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Question Paper Code : 30930

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2024.

Sixth/Eighth Semester

Mechanical Engineering

ME 8693 — HEAT AND MASS TRANSFER

(Common to Mechanical Engineering (Sandwich))

(Regulations 2017)

Time : Three hours

Maximum : 100 marks

(Use of Approved HMT Data Book is permitted)

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define conduction.
2. Mention the use of lumped heat analysis.
3. Highlight the significance of Reynolds number in heat transfer.
4. Define free and forced convection.
5. Differentiate between pool boiling and flow boiling.
6. Draw the temperature profile for parallel flow and counter flow heat exchangers.
7. Define shape factor.
8. List any two properties of black body radiation.
9. Write the Fick's law of diffusion.
10. Mention the difference between the heat and mass transfer.

PART B — (5 × 13 = 65 marks)

11. (a) A double glazed window is made of 2 glass panes of 6 mm thick each with an air gap of 6 mm between them. Assuming that the air layer is stagnant and only conduction is involved, determine the thermal resistance and overall heat transfer coefficient. The inside is exposed to convection with $h = 1.5 \text{ W/m}^2\text{K}$ and the outside to $9 \text{ W/m}^2\text{K}$. Compare the values with that of a single glass of 12 mm thickness. The conductivity of the glass = 1.4 W/mK and that for air is 0.025 W/mK .

Or

- (b) Determine the heat flow for
- (i) rectangular fins and
 - (ii) triangular fin of 20 mm length 3 mm base thickness. Thermal conductivity = 45 W/mK . Convection coefficient = $100 \text{ W/m}^2\text{K}$, base temperature = 120°C surrounding fluid temperature = 35°C . Determine also the fin effectiveness.
12. (a) In a process water at 30°C flows over a plate maintained at 10°C with a free stream of 0.3 m/s . Determine the hydrodynamic boundary layer thickness, thermal boundary layer thickness, local and average values of friction coefficient, heat transfer coefficient and refrigeration necessary to maintain the plate temperature. Also find the values of displacement and momentum thicknesses. Consider a plate of $1 \text{ m} \times 1 \text{ m}$ size.

Or

- (b) Water at a bulk mean temperature at 40°C flows through a tube of 0.05 m inner diameter with a velocity of 0.025 m/s . The tube is 2 m long and its surface is at a constant temperature of 60°C . Determine the heat transfer and the mean temperature rise during the flow. Assume hydrodynamic boundary layer already developed.
13. (a) Water at atmospheric pressure (saturation temperature = 100°C) is boiling on a brass surface heated from below. If the surface is at 108°C , determine the heat flux and compare the same with critical heat flux.

Or

- (b) Determine the area required in parallel flow heat exchanger to cool oil from 60°C to 30°C using water available at 20°C . The outlet temperature of the water is 26°C . The flow of oil is 10 kg/s . The specific heat of the oil is 2200 J/kg K . The overall heat transfer coefficient $U = 300 \text{ W/m}^2\text{K}$. Compare the area required for a counter flow exchanger.

14. (a) A furnace of $2\text{ m} \times 1.5\text{ m} \times 1.5\text{ m}$ size contains gases at 1500 K while the walls are at 500 K . The gas contains 18% of CO_2 and 12% of water vapour by volume. Determine the heat exchange from the gases to the walls. The total pressure is 2 atm . Assume black surface.

Or

- (b) A filament is in the shape of a cylinder of 1 mm diameter and 25 mm length and is in an evacuated space enclosed by transparent medium. The filament is initially maintained at 2900 K by power supply. Determine the time needed for the filament to cool to 1300 K after power supply is cut.
15. (a) A tank contains a mixture of CO_2 and N_2 in the mole portions of 0.2 and 0.8 at 1 bar and 290 K . It is connected by a duct of sectional area 0.1 m^2 to another tank containing a mixture of CO_2 and N_2 in the molal proportion of 0.8 and 0.2 . The duct is 0.5 m long. Determine the diffusion of CO_2 and N_2 . $D = 0.16 \times 10^{-4}\text{ m}^2/\text{s}$.

Or

- (b) Acetic acid diffuses into a nondiffusing film of water of 1 mm thickness. The concentration of acid on the opposite sides of the film are 9% and 3% of acid by weight. The diffusivity at this temperature is $0.95 \times 10^{-9}\text{ m}^2/\text{s}$. Determine the rate of diffusion of acid. The molecular weight of the acid is 60 . The density of the solution with 9% acid is 1012 kg/m^3 and for the 3% solution it is 1003.2 kg/m^3 .

PART C — ($1 \times 15 = 15$ marks)

16. (a) A nuclear reactor fuel rod of solid cylinder of 25 mm is converted into “+” shaped form of thickness 6 mm . The heat generation rate is 50 MW/m^3 . Thermal conductivity is 24.2 W/mK . The heat generated is absorbed by a fluid at 200°C . Determine the convective heat transfer coefficient on the surface.

Or

- (b) Water at the rate of 4 kg/s is heated from 35°C to 50°C in a shell and tube heat exchanger. The water is to be flown inside tubes of 2 cm diameter with an average velocity of 40 cm/s . Hot water is available at 85°C and at the rate of 2 kg/s is used as the heating medium on the shell side. The length of the tube should not exceed 2 m . Calculate the :
- (i) number of tube pass
 - (ii) number of tube per pass and
 - (iii) length of the tube for one shell pass, assuming overall heat transfer co-efficient as $1500\text{ W/m}^2\text{K}$.