Reg. No. :

Question Paper Code : 20866

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 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 × 2 = 20 marks)

1. Write the three dimensional heat transfer Poisson and laplace equation in Cartesian co-ordinates.

2. A 3 mm wire of thermal conductivity 19 W/mK at a steady heat generation of 500 MW/m^3. Determine the centre temperature if the outside temperature is maintained at 25° C.

3. Define critical Reynolds number. What is its typical value for flow over a flat plate and flow through a pipe?

4. Define velocity boundary layer thickness.

5. What are the limitations of LMTD method? Discuss the advantage of NTU over the LMTD method?

6. Indicate the differences between boiling and condensation.

7. Two parallel radiating Planes 10 × 50 cm are separated by a distance of 50 cm. What is the radiation shape factor between the planes?

8. Mention the purpose of radiation shield.

9. Provide any two examples of mass transfer.

10. State Fick's law of diffusion.

PART B — (5 × 13 = 65 marks)

11. (a) Derive the Heat conduction equation in cylindrical coordinates.

Or

(b) A furnace wall is made up of three layer of thickness 25 cm, 10 cm and 15 cm with thermal conductivities of 1.65 W/mK and 9.2 W/mK respectively. The inside surface is exposed to gases at 1250°C with a convection coefficient of 25 W/m² K. The inside surface is at 1100°C, the outside surface is exposed to air at 25°C with convection coefficient of 12 W/m² K. Determine :

(i) the unknown thermal conductivity

(ii) the overall heat transfer coefficient

(iii) All the surface temperatures.

12. (a) Air at 25°C at the atmospheric pressure is flowing over a flat plate at 3m/s. If the plate is 1m wide and the temperature T_w = 75°C. Calculate the following at a location of 1 m from leading edge.

(i) Hydrodynamic boundary layer thickness,

(ii) Local friction coefficient,

(iii) Thermal heat transfer coefficient,

(iv) Local heat transfer coefficient.

Or

(b) A thin 100 cm long and 10 cm wide horizontal plate is maintained at a uniform temperature of 150°C in a large tank full of water at 75°C. Estimate the rate of heat to be supplied to the plate to maintain constant plate temperature as heat is dissipated from either side of plate.

13. (a) Discuss in detail on the pool boiling regimes of water at atmospheric pressure.

Or

(b) In a cross flow heat exchangers, both fluids unmixed, Hot fluid with a specific heat of 2300 J/kg K ,enters at 380°C and leaves at 300°C. Cold fluids enter at 25°C and leaves 210°C. Calculate the required surface area of heat exchanger. Take overall heat transfer co-efficient is 750 w/m² K. Mass flow rate of hot fluid is 1 kg/s.

14. (a) The sun emits maximum radiation at $\lambda = 0.52\ \mu$. Assuming the sun to be a black body, calculate the surface temperature of the sun. Also calculate the monochromatic emissive power of the sun's surface.

Or

(b) A black body at 3000 K emits radiation. Calculate the following :

(i) Monochromatic emissive power at 1 μm wave length

(ii) Wave length at which emission is maximum

(iii) Maximum emissive power

(iv) Total emissive power

(v) Calculate the total emissivity of the furnace if it is assumed as a real surface having emissivity equal to 0.85.

15. (a) A vessel contains binary mixture of O_2 and N_2 with partial pressure in the ratio 0.21 and 0.79 at 15°C. The total pressure of the mixture is 1.1 bar.

Calculate the following :

(i) Molar concentrations

(ii) Mass densities

(iii) Mass fractions

(iv) Molar fraction of each species.

Or

(b) Discuss in detail on the Analogy between heat and mass transfer with real time examples.

PART C — (1 × 15 = 15 marks)

16. (a) A motor body is 360 mm in diameter (outside) and 240 mm long. Its surface HO temperature should not exceed 55°C when dissipating 340 W. Longitudinal fins of 15 mm thickness and 40 mm height are proposed. The convection coefficient is 40W/m² C. Determine the number of fins required. Atmospheric temperature is 30°C. Thermal conductivity = 40 W/m°C.

Or

(b) A steel tube with 5 cm ID, 7.6 cm OD and k = 15W/m° C is covered with an insulative covering of thickness 2 cm and k = 0.2 W/m C. A hot gas at 330° C with h = 400 W/m²° C flows inside the tube. The outer surface of the insulation is exposed to cooler air at 30° C with h = 60 W/m²° C. Calculate the heat loss from the tube to the air for 10 m of the tube and the temperature drops resulting from the thermal resistances of the hot gas flow, the steel tube, the insulation layer and the outside air.

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