BT MRE-IV(S)-06-22-0769 Reg. No. [ ] **B**

# *B.Tech. Degree IV Semester Supplementary Examination in Marine Engineering June 2022*

## MRE 1402 THERMODYNAMICS AND HEAT TRANSFER

*(2013 Scheme)*

Time: 3 Hours Maximum Marks: 100

$(5 \times 20 = 100)$

I. (a) State and Explain Carnot's theorem. (5)

(b) A vessel having a capacity of 0.05 $m^3$ contains a mixture of saturated water and saturated steam at a temperature of 245°C. The mass of liquid present is 10 Kg. Find the following: (i) Specific enthalpy (ii) Specific entropy (iii) Specific internal energy. (5)

(c) A heat pump working on a reversed Carnot cycle takes in energy from a reservoir maintained at 5°C and delivers it to another reservoir where temperature is 77°C. The heat pump derives power for its operation from a reversible engine operating within the higher and lower temperatures of 1077°C and 77°C. For 100 KJ/kg of energy supplied to reservoir at 77°C, estimate the energy taken from the reservoir at 1077°C. (10)

**OR**

II. (a) Write short notes on combustion equations. Write the combustion equations of Hydrogen and carbon. (10)

(b) One Kg of ethane ($C_2H_6$) is burned with 90% of theoretical air. Assuming complete combustion of hydrogen in the fuel determine the volumetric analysis of the dry products of combustion. (10)

III. (a) With the help of P-V and T-S diagram Explain Rankine cycle. (10)

(b) In a steam power cycle, the steam supply is at 15 bar and dry and saturated. The condenser pressure is 0.4 bar. Calculate the Carnot and Rankine efficiencies of the cycle. Neglect Pump Work. (10)

**OR**

IV. (a) Explain the different methods of compounding of steam turbine with the help of neat figures. (10)

(b) In a De-Laval turbine steam issues from the nozzle with a velocity of 1200 m/s. The nozzle angle is 20°, the mean blade velocity is 400 m/s, and the inlet and outlet angles of blade are equal. The mass of steam flowing through the turbine per hour is 1000 Kg. Calculate (i) Blade angles (ii) Relative velocity of steam entering the blades (iii) Power developed (iv) Blade efficiency. (10)

V. (a) Derive an expression for the work done in a single stage air compressor with clearance. (10)

(b) A single stage reciprocating compressor takes 1 $m^3$ of air per minute at 1.013 bar and 15°C and delivers it at 7 bar. Assuming that the law of compression is $pv^{1.35}$ = constant, and the clearance is negligible, Calculate the indicated power. (10)

**OR**

VI. (a) Draw P-V diagram for two stage compressor with perfect inter-cooling and explain. (10)

(b) A two stage air compressor with complete intercooling delivers air to the mains at a pressure of 30 bar, the suction conditions being 1 bar and 15°C. If both cylinders have the same stroke, find the ratio of cylinders diameter, for the efficiency of compression to be maximum. Assume the index of compression to be 1.3. (10)

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BT MRE-IV(S)-06-22-0769

VII. (a) Derive the general heat conduction equation in Cartesian co-ordinates. Derive Laplace equation from it. (10)

(b) A composite wall is made up of three layers 15 cm, 10 cm and 12 cm of thickness. The first layer is made up of material with k = 1.45 W/m°C for 60% of area and rest of the material with k = 2.5 W/m°C. The second layer is made with material of k = 12.5 W/m°C for 50% of the area and the rest of the material with k = 18.5 W/m°C. The third layer is of single material with k = 0.76 W/m°C. The composite slab is exposed to warm air at 26°C and cold air of –20°C on the other side. The inner and outer heat transfer co-efficient are 15 W/m$^2$°C and 20 W/m$^2$°C. Determine heat flux rate and interface temperatures. (10)

**OR**

VIII. (a) Hot air at a temperature of 65°C is flowing through a steel pipe of 120 mm diameter. The pipe is covered with two layers of different insulating materials of thickness 60 mm and 40 mm, and their corresponding thermal conductivities are 0.24 and 0.4 W/m°C. The inside and outer heat transfer coefficients are 60 and 12 W/m°C. The atmosphere is at 20°C. Find the rate of heat loss from 60 m length of pipe. (10)

(b) Explain: (10)

(i) Black body

(ii) Total emissive power

(iii) Stefan-Boltzmann law.

IX. (a) Explain Logarithmic Mean Temperature difference. Derive LMTD for parallel flow Heat exchanger. (10)

(b) Steam enters a counter flow heat exchanger, dry saturated at 10 bar and leaves at 350°C. The mass flow of steam is 800 Kg/min. The gas enters the heat exchanger at 650°C and mass flow rate is 1350 kg/min. If the tubes are 30 mm diameter and 3 m long, Determine the number of tubes required. Neglect the resistance offered by metallic tubes. Use the following data: (10)

For steam: $T_{sat} = 180$°C (at 10 bar); $C_{ps} = 2.71$ KJ/kg°C; $h_s = 600$ W/m$^2$°C

For gas: $C_{pg} = 1$ KJ/kg°C; $h_g = 250$ W/m$^2$°C

**OR**

X. (a) Explain the different non-dimensional numbers used in heat transfer. Also explain their physical importance. (10)

(b) Explain condensers and evaporators used in Marine applications. (10)

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