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06ME65

Sixth Semester B.E. Degree Examination, June / July 2014
Heat and Mass Transfer

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer FIVE full questions, selecting at least TWO questions from each part.***
2. ***Use of heat transfer data handbook, charts and steam table permitted.***

PART – A

1 a. Briefly explain the three modes of heat transfer. **(06 Marks)**

b. Derive the general equation for the three dimensional unsteady state heat conduction with uniform rate of heat generation in an isotropic solid. **(08 Marks)**

c. The composite wall of an oven consists of three materials, two of which are of known thermal conductivities, K_A = 20 W/m-K and K_C = 50 W/m-K and known thicknesses, L_A = 0.30 m and L_C = 0.15 m. The third material, B which is sandwiched between materials A and C, is of unknown thermal conductivity, K_B but of known thickness, L_B = 0.15 m. Under steady operating conditions it was found that the outside surface of material C is at 20°C, the inside surface of material A is at 600°C. This surface is in contact with hot air at 800°C and the inside surface heat transfer coefficient is 25 W/m^{2}K. What is the value of K_B? **(06 Marks)**

2 a. Find steady state heat flux through the composite slab made up of two materials A and B of thickness 5 cm and 10 cm respectively. Inner surface of A is maintained at a temperature of 600°C and outer surface of B is maintained at 30°C. Also find the interface temperature between A and B. The thermal conductivities of two materials vary linearly with temperature in following manner:
K_A = 0.05[1+0.008T] W/mK and K_B = 0.04[1+0.0075T] W/mK. **(08 Marks)**

b. Fins, Twelve in number having K = 75 W/mK and 0.75 mm thickness protrude 25 mm from cylindrical surface. 50 cm diameter and 1 mt length placed in an atmosphere of 40°C. If the cylinder surface is maintained at 150°C and heat transfer co-efficient is 23 W/m^{2}K. Calculate (i) The rate of heat transfer (ii) The percentage of increase of heat transfer due to fins (iii) Determine temperature at the centre of fin. **(12 Marks)**

3 a. Consider a slab of thickness L, initially at a uniform temperature T_0 for time t > 0, heat is supplied to the slab from one of its boundary surfaces at a constant rate q_0 W/m^2, while heat is dissipated by convection from other boundary surface into a medium at a uniform temperature T_∞ with surface heat transfer co-efficient h, neglecting internal temperature gradients (lumped parameter method), derive an expression for the temperature of the slab as a function of time. **(12 Marks)**

b. A 120 mm diameter apple (ρ = 990 kg/m^3, C_p = 4170 J/kgK, K = 0.58 W/mK), approximately spherical in shape is taken from a 25°C environment and placed in a refrigerator where temperature is 6°C and average convective heat transfer co-efficient over apple surface is 12.8 W/m^{2}K. Determine temperature at the centre of apple after a period of 2 hrs. **(08 Marks)**

4 a. Explain the following:
i) Velocity boundary layer thickness. ii) Thermal boundary layer thickness.
iii) Hydrodynamic enterence length. iv) Thermal Enterence length. **(12 Marks)**

b. Air at 20°C and at atmospheric pressure flows over a flat plate at a velocity of 3 mt/sec. If the plate is 30 cm length and temperature of 60°C. Calculate
i) Velocity and thermal boundary layer thickness.
ii) Average HT co-efficient.
iii) Total drag force on the plate per unit width.
Take the following properties of air $\rho = 1.181$ g/m^3, $\gamma = 17 \times 10^{-6}$ m^2/sec, K = 0.0272 W/mK, C_p = 1.007 KJ/kgK, Pr = 0.705. **(08 Marks)**

PART – B

5 a. Obtain an empirical expression in terms of dimensionless numbers for a heat transfer co-efficient, in case of forced convection heat transfer. **(10 Marks)**

b. Air at 2 bar and 40°C is heated as it flows through tube of diameter 30 mm at velocity 10 m/sec. Calculate the heat transfer / unit length of the tube when wall temperature is maintained at 100°C all along the length of the tube. How much would be the bulk temperature increases over one meter length of the tube, use following relation: $Nu = 0.023 R_e^{0.8} P_r^{0.4}$ **(10 Marks)**

6 a. Obtain an expression for effectiveness of a parallel flow heat exchanger in terms of NTU and capacity ratio. **(08 Marks)**

b. Show that when capacity ratio is equal to unity (C = 1) for a counter flow heat exchanger then effectiveness is given by, $\in = \frac{NTU}{(NTU+1)}$ **(04 Marks)**

c. A refrigerator is designed to cool 250 kg/hr of hot liquid of sp.heat 3350 J/kgK at under 120°C using parallel flow heat exchanger in which 1000 kg/hr of cooling water is available for cooling purpose at temperature 10°C if the overall heat transfer co-efficient is 1160 W/m^{2}K and surface area of heat exchanger is 0.25 m^2. Calculate the outlet temperature of cooled liquid and water. Also determine effectiveness of heat exchanger. **(08 Marks)**

7 a. List all the assumptions made in Nusselt's theory of laminar film condensation on vertical surface. **(06 Marks)**

b. Define : i) Mass concentration ii) Molar concentration. **(04 Marks)**

c. Water at atmospheric pressure is to be boiled in polished copper pan. The diameter of the pan is 350 mm and kept at 115°C, calculate the following : i) Power of burner ii) Rate of evaporation kg/hr iii) Critical heat flux for these conditions. **(10 Marks)**

8 a. State and prove Kirchoff's law of radiation. **(06 Marks)**

b. Explain the following: i) Solid angle ii) Radiosity iii) Irradiation. **(06 Marks)**

c. Two large parallel plates at 800 K and 600 K have emmissivities of 0.5 and 0.8 respectively. A radiation shield having emissivity of 0.1 on the surface facing 800 K plate and 0.05 on the surface facing 600 K plate is placed between the two plates in parallel direction with respect to the plates. Calculate
(i) The radiation heat transfer between the two plates in presence of the radiation shield.
(ii) The equilibrium temperature of the shield.
(iii) The rate of heat transfer between the two plates without the presence of the radiation shield. **(08 Marks)**

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