Code: 20A03603T

R20

B.Tech III Year II Semester (R20) Regular Examinations August 2023

HEAT TRANSFER

(Mechanical Engineering)

Time: 3 hours Max. Marks: 70

PART – A

(Compulsory Question)

*****

1 Answer the following: (10 X 02 = 20 Marks)

(a)	How the overall heat transfer coefficient is related to resistances on a composite wall case?	2M
(b)	Differentiate between fin efficiency and fin effectiveness.	2M
(c)	What do you mean by thermal boundary layer?	2M
(d)	Draw the laminar and turbulent velocity boundary layer for natural convection on a vertical plate.	2M
(e)	Differentiate between evaporation and boiling.	2M
(f)	What is bubbly flow in boiling?	2M
(g)	Draw temperature Vs length profiles for the condenser and evaporator.	2M
(h)	What is a fouling factor? How is it plays an important role in a heat exchanger?	2M
(i)	Find the shape factor of the curved portion of the hemispherical bowl concerning the upper flat surface when the area of curved and flat surfaces are A1 and A2 respectively.	2M
(j)	Give the significance of Schmidt number.	2M

PART – B

(Answer all the questions: 05 X 10 = 50 Marks)

2	(a)	What is the overall heat transfer coefficient? Deduce an expression for this in a composite wall having three different materials of three different thicknesses and thermal conductivities. Two different fluids having different fluid properties are passing over two outer surfaces of the composite wall.	5M
	(b)	Deduce the expression for the Critical thickness of insulation in a cylindrical pipe.	5M

OR

3		A 50 cm × 50 cm copper slab, 6 mm thick at a uniform temperature of 350℃, suddenly has its surface temperature lowered to 30℃. Find the time at which the slab temperature becomes 100℃. Density, specific heat, thermal conductivity and heat transfer coefficients are 9000 kg/m^3, 0.38 kJ/kgK, 370 W/mK, and 1000 W/m^{2}K respectively. Also, find out the rate of cooling after 60 seconds.	10M
4		Engine oil at 30℃ is flowing with a velocity of 2 m/s along the length of a flat plate, maintained at 90℃. Calculate at a distance of 40 cm, from the leading edge, (i) hydrodynamic and thermal boundary layer by the exact method (ii) local and average values of friction coefficient (iii) local and average heat transfer coefficient (iv) heat transferred from the first 40 cm of the plate for unit width.	10M

OR

Contd. in Page 2

5 (a) A horizontal cylinder has a diameter of D=5 cm and a length L=50 cm. Its surface is maintained at 35℃ while the surrounding air is 20℃. Neglecting radiation calculate the rate of heat transfer from the cylindrical surface at the steady state. The properties of air are 5M
$v = 16 \times 10^{-6}$ m^2/s
$kf = 26 \times 10^{-3}$ W/mK
Pr = 0.707

$$\mathrm{Nu_d} = 0.518\left[1+\left(\frac{0.6}{\mathrm{Pr}}\right)^{0.6}\right]^{-5/12}\left(\mathrm{Gr_d\,Pr}\right)^{1/4}$$

(b) Experimental results for heat transfer over a flat plate with an extremely rough surface were found to be correlated by an expression of the form 5M

$$\mathrm{Nu}_x = 0.04\,\mathrm{Re}_x^{0.9}\,\mathrm{Pr}^{1/3}$$

Where Nu_x is the local value of the Nusselt number at a position x measured from the leading edge of the plate. Obtain an expression for the ratio of the average heat transfer coefficient between the leading edge and location x to the local heat transfer coefficient at x.

6 Draw and explain the boiling curve for pool boiling (water) and show the burnout point. What is its significance? 10M

OR

7 Differentiate between film condensation and drop wise condensation. 10M

8 Derive an expression for the effectiveness of a parallel flow HX in terms of NTU and capacity ratio. 10M

OR

9 (a) A HX is required to cool 55000 kg/h of alcohol from 66℃ to 40℃ using 40000 kg/h of water entering at 5°C. Calculate (i) exit temperature of water (ii) heat transfer (iii) surface area required for (a) parallel type and (b) counter flow type of HX. U = 580 W/m2K, $C_{palcohol}$ = 3760 J/kgK, C_{pwater}= 4180 J/kgK. 5M

(b) Copper pipe (k=35 W/mK) of 17.5 mm ID and 20 mm OD conveys water and the oil flows through the annular passage between this pipe and the steel pipe. On the waterside, the film coefficient is 4600 W/m^2K and the fouling factor is 0.00034 m^2K/W. The corresponding values for the oil side are 1200 W/m^2K and 0.00086 m^2K/W. Calculate the overall heat transfer coefficient between the water and oil based on the outside are 1200 W/m2K and 0.00086 m^2K/W. Calculate the overall heat transfer coefficient between water and oil based on the outside surface area of the inner pipe. 5M

10 (a) What is a radiation shield? Deduce the heat loss between two parallel plates having a shield in between them. 5M

(b) Explain Kirchhoff's law, Planck's law, Wein's law, and Stefan Boltzman law. 5M

OR

11 Consider a long duct of an equilateral triangular section of side 0.75 m. Surfaces 1 and 2 are maintained at 700K and 1000K while surface 3 is insulated. The emissivity of surface 1 is 0.8 and surface 2 is black. Determine the rate at which energy must be supplied to surface 2 to maintain these operating conditions. 10M

*****

Code: 20A03603T

R20

B.Tech III Year II Semester (R20) Supplementary Examinations January 2024

HEAT TRANSFER

(Mechanical Engineering)

Time: 3 hours Max. Marks: 70

PART – A

(Compulsory Question)

*****

1 Answer the following: (10 X 02 = 20 Marks)

(a) What is the critical insulation radius when k = 0.50 W/mK and h = 10 W/m^{2}K? 2M

(b) What do you mean by transient heat conduction? What are various non-dimensional numbers used in transient heat conduction? 2M

(c) Show the velocity and temperature profiles for fully developed cases in pipelines. 2M

(d) Define Rayleigh number. Give its significance. 2M

(e) What do you mean by stratified flow and why does it occur in horizontal pipelines? 2M

(f) What is Rohsenow correlation in boiling? 2M

(g) What is the physical significance of NTU? 2M

(h) Why are counter flow heat exchangers mostly used compared to parallel flow type? 2M

(i) Explain Kirchhoff's law. 2M

(j) How Schmidt and Prandtl number are analogous to each other? 2M

PART – B

(Answer all the questions: 05 X 10 = 50 Marks)

2 (a) Derive 3D heat conduction equation in Cartesian coordinates. 5M

(b) Based on the above relation, Derive expressions for temperature distribution and heat dissipation in a straight fin of rectangular profile for the infinitely long fin. 5M

OR

3 (a) A 0.8 m high and 1.5 m wide double-pane window consists of two 4 mm thick layers of glass (k = 78 W/mK) separated by a 10 mm wide stagnant air space (k = 0.026 W/mK). Determine the rate of heat transfer through this window and the temperature of the inside surface, when the room is maintained at 20°C and the outside air is at -10°C. Take the convection coefficient on the inside and outside surfaces of the window as 10 and 40 W/m^{2}K respectively. Find the overall heat transfer coefficient. 5M

(b) A stainless steel rod of outer diameter 1 cm originally at a temperature of 300°C is suddenly immersed in a liquid at 120°C for which the convective heat transfer coefficient is 50 W/m^{2}K. Determine the time required for the rod to reach a temperature of 100°C. Assume the density of steel is 7800 kg/m^3, Specific heat as 450 J/kgK and thermal conductivity is 40 W/mK. 5M

4 A rectangular plate is 120 cm long in the direction of flow and 200 cm wide. The plate is maintained at 80°C when placed in nitrogen that has a velocity of 2.5 m/s and a temperature of 0°C. Determine (i) the average heat transfer coefficient, (ii) the total heat transfer from the plate, (iii) Nusselt number. The properties of Nitrogen at 40°C are ρ = 1.142 kg/m^3, Cp = 1.04 kJ/kgK, v = 15.63×10^{-6} m^2/s and k = 0.0262 W/mK. 10M

OR

5 How are the principal dimensionless parameters of natural convection determined from the boundary layer equations concerning continuity, momentum and energy? 10M

Contd. in Page 2

6		Explain the Regimes of boiling with a sketch.	10M
		OR	
7		Sketch and explain the Flow pattern map in flow boiling for horizontal tube.	10M
8		Derive LMTD for parallel flow and counter flow type heat exchangers.	10M
		OR	
9		Consider a heat exchanger for cooling oil which enters at 180°C and cooling water enters at 25℃. The mass flow rates of oil and water are 2.5 and 1.2 kg/s respectively. Area for heat transfer =16 m^2. Specific heat data for oil and water and overall U are 1900 J/kgK, 4184 J/kgK and 285 W/m^2K. Calculate outlet temperatures of oil and water parallel and counter flow HX.	10M
10	(a)	Define the following terms: (i) Total emissive power (E), (ii) Monochromatic emissive power (Eλ), (iii) Emissivity, (iv) Intensity of radiation, (v) Radiosity.	5M
	(b)	Give a short note on Solar radiation in Earth's atmosphere.	5M
		OR	
11		Two parallel gray planes have emissivities of 0.8 and 0.7 and are maintained at 800℃ and 1500℃. What is the net radiant energy exchange? What would be the reduction in heat transfer if a radiation shield of polished aluminum (ε = 0.04) is placed between them?	10M

*****