B.E. 6th Semester (Mech. Engg.) Examination, December–2010

HEAT TRANSFER

Paper - ME-306-E

Time allowed : 3 hours] *[Maximum marks :100*

Note : *Attempt any* ***five*** *questions. All questions carry equal marks.*

1. (a) Discuss the mechanism of thermal conduction in gases, liquids and solids. 4

(b) Show that heat flow lines must be normal to isotherms in conduction heat transfer. Will it be true for convection heat transfer? 6

(c) A square silicon chip (k=150W/m.k.) is of width W=5mm on a side and of thickness t = 1mm. The chip is mounted in a substrate such that its side and back surfaces are insulated, while the front surface is exposed to a coolant. If 4W are being dissipated in circuits mounted to the back surface of the chip, what is the steady-state temperature difference between back and front surfaces? 10

2. (a) Consider a cold canned drink left on a dinner table. Would you model the heat transfer to the drink as one-, two-, or three-dimensional? Would the heat transfer by steady or transient? Also, which coordinate system would you use to analyse this heat transfer problem, and where would you place the origin? 10

(b) A long cylindrical rod of 10 cm consists of nuclear reacting material (k=0.0W/m.K) generating 24,000W/m^3 uniformly throughout its volume. This rod is encapsulated within another cylinder having an outer radius of 20 cm and a thermal conductivity of 4W/m.K. the outer surface is surrounded by a fluid at 1000C, and the convection coefficient between the surface and the fluid is 20W/m^2.K. Find the temperatures at the interface between the two cylinders and at the outer surface. 10

3. (a) Two pin fins are identical, except that the diameter of one of them is twice the diameter of the other. For which fin will the (a) efficiency and (b) effectiveness be higher? Explain. 10

(b) The long copper rods of diameter D=1 cm are soldered together end to end, with solder having melting point of 6500C. The rods are in the air at 250C with a convection coefficient of 10W/m^2.K. What is the minimum power input needed to effect the soldering? 10

4. (a) What are Heisler Charts? How these charts are used to obtain temperature distribution when both conduction and convection resistance are almost of equal importance? 6

(b) A 12cm diameter cylindrical bar, initially at a uniform temperature of 40^0C, is placed in a medium at 650^0C with a convective coefficient of $22 W/m^2K$. Determine the time required for the centre to reach 255^0C. Also workout the temperature of surface at this instant. For the material of the bar : 10

$k=20 W/mK$; $\rho=580 kg/m^3$; $c=0.1050 J/kg\ K$.

5. (a) Consider a thin hollow cylinder of 8 cm diameter and 10 cm length. If the radiant shape factor of the circular surface of this cylinder is 0.172, make calculations for the shape factor of the curved surface of the cylinder with respect to itself. 14

(b) Define the total and spectral black body emissive powers. How are they related to each other? 6

6. The hot air at 135^0C needed for a drying plant is obtained by passing 2.5 kg/s of atmosphere air at 1 bar pressure and 27^0C temperature over tubes through which hot oil is circulated. The tubes have 2 cm bore, 1.5 mm thickness and are made of material having thermal conductivity 52.5W/m-deg. The oil enters

these tubes at 210^0C and leaves at 305^0C. Assuming that air is flowing in opposite direction to oil, calculate : (i) overall heat transfer coefficient (ii) total heating surface (iii) number of tubes and number of passes if the overall length of heater is restricted to 3.2m. For air : c_p = 1005J/kg-deg, R = 287J/kg-deg and convective heat transfer coefficient from air to metal h = 172.42W/m^2-deg; For oil : c_p = 1885j/kg-deg, k = 0.129W/m-deg, $\mu = 2.07 \times 10^{-3}$ kg/m-s and flow rate = 500 kg/s/m^2 and heat transfer coefficient for oil to metal is governed by the relation hd/k = $0.023(Re)^{0.8} (Pr)^{0.3}$. 20

7. Steam enters a counter flow heat exchanger, dry saturated at 10 bar and leaves at 350^0C. The mass flow of steam is 800kg/min. The gas enters the heat exchanger at 650^0C and mass flow rate is 1350kg/min. If the tubes are 30mm diameter and 3m long, determine the number of tubes required. Neglect the resistance offered by metallic tubes. Use following data : For steam c_{ps} = 2.71kj/kg^{0}C; h_s = 600 W/m^2 ^{0}C for gas : c_{pg} = 1kj/kg ^{0}C; h_g = 250 W/m^2 ^{0}C.

8. (a) Derive the relation for calculation of thickness of film for laminar film condensation using Nusselt theory. 10

(b) What is the meaning of burnout point in a boiling curve? How is burnout avoided in the design of steam boilers? 10