BME-027

BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING (COMPUTER INTEGRATED MANUFACTURING)

Term-End Examination

December, 2011 01492

BME-027 : HEAT AND MASS TRANSFER

Time : 3 hours *Maximum Marks : 70*

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

1. (a) Determine the heat flow across a plane wall of 10cm thickness with a thermal conductivity of 8.5 W/mK, when the surface temperatures are steady and at 200°C and 50°C. The wall area is 2 m^2. Also find the temperature gradient in flow direction. 5+5

(b) A wall is constructed of several layers. The first layer consists of brick (k = 0.66 W/mK), 25 cm thick, the second layer 2.5 cm thick mortar (k = 0.7 W/mK), the third layer 10 cm thick limestone (k = 0.66 W/mK) and outer layer of 1.25 cm thick plaster (k = 0.7 W/mK). The heat transfer coefficients on interior and exterior of the wall fluid layers are 5.8 W/m^2K, and 11.6 W/m^2K, respectively.

Find :

(i) Overall heat transfer coefficient

(ii) Overall thermal resistance per m^2,

(iii) Rate of heat transfer per m^2, if the interior of the room and at 26°C while outer air is at −7°C.

(iv) Temperature at the junction between mortar and limestone.

2. (a) What are the three modes of heat transfer ? Explain their pòtential for occurance. 5+5

(b) A square plate heater (size 15 cm × 15 cm) is inserted between two slabs. Slab A is 2 cm thick (k = 50 W/mK) and slab B is 1cm thick (k = 0.2 W/mK). The outside heat transfer coefficient on both sides of A and B are 200 W/m^2K and 50 W/m^2K respectively. The temperature of surrounding air is 25°C. If the rating of heater is 1 kW, find.

(i) Maximum temperature in the system

(ii) Outer surface temperature of two slabs.

3. (a) Prove that the shape factor of a cylindrical cavity of diameter D and height H with respect to itself is 5+5

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

(b) A furnace has a small observation hole of 2.5 cm diameter. If the furnace temperature is 600°C.

find :

(i) the rate of energy loss from the hole due to radiation.

(ii) the wave length at which emission is maximum.

4. (a) A steam pipe is covered with two layes of insulation, first layer being 3 cm thick and second 5 cm. The pipe is made of steel (k = 58 W/mK) having inner diameter of 160 mm and outer diameter of 170 mm. The inside and outside film coefficients are 30 W/m^2K and 5.8 W/m^2K, respectively. Calculate the heat lost per metre of pipe, if the steam temperature is 300°C and air temperature is 50°C. The thermal conductivity of two insulating materials are 0.17 W/mK and 0.093 W/mK, respectively. **5+5**

(b) A 3 cm outer diameter steam pipe is to be covered with two layers of insulation each having thickness of 2.5 cm. The average thermal conductivity of one material is five times of the other. Determine the percentage decrease in heat transfer, if better insulating material is kept next to pipe surface than it is as outer layer. Assume that the outside and inside temperatures are fixed.

5. (a) What do you mean by fovling factor ? State the causes of fovling. 5+5

(b) Explain shell and tube type heat exchanger. Why baffles are used ?

6. (a) Define the diffusion co-efficient for a binary mixture. Is this co-efficient dependent upon temperature, pressure, and composition of the mixture ? 5+5

(b) Sun emits maximum radiation at wavelength of $\lambda = 0.52$ micron. Assuming sun as a black body, find the surface temperature of the sun and emissive power at that temperature.

7. (a) Explain the phenomenon of equimolar counter diffusion. Derive an expression for equimolar counter diffusion between two gasses or liquids. 5+5

(b) A hot water radiator of overall dimensions $2\ m \times 1\ m \times 0.2\ m$ is used to heat the room at 18°C. The surface temperature of radiator is 60°C and its surface is black. The actual surface of the radiator is 2.5 times the area of its envelope for convection for which the convection coefficient is given by

$$h_c = 1.3\ (\Delta T)^{1/3}\ W/m^2K$$

Calculate the rate of heat loss from the radiator by convection and radiation.

8. (a) Show by dimensional analysis that mass transfer by forced convection can be expressed by **5+5**

$Sh = f\ (Re, Sc)$

where

Sh = Sherwood number

Sc = Schemidth number, and

Re = Reynolds number

(b) An open circular tank of 7.6 m diameter contains a volatile solvent at 25°C. The top of the surface of liquid is covered by a stagnant air film of 5 cm thick. The concentration of solvent vapour beyond thin film may be neglected. If the solvent is worth Rs.200/- per litre, estimate the loss per day.

Data Given :

vapour pressure of solvent at :

25°C = 100 mm of Hg,

sp. gr. of solvent = 0.88,

molecular weight = 78,

diffusivity in air = $0.09\ cm^2/sec$

9. (a) 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 $1.68 \times 10^{-5}\ m^2/sec$ and $2.173 \times 10^{-9}\ m^2/sec$ respectively. **5+5**

(b) Air with a velocity of 3 m/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/kgK,

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

D = 0.15 m^2/hr.

10. (a) Define Fick's first and second law of diffusion.Describe the various mechanism of mass transfer. **5+5**

(b) Discuss the analogy between heat and mass transfer.