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BME-027

B. TECH. MECHANICAL ENGINEERING (COMPUTER INTEGRATED MANUFACTURING) (BTME)

Term-End Examination

June, 2019

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) State Fourier law of heat conduction and by using it derive an expression for steady state heat conduction through a plane wall of thickness L, maintains its two surfaces at temperatures T_1 and T_2 respectively. 5

   (b) To determine thermal conductivity of hydrogen, a hollow tube with a heating wire concentric to the tube is often used. Essentially the gas between the wire and the wall is a hollow cylinder and an electric

current passing through the wire acts as a heat source. 5

Use the following data :

T_1 = wire temperature = 200°C

T_2 = tube wall temperature = 150°C

I = current in the wire = 0.5 A

V = voltage drop over 0.3 m section of wire = 3.6 V

r_2 = tube radius = 0.125 cm

r_1 = wire radius = 0.0025 cm

L = length of the wire = 0.3 m

2. A surface at 200°C is exposed to surroundings at 60°C and convects and radiates heat to the surroundings. Calculate the heat transfer rate from surface to surroundings. If the convection co-efficient is 80 W/m^2 K. Consider the black bodies for radiation heat transfer. 10

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

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

(b) Two black bodies exchange radiation heat are maintained at 1500°C and 150°C respectively. Calculate the radiation heat flux due to radiation between them. 5

4. (a) How does the heat conduction differ from heat convection ? What are the thermal insulators ? 5

   (b) A metal plate with dimension 5 m × 3 m with negligible thickness has a surface temperature of 300°C. One size of it looses heat to the surrounding air at 30°C. The heat transfer co-efficient between plate surface and air is 20 W/m²K. The emissivity of the plate surface is 0.8. 5

   Calculate :

   (i) Rate of heat loss by convection

   (ii) Rate of heat loss by radiation

   (iii) Combined convection and radiation heat transfer coefficient.

5. The thermal conductivity k, the density ρ and specific heat C of an aluminium plate are 160 W/mK, 2790 kg/m³ and 0.88 kJ/kg-K respectively. Calculate the thermal diffusivity of the material. 10

6. A thermopane window consists of two 5 mm thick glass (k = 0.78 W/mK) sheets separated by 10 mm stagnant air gap (k = 0.025 W/mK). The convection heat transfer co-efficient for inner and outside air are 10 W/m²K and 50 W/m²K respectively. Determine the rate of heat loss per

m^2 of the glass surface for a temperature difference of 60°C between the inside and outside air. 10

7. (a) What is the difference between fin effectiveness and fin efficiency ? 5

   (b) Show that the resistance offered by a hollow sphere of radii r_1, r_2 and constant thermal conductivity is given by : 5

$$R_{sph} = \frac{r_2 - r_1}{4\pi r_1 r_2 k}.$$

8. Compare Newton's law of viscosity, Fourier law of heat conduction and Fick's law of diffusion. 10

9. 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. 10
   Take diffusion co-efficient of 25.6×10^{-6} m^2/s.

10. Answer any *two* of the following :

   (a) What is the major difference between Laminar and Turbulent mass transfer ? 5

   (b) Describe the surface condenser with neat diagram. 5

   (c) What are the different types of evaporators ? Explain any *one* of them with neat diagram. 5