Total No. of Questions : 12]

SEAT No. :

P2389

[Total No. of Pages :5

[5153]- 12
T.E. (Mech.)
HEAT TRANSFER
(2008 Pattern) (Semester - II)

Time : 3 Hours] *[Max. Marks :100*

Instructions to the candidates:

1) *Answers to the two sections should be written in separate answer books.*
2) *Answer any three questions from each section.*
3) *Neat diagrams must be drawn wherever necessary.*
4) *Figures to the right side indicate full marks.*
5) *Use of Calculator is allowed.*
6) *Assume Suitable data if necessary.*

SECTION - I

Q1) a) How does the thermal conductivity of insulating material vary with temperature? Explain with the help of suitable sketch. **[4]**

b) Define thermal conductivity and thermal diffusivity. State their units. **[4]**

c) A refrigerator stands in a room. Where air temperature is 21°C. The surface temperature on the outside of the refrigerator is 16°C. The sides are 30 mm Thick and has an equivalent thermal conductivity of 0.10 W/m. K. The heat transfer coefficient on the outside is 10W/m ^{2}.K. Assume one dimensional conduction through the sides, calculate the net heat flow rate and the inside surface temperature of the refrigerator. **[8]**

OR

Q2) a) State Fourier law of heat conduction and by using it derive an expression for steady state heat conduction through a long hollow cylinder of radii r_1 and r_2 maintains its two surfaces at temperatures, T_1 and T_2, respectively. **[6]**

b) Derive three dimensional generalize differential heat conduction equation in Cartesian coordinates and deduce it to one dimensional steady state heat conduction without heat generation. **[10]**

P.T.O.

Q3) a) Explain the concept of critical thickness of insulation on cylinder with the help of suitable illustration and sketches (s). **[6]**

b) A steam pipe of 5 cm inside diameter and 6.5 cm outside diameter is covered with a 2.75 cm radial thickness of high temperature insulation (k = 1.1 W/m. K). The surface heat transfer coefficient for inside and outside surfaces are 4650 W/m^2. K and 11.5 W/m^2. K, respectively. The thermal conductivity of the pipe material is 45 W/m.K. If the steam temperature is 200°C and ambient air temperature is 25°C, determine Heat loss per metre length of pipe. **[10]**

OR

Q4) a) Derive an expression for temperature distribution in a plane wall under steady state heat conduction with uniform heat generation. The wall is insulated on left surface and maintained at temperature T_S on right surface. **[8]**

b) A hollow sphere of inside radius 30 mm and outside radius 50 mm is electrically heated at its inner surface at a constant rate of 105 W/m^2. The outer surface is exposed to a fluid at 30°C, with heat transfer coefficient of 170 W/m^2.K. The thermal conductivity of the material is 20 W/m.K. Calculate inner and outer surface temperatures. **[8]**

Q5) a) Derive an expression for temperature distribution for unsteady state heat conduction using lumped heat capacity method. State assumptions in method. **[8]**

b) An aluminium sphere weighing 6 kg and initially at temperature of 350°C is suddenly immersed in a fluid at 30°C with convection coefficient of 60 W/m^2.K. Estimate the time required to cool the sphere to 100°C. Take thermophysical properties as

$C = 900$ J/kg. K, $\rho = 2700$ kg/m^3, $k = 205$ W/m.K. **[10]**

OR

Q6) a) What is the difference between fin effectiveness and fin efficiency? **[4]**

b) Explain the criteria of selection of fins. **[4]**

c) An aluminium alloy fin (k = 200 W/m.K), 3.5 mm thick and 2.5 cm long protrudes from a wall. The base is at 420°C and ambient air temperature is 30°C. The heat transfer coefficient may be taken as 11 W/m^2.K. Find the heat loss and fin efficiency, if the heat loss from fin tip is negligible. **[10]**

SECTION - II

Q7) a) State: **[8]**

i) Kirchoff's law of radiation,

ii) Wien's displacement law,

iii) Stefan Boltzman law,

iv) Define diffuse body

b) A hot water radiator of overall dimensions 2×1×0.2 m is used to heat the room at 18°C. The surface temperature of radiator is 60°C and its surface is black. The actual surface of the radiator is 2.5 times the area of its envelop for convection for which the convection coefficient is given by $h_c = 1.3\ (\Delta T)^{1/3}$ $W/m^2.K$. Calculate the rate of heat loss from the radiator by convection and radiation. **[8]**

OR

Q8) a) Define **[4]**

i) White body, and

ii) Opaque body.

b) Write a short note on gray body approximation. **[4]**

c) A black metal plate (k = 25 W/m. K) at 300°C is exposed to surrounding air at 30°C. It convects and radiates heat to surroundings. If the convection coefficient is 25 $W/m^2.K$. What is the temperature gradient in the plate? **[8]**

Q9) a) Explain the physical mechanism of convection heat transfer. **[4]**

b) Calculate the approximate Reynolds numbers and state if the flow is laminar or turbulent for a 10 m long yatch sailing at 13 km/h in sea water, $\rho = 1000\ kg/m^3$ and $\mu = 1.3\times10^3$ kg/m.s. **[4]**

c) Explain the Reynolds Colburn analogy for turbulent flow over a flat plate. **[8]**

OR

Q10) a) Discuss the dimensional analysis for forced convection heat transfer. **[8]**

b) Air at 27° C is flowing across a tube with a velocity of 25 m/s. The tube could be either a square of 5 cm side or a circular cylinder of 5 cm dia. Compare the rate of heat transfer in each case, if the tube surface is at 127°C. **[8]**

Use the corrclation:

$Nu\ C\ Re^{n}\ Pr^{1/3}$

where, C = 0.027, n = 0.805 for cylinder

C = 0.102, n = 0.675 for square tube.

Take the properties of air at 77°C = 350 K

$\rho = 0.955$ kg/m^3, $K_f = 0.03$ W/m.K.

$v = 20.92\times10^{-6}$ m^2/s, Pr = 0.7, and $C_p = 1.009$ kJ/kg. K.

Q11) a) What do you mean by fouling factor? State the causes of fouling? **[4]**

b) Define effectiveness of heat exchanger. How is maximum heat transfer rate is obtained? **[4]**

c) Steam enters a counter flow heat exchanger, dry saturated at 10 bar and 180°C. It leaves at 350°C. The mass flow rate of the steam is 720 kg/min. The hot gas enters the exchanger at 650°C with mass flow rate of 1320kg/min. If the tubes are 30 mm in diameter and 3 m long, determine the surface are of tubes required. Neglect the resistance offered by metallic tubes. Use following. **[10]**

data:

For steam $C_{p.s.} = 2.71$ kJ/kg. K, and $h_i = 600$ W/m^2.K. For gas $C_{p.g}$ 1 kJ/kg.K and $h_o = 250$ W/m^2.K.

OR

Q12) a) Compare film wise and dropwise condensation. **[4]**

b) A heat exchanger is required to cool 55,000 kg/h of alcohol from 66°C to 40°C in a parallel flow heat exchanger using 40,000 kg/h of water entering at 5°C. Calculate. **[10]**

i) Exit temperature of water,

ii) Heat transfer rate,

iii) Surface area required

Take overall heat transfer coefficient.

$U = 580\ W/m^2.K$

C_p (alcohol) = 3760 J/kg.K.

C_p (water) = 4180 J/kg. K.

c) State the limitations of LMTD methods. **[4]**