(Following Paper ID and Roll No. to be filled in your Answer Book)
PAPER ID : 2104 Roll No.

B.Tech.

(SEM. V) ODD SEMESTER THEORY EXAMINATION 2013-14

HEAT AND MASS TRANSFER

Time : 3 Hours *Total Marks : 100*

Note :— Attempt **all** questions.

1. Attempt any **two** out of the following : **(10×2=20)**

(a) (i) What is critical thickness of insulation ?

(ii) Explain thermal contact resistance.

(b) A steam pipe is covered with two layers of insulation. The inner layer (k = 0.17 W/m) is 30 mm thick and outer layer (k = 0.023 W/mK) is 50 mm thick. The pipe is made of steel (k = 58 W/mK) and has inner diameter and outer diameter of 160 and 170 mm, respectively. The temperature of saturated steam is 300°C and the ambient air is at 50°C. If the inside and outside heat transfer coefficients are 30 and 5.8 W/m²K respectively, calculate the rate of heat loss per unit length of the pipe.

(c) A brick (k = 1.2 W/mK) wall 0.15 m thick separates hot combustion gages of a furnace from the outside ambient air which is at 25°C. The outer surface temperature of the brick wall is found to be 100°C. If the natural convection heat transfer coefficient on the outside of the brick wall is

20 W/m²K and its emissivity is 0.8, calculate the inner surface temperature of the brick wall.

2. Attempt any **two** out of the following : **(10×2=20)**

(a) Explain the utility of Heisler chart in transient heat conduction problem.

(b) A stainless steel fin (k = 20 W/mK) having a diameter of 20 mm and a length of 0.1 m is attached to a wall at 300 °C. The ambient temperature is 50°C and the heat transfer coefficient is 10 W/m²K. The fin tip is insulated. Determine :

(i) The rate of heat dissipation from the fin

(ii) The temperature at the fin tip.

(c) A thermo couple junction which can be approximated as a 1 mm diameter sphere is used to measure a gas stream of $T_\alpha = 200°C$. Junction is at initially 25°C. Determine how long it will take for the thermocouple to read 199°C. Properties of the thermocouple junction are $\rho = 8500$ kg/m³, C = 320 J/kgK, and k = 35 W/mK. The heat transfer coefficient between the junction and the gas is 210 W/m²K.

3. Attempt any **two** out the following : **(10×2=20)**

(a) Show that in natural convection heat transfer :

$$\overline{Nn} = f(Gr, Pr)$$

(b) Air at 27°C and 1 atm flows over a flat plate at a velocity 3 m/s. The plate is heated over its entire length to a temperature of 70°C. Calculate the heat transferred if the plate length is 45 cm and width is 1 m. Properties of air, $\nu = 17.36 \times 10^{-6}$ m²/s,

$k = 0.02749$ W/mK, $C_p = 1.006$ kJ/kgK, $Pr = 0.7$.

Take, $\overline{Nu}_L = 0.664\ Re_L^{0.5}\ Pr^{1/3}$

(c) Air at 2 atm and 200°C is heated as it flows at a velocity of 12 m/s through a tube with a diameter of 3 cm. 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. Calculate :

(i) the heat transfer per unit length of the tube

(ii) the increase in bulk temperature of air over a 4m length of the tube. Properties of air, $Pr = 0.681$, $\mu = 2.57 \times 10^{-5}$ kg/ms, $k = 0.0386$ W/mK, $C_p = 1.025$ kJ/kgK, $\rho = 1.493$ kg/m^3. Use : $\overline{Nu} = 0.023 Re^{0.8} . Pr^{0.4}$.

4. Attempt any **two** out of the following : **(10×2=20)**

(a) Define :

(i) Gray Body and

(ii) Radiation shape factor

and prove reciprocity rule.

(b) A small sphere (outside diameter = 60 mm with a surface temperature of 300°C is located at the geometric centre of a large sphere (inside diameter = 360 mm) with an inner surface temperature of 15°C. Calculate how much of heat emitted from the large sphere inner surface is incident upon the outer surface of the small sphere, assuming that both surfaces approach black body behavior. What is the net exchange of heat between the two spheres ?

(c) What do you understand by "Radiation Shield" ? If n number of radiation shields are used between two parallel plates, determine the relation for heat transfer using n shields in terms of original heat transfer (without shields). Take emissivities of all surfaces to be ϵ.

5. Attempt any **two** out of the following : **(10×2=20)**

(a) (i) Explain Ficks law of mass diffusion.

(ii) Discuss physical significance of Sherwood No. and Schmidt No.

(b) After a long time in service, a counterflow oil cooler is checked to ascertain if its performance has deteriorated due to fouling. In the test a standard oil flowing at 2.0 kg/s is cooled from 420 K to 380 K by a water supply of 1.0 kg/s at 300 K at inlet. If the heat transfer surface is 3.33 m^2 and the design value of the overall heat transfer coefficient is 930 W/m^2K, how much has it been reduced by fouling ? Take C_p of oil as 2330 J/kgK, C_p of water 4174 J/kgK.

(c) Estimate the power required to boil water in a copper pan, 0.35 m in diameter. The pan is maintained at 120°C by an electric heater. What is the evaporation rate ? Properties : Saturated water at 100°C, $\rho_L = 957.9\ kg/m^3$ $\rho_v = 0.5955\ kg/m^3$ $C_{PL} = 4.217\ kJ/kgK$, $\mu_L = 279\times10^{-6}\ Ns/m^2$, $P_r = 1.76$, $h_{fg} = 2257\ kJ/kg$ and $\sigma = 58.9\times10^{-3}\ N/m$. Use

$$q'' = \mu_L * h_{fg}\left[\frac{g(\rho_L - \rho_v)}{\sigma}\right]^{1/2}\cdot\left[\frac{C_{p_L}\cdot\Delta T_e}{C_{s_f}\cdot h_{fg}\cdot P_{r_L}^{n}}\right]^3$$

$C_{sf} = 0.013$; $n = 1.0$