14981

No. of Printed Pages : 4

BME-027

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

Term-End Examination

December, 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 calculator is permitted.*

1. (a) Define thermal conductivity. How does thermal conductivity vary with temperatures for metals and alloys ? 5

   (b) Define Fick's Law of Diffusion. Show that for a equimolar counter diffusion of two species A and B : 5

$$D_{AB} = D_{BA}$$

2. (a) Derive an expression for heat transfer and temperature distribution for a rectangular fin with its tip at adiabatic condition. 5

(b) A steel tube of length 20 cm with internal and external diameters of 10 and 12 cm is quenched from 500°C to 30°C in a large reservoir of water at 10°C. Below 100°C the heat transfer coefficient is 1.5 kW/m²-K. Above 1000°C it is less owing to a film of vapour being produced at the surface and an effective mean value between 500°C and 100°C is 0.5 kW/m²-K. Neglecting internal thermal resistance of steel tube, determine the quenching time. 5

3. (a) Explain the forward difference, central difference and backward difference schemes. 6

(b) What are the different types of numerical errors ? Explain with suitable examples. 4

4. With the help of Buckingham π-theorem, show that for forced convection heat transfer $Nu_d = B\, Re_d^a\, Pr^b$. 10

5. (a) Lubricating oil at a temperature of 60°C enters a 1 cm diameter tube with a velocity 3.5 m/s. The tube surface is maintained at 30°C. Calculate the tube length required to cool the oil to 45°C. Assume that the oil

has the following average properties for the temperature range of this problem : $P = 865$ kg/m^3; $k = 0.14$ W/m-K; $C_p = 1.78$ kJ/kg-K and $\upsilon = 9 \times 10^{-6}$ m^2/s. 6

(b) Define eddy viscosity. Explain Prandtl mixing length concept for turbulent flow over a flat plate. 4

6. (a) What is Stefan-Boltzmann law ? How is Stefan-Boltzmann law derived from Planck's law of thermal radiation ? 5

(b) Explain the electrical analogy for radiative heat transfer in a black enclosure. 5

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

(b) 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

8. What is the major difference between laminar and turbulent mass transfer ? Show that for a mass transfer in a boundary layer over a flat plate $Sh = 0.664\ Re_L^{1/2}\ Sc^{1/3}$. 10

9. (a) Illustrate with sketches the flow path arrangement for the following types of shell and tube heat exchanger : 4

   (i) Single shell pass, two tube pass counterflow

   (ii) Two shell pass, four tube

   (b) A counterflow 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/m² °C. Calculate the heat transfer area required 6

10. (a) Distinguish between the filmwise and dropwise condensation. What are the conditions to maintain a dropwise condensation ? 5

   (b) Classify steam generators. With the help of suitable sketch, explain the construction and working of a water tube boiler. 5