01397

BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING (COMPUTER INTEGRATED MANUFACTURING)

Term-End Examination

June, 2010

BME-027 : HEAT AND MASS TRANSFER

Time : 3 hours *Maximum Marks : 70*

Note : *Attempt **any seven** questions. Use of calculator is **permitted**.*

1. (a) Enumerate the three modes by which heat can be transferred from one place to another. Explain the mechanism with suitable examples. 5+5

   (b) A furnace wall is made up of three layers, one of brick, one of insulating brick and one of red brick. The inner and outer surfaces are at 870°C and 40°C respectively. The respective thermal conductivities of the layers are 1.17 $W/_{mK}$, 0.139 $W/_{mK}$ and 0.875 $W/_{mK}$ respectively, and thickness are 22 cm, 7.5 cm and 11 cm. Assume close bonding of the layers at their interfaces, find out the rate of heat loss per square meter per hour and interface temperature.

2. (a) What do you understand by the term local and average 'convective heat transfer co-efficient' and 'overall heat transfer co-efficient' ? 5+5

(b) The inner surface of a plane brick wall is at 60°C and the outer surface is at 35°C, calculate the rate of heat transfer per m^2 of surface area of the wall, which is 220 mm thick. The thermal conductivity of the brick is 0.51 $W/m\,°C$.

3. (a) Classify the heat exchangers according to the flow directions of fluid and give few examples of each in actual field of application. 5+5

(b) A body at 1000°C in black surrounding at 500°C has an emissivity of 0.42 at 1000°C and an emissivity of 0.72 at 500°C. Calculate the rate of heat loss by radiation per m^2.

(i) When the body is assumed to be grey with $\epsilon = 0.42$, and

(ii) When the body is not grey. Assume that the absorptivity is independent of the surface temperature.

4. (a) What do you mean by critical radius of insulation ? Show that it is given by $\frac{K}{h}$ where K is the thermal conductivity of insulation and h is the heat transfer coefficient. (Assume cylindrical geometry). 5+5

(b) In a heat exchanger water flows through a long 2.2 cm ID copper tube at a bulk velocity of 2m/sec and is heated by steam condensing at 150°C on the outside of the tube. The water enters at 15°C and leaves at 60°C. Find the heat transfer coefficient of water. The properties of water at bulk temperature of 37.5°c are $\rho = 990$ kg/m^3, $C_p = 4160$ J/kg K, $\mu = 0.00069$ kg/m sec, $K = 0.63 \; {}^{W}/_{mK}$.

5. (a) Discuss the criteria of selection of fins. 5+5

(b) Derive a correlation for forced convection heat transfer coefficient, using dimensional analysis for flow through a pipe. Give the physical significance of each dimensional members.

6. (a) How does transient heat conduction differ from steady state heat conduction ? Define Biot number and tuner number and explain the physical significance. 5+5

(b) A thin metal plate of 5 cm diameter is suspended in air at 25°C. Radiation energy of 2.9 Watt from a distant furnace falls on one face of the plate. The unit surface conductance for convection at both faces of the plate is estimated to be 93 W/m^2. If the plate attains a steady temperature of 30°C, find the reflectivity of the plate.

7. (a) Explain Fick's law of diffusion. What is mass diffusivity ? Explain the physical significance of Prandtl number. 5+5

(b) Prove that the shape factor of hemi-spherical boul of diameter D with respect to itself is 0.5.

8. (a) Prove that the mean temperature difference in a counter flow heat exchanger is given by 5+5

$$\text{LMTD}\ (t_m) = \frac{t_1 - t_2}{\text{Log}_e \frac{t_1}{t_2}} .$$

(Symbols carries usual meanings).

(b) Estimate the net radiant energy inter change per square metre for very large two parallel planes at temperatures of 538°C and 315°C. The emissivites of hot and cold planes are 0.9 and 0.7 respectively.

9. (a) A spherical shell of radii r_1 and r_2 is made of material with thermal conductivity $K = K_0 T^2$. Derive an expression for the heat transfer rate if the surfaces are held at temperatures T_1 and T_2 respectively. **5+5**

(b) Oxygen is diffusing through carbon monoxide with carbon monoxide non-diffusing. The total pressure is 1 atmosphere and temperature is 0°C. The partial pressure of oxygen at two planes 0.2 cm apart is 100 mm and 50 mm of Hg respectively. The diffusivity of mixture is 1.85×10^{-5} m^2/sec. Calculate the rate of diffusion of oxygen in kg mole/m^2 sec through each square cm of two planes.

10. (a) Define Grashoff number, Rayleigh number and Stanton number. Explain their importance in convective heat transfer. **5+5**

(b) Air with a velocity of 3m/sec is flowing over a tray of full of water. Assuming temperature of 20°C and temperature of water on the surface 15°C, determine the amount of water evaporated per hour. Length of the tray along the air flow direction is 30 cm and its width is 50 cm. Take total pressure of water as 1.00 bar and partial pressure of water vapour in it as 0.0078 bar.

Properties of air are :

$\rho = 1.205 \ {kg}/{m^3}$, $C_p = 1.00 \ {kJ}/{kg\,K}$,

$K = 0.025 \ {W}/{mK}$, $\upsilon = 15 \times 10^{-6} \ {m^2}/{sec}$,

$D = 0.15 \ {m^2}/{hr}$.
