Total No. of Questions : 10]

SEAT No. :

P1695

[Total No. of Pages : 4

[5460]-512
T.E. (Mech./Auto./Mech.-Sandwich)
HEAT TRANSFER
(2015 Pattern)

Time : 2½ Hours] *[Max. Marks : 70*

Instructions to the candidates:

1) *Solve Q.1 or 2, Q.3 or 4, Q.5 or 6, Q.7 or 8, Q.9 or 10.*
2) *Assume suitable data whenever necessary.*
3) *Use of non-programmable pocket calculator is allowed.*
4) *Draw neat diagram whenever necessary.*
5) *Figures to the right indicate full marks.*

Q1) a) Write down the three dimensional heat conduction equations only with standard notation in Cylindrical and Spherical coordinates. **[4]**

b) The roof of an electrically heated home is 6 m long, 8 m wide and 0.25 m thick and is made of a flat layer of concrete whose thermal conductivity is $k = 0.8$ W/m-K. The temperature of the inner and the outer surface of the roof on one night are measured to be 15°C and 4°C, respectively for a period of 10 hours. Determine **[6]**

i) The rate of heat loss through the roof that night and

ii) The cost of the heat lost to the home owner if the cost of electricity is ₹ 8.63/ kWh.

OR

Q2) a) What are the different types of insulators. **[4]**

b) A 2 m long and 0.3 cm diameter electric wire extends across a room at 15 °C. Heat is generated in the wire as a result of resistance heating and surface temperature of wire is measured to be 152 °C in steady operation. Also the voltage drop and electric current through the wire are measured to be 60 V and 1.5 A, respectively. Disregarding any heat transfer by radiation, determine the convection heat transfer coefficient for heat transfer between the outer surface of the wire and the air in the room. **[6]**

P.T.O.

Q3) a) Plane wall exposed to convection environment on its sides, with heat generation, write down boundary conditions. **[2]**

b) A 15 mm diameter mild steel sphere (k = 42 W/m °C) is exposed to cooling air flow at 20 °C resulting in the convective coefficient h = 120 W/m^2 °C. Determine the following-

i) Time required for cooling the sphere from 550°C to 90°C.

ii) Instantaneous heat transfer rate 2 min. after the start of cooling

iii) Total energy transferred from the sphere during the first 2 min.

For mild steel take: Density = 7850 kg/m^3, Specific Heat = 475 J/kg °C, Thermal Diffusivity = 0.045 m^2/h **[8]**

OR

Q4) a) What is a time constant? **[2]**

b) A centrifugal pump which circulates hot liquid metal at 500 °C is driven by electric motor; the motor is coupled to the pump impeller by horizontal steel shaft 25 mm in diameter. The temperature of the motor is limited to maximum value 60 °C with ambient air 25 °C. What length of the shaft should be specified between motor and the pump? The thermal conductivity of shaft material is 35 W/mK and convective film coefficient between steel shaft and air is 15.7 W/m^{2}K. Consider the steel shaft as fin with insulated end. **[8]**

Q5) a) Explain in detail the velocity boundary layer and thermal boundary layer. **[6]**

b) Air at 2 bar and 200 °C is heated as it flows through a tube with a diameter of 25.4 mm at a velocity of 10 m/s. Calculate the heat transfer per unit length of the tube, if a constant heat flux condition is maintained at the wall and the wall temperature is 20 °C above the air temperature, all along the length of the tube. How much would the bulk temperature increase over 3 m length of the tube?

Properties of Air at temperature at 200 °C:

ρ = 1.493 kg/m^3

C_p = 1.025 kJ/kg.K, k_f = 0.0386 W/m.K,

μ = 2.57× 10^{-5} Ns/m^2, Pr = 0.681

Use the co relation **Ave. Nu = 0.023.Re$^{0.8}$. Pr$^{0.4}$** **[10]**

OR

Q6) a) What are the differences between natural and force convection? Give examples. **[6]**

b) A nuclear reactor with its core constructed of parallel vertical plates 2.2 m high and 1.4 m wide has been designed on free convection heating of liquid bismuth. The maximum temperature of the plate surface is limited to 960 °C while the lowest allowable temperature of bismuth is 340 °C. Calculate the maximum possible heat dissipation from both sides of each plate.

For the convection coefficient, the approximate co relation is,

$\mathbf{Nu = 0.13\ (\mathit{Gr.\ Pr})^{0.333}}$

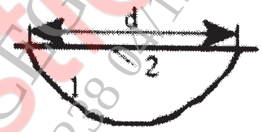
Where, different parameters are evaluated at the mean film temperature with standard notation.

$\rho = 10^4$ kg/m³, $\mu = 3.12$ kg/m-h, $C_p = 150.7$ J/kg.K, $k = 13.02$ W/m.K, **[10]**

Q7) a) What is a solid angle? Explain with diagram. **[6]**

b) Define Kirchhoff's law and prove that when the black body is thermally equilibrium with the surrounding its emissivity is equal to absorptivity. **[4]**

c) Find the shape factor with respect to itself in given figure below. Assume surface 1 is a hemispherical cavity. **[6]**



OR

Q8) a) Define gray body? **[2]**

b) What are properties of view factor? **[6]**

c) Two large parallel planes with emissivity 0.6 are at 900 K and 300 K. A radiation shield with side polished and having emissivity of 0.05, while emissivity of other side is 0.4 is proposed to be used. Which side of the shield to face the hotter plane, if the temperature of the shield is kept to be minimum? Justify your answer. **[8]**

Q9) a) For counter flow heat exchanger prove that,

$$LMTD = (\Delta T_1 - \Delta T_2) / \ln (\Delta T_1 / \Delta T_2)$$

With standard notation. **[8]**

b) In a shell and tube heat Exchanger, tubes are 4 m long, 3,1 cm O.D. and 2.7 cm I.D. Water is heated from 22 °C to 45 °C by condensing steam at 100 °C on the outsides of the tubes. Water flow rate through the tubes is 10 kg/s. Heat transfer coefficient on steam side is 5500 W/m^2K and water side is 850 W/m^2K. Neglect material resistance as well as fouling resistance, don't consider the correction factor. Find the number of tubes. **[10]**

OR

Q10) a) Explain in detail the pool boiling curve. **[6]**

b) Differentiate between film wise and drop wise condensation **[4]**

c) Write a short note on : **[8]**

i) Heat Pipe.

ii) Electronic Cooling system.

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