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10AU65

Sixth Semester B.E. Degree Examination, Aug./Sept. 2020
Heat and Mass Transfer

Time: 3 hrs. Max. Marks:100

Note: ***1. Answer FIVE full questions, selecting atleast TWO questions from each part.***
2. Use of heat transfer Data Hand Book/Steam tables permitted.
3. Missing data, if any, may be suitably assumed.

PART – A

1 a. State the basic laws governing the three modes of heat transfer, with the relevant equations. **(06 Marks)**

b. Obtain the general three dimensional equation in Cartesian co-ordinate system. State the assumptions made. **(10 Marks)**

c. A concrete wall of thickness 15cm has a thermal conductivity of K = 0.76W/m°C. The inside surface is exposed to air at T_i = 20°C and the outer surface to air at T_0 = –20°C. The heat transfer coefficients for the inside and outside surfaces are h_1 = 10W/m^2°C and h_0 = 40 W/m^2°C. Determine the rate of heat loss square meter of the wall surface. **(04 Marks)**

2 a. Discuss the significance of the term critical thickness of insulation and obtain an expression for the same in case of cylindrical body. **(10 Marks)**

b. A conductor with diameter = 0.8cm carrying an electrical current passes through an ambient at T_{amb} = 30°C with a convective heat transfer coefficient h = 120 W/m^2°C. The temperature of the conductor is to be maintained at T_1 = 130°C. Calculate the rate of heat loss per 1m length of the conductor for
i) the conductor bare and
ii) the conductor covered with Bakelite K = 1.2 W/m°C with radius corresponding to the critical radius of the insulator
iii) The percentage change in the heat transfer. **(10 Marks)**

3 a. Discuss the term transient conduction. Obtain a general expression for the temperature distribution in lumped system analysis in terms of Biot and Fourier numbers. **(10 Marks)**

b. An iron sphere K = 60 W/m°C, C_p = 460j/kg°C, density ρ 780kg/m^3, α = 1.6 × 10^{-5}m^2/s, of diameter D = 5cm is initially at a uniform temperature T_1 = 225°C. Suddenly the surface of the sphere is exposed to an ambient at T_{amb} = 25°C with a heat transfer coefficient h = 500 W/m^2°C. Calculate the centre temperature and the temperature at a depth of 1cm from the surface at, t = 2 minutes after the start of cooling. Calculate the energy removed from the sphere during this time period. **(10 Marks)**

4 a. Discuss the development of hydrodynamic and thermal boundary layers for the case of the flow over a body. **(08 Marks)**

b. Distinguish between the terms local and average heat transfer coefficients. **(04 Marks)**

c. Consider a square plate 0.5m × 0.5m with one surface insulated and the surface maintained at T_w = 385 K, which is placed in quiescent air at atmospheric and at T_a = 315K. Calculate :
i) The average heat transfer coefficient and the heat transfer rate for free convection when the plate is horizontal and the hot surface faces up
ii) The average heat transfer coefficient when the plate is kept vertical. **(08 Marks)**

PART – B

5 a. Show by the application of dimensional analysis that for forced convection Nusselt Number = function of (Reynolds and Prandtl Numbers). **(08 Marks)**

b. Define and state the significance of any two of the following non dimensional numbers Reynolds, Prandtl and Nusselt numbers. **(06 Marks)**

c. Atmospheric air at T_a = 400K with a velocity of U = 1.5m/s flows over a flat plate L = 2m long maintained at T_w = 300K. Calculate the average heat transfer coefficient x = 0 to x = L = 2m. Calculate heat transfer rate from the air stream to the plate from x = 0 to x = L = 2m for w = 0.5m. **(06 Marks)**

6 a. Enlist the classification of Heat Exchangers based on flow arrangement and obtain an expression for the Log Mean Temperature Difference of a Parallel flow heat exchanger. **(10 Marks)**

b. A counter flow heat exchanger of heat transfer area A = 12.5m^2 is to cool oil [C_{ph} = 2000 J/kg K] with water [C_{pc} = 4170 j/kg K]. The oil enters at $T_{h,\,in}$ = 100°C and m_h = 2kg/s, while the water enters at $T_{c,in}$ = 20°C and $m_{c,\,in}$ = 20°C and m_c = 0.48kg/s. The overall heat transfer is U_m = 400 W/m^{2}C. Calculate the exit temperature of water $T_{c,\,out}$ and the total heat transfer rate. **(10 Marks)**

7 a. List the assumptions made in the theory of laminar film – wise condensation. **(03 Marks)**

b. Explain in brief the regimes of pool boiling phenomenon with a sketch. **(07 Marks)**

c. Air free saturated steam at T_V = 65°C(P = 0.25 bar) condenses on the outer surface of a 2.5cm OD, 3m long vertical tube maintained at uniform surface temperature of 35°C. Assuming film wise condensation, calculate the average heat transfer coefficient over the entire length of the tube and the mass flow rate of condensation (kg/s) over the tube. **(10 Marks)**

8 a. Differentiate between a block body and a gray body. **(04 Marks)**

b. Discuss the following in brief : i) Radiation shield ii) Kirchoff's law. **(06 Marks)**

c. Two large parallel plates at T_1 = 800 K and T_2 = 600 K have emissivities ϵ_1 = 0.5 and ϵ_2 = 0.8 respectively. A radiation shield having an emissivity 0.05 is placed in between the plates. Calculate the heat transfer rate of heat transfer rate by radiation per sq meter with and without the radiation shield and the % reduction in heat transfer. **(10 Marks)**

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