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BIME-034

B.Tech. MECHANICAL ENGINEERING (BTMEVI)

Term-End Examination

00874

June, 2013

BIME-034 : HEAT AND MASS TRANSFER

Time : 3 hours *Maximum Marks : 70*

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

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1. (a) State the Fourier law of heat conduction and by using it derive an expression for steady state heat conduction through a plane wall of thickness L that maintains its two surfaces at temperatures T_1 and T_2 respectively. 7+7

   (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 mortrar (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 of interior and exterior of the wall fluid layers are 5.8 W/m^2K, and 11.6 W/m^2K respectively.

Find :

(i) Over all heat transfer coefficient

(ii) Overall thermal resistance per m^2,

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

2. (a) Prove that the thermal resistance offered by a hollow long cylinder of constant thermal conductivity is given by **7+7**

$$R_{cyL} = \frac{l_n\left(\frac{r_2}{r_1}\right)}{2\pi LK}$$

Where symbols carries their usual meaning.

(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.

3. (a) How does transient heat conduction differ from steady state heat conduction ? What is fourier number ? What is its physical significance ? 7+7

(b) A steam pipe is covered with two layers of insulation, first layer being 3 cm thick and second 5 cm. The pipe is made of steel (K = 0.58 W/mK) having ID of 160 mm and OD of 170 mm. The inside and outside film co-efficients 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.

4. (a) What are the differences between natural and forced convection ? 7+7

(b) Estimate heat transfer rate from a 100W incandescent bulb at 140°C to an ambient at 24°C. Approximate the bulb as 60 cm diameter sphere. Calculate percentage of power loss by natural convection.

Use following correlation and air properties :

$N_u = 0.60 \, (G_r \, P_r)^{1/4}$

The properties of air at 82°C are :

$v = 21.46 \times 10^{-6} m^2/s$;

$K_f = 30.38 \times 10^{-3}$ W/mK ; $P_r = 0.699$.

5. (a) What is a black body ? What are its properties ? Why does a cavity with a small hole behave as a black body ? 7+7

(b) Calculate the equilibrium temperature for a plate, exposed to a solar flux of 700 W/m^2 and convection environment at 25°C, with convection co-efficient of 10 W/m^2K. If the plate is coated with

(i) White paint : $\alpha_{sun} = 0.12$; $\alpha_{plate} = 0.9$

(ii) Flat black paint :

$\alpha_{sun} = 0.96$, $\alpha_{plate} = 0.95$.

6. (a) What is a heat exchanger ? Where are they used ? What do you mean by fouling factor ? State the causes of fouling. 7+7

(b) A heat exchanger is required to cool 55000 kg/hr of alcohol from 66°C to 40°C using 40000 kg/hr of water entering at 5°C. Calculate :

(i) exit temperature of water

(ii) heat transfer rate

(iii) surface area required for parallel flow type and counter flow type of heat exchanger.

Take overall heat transfer coefficient $U = 580\ W/m^2K$.

C_p (alcohol) = 3760 J/kg K.

C_p (water) = 4180 J/kg K.

7. (a) Explain Fick's law of diffusion. What is mass diffusivity ? What is its dimension ? 7+7

(b) Air at 50°C and 1atm flow over the surface of a water reservoir at an average velocity of 2.3 m/sec. The water surface is 0.65 m long and 0.65 m wide. The water surface temperature is estimated at 30°C. The relative humidity of air is 40%. The density of air is 1.105 kg/m^3 and its viscosity is 1.943×10^{-5} kg/ms. Calculate the amount of water vapour that evaporates per hour per sqm of water surface and state the direction of diffusion.