01763

BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING (COMPUTER INTEGRATED MANUFACTURING)

Term-End Examination

December, 2010

BME-027 : HEAT AND MASS TRANSFER

Time : 3 hours *Maximum Marks : 70*

Note : *Attempt any seven questions. All questions carry equal marks. Use of calculator is permitted.*

(a) Differentiate thermal conductivity, thermal diffusivity and momentum diffusivity. 5+5

(b) An ice box has a composite wall made up of 1mm thick aluminium sheet on the inside surface, 3 cm thick wooden board on the outside and 5 cm cork insulation between the two. Ice at -5°C is in contact with the aluminium surface. The unit surface conductance on the outside the box is 11.61 W/m^2k. The thermal conductivities of wood, cork and aluminium are 0.209 W/mk, 4.2×10^{-3} W/mk, 205.83 W/mk respectively. The outside temperature is 27° C. Calculate

(i) The thermal resistance of the composite wall.

(ii) The overall thermal resistance, and

(iii) the rate of heat transfer per unit area.

2. (a) Discuss the critical thickness of insulation and its importance in reference to a spherical geometry. 5+5

(b) A reactor's wall 320 mm thick, is made up of an inner layer of fire brick (k=0.84 W/m°C) covered with a layer of insulation (k=0.16 W/m°C). The reactor operates at a temperature of 1325°C and the ambient temperature is 25°C.

(i) Determine the thickness of fire brick and insulation which gives minimum heat loss.

(ii) Calculate the heat loss presuming that the insulating material has a maximum temperature of 1200°C.

3. (a) Draw the temperature gradient through a plane wall when the thermal conductivity 5+5

(i) remains constant with increase in temperature

(ii) increases with increase in temperature

(iii) decreases with decrease in temperature

(b) An exterior wall of a house may be approximated by a 0.1 m layer of common brick (k=0.7W/m°C) followed by a 0.04m layer of gypsum plaster (k=0.48W/m°C). What thickness of loosely packed rock wool insulation (k=0.065W/m°C) should be added to reduce the heat loss or (gain) through the wall by 80 percent ?

4. (a) Distinguish between the natural and forced convection heat transfer with suitable applications. 5+5

(b) A mild steel tank of wall thickness 12 mm contains water at 95°C. The thermal conductivity of mild steel is 50 W/m°C, and the heat transfer coefficient for the inside and outside the tank are 2850W/m^2 °C, respectively. If the atmospheric temperature is 15°C, Calculate:

(i) The rate of heat loss per m^2 of the tank surface area;

(ii) The temperature of the outside surface of the tank.

5. (a) Explain the concept of black body and grey body in radiation terminology. 5+5

(b) In a counter-flow double pipe heat exchanger, water is heated from 25° C to 65° C by an oil with a specific heat of 1.45 KJ/kg K and mass flow rate of 0.9 kg/sec. The oil is cooled form 230° C to 160° C. If the overall heat transfer coefficient is 420 W/m^2 °C, Calculate the following:

(i) The rate of heat transfer, and

(ii) The mass flow rate of water.

6. (a) Define absorptivity, reflectivity and transmissivity. 5+5

(b) Prove that the shape factor of a cylindrical cavity of diameter D and height H with respect to itself is

$$F_{1\to 1} = \frac{4H}{4H+D}$$

7. (a) Express the rate of heat flow in terms of a convective heat transfer co - efficient by an equation and write the analogous equation for mass transfer. **5+5**

(b) Determine the mass transfer coefficient of a certain vapour flowing over a flat plate 300 mm long at a Reynolds number of 2.15×10^5, when the kinematic viscosity and mass diffusivity are $1.68 \times 10^{-5} m^2/s$ and $2.173 \times 10^{-9} m^2/sec$ respectively.

8. (a) Define the Fourier number and Biot number for mass transfer. **5+5**

(b) Air at 35° C and 1 atm flow at a velocity of 30m/sec over a flat plate of 0.5m long. Calculate average mass transfer coefficient of water vapour in air. Assume concentration of vapour in air as very very small. Take diffusion coefficient of water vapour in air as $D = 0.256 \times 10^{-4}$ m/sec. Properties of air at 35°C, $\rho = 1.146$ kg/m^3, Cp=1.006 KJ/kg K, $\mu = 2 \times 10^{-5}$ kg/m sec

9. (a) Show by Rayleigh's method that in forced convection heat transfer, the Nusselt number is a function of Reynolds' number and Prandtl number. **5+5**

(b) Define Fick's first and second law of diffusion. Describe the various mechanism of mass transfer.

10. (a) Insulation boards are made up of three layers of materials of conductivities k_1, k_2, and k_3 of thickness x_1, x_2 and x_3 respectively. They are bolted together by metal bolts of cross-section area A_1 m^2 per m^2 of board area. Metal conductivity is k_4. If the temperature on either side of board are t_1 and t_4, determine an expression to find the heat flow per m^2 of area of board. (Use thermal circuit analysis) 5+5

(b) For convective mass transfer, name the non dimensional number that plays the same role in mass transfer as that of Prandtl number in heat transfer, and write down an expression and physical significance for the same.
