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Paper Code : PC-ME501 Heat Transfer

UPID : 005613

Time Allotted : 3 Hours *Full Marks :70*

The Figures in the margin indicate full marks.

Candidate are required to give their answers in their own words as far as practicable

Group-A (Very Short Answer Type Question)

1. Answer *any ten* of the following : [1 x 10 = 10]

(I) Thermal diffusivity of substance is given by _____.

(II) Self surface factor is zero for _____.

(III) LMTD for counter flow heat exchanger compared to parallel flow is _____.

(IV) Emissivity of perfectly black body is _____.

(V) According to Newton's law of cooling, the rate of heat transfer in convection is _____.

(VI) The wavelength of the radiation emitted by a body depends upon _____.

(VII) Nusselt number is defined by _____.

(VIII) The process of heat transfer from one particle of the fluid to anther by the actual movement of the fluid particles caused by some mechanical means, is known as _____.

(IX) According to Wein's displacement law, the maximum monochromatic emissive power is proportional to _____.

(X) The curve for unsteady state cooling or heating of bodies is a _____.

(XI) The value of Prandtl number for air is about _____.

(XII) A non-dimensional number generally associated with natural convection heat transfer is _____.

Group-B (Short Answer Type Question)

Answer *any three* of the following : [5 x 3 = 15]

2. Discuss the classifications of heat exchanger. [5]

3. Proof Fourier's law of heat conduction. [5]

4. What is the importance of fluid and thermal boundary layer? Discuss the relationship with Prandtl number. [5]

5. What is surface resistance and space resistance? [5]

6. Short notes on Lamberts cosine law and Weins displacement law. [5]

Group-C (Long Answer Type Question)

Answer *any three* of the following : [15 x 3 = 45]

7. (a) A steam pipe, 10 cm ID and 11cm OD is covered with an insulating substance (K=1 W/mK). The steam temperature and ambient temperatures are 200^0C and 20^0C respectively. If the convective heat transfer coefficient between the insulation surface and air is 8 W/m2K, find the critical radius of insulation. For the value of r_0, calculate the heat loss per meter of pipe and the outer surface temperature. Neglect the resistance of the pipe material. [8]

(b) Steel pipe line (K=50 W/mK) of ID 100 mm and the OD 110 mm is to be covered with two layers of insulation each having a thickness of 50 mm. The thermal conductivity of the first insulation material is 0.06 W/mK and that of the second is 0.12 W/mK. Calculate the loss of heat per meter length of pipe and the interface temperature between the two layers of insulation when the temperature of the inside tube surface is 250^0C and that of the outside surface of the insulation is 50^0C. [7]

8. (a) Write the unsteady state heat transfer equation in cylindrical coordinates and discuss all the terms. [7]

(b) A mercury thermometer placed in oil well is required to measure temperature of compressed air flowing in a pipe. The well is 140 mm long and is made of steel (k=50W/moC) of 1 mm thickness. The temperature recorded by the well is 100^0C while pipe wall temperature is 50^0C. Heat transfer coefficient between the air and well wall is 30 W/m20C. Estimate true temperature of air. [8]

9. (a) Find out the temperature distribution equation for lumped parameter analysis. [8]

(b) Calculate the heat transfer by fin for insulated at tip. [7]

10. (a) A heat exchanger is to be designed to cool ethyl alcohol (=3.84 KJ/Kg K) from 75^0C to 45^0C with cooling water entering at 15^0C. The flow rates of ethyl alcohol and water are 8 Kg/s and 9.6 Kg/s respectively. If the overall heat transfer coefficient based on the outer tube surface is 500 W/m2 K. Calculate the requisite heat exchanger length for [7]
i) Parallel flow and ii) Counter flow configurations Given, Tube outer dia = 30 mm and no of tubes =20. Write your comments.

(b) In a counter-flow double pipe heat exchanger, water is heated from 25^0C to 65^0C by an oil with a specific heat of 1.45 KJ/KgK and mass flow rate of 0.9 Kg/s. The oil is cooled from 230^0C to 160^0C. If the overall heat transfer coefficient is 420 W/m20C, calculate the following [8]
(i) The rate of heat transfer, (ii) The mass flow rate of water and (iii) the surface area of the heat exchanger.

11. (a) Two parallel infinite grey surfaces are maintained at temperature of 127^0C and 227^0C respectively. [8]
If the temperature of the hot surface is increased to 327^0C by what factor is the net radiation exchange per unit area increased? Assume the emissivity of cooler and hotter surfaces to be 0.9 and 0.7 respectively.

(b) A cylindrical enclosure is formed by three surfaces. Both end closing discs is having same emissivity (0.85) and same temperature (400^0C), curved surfaces is having emissivity of 0.8 and temperature of 500^0C. Diameters of two closing flat discs and interspacing between the two are 25 mm and 100 mm respectively. Shape factor between two identical discs is 0.05. Calculate the net rate of radiant heat flow leaving from cylindrical surface and reaching to each surface. [7]

*** END OF PAPER ***