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Question Paper Code : 90869

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2022.

Sixth/Eighth Semester

Mechanical Engineering

ME 8693 — HEAT AND MASS TRANSFER

(Common to Mechanical Engineering (Sandwich))

(Regulations 2017)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. Tell whether providing extended surface will always results in increased heat transfer.

2. The inner surface of a plane brick wall is at 60°C and the outer surface is at 30°C. Calculate the rate of heat transfer per m^2 of surface area of the wall, which is 220 mm thick. The thermal conductivity of the brick is 0.2 W/m°C.

3. Define Reynolds Analogy.

4. What is Free Convection? Give Examples.

5. Classify the heat exchangers according to the relative direction of fluid motion.

6. Differentiate Film condensation and Dropwise condensation.

7. State Lamberts cosine law of radiation.

8. Assuming the sun to be a black body emitting radiation with maximum intensity at $\lambda = 0.49\,\mu m$. Calculate the surface temperature of the sun.

9. Define the Ficks law of diffusion.

10. What is meant by Sherwood number in convective mass transfer?

PART B — (5 × 13 = 65 marks)

11. (a) Derive the General heat conduction equation in cylindrical coordinates. (13)

Or

(b) Find out the amount of heat transferred through an iron fin of length 50 mm, width 100 mm and thickness 5 mm. Assume k = 210 KJ/mh°C and h = 42 KJ/m²h°C for the material of the fin and the temperature at the base of the fin as 80°C. Also determine the temperature at tip of the fin, if the atmosphere temperature is 20°C. (13)

12. (a) A Plate of length 750 mm and width 250 mm has been placed longitudinally in a stream of crude oil which flows with a velocity of 5 m/s. If the oil has a specific gravity of 0.8 and kinematic viscosity of 1 stoke. Calculate

(i) Boundary layer thickness at the middle of the plate

(ii) Shear stress at the middle of the plate

(iii) Friction drag on one side of the plate (13)

Or

(b) Air at 20°C and 1.013 bar flows over a flat plate at 40 m/s. The plate is 1 m long and is maintained at 60°C. Assuming unit depth, calculate the heat transfer from the plate. Use the following correlation

$Nu_L = (\mathrm{Pr})^{0.33}(0.037(\mathrm{Re}_L)^{0.8} - 850)$ (13)

13. (a) Saturated steam at 120°C condenses on a 2 cm OD vertical tube which is 20 cm long. The tube wall is maintained at a temperature of 119°C. Calculate the average heat transfer coefficient and the thickness of the condensate film at the base of the tube. Assume Nusselt's solution is valid. Given

$P_{sat} = 1.985$ bar, $\rho_w = 943$ kg/m^3, $h_{fg} = 2202.2$ kJ/kg.

$K_w = 0.686$ W/m K, $\mu = 237.3 \times 10^{-6}$ Ns/m^2. (13)

Or

(b) A Counter - flow heat exchanger is employed to cool 0.55 kg/s ($C_p = 2.45$ kJ/kg°C) of oil from 115°C to 40°C by the use of water. The inlet and outlet temperature of cooling water are 15°C and 75°C respectively. The overall heat transfer coefficient is expected to be 1450 W/m²°C. Using NTU method, calculate the following

(i) The mass flow rate of water

(ii) The effectiveness of the heat exchanger

(iii) The surface area required (13)

14. (a) The net radiation from the surfaces of two parallel plates maintained at T_1 and T_2 is to be reduced by 99%. Calculate the number of screens to be placed between the two surfaces to achieve this reduction in heat exchange assuming the emissivity of the screens as 0.05 and the emissivity of surfaces as 0.8. (13)

Or

(b) Two black discs each of diameter 500 mm are placed directly Opposite at a distance of 1 m apart. The discs are maintained at 1000 K and 500 K respectively. Calculate the heat flow between the discs:

(i) When no other surfaces are present

(ii) When the discs are connected by right cylindrical black no-flux surface. (13)

15. (a) Derive the general mass transfer equation in Cartesian coordinates (13)

Or

(b) Air at 1 atm and 25°C, containing small quantities of iodine, flows with a velocity of 6.2 m/s inside a 35 mm diameter tube. Calculate mass transfer coefficient for iodine. The thermophysical properties of air are :

$\nu = 15.5 \times 10^{-6}$ m^2/s, $D = 0.82 \times 10^{-5}$ m^2/s (13)

PART C — (1 × 15 = 15 marks)

16. (a) Consider two large parallel plates one at $t_1 = 727$°C with emissivity $\varepsilon_1 = 0.8$ and other at $t_2 = 227$°C with emissivity $\varepsilon_2 = 0.4$. An aluminium radiation shield with an emissivity $\varepsilon_s = 0.05$ on both sides is placed between the plates. Calculate the percentage reduction in heat transfer rate between the two plates as a result of the shield

Use $\sigma = 5.67 \times 10^{-8}$ W/m^{2}K^4. (15)

Or

(b) Derive an expression for Logarithmic Mean Temperature Difference (LMTD) in case of counter flow heat exchanger (15)

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