MEC-E4006 Ship Operations in Ice

EXAMINE 22.02.2023
Time: 09-12
K215, K1 building
(Answers either in Finnish or English)

Question 1:

A ship's performance was studied with model scale testing in open water. The tests revieled that the open water resisitance R_{ow}(v=speed [m/s]) and the effective thrust T_{eff}(v=speed [m/s]) in kN, that account the thrust deduction t, can be described with the following functions in full-scale:

$T_{eff}=T(1-t)=-3v^2-150v+2500$ [kN]
$R_{ow}= 2v^3-15v^2+70v$ [kN]

The hull design and applicable parameters are presented in the Appendix A. If you measure or estimate hull angles from the lines, return the lines with the answer papers.

a) What is the maximum open water speed the ship can achieve? (1p)
b) What speed the ship could achieve in level ice having a thickness of 0.75 m and flexural strength of 500 kPa. Hull-ice friction can be assumed to be 0.1. (2p)
c) How much the speed would increase, if the available power would be increased with 50%? (2p) Hint: the power is not given, but you should estimate it from the T_{eff} curve and the given propulsion configurations. Assume that the shape of effective propulsion curve remains the same and you can scale it with the new bollard pull.
d) How thick ice the ship could break with a 5 kn speed with the two power settings? (2p)

Question 2:

The vessel presented in Question 1 has transverse framing system with a frame spacing of 0.4 m and a span of 2.0 meters. It is constructed from common AH36 shipbuilding steel.

a) What plate thickness the vessel should have at the stern area to fullfil the requirements of FSICR 1A? (2p)
b) If one would like to reduce the plate thickness by 30%, what the frame spacing should be? (1p)
c) IACS PC6 and FSICR 1A Super could be considered as corresponding ice classes. Why the design load magnitude is clearly different, but the structure obtained from the rule calculation can be close to each other? (2p)

Question 3:

Describe how the possible propeller-ice interaction affects
a) the design requirements and the performance of the propeller, (2p)
b) the machinery design and aspects to be considered in it, (2p)
c) what are typical machinery-propulsion concepts for icebreakers. (2p)

Question 4:

a) Ice-induced load on a ship hull can be estimated theoretically based on the conservation of energy. Describe how it can be done in practice starting from the energy balance. Pay attention on what assumptions and information are required in different steps to determine the ice load. (3p)
Note: Equations can be presented to clarify the description. Presenting only equations without description does not give points.

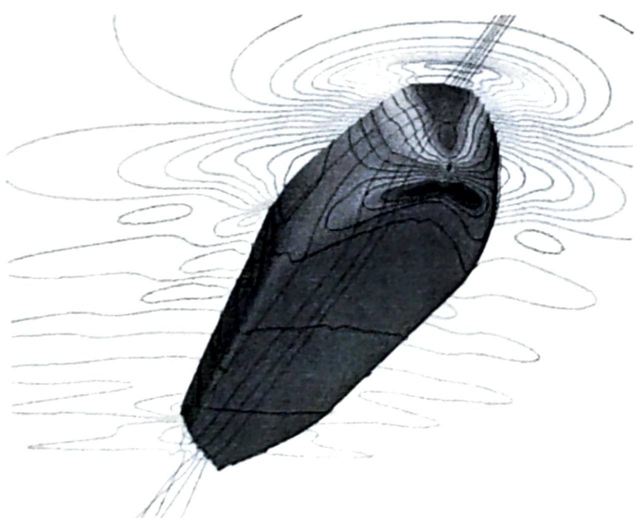
b) EEDI was relatively recently enforced in IMO. Describe EEDI briefly. What is the purpose of EEDI and how it is defined? How the obtained EEDI value can be decreased? What are the possible impacts to the ship performance in ice? (3p)

Question 5:

You are working in a ship design office and you are competing with another office from a newbuilding project. You hear that the competing company has been able to fullfil the design icebreaking capability with less power than your design. Below is your office's current design.

What things could be altered in <u>the hull design</u> to decrease the required engine power to achieve the target speed in ice conditions? Try to identify at least three points that you consider woud have a significant impact for straigth a head operations.

You are allowed to do significant changes to the design and even the main dimensions. For each alteration, describe why the alteration would improve the ice performance and how the alteration would affect the other common performance indicators of a merchant vessel (i.e. open water performance and cargo transport factors). (6p).



Appendix A – Ship main dimensions and lines

MAIN DIMENSIONS	
LENGTH, OVER ALL	172.6 m
LENGTH, DESIGN WATERLINE (DWL)	165.0 m
LENGTH, BETWEEN PERPENDICULARS	165.0 m
BEAM, DWL	26.4 m
DRAFT, DWL	7.7 m
DEPTH TO MAIN DECK	14.3 m
BLOCK COEFFICIENT	0.774
PROPULSION	
PROPELLER	Controllable pitch (ø 5.2 m)