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Question Paper Code : 72151

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2017.

Fifth/Sixth/Seventh Semester

Mechanical Engineering

ME 6502 — HEAT AND MASS TRANSFER

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

(Regulations 2013)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Distinguish between conduction and convection heat transfer.

2. State some practical applications of transient heat transfer analysis.

3. How Reynolds and Colburn analogies differ with each other.

4. Define Grashof number and explain its significance in free convection heat transfer.

5. Draw the pool boiling curve for water.

6. Sketch the temperature variation of condenser and evaporator.

7. State Lambert's cosine law for radiation.

8. What are the applications of radiation shields?

9. Distinguish between mass concentration and molar concentration.

10. Give examples for free and forced convection mass transfers.

PART B — ($5 \times 16 = 80$ marks)

11. (a) (i) Steam at 320°C flows in a cast iron pipe (k= 80 W/mK) whose inner and outer diameters are $D_1 = 5$ cm and $D_2 = 5.5$ cm, respectively. The pipe is covered with 3-cm-thick glass wool insulation with k = 0.05 W/mK. Heat is lost to the surroundings at 5°C by natural convection and radiation, with a combined heat transfer coefficient of $h_2 = 18$ W/m^2 K. Taking the heat transfer coefficient inside the pipe to be $h_1 = 60$ W/m^2 K, determine the rate of heat loss from the steam per unit length of the pipe. Also determine the temperature drops across the pipe shell and the insulation. (10)

(ii) Write short notes on types of extended surfaces or fins. (6)

Or

(b) (i) Circumferential aluminum fins (k=200 w/mk) of rectangular profile (1.5 cm wide × 1 cm thick) are fitted onto a 2.5 cm diameter tube. The fin base temperature is 170°C and the ambient air temperature is 25°C. Estimate the heat loss per fin. The heat transfer coefficient 'h' may be taken as 130 w/m^{2}K. (8)

(ii) The ground at a particular location is covered with snow pack at –10°C for a continuous period of three months, and the average soil properties at that location are $k = 0.4$ W/mk and $\alpha = 0.15 \times 10^{-6}$ m^2/s. Assuming an initial uniform temperature of 15°C for the ground, determine the minimum burial depth to prevent the water Pipes from freezing. (8)

12. (a) (i) Air flows over a flat plate at a velocity of 10 m/s. Air and surface temperature of the plate are 20°C and 580°C respectively. Calculate the amount of heat transferred per metre width from both sides of the plate over a distance of 40 cm from the leading edge. (8)

(ii) Engine oil flows through a 50 mm diameter tube at an average temperature of 147°C. The flow velocity is 80 cm/s. Calculate the average heat transfer coefficient if the tube wall is maintained at a temperature of 200°C and it is 2 m long. (8)

Or

(b) Consider a 0.6 m × 0.6 m thin square plate in a room at 30°C. One Side of the plate is maintained at a temperature of 90°C, while the other side is insulated. Determine the rate of heat transfer from the plate by natural convection if the plate is (i) vertical (ii) horizontal with hot surface facing up, and (iii) horizontal with hot surface facing down. (16)

13. (a) Water is to be boiled at atmospheric pressure in a mechanically polished stainless steel pan placed on top of a heating unit The inner surface of the bottom of the pan is maintained at 108°C. If the diameter of the bottom of the pan is 30 cm, determine (i) the rate of heat transfer to the water and (ii) the rate of evaporation of water. (16)

Or

(b) A 2-shell passes and 4-tube passes heat exchanger is used to heat glycerin from 20°C to 50°C by hot water which enters the thin –walled 2-cm-diameter tubes at 80°C and leaves at 40°C. The total length of the tubes in the heat exchanger is 60 m. The convection heat transfer coefficient is 25 W/m^2 K on the glycerin (shell) side and 160 W/m^2K on the water (tube) side. Determine the rate of heat transfer in the heat exchanger (i) before any fouling and (ii) after fouling with a fouling factor of 0.0006 m^2 k/W occurs on the outer surfaces of the tubes. (16)

14. (a) (i) The filament of a round bulb is maintained at a temperature of 2000 k and it is assumed to be a black body. The transmissivity of the bulb glass is 0.92 in the visible range ($0.35 < \lambda < 0.75$ μm) of the radiation. Calculate the amount of energy transmitted. (8)

(ii) The surfaces of a double walled spherical vessel used for storing liquid oxygen are covered with a layer of silver having an emissivity of 0.03. The temperature of the outer surface of the inner wall is –153°C and the temperature of the inner surface of the outer wall is 27°C. The spheres are 21 cm and 30 cm in diameter, with the space between them evacuated. Calculate the radiation heat transfer through the walls into the vessel and the rate of evaporation of liquid oxygen if its rate of vaporization is 220 kJ/kg. (8)

Or

(b) Two parallel plates 2 m × 1 m are spaced 1 m apart. The plates are at a temperature of 727°C and 227°C and their emissivities are 0.3 and 0.5 respectively. The plates are located in a large room, the walls of which are at 27°C. Determine the rate of heat loss from each plate and the heat gain by the walls. (16)

15. (a) Two large vessels contain uniform mixture of air and sulphur dioxide at 1 atm and 273K, but at different concentrations. Vessel 1 contains 80% air and 20% SO_2 by volume or mole percentage whereas vessel 2 contains 30% air and 70% SO_2 by mole percentage. The vessels are connected by a 10 cm inner diameter 1.8 m long pipe. Determine the rate of transfer of air between these two vessels by assuming that a steady state transfer takes place. The mass diffusivity of air– SO_2 mixture at 1 atm and 273 K is 0.122×10^{-4} m^2/s. (16)

Or

(b) The water in a 5 m × 15 m outdoor swimming pool is maintained at a temperature of 27°C. The average temperature and relative humidity are 37°C and 40% respectively. Assuming a wind speed of 2m/s in the direction of the long side of the pool, estimate the mass transfer coefficient for the evaporation of water from the pool surface and the rate of evaporation in kg/day. (16)
