BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING (COMPUTER INTEGRATED MANUFACTURING)

02514

Term-End Examination

June, 2013

BME-027 : HEAT AND MASS TRANSFER

Time : 3 hours *Maximum Marks : 70*

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

1. (a) Explain the mechanism of heat transfer modes. 5

(b) Two large aluminium plates (k = 250W/mK) each 3 cm thick , with 8 μm surface roughness are placed in contact under 10^5 N/m^2 pressure in air. The temperature at the outside surfaces are 420°C and 450°C. Calculate 5

(i) the heat flux

(ii) the temperature drop due to the contact resistance , and

(iii) the contact temperatures

Thermal contact resistance with air as the interface fluid for 8 μm roughness is 2.65×10^{-4} m^{2}K/W.

2. (a) Explain the Lumped Capacitance Method. What are the assumptions associated with this method. 5

(b) Steel ball bearings ($k = 50 W/mK$, $\alpha = 1.3 \times 10^{-5}$ m^2/s) having a diameter of 40 mm are heated to a temperature of 650°C and then quenched in a tank of oil at 55°C. If the heat transfer coefficient between the ball bearings and oil is $300 W/m^2K$, determine the duration of time the bearings must remain in oil to reach a temperature of 200°C. 5

3. (a) Explain the terms 'Fin efficiency' and 'Fin effectiveness'. When is the use of fin is not justified ? 5

(b) Determine the heat transfer rate from the rectangular fin of length 20 cm, width 40 cm and thickness 2 cm. The tip of the fin is not insulated and the fin has a thermal conductivity of $150 W/mK$. The base temperature is 100°C and the fluid is at 20°C. The heat transfer coefficient between the fin and the fluid is $30 W/m^2K$. 5

4. (a) Explain with the help of a diagram the concept of hydrodynamic and thermal boundary layer for a laminar flow over a thin flat plate. 5

(b) Air at 20°C and 1 atm flows over a flat plate at 40 m/s. The plate is 80 cm long and is maintained at 60°C. Assuming unit depth in z-direction, calculate the heat transfer rate from the plate. Properties of air at 40°C are : 5

$Pr = 0.7$, $k = 0.02723$ W/mK,

$\rho = 1.128$ kg/m^3,

$C_P = 1.007$ kJ/kg K and

$\mu = 1.906 \times 10^{-5}$ kg/ms.

[For $Re_L > 5 \times 10^5$; $\overline{Nu}_L = \frac{\overline{h}L}{k} = (0.036$

$Re_L^{0.8} - 871)Pr^{1/3}$]

5. (a) What do you mean by radiation intensity ? Explain the terms - radiosity, emission and spectral intensity. 5

(b) A surface emits as a black body at 2000 K. What is the rate per unit area (W/m^2) at which it emits radiation in directions corresponding to $0° \leq \theta \leq 60°$ and in the wavelength interval $3\ \mu m \leq \lambda \leq 5\ \mu m$? 5

[$F(0 \rightarrow 3) = 0.737$; $F(0 \rightarrow 5) = 0.914$].

6. (a) Explain Hottel's cross string method for estimating shape factor for infinitely long surfaces. Derive the expression for F_{12} in terms of areas and lengths of surfaces. 5

(b) Two very large parallel plates with emissivities 0.3 and 0.8 exchange radiative energy. Determine the % reduction in radiative energy transfer when a polished aluminium radiation shield ($\epsilon = 0.04$) is placed between them. 5

7. (a) Classify heat exchangers. Develop an expression for the overall heat transfer coefficient. 5

(b) A counter flow shell and tube heat exchanger is used to heat water at a rate of $m = 0.8 kg/s$ from $T_i = 20°C$ to $T_o = 80°C$, with hot oil entering at 120°C and leaving at 85°C. The overall heat transfer coefficient is $U = 125\ W/m^2\ °C$. Calculate the heat transfer area required. 5

8. (a) Draw the schematic of Pool boiling curve. Explain Nucleate boiling regime. 5

(b) Distinguish between the film - wise and drop wise condensation. What are the conditions to maintain a dropwise condensation? 5

9. (a) What is Sherwood number ? By dimensional analysis establish the relationship between the Sherwood number, Reynolds number and Schmidt number. 5

(b) A large foundation of pure water at 26.1°C is flowing parallel to a flat plate of solid benzoic acid, where L = 0.224 m in the direction of flow. The water velocity is 0.061 m/s. The solubility of benzoic acid in water is 0.02948 kg mol/m^3. The diffusivity of benzoic acid is $1.245 \times 10^{-9} m^2/s$. Calculate the mass transfer coefficient k_2 and the flux N_A. 5

10. (a) Derive the continuity equation for a binary mixture. 5

(b) What is Stefan Boltzmann law ? How is Stefan Boltzmann law derived from Planck's law of thermal radiation ? 5