Group - C (Answer any two) [15x2=30]

6. (a) In a condenser steam flows outside the tubes of radii 60 mm and 54 mm and sea water flows inside the tubes. The thermal conductivity of the tube material is 70 W/mK. The steam and water temperatures are below 52°C. The convection coefficient on the steam side is 10000 W/m^{2}K and the value on water side is 600 W/m^{2}K.
(i) Calculate the values of overall coefficients of heat transfer based on the inside area, and (ii) Draw the thermal circuit diagram along with the space diagram showing all the resistances. Given fouling factor for sea water below 52°C and for steam = 0.0000877. [(6+2)+7=15]

(b) Two large aluminium (k = 220 W / m K) sheet, each 25 mm thick, with 10μm surface roughness are placed in contact at 10^5 N/m^2 pressure with the outside surface temperature of 400°C and 450°C. The thermal contact resistance is 3.05×10^{-4} m^2 K / W. Find (i) the heat flux, (ii) the temperature drop due to contact resistance and (iii) Draw the thermal circuit diagram along with the space diagram.

7. (a) A room 3 m in length, 2 m in width and 4 m In height is heated from the ceiling by maintaining it at a temperature of 300 °C. If side walls and floor are maintained at 200 °C, calculate the rate of heat transfer from the ceiling to floor and side walls when the emissivity of all surfaces is 0.5. Draw the radiation network diagram. (7+8=15)

(b) Water at 40°C flows over a flat plate with a free stream velocity of 0,5 m/s. Determine the local and average friction coefficient at 0.7 m from the leading edge. Also determine the local wall shear stress. Given $\nu = 1.006 \times 10^{-6}$ m^2/s.

8.(a) A liquid flows through a tube of 4 cm diameter, which is having outer surface emissivity 0.04 and temperature 100 K. The tube is concentric with a larger tube of 6 cm diameter and inner surface is having emissivity of 0.06 and temperature of 400 K. (i) Find the heat transfer per unit length without shield. (ii) Find also the reduction in radiation heat transfer if a thin radiation shield of 5 cm diameter and emissivity of 0.012 on both sides is inserted between the tubes. (iii) Also draw the radiation network diagram. Assume the space between the surfaces as vacuum. [(3+4+3)+5=15]

(b) A counterflow shell and tube exchanger is used to heat water with hot exhaust gases. The water flows at a rate of 3 kg / sec while the exhaust gas, s = 1000 J/kg°C flows at the rate of 6 kg/sec. If the heat transfer surface area is 35 m^2 and the overall heat transfer coefficient is 210 W/m^2°C, calculate the NTU for the heat exchanger.

Ex/Prod/PC/B/T/212/2023

JADAVPUR UNIVERSITY

Bachelor in Production Engineering Examination - 2023

2nd Year – 1st Semester

Thermodynamics & Heat Transfer

Time : 3 Hours Full Marks : 100

*Answer **Group – A(Compulsory) and any two** from Group – B & Group – C [40+30+30=100]*

Group – A (Compulsory) [(10x1)+(5x6)=40]

Note:1. All the notations or symbols used in any formula should be explained clearly.
2. Assume any appropriate missing data if you feel so.

1. Select the suitable answer from the multiple choices or answer the question from the followings:

(i) In a two fluid heat exchanger, the inlet and outlet temperatures of the hot fluid are 65 °C and 43 °C. Find the type of flow of the heat exchanger.

(ii) A furnace wall has a thickness of 200 mm and the rate of heat conduction is 100 W / m^2 with surface temperatures of 600 °C and 400 °C. Find out the thermal conductivity.

(iii) PMM2 violates the (a) First law of thermodynamics, (b) Clausius statement, (c) Kelvin-Planck statement, (d) third law of thermodynamics.

(iv) Prove that the emissivity of a black body is 1.

(v) Fill up the blank: The total radiant energy leaving a gray surface per unit time and per unit surface area is called _____.

(vi) The more effective way of increasing the efficiency of a Carnot engine is to (a) increase higher temperature, (b) increase lower temperature, (c) decrease lower temperature, (d) decrease higher temperature.

(vii) The temperature at which water vapour starts condensing is called (a) Wet bulb temperature, (b) Triple point temperature, (c) Dew point temperature, (d) Dry bulb temperature.

(viii) A thermodynamic cycle is impossible if, (a) $\oint dQ/T > 0$, (b) $\oint dQ/T < 0$, (c) $\oint dQ/T = 0$.

(ix) The exergy of an isolated system in a process (a) can never decrease, (b) can never increase, (c) always remains constant, (d) is always zero.

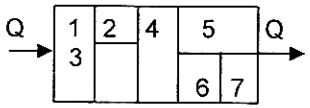
(x) In case of electric wire if we add insulation after the critical radius, the heat loss will (a) decrease, (b) increase, (c) unaltered.

2. Define the following terms: (10x3=30)

(i) Explain two-stage Vapour Compression system with a flash intercooler by showing P-H and Flow diagrams.

(ii) Draw temperature profile diagram corresponding to space diagram of a heat exchanger having one shell pass(mixed fluid) and two tube passes(unmixed fluid).

(iii) Draw the analogous electric circuit of heat flow i.e. thermal circuit diagram Indicating all the resistances for a composite wall as shown in figure.



(iv) Draw the radiation network diagram for interchanging radiation energy between two infinite parallel gray surfaces.

(v) Discuss the limitations of the fin surfaces.

(vi) Show that the change in enthalpy of steam is equal to the heat transfer at constant pressure.

(vii) Thermal efficiency of a Carnot engine is 2/5. Find the COP of a refrigerator working on Carnot cycle.

(viii) Air is flowing in a 0.3 m diameter pipe at a uniform velocity of 0.25 m/sec. The temperature is 30°C and pressure is 2 bar. Determine the mass flow rate.

(ix) Determine the value of monochromatic emissive power of a black body at a temperature of 1000°C and at a wavelength of 5 mircron.

(x) State the different psychrometrics properties of air water-vapour mixture that can be read easily from the psychrometric chart. Mention their units also.

Group - B (Answer any **two**) [15x2=30]

3. (a) How does a heat pump differ from a refrigerator? Show with block diagrams. (4+6+5=15)

(b) An insulated rigid tank initially at zero pressure is connected through a valve to an infinite source supply line of steam at 0.80 MPa and 573 K. The valve is slowly opened to allow the steam to flow into the tank until the pressure reaches 0.80 MPa, and at which point the valve is closed. Calculate the final temperature of the steam in the tank.

(c) Find the change in entropy of 20 gm of water at 25°C, when it is converted to ice at –15°C.

4. (a) A cylinder of 2 m^3 has air at 0.5 MPa and temperature of 375 K. Air is released in atmosphere through a valve on cylinder so as to run a frictionless turbine. Find the amount of work available from the turbine assuming no heat loss and complete KE being used for running turbine. (8+7=15)

(b) A room requires 2.5 x 10^5 kJ / hr for heating in winter. Heat pump is used to absorb heat from cold air outside in winter and send heat to the house. Work required to operate the heat pump is 3.5 x 10^4 kJ /hr. Determine (i) heat abstracted from outside, (ii) co-efficient of performance, (iii) draw the block diagram of the system.

5. (a) A vapour compression cycle works on Freon-12 refrigerant with condensation temperature of 35°C and evaporator temperature of – 15°C .Refrigeration effect of 3 ton is desired from the cycle. (i) Draw the flow diagram along with T-S and P-H representations, and (ii) determine the COP of the system. (10+5=15)

Temperature °C [for Freon – 12]	Specific heat kJ/kg.K	
	C_{pf}	C_{pg}
- 15	-	0.60
35	0.98	0.75

(b) Determine the molecular weight of a gas if its specific heats at constant pressure and volume are 2.286 kJ/kg K and 1.768 kJ/kg K respectively.

[Turn Over]