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Question Paper Code : 42281

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2010.

Sixth Semester

Mechanical Engineering

ME 1351 — HEAT AND MASS TRANSFER

(Regulation 2004)

(Common to B.E. (Part-Time) – Fifth Semester – Regulation 2005)

Time : Three hours Maximum : 100 marks

Use of Steam Tables, Mollier Chart and HMT Data Book is permitted.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. State Fourier's law of conduction.

2. Explain the significance of fin effectiveness and fin efficiency.

3. Define thermal boundary layer thickness.

4. State Buckingham's π Theorem.

5. What does pool boiling mean?

6. Define effectiveness as applied to heat exchangers.

7. Define configuration factor.

8. Define irradiation and radiosity.

9. What are the modes of mass transfer?

10. Determine the mole fraction of the water vapour at the surface of a lake whose temperature is 15°C. the atmospheric pressure at lake level is 92 kpa.

PART B — (5 × 16 = 80 marks)

11. (a) A steam pipe 160 mm ID and 170 mm OD is covered with two layers of insulation. The thickness of the insulation are 30 mm and 50 mm respectively. The thermal conductivity values are 210, 0.60 and 0.33 kJ/mhr°C respectively. The temperature of the inner surface of the pipe is 300°C and that of the outer surface is 50°C. Determine the quantity of heat flux per meter length of steam pipe and the layer contact temperature.

Or

(b) An aluminium plate (k = 160 W/m°C, ρ = 2790 kg/m^3, C_p = 0.86 kJ/kg°C) of thickness L = 3 cm and at a uniform temperature of 225°C is suddenly immersed at time t = 0 in a well stirred fluid maintained at a constant temperature T_a = 25°C. Take h = 320 W/m^2 °C. Determine the time required for the center of the plate to reach 50°C.

12. (a) One – hundred electrical components, each dissipating 25 W, are attached to one surface of a 0.2 m square copper plate, and all of the dissipated energy is transferred to water in parallel flow over the upper surface. A protuberance at the leading edge of the plate acts to trip the boundary layer, and plate itself may be assumed to be isothermal. The water velocity and temperature are 2 m/s and 17°C respectively

(i) Find the temperature of the copper plate.

(ii) If each component has a plate contact surface area of 1 cm^2 and the corresponding area specific contact resistance is 2×10^{-4} m^2. What is the component temperature?

Or

(b) A vertical pipe 60 mm diameter and 3 m height is maintained at a constant temperature of 100°C. The pipe is surrounded by still atmospheric air at 50°C. Find heat loss by convection.

13. (a) Dry saturated steam at a pressure of 2.45 bar condenses on the surface of a vertical tube of height 1 m. The tube surface temperature is kept at 117°C. Estate the thickness of the condensate film and the local heat transfer coefficient at a distance of 0.2 m from the upper end of the tube.

Or

(b) Saturated steam at 90°C (p = 70.14 kpa) condenses on the outer surface of a 1.5 m long 2.5 m OD vertical tube maintained at a uniform temperature T_α = 70°C. Assuming film condensation, calculate

(i) The local heat transfer coefficient at the bottom of the tube

(ii) The average heat transfer coefficient over the entire length of the tube, and

(iii) Heat transfer rate Properties of water at 80°C are $\rho_l = 974$ kg/m^3 $K_l = 0.668$ W/mK, $\mu_\rho = 0.335 \times 10^3$ Ns/m^2 h_{fg} = 2309 kJ/kg, $\rho_v << \rho_l$ is $\rho_v = 0$.

14. (a) Determine the net radiant heat exchange m^2 area for two infinite parallel plates held at temperature of 800 K and 500 K. Emissivity is 0.7 for hot plate and 0.5 for cold plate. What should be the emissivity of a polished aluminium shield placed between them if heat flow is reduced to 40% of its original value?

Or

(b) Two large parallel plates with emissivity 0.8 are exchanging heat by radiation. One plate has a temperature of 1000 K while the other plate is at 400 K temperature It is proposed to interpose a radiation shield with emissivity value of 0.05 one side and 0.6 on the other side. The design condition stipulates that low emissivity side should face hotter plate. How would the shield temperature be affected if during installation mistake occurs and higher emissivity side placed facing the hot plate?

15. (a) A distillation column containing a mixture of benzene and toluene is at a pressure of 1 atm and 100°C. The liquid and vapour phases contain 30% and 45% of bezene on mole basis. At 100°C the vapour pressure of toluene is 70 kN/m^2 and the diffusivity is 5×10^{-6} m^2/s. Find the rate of interchange of benzene and toluene between the liquid and vapour phases if resistance to mass transfer lies in a film of 0.25 mm thick. Take atmospheric pressure as 101 kN/m^2 and universal gas constant of 8.314 JK^{-1}m^{-1}.

Or

(b) Water is available at the bottom of a well of 2.5 m diameter and 5 m deep. Estimate its diffusion rate into dry air at 25°C. The diffusion coefficient of water vapour into dry air is 0.0925 m^2/h and the atmospheric pressure is 1.032 bar.
