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TME-505

(Following Paper ID and Roll No. to be filled in your Answer Book)

PAPER ID : 4078Roll No. **B. Tech.**

(SEM. V) EXAMINATION, 2008-09
HEAT & MASS TRANSFER

*Time : 3 Hours**[Total Marks : 100*

- Note :*
- (i) Attempt all five questions.*
 - (ii) Use of Heister charts is allowed.*
 - (iii) Use the data and expressions provided in the question paper.*
 - (iv) Assume missing data suitably, if any.*

1 Attempt any **four** of the following : **5×4=20**

- (a) Derive an expression for overall heat transfer coefficient for a plane wall.
- (b) Derive an expression for maximum temperature within a plane wall subjected to one dimensional conduction with uniform heat generation, in terms of surface temperature.
- (c) Derive an expression for critical radius of insulation for cylindrical body. Give practical example to explain the concept of critical radius.
- (d) A plane wall of area 5 m^2 and thickness 10 cm is subjected to one dimensional heat conduction. Find the heat transfer rate if the surfaces of wall are at 400°C and 100°C and the conductivity of wall varies as follows :

$$K = 0.5 (1 + 0.0065 t)$$

where K is in W/m.K and t is in $^\circ\text{C}$.

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- (e) What do you understand by "Contact Resistance"? How can it be reduced?
- (f) Derive an expression for thermal resistance of spherical body.

2 Answer any **two** of the following : **10×2=20**

- (a) A large metal plate 10 cm thick is initially maintained at a temperature of 500°C. It is suddenly exposed to a surrounding at 140°C with a heat transfer coefficient of 570 W/m².K. At a later instant its center plane reaches a temperature of 356°C. Find the temperature of a plane at a distance of 2.5 cm from the mid plane at the same instant. Take :

$$K = 170 \text{ W/m} \cdot K, \quad \alpha = 4.78 \times 10^{-5} \text{ m}^2 / \text{s}.$$

- (b) Derive the following expression for transient conduction

$$\theta/\theta_i = \exp[-B_i \cdot F_0]$$

- (c) A brass rod ($K = 133 \text{ W/m} \cdot K$) 100 mm long and 5 mm in diameter extends horizontally from a casting at 200°C. The rod is in air at $T_\infty = 20^\circ \text{C}$ and $h = 30 \text{ W/m}^2 \cdot K$. What is the rate of heat transfer to air and temperature of the free end of the rod?

3 Attempt any **two** of the following : **10×2=20**

- (a) Outer surface of a 12.5 mm radius tube is maintained at 100°C. Water at 20°C with a flow rate of 1 kg/s enters the tube. Find the length of tube, if water leaves at 80°C. Take for water



- (i) At 50°C : $P_r = 3.56$, $C_p = 4181 \text{ J/kg} \cdot \text{K}$,
 $\mu = 5.48 \times 10^{-4} \text{ N} \cdot \text{s/m}^2$,
 $K = 0.643 \text{ W/m} \cdot \text{K}$
- (ii) At 100°C : $\mu = 2.79 \times 10^{-4} \text{ N} \cdot \text{s/m}^2$
 for fully developed turbulent pipe flow.

$$Nu_{\phi} = 0.027 \text{ Re}_D^{4/5} \text{ Pr}^{1/3} (\mu/\mu_s)^{0.14}$$
- (b) (i) Discuss the analogy of heat and mass transfer.
 (ii) Define and explain : Nusselt number, Prandtl number and Reynold number.
- (c) Explain the physical mechanism of free convection with the help of example and neat sketch. Discuss the significance of various dimensionless numbers to natural convection.

4 Attempt any **two** of the following : 10

- (a) Explain the following :
- (i) Gray body
 - (ii) Diffuse emitter
 - (iii) Emissivity
- (b) Two concentric spheres of diameter $D_1 = 0.8 \text{ m}$ and $D_2 = 1.2 \text{ m}$ are separated by an air space and have surface temperatures of $T_1 = 127^{\circ}\text{C}$ and $T_2 = 27^{\circ}\text{C}$. Find the net rate of radiation exchange between the spheres
- (i) If the surfaces are black
 - (ii) If the surfaces are diffuse and gray with $\epsilon_1 = 0.5$ and $\epsilon_2 = 0.05$.



- (c) Consider a diffuse circular disk of diameter D and area A_j and a plane diffuse surface of area $A_i \ll A_j$. The surfaces are parallel and A_i is located at a distance L from the centre of A_j . Obtain the following expression for the view factor

$$F_{ij} = \frac{D^2}{D^2 + 4L^2}$$

5 Answer any **two** of the following : 10×2=20

- (a) Discuss various modes of pool boiling with the help of pool boiling curve. List various regimes of forced boiling inside a tube.
- (b) Discuss the significance of the following :
- (i) Fouling factor
 - (ii) Schmidt number and Sherwood number
 - (iii) Impermeable surface.
- (c) A concentric tube heat exchanger uses water, which is available at 15°C, to cool ethylene glycol from 100°C to 60°C. The water and glycol flow rates are same at 5 kg/s. Determine the effectiveness of heat exchanger.

Take: $C_p(\text{water}) = 4178 \text{ J/kg} \cdot \text{K}$

$C_p(\text{ethylene glycol}) = 2650 \text{ J/kg} \cdot \text{K}$

Can you comment, whether the heat exchanger is working in parallel flow or counter flow modes of operation ?

