the system functionality.(6P)

Question 4:

Compare the conventional four propeller (2 at aft and 2 at bow) and fixed propeller axis electrical propulsion system with a new 3 POD propulsion (2 at aft , 1 at bow) system on the ice-breaker. The main benefits and draw backs for these systems. (6P)

Question 5:

The new Polarcode came into force 1.1.2017, describe shortly the new POLARIS risk based system used in the new Polarcode (6P)