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10ME63

Sixth Semester B.E. Degree Examination, Dec.2019/Jan.2020
Heat and Mass Transfer

Time: 3 hrs. Max. Marks:100

Note: *1. Answer any FIVE full questions, selecting at least TWO full questions from each part.*
2. Use of heat and mass transfer data hand book is permitted.

PART – A

1 a. Explain briefly:
i) Thermal resistance concept
ii) Convective heat transfer coefficient
iii) Boundary condition of 3^{rd} kind. **(06 Marks)**

b. Heat is generated at a constant rate g_0 W/m^3 in a copper rod of radius r = a by the passage of electric current. The heat is dissipated by convection from the boundary surface at r = a into the ambient air at temperature T_∞ with a heat transfer coefficient h. Write the mathematical formulation of this heat conduction problem for the determination of one dimensional steady state temperature distribution T(r) within the rod. **(04 Marks)**

c. A furnace wall is made of composite wall of total thickness 55cm. The inside layer is made of refractory material of K = 2.3 W/m K and outside layer is made of an insulating material of K = 0.2 W/m K. The mean temperature of the gases inside furnace is 900°C and interface temperature is 520°C. The heat transfer coefficient between gases and inner surface can be taken as 230 W/m^2 K and between outer surface and atmosphere as 46 W/m^2 K. Assuming temperature of surrounding as 30°C, Calculate: i) Required thickness of each layer ii) rate of heat loss per unit area and iii) the temperature of surface exposed to gases and of the surface exposed to atmosphere. **(10 Marks)**

2 a. Show that for a sphere, critical radius of insulation is given by : $r_c = \dfrac{2K_{ins}}{h}$. **(06 Marks)**

b. "Adition of fins may not necessarily increase the heat transfer from a surface; it may even decrease the heat transfer". Comment on this statement. **(04 Marks)**

c. Aluminium square fins (0.5mm × 0.5mm) of 10mm length are provided on the surface of an electronic device to carry 1W of energy generated by the device. The temperature at the surface of the device should not exceed 80°C, while temperature of the surrounding medium is 40°C. Assume K for aluminium 190 W/m K, h = 120 W/m^2 K. Find the number of fins required, neglecting heat loss from the end of the fin. **(10 Marks)**

3 a. What is lumped system analysis? What is the criterion to apply lumped system analysis? **(04 Marks)**

b. What is a semi-infinite medium? Give examples of solid bodies that can be treated as semi-infinite medium for heat transfer purposes. **(04 Marks)**

c. An orange of diameter 10cm is initially at a uniform temperature of 30°C. It is placed in a refrigerator in which air temperature is 2°C. If heat transfer coefficient between air and orange is 50W/m^2 K; determine the time required for the centre of the orange to reach 10°C. Assume the thermal properties of the orange are the same as that of water at the same temperature. Also calculate the temperature at 3cm from the surface of orange at that time. **(12 Marks)**

4 a. The exact expression for the local drag co-efficients C_x for laminar flow over a flat plate is given by $C_x = \frac{0.664}{\sqrt{R_{ex}}}$. Air at atmospheric pressure and at T_∞ =300K flows with a velocity of u_∞ = 1.5 m/s along the plate. Determine the distance from the leading edge of the plate where transition begins from laminar to turbulent flow. Calculate the drag force acting per 1-m width of the plate over the distance from x = 0 to where the transition starts. **(10 Marks)**

b. A horizontal steam pipe of 10cm OD runs through a room where the ambient air is at 20°C. If the outside surface of the pipe is at 180°C, and the emissivity of the surface is 0.9, find out the total heat loss per metre length of pipe. **(10 Marks)**

PART – B

5 a. Water flows in a tube of ID 1.5cm at the rate of 0.05 m^3/hr. If receives a uniform wall heat flux 1000 W/m^2. Calculate: i) The value of local heat transfer co-efficient ii) The wall temperature at a section where both the velocity and temperature profiles are fully developed and the local bulk mean temperature is 40°C. **(10 Marks)**

b. A refrigerated truck is moving at a speed of 85 km/hr where ambient temperature is 50°C. The body of truck is of rectangular shape of size 10m(L) × 4m(W) × 3m(H). Assume the boundary layer is turbulent and the wall surface temperature is at 10°C. Neglect the heat transfer from vertical front and backside of truck and flow of air is parallel to 10m long side. Calculate heat loss from the four surfaces. **(10 Marks)**

6 a. Draw temperature v/s length of heat exchanger profiles for i) Condenser ii) Evaporator iii) Counter flow heat exchanger with $c_h = c_c$. **(06 Marks)**

b. Briefly explain compact heat exchangers. **(04 Marks)**

c. Water enters a counterflow double pipe heat exchanger at 15°C flowing at a rate of 1300 kg/hr. It is heated by oil (c_p = 2000 J/kg K) flowing at the rate of 550 kg/hr from an inlet temperature of 94°C for an area 1m^2 and overall heat transfer coefficient of 1075 W/m^2 K. Determine the total heat transfer and outlet temperature of water and oil. **(10 Marks)**

7 a. State the Fick's law of diffusion and explain its analogy with Fourier's law of heat conduction. **(04 Marks)**

b. Define the following:
   i) Mass diffusion coefficient
   ii) Mass transfer co-efficient
   iii) Correction for convection mass transfer. **(06 Marks)**

c. Dry saturated steam at a pressure of 2.45 bar condenses on the surface of a vertical tube of height 1m. The tube surface temperature is kept at 117°C. Estimate the thickness of condensate film and local heat transfer co-efficient at a distance of 0.2m from the upper end of the tube. **(10 Marks)**

8 a. Explain the following:
   i) Emissivity
   ii) Black body and grey body
   iii) Plank's law of monochromatic radiation. **(06 Marks)**

b. Prove that emissive power of a black body is π times the intensity of the emitted radiation. **(08 Marks)**

c. A cubical room 4m × 4m × 4m is heated through the ceiling by maintaining if at uniform temperature by 350K, while walls and the floor are at 300K. Assuming that all surfaces have an emissivity of 0.8, determine the rate of heat loss from ceiling by radiation. **(06 Marks)**

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