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B.Tech. MECHANICAL ENGINEERING (BTMEVI)

Term-End Examination

June, 2014

BIME-034 : HEAT AND MASS TRANSFER

Time : 3 hours *Maximum Marks : 70*

Note : *Attempt **any five** questions. Assume missing data suitably, if any. Use of scientific calculator is **permitted.** Use of Heat and Mass transfer data book permitted.*

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1. (a) A wall thickness L is made of material whose thermal conductivity varies with temperature as follows : $K = K_0 T^2$. Find the expression for steady state conduction through wall/m^2 and mean thermal conductivity if two surfaces are maintained at temperatures T_1 and T_2. **6+8=14**

   (b) A reactor's wall 320 mm thick is made up of an inner layer of Fire brick (k = 0.84 W/mK) covered with a layer of insulation (k = 0.16 W/mK). The reactor operates at a temperature of 1350°C and the ambient temperature is 25°C. Determine the thickness of insulation which gives minimum heat loss and also calculate the heat loss presuming that insulating material has a maximum temperature of 1200°C.

2. (a) Derive the expression for temperature distribution and heat flow through spherical system. 7+7=14

(b) Derive the expression for temperature distribution for short fin with end insulated.

3. (a) A stainless steel wire length 2 m and diameter 2.5 mm is submerged in a fluid at 45° C and an electric current of 300 A passes through it. Determine the temperature of the wire at the centre and at the surface of the wire. Take $k = 20$ W/mK, $\rho = 70$ $\mu\Omega$cm, $h = 4$ kW/m^2K. 7+7=14

(b) A 12 mm diameter mild steel ($k = 42$ W/mk) sphere is exposed to air at 27° C. Determine the time required to cool the sphere from 550°C to 100°C.

Take $h = 114$ W/m^2K, $\rho = 7800$ kg/m^3, $\alpha = 0.0043$ m^2/hr, $C = 475$ J/kgK.

4. (a) Derive the relationship between effectiveness and NTU for a counterflow Heat exchanger. 7+7=14

(b) A single pass counterflow shell and tube heat exchanger is used to heat water from 20°C to 80°C at the rate of 5 kg/s using oil entering the shell side at 140° C and leaving at 90°C. Calculate the heat transfer surface required. Take $U = 400$ W/m^2 K.

5. (a) Explain the followings : 6+8=14

(i) Emissivity

(ii) Planck's law

(iii) *Wien's* law of Radiation

(b) Two large parallel planes with emissivities of 0.3 and 0.5 are maintained at temperatures at 527°C and 27°C respectively. A radiation shield ($\epsilon_e = 0.05$) is placed between them. Determine the radiation heat transfer between them with shield and without shield.

6. (a) Show by dimensional Analysis for Forced Convection
$Nu = \phi(Re, Pr)$ **7+7=14**

(b) A vertical cylinder 1.5 m high and 180 mm diameter is maintained at 100°C in an atmospheric environment of 20°C. Calculate heat loss by Free convection from the surface of the cylinder. Use relation

$$Nu = 0.10(Gr\ Pr)^{\frac{1}{3}}$$

Take properties of air at mean temperature:
$\rho = 1.06\ kg/m^3$, $\gamma = 18.97 \times 10^{-6}\ m^2/s$
$Cp = 1.004\ kJ/kgK$, $k = 0.142\ kJ/hr\ mK$.

7. Write short notes on the following : **5+4+5=14**
(a) Film pool boiling
(b) Thermal boundary layer
(c) Lumped heat system