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BME-027

B.Tech. MECHANICAL ENGINEERING (COMPUTER INTEGRATED MANUFACTURING)

00192

Term-End Examination

December, 2017

BME-027 : HEAT AND MASS TRANSFER

Time : 3 hours *Maximum Marks : 70*

Note : *Answer any* ***five*** *questions. All questions carry equal marks. Use of scientific calculator is permitted. Assume suitable data, if any.*

1. (a) Differentiate between Thermal Conductivity and Thermal Diffusivity.

   (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/m-K, 0·139 W/m-K and 0·875 W/m-K respectively and thicknesses are 22 cm, 7·5 cm and 11 cm respectively. Assuming close bonding of the layers at their interfaces, find out the rate of heat loss per square metre per hour and interface temperatures. *4+10*

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

$$F_{1\to1} = \frac{4H}{4H + D}.$$

(b) An ice box has walls constructed of a 10 cm layer of cork board contained between two wooden walls and is 2 cm thick. Find the rate of heat removal in kJ per m^2 per hour if the inner wall surface is kept at – 10°C while the outer surface temperature is 30°C. Thermal conductivities of cork board and wood are 0·146 kJ/m hr °C and 0·376 kJ/m hr °C respectively. *4+10*

3. (a) What is critical thickness of insulation on a small diameter wire or pipe ? Explain its physical significance.

(b) A furnace is of spherical shape, with 300 mm and 350 mm inner and outer radii. The inner and outer surface temperatures are 450°C and 50°C respectively. The furnace is made of refractory material of mean thermal conductivity of 0·465 W/m-K. Find the rate of heat transfer. If the furnace is covered with 25 mm thick insulating material (k = 0·058 W/m-K) and the temperature of insulation surface is 35°C, find the reduction in rate of heat transfer with insulating material. *4+10*

4. (a) Define Fick's first and second law of diffusion.

(b) Air flows over a flat plate at a velocity of 3 m/s and ambient conditions are: the pressure is 760 mm of Hg and temperature is 15°C. The plate is maintained at 85°C. If the length of the plate is 100 cm along the flow of air, find out the heat lost by 50 cm of the plate which is measured from the trailing edge. Plate width is 50 cm. The properties of air at mean temperature of 50°C are as follows :

$\rho = 1{\cdot}093\ kg/m^3$,

$C_p = 1{\cdot}005\ kJ/kg\text{-}K$,

$k = 2{\cdot}826 \times 10^{-2}\ W/m\text{-}K$,

$\nu = 17{\cdot}95 \times 10^{-6}\ m^2/sec.$ *4+10*

5. (a) Distinguish between natural and forced convection heat transfer.

(b) Calculate the heat transfer coefficient for water being heated in a tube having 40 mm inside diameter. The water flows through the tube with a velocity of 1 m/sec. The mean temperature of water is 45°C. The temperature of the tube wall is 95°C. The length of the tube is 2 m. Choose an appropriate correlation and use properties of water as follows :

$\rho = 980\ kg/m^3$, $\nu = 0{\cdot}55 \times 10^{-6}\ m^2/sec$,

$C_p = 4{\cdot}187\ kj/kg\text{-}K$, $k = 0{\cdot}644\ W/m\text{-}K$. *4+10*

6. (a) Determine the mass transfer coefficient of a certain vapour flowing over a flat plate 300 mm long at a Reynolds number of $2{\cdot}15 \times 10^5$ when the kinematic viscosity and mass diffusivity are $1{\cdot}68 \times 10^{-5}$ m^2/s and $2{\cdot}173 \times 10^{-9}$ m^2/sec respectively.

(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 ? 7+7

7. (a) Define the diffusion coefficient for a binary mixture. Is this coefficient dependent upon pressure, and composition of the mixture ? Explain.

(b) Show by dimensional analysis that mass transfer by forced convection can be expressed by

$$Sh = f(Re, Sc)$$

where symbols carry their usual meaning. 7+7

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

(b) What do you mean by Fouling Factor ? State the causes of fouling. 7+7
