Total No. of Questions : 10]

SEAT No. :

P3342

[Total No. of Pages : 4

[5353]-512

T.E. (Mechanical)

HEAT TRANSFER

(2015 Pattern)

Time : 2Hour 30Minutes] ***[Max. Marks : 70***

Instructions to the candidates:

1) ***Answer Q.1 or 2, 3 or 4, 5 or 6, 7 or 8 and 9 or 10.***
2) ***Draw Neat diagrams wherever necessary.***
3) ***Use of scientific calculator is allowed.***
4) ***Assume suitable data where ever necessary.***
5) ***Figures to the right indicate full marks.***

Q1) a) Write the boundary conditions for insulated surface and convective surface. **[2]**

b) Define thermal diffusivity and its physical significance. **[2]**

c) A hollow cylinder with inner radius 30 mm and outer radius 50 mm is heated at the inner surface at a rate of 105 W/m^2 and dissipated heat by convection from outer surface into a fluid at 80°C with heat transfer coefficient of 400 $W/m^2.K$. There is no energy generation and thermal conductivity of the material is constant at 15 W/m.K. Calculate the temperatures of inside and outside surfaces of the cylinder. **[6]**

OR

Q2) a) Define fin effectiveness and fin efficiency. **[4]**

b) A hollow spherical form is used to determine thermal conductivity of an insulating material. The inner diameter is 50 mm and outer diameter is 100 mm. A 40 W heater is placed inside and under steady state conditions, the temperature at 32 and 40 mm radii were found to be 100°C and 70°C, respectively. Determine the thermal conductivity of the material. Also calculate the outside temperature of sphere. If surrounding air is at 30°C, calculate convection heat transfer coefficient over the surface. **[6]**

Q3) a) Write brief information and applications of fibrous and cellular insulating materials. **[4]**

b) Derive expressions for temperature distribution and heat transfer rate for an infinite long fin attached to wall at temperature T_0, when general solution to temperature distribution is **[6]**

$$\frac{T(x)-T_\infty}{T_0-T_\infty}=C_1 m^{-mx}+C_2 e^{mx} \quad \text{where} \quad m=\sqrt{\frac{hp}{kA_c}}$$

OR

Q4) a) Define time constant of thermocouple. **[2]**

b) A solid steel ball 5 cm in diameter and initially at 450°C is quenched in a controlled environment at 90°C with convection coefficient of 115 W/m^2.K. Determine the time taken by centre to reach a temperature of 150°C. Take thermophysical properties as C = 420 J/kg.K, ρ =8000 kg/m^3, and k = 46 W/m.K. **[6]**

c) Define apparent thermal conductivity. **[2]**

Q5) a) What is physical significance of Reynolds number?

How is it expressed for (i) flow over a flat plate of length L, (ii) flow over a cylinder of diameter D, and (iii) flow through a rectangular tube of cross-section a × b? **[2 + 4]**

b) The velocity profile u(x, y) for a boundary layer flow over a flat plate is given by **[6]**

$$\frac{u(x,y)}{u_\infty}=\frac{3}{2}\frac{y}{\delta}-\frac{1}{2}\left[\frac{y}{\delta}\right]^3$$

where the boundary layer thickness δ(x) is the function of x and is given by

$$\delta(x)=\sqrt{\frac{280\nu x}{13u_\infty}}$$

Develop an expression for local drag coefficient C_{fx}.

c) Calculate the approximate Grashof number and state if the flow is laminar or turbulent for the following: **[2 + 2]**

i) A central heating radiator, 0.6 m high with a surface temperature of 75°C in a room at 18°C, ($\rho = 1.2$ kg/m^3, Pr = 0.72, and $\mu = 1.8 \times 10^{-5}$ kg/ms).

ii) Air at 20°C ($\rho = 1.2$ kg/m^3, Pr = 0.72 and $\mu = 1.8 \times 10^{-5}$ kg/ms) adjacent to a 60 mm dia. horizontal light bulb, with a surface temperature of 90°C.

OR

Q6) a) Why the heat transfer coefficient for natural convection is much less than that for forced convection? **[4]**

b) Water at 20°C enters a 2 cm diameter tube with a velocity of 1.5 m/s. The tube is maintained at 100°C. Find the tube length required to heat the water to a temperature of 60°C. Use properties of fluid as

Pr = 4.31, $\rho = 992.2$ kg/m^3, $C_p = 4174$ J/kg.K, $k_f = 0.634$ W/m.K, $\nu = 0.659 \times 10^{-6}$ m^2/s. **[6]**

c) Establish dimensional analysis for forced convection heat transfer. **[6]**

Q7) a) Define black body radiation, Radiocity and Irradiation with their characteristics. **[6]**

b) Define total emissive power and Intensity of radiation. **[4]**

c) 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 envelope for convection for which the convection coefficient is given by hc = 4.51 W/m^2.K .Calculate the rate of heat loss from the radiator by convection and radiation. **[6]**

OR

Q8) a) In what manner Gray body approximation simplifies the radiation problems? **[4]**

b) Explain the superposition or additive rule of radiation view factor. **[4]**

c) A cryogenic fluid flows through a long tube of 20 mm diameter, the outer surface of which is diffuse and gray ($\varepsilon_1 = 0.02$) at 77 K. This tube is concentric with a larger tube of 50 mm diameter, the inner surface of which is diffuse and gray ($\varepsilon_2 = 0.05$) and at 300 K. The space between the surfaces is evacuated. Calculate the heat gain by cryogenic fluid per unit length of tubes. If a thin radiation shield of 35 mm diameter ($\varepsilon_3 = 0.02$) both sides is inserted midway between the inner and outer surfaces, calculate the percentage change in heat gain per unit length of the tube. **[8]**

Q9) a) Differentiate between filmwise and drop wise condensation. Which type of condensation is desirable and which type of condensation occurs in actual? State. **[6]**

b) Write a short notes on Fouling factor. **[4]**

c) A pipe (k = 59 W/m.K) with an inner diameter of 3.75 cm and wall thickness of 0.318 cm is externally heated by steam at a temperature of 180°C. The water flows through the pipe with a velocity of 1.22 m/s.Calculate the length of pipe required to heat water from 30°C to 90°C. Assume the overall heat transfer coefficient based on inner diameter as 3529.4 $W/m^2.K$. **[8]**

OR

Q10) a) Define effectiveness, NTU and capacity ratio of a heat exchanger. **[6]**

b) Cold water at 1495 kg/h enters at 25°C through a parallel flow heat exchanger to cool 605 kg/h of hot water entering at 70°C and leaving at 50°C. Find the area of the heat exchanger. The individual heat transfer coefficients on both sides are 1590 $W/m^2.K$. Find also the exit temperatures of cold and hot fluid streams, if the flow of hot water is doubled. Assume the individual heat transfer coefficients are proportional to 0.8th power of the flow rate. For water C_p = 4180 J/kg.K. **[12]**