00132

BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING (COMPUTER INTEGRATED MANUFACTURING)

Term-End Examination

June, 2011

BME-027 : HEAT AND MASS TRANSFER

Time : 3 hours *Maximum Marks*

Note : *Answer **any seven** questions. All questions **carry e** marks. Use of calculator is **permitted**.*

1. (a) A black metal plate (k = 25 W/mK) at 300°C is exposed to surrounding air at 30°C. It convects and radiates heat to surroundings. If the Convection coefficient is 25 W/m^2K, what is the temperature gradient in the plate ?

Given : $\sigma = 5.67 \times 10^{-8}$ $W/m^2 K^4$.

(b) A large window glass 0.5 cm thick (k = 0.78 W/mK) is exposed to warm air at 25°C, over its inner surface, with convection coefficient of 15 W/m^2K. The outside air is − 15°C with convection coefficient of 50 W/m^2K. Determine the heat transfer rate and temperature at the inner and outer surface of the glass.

(a) The composite wall of an oven consists of three materials, two of them are of known thermal conductivity, $K_A = 20$ W/mK, and $K_c = 50$ W/mK and known thickness $L_A = 0.3$m and $L_c = 0.15$m. The third material B, which is sandwiched between material A and C is of known thickness $L_B = 0.15$m, but of unknown thermal conductivity K_B. **5+5**

Under steady state operating conditions, the measurement reveals an outer surface temperature of material C is 20°C and inner surface of A is 600°C and over air temperature is 800°C. The inside convection coefficient is 25 W/m^{2}K. What is the value of K_B ?

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

(a) A wall 30 cm thick of size 5m x 3m made of red bricks (k = 0.35 W/mK). It is covered on both sides by the layers of plaster 2 cm thick (k = 0.6 W/mK). The wall has a window of size 1m × 2m. The window door is made of glass, 12 mm thick having thermal conductivity 1.2 W/mK. Estimate the rate of heat flow through the wall. Inner and outer surface temperature are 10°C and 40°C, respectively. **5+5**

(b) A composite insulating wall has three layers of material held together by 3 cm diameter aluminium rivet per $0.1m^2$ of surface. The layers of material consists of 10 cm thick brick with hot surface at 200°C, 1 cm thick wood with cold surface at 10°C. These two layers are interposed by third layer of insulating material 25 cm thick. The conductivity of the material are

k_{brick} = 0.93 W/mK ; $k_{insulation}$ = 0.12,W/mK, K_{wood} = 0.175 W/mK, $k_{aluminium}$ = 204 W/mK

Assuming one dimensional heat flow. Calculate the percentage increase in heat transfer rate due to rivets.

4. (a) A steel pipe (k = 35 W/mK), with inner radius 25 mm and outer radius 30 mm is insulated with 85% magnesia insulation (k = 0.055 W/mK). The temperature at the interface between pipe and insulation is 300°C, while the temperature on outer surface of insulation must not exceed 70°C, with permissible heat loss of 700 W/m.

Calculate.

(i) The minimum thickness of insulation, and

(ii) The temperature of inside surface of pipe.

(b) Isotropic radiation of intensity 145.34 W/m^2 steradian falls on a diffuse reflection of area 0.2 m^2. If it reflects 54.65 watt, what should be the absorptivity of the surface ?

5. (a) What is a heat exchanger ? Where are they used ? Classify heat exchanger in three broad classes. 5+

(b) Distinguish between natural and forced convection heat transfer.

6. (a) What is critical thickness of insulation on a small diameter wire or pipe ? 5+
Explain its physical significance and derive an expression for the same.

(b) Estimate the diffusion rate of water from the bottom of the test tube 1.5 cm in diameter and 15 cm long into dry atmospheric air at 25°C.
Take diffusion co-efficient of 25.6×10^{-6} m^2/sec; partial pressure corresponding to saturation temperature of 25°C
$P_s = 3.169$ kPa.

7. (a) Define the Schmidth number, Sherwood number, and Lewis numbers. What is the physical significance of each. 5+

(b) Define absorptivity, reflectivity and transmissivity.

8. (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) Estimate the diffusion rate of water from the bottom of a test tube 1.5 cm in diameter and 15 cm long into dry atmosphere at 25°C. Take diffusivity of water in air as 0.256 cm^2/sec, and saturation pressure of water at 25°C = 0.0316 bar.

9. (a) What is convective mass transfer co - efficient and what are its units ? 5+5

(b) Define the Fourier number and Biot number for mass transfer.

10. (a) Explain the molecular diffusion through a Stagnant gas. 5+5

(b) Air at 35°C and 1 atm flows at a velocity of 30 m/sec over a flat plate of 0.5 m 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, $C_p = 1.006$ kJ/kgK,

$\mu = 2x10^{-5}$kg/m sec.