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Question Paper Code : 20813

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2018.

Fifth/Sixth/Seventh Semester

Mechanical Engineering

ME 6502 — HEAT AND MASS TRANSFER

(Common to Mechanical Engineering (Sandwich), Mechanical and Automation Engineering)

(Regulations 2013)

(Also common to PTME 6502 – Heat and Mass Transfer
B.E. Part time – Fourth Semester Mechanical Engineering – Regulations 2014)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What are the three modes of heat transfer?

2. Define Fin effectiveness.

3. What is meant by displacement thickness?

4. State the characteristics of a boundary layer.

5. What is meant by dropwise condensation?

6. Two fluids A and B exchange heat in a counter flow heat exchanger. Fluid A enters at 420°C and has a mass flow rate of 1 Kg/s. Fluid B enters at 20°C and has a mass flow rate of 1 Kg/s. The effectiveness of heat exchanger is 75%. Determine the exit temperature of fluid B.

7. The effective temperature of a body having an area of 0.12 m^2 is 527°C. Calculate the wavelength of the maximum monochromatic emissive power.

8. What are the properties of black body?

9. Give any two examples of mass transfer in day to day life.

10. What do you mean by equimolar counter diffusion?

PART B — (5 × 13 = 65 marks)

11. (a) Calculate the critical radius of insulation for asbestos (K = 0.172 W/mK) surrounding a pipe and exposed to room air at 300 K with h = 2.8 W/m^2K. Calculate the heat loss from a 475 K, 60 mm diameter pipe when covered with the critical radius of insulation and without insulation. (13)

Or

(b) Aluminium fins of rectangular profile are attached on a plane wall with 5 mm spacing. The fins have thickness y = 1 mm and length l = 10 mm and the thermal conductivity k = 200 W/mK. The wall is maintained at a temperature of 200°C and the fins dissipate heat by convection into the ambient air at 40°C with heat transfer coefficient h = 50 W/m^2K. Determine the heat loss. (13)

12. (a) Air at atmospheric pressure and 200°C flows over a plate with a velocity of 5 m/s. The plate is 15 mm wide and is maintained at a temperature of 120°C. Calculate the thicknesses of hydrodynamic and thermal boundary layers and the local heat transfer coefficient at a distance of 0.5 m from the leading edge. Assume the flow is on one side of the plate. Take ρ = 0.815 Kg/m^3, μ = 24.5 × 10^{-6} Ns/m^2, Pr = 0.7 and k = 0.0364 W/mK. (13)

Or

(b) A horizontal heated plate measuring 1.5 m × 1.1 m and at 215°C, facing upwards, is placed in still air at 25°C. Calculate the heat loss by natural convection. The convective film coefficient for free convection is given by the following empirical relation.

$h = 3.05\,(T_f)^{1/4}\ W/m^2\,^\circ C$

Where Tf is the mean film temperature in degree kelvin. (13)

13. (a) (i) Discuss the different types of processes for condensation of vapours on a solid surface. (9)

(ii) What are the factors affecting Nucleate Boiling. (4)

Or

(b) A Counter flow heat exchanger is to heat air entering at 400°C with a flow rate of 6 Kg/s by the exhaust gas entering at 800°C with a flow rate of 4 Kg/s. The overall heat transfer coefficient is 100 W/m^2K and the outlet temperature of air is 551.5°C. Specific heat of air Cp for both air and exhaust gas can be taken as 1100 J/KgK. Calculate

(i) Heat transfer area needed

(ii) Number of transfer units. (13)

14. (a) The filament of a 75 W light bulb may be considered a black body radiating into a black enclosure at 70°C. The filament diameter is 0.10 m and length is 5 cm. Considering the radiation, determine the filament temperature. (13)

Or

(b) Explain the following :

(i) Total Emissive power. (3)

(ii) Stefan-Boltzmann law. (3)

(iii) Definition of Geometric factor, and an expression for the geometric factor F_{11} for the inside surface of a black hemispherical cavity of radius R with respect to itself. (7)

15. (a) Explain in detail the various modes of mass transfer. (13)

Or

(b) Hydrogen gas is maintained at 5 bar and 1 bar on opposite sides of a plastic membrane, which is 0.3 mm thick. The temperature is 25°C and the binary diffusion coefficient of hydrogen in the plastic is $8.7 \times 10^{-8}\ m^2/s$. The solubility of hydrogen in the membrane is 1.5×10^{-3} kg mol/m^3 bar. What is the mass flux of hydrogen by diffusion through the membrane? (13)

PART C — (1 × 15 = 15 marks)

16. (a) Derive an expression for logarithmic mean temperature difference (LMTD) in the case of parallel flow heat exchanger. (15)

Or

(b) A mild steel tank of wall thickness 12 mm contains water at 95°C. The thermal conductivity of mild steel is 50 W/m°C and the heat transfer coefficients for the inside and outside the tank are 2850 and 10 $W/m^2\,^\circ C$ respectively. If the atmospheric temperature is 15°C, Calculate

(i) The rate of heat loss per m^2 of the tank surface area.

(ii) The temperature of the outside surface of the tank. (15)