B.E./B.TECH. DEGREE EXAMINATION, DECEMBER 2020

Fifth Semester

ME16502-HEAT AND MASS TRANSFER

(Use of Heat and Mass transfer Data book is permitted)

(Regulation 2016)

Time: Three hours Maximum: 80 Marks

Answer **ALL** questions

PART A - (8 X 2 = 16 marks)

1. Heat is transferred by all three modes of transfer, viz, conduction, convection and radiation in

   (a) electric heater, (b) steam condenser, (c) melting of ice, (d) refrigerator condenser coils

   (e) boiler.

2. Emissivity of a white polished body in comparison to a black body is

   (a) higher, (b) lower, (c) same, (d) depends upon the shape of body, (e) none of the above.

3. In free convection heat transfer, Nusselt number is function of

   (a) Grashoff number and Reynold number(b) Grashoff number and Prandtl number

   (c) Prandtl number and Reynold number, (d) Grashoff number Prandtl number and Reynold number (e) none of the above.

4. The heat transfer co-efficient in film type condensation is _____ that for dropwise condensation

   (a) is same as b) lower than (c) greater than (d) half

5. Define the term thermal conductivity. Also mention the behavior of liquid and gases thermal conductivity for change in temperature

6. Two parallel radiating planes 100 x 50 cm are separated by a distance of 50 cm. What is the radiation shape factor between the planes?

7. Define hydraulic mean diameter and Velocity boundary layer

8. Explain Equimolar counter diffusion

PART B - (4 X16 = 64 marks)

09. (a) (i) Steam at 350°C flowing in a pipe (K= 80 W/m^{2}K) 5 cm inner diameter, outer diameter 5.6 cm covered with 3 cm thick insulation (K= 0.05 W/mK). Heat is lost to the surroundings at 5°C by natural convection with h_1 = 20 W/m^{2}K and h_2 = 60 W/m^{2}K. Determine the rate of heat loss from the pipe per unit length. **(8)**

    (ii) A steel rod 15 cm diameter 90 cm long, K= 40 W/mK, attached to its wall dissipates heat at the rate of 45 W with h = 15 W/m^{2}K, to determine the rate of heat loss from the rod including the fin tip. **(8)**

(OR)

(b) (i) In a production facility, large brass plate of 4 cm thickness that are initially at a uniform temperature of 20° C are heated by passing then through a oven that is maintained at 500° C. the plates remain in the oven for a period of 7 min. Taking the combined convection and radiation heat transfer coefficient of h = 120 W/m^{2}K, determine the surface temperature of the plates when they come out of the oven. **(8)**

(ii) A long cylindrical bar (K= 17.4 W/mK, α = 0.019 m^2/h) of radius 80 mm comes out of a oven at 830°C throughout and is cooled by quenching it a large bath of 40°C coolant. The heat transfer coefficient between bar surface and coolant 180 W/m^{2}K. Determine (i) the time taken by the shaft centre to reach 120°C (ii) The surface temperature of the shaft when its center temperature is 120°C **(8)**

10. (a) (i) Castor oil at 25°C flows at a velocity of 0.1m/s part a flat plate, in a certain process. If the plate is 4.5 m long and is maintained at a uniform temperature of 98°C, determine the following (i)the hydrodynamic and thermal boundary layer (ii) the local heat transfer coefficient at the trailing edge and properties of oil at 60°C are ρ = 956.8 kg/m^3 υ = 0.65 x 10^{-4} m^2/s, k = 0.213 W/mK **(8)**

(ii) A long 12 cm diameter steam pipe whose surface temperature is 90°C passes through some open area that is not protected against the winds. Determine the rate of heat loss from the pipe per unit of its length when the air is at 1 atmosphere pressure and 7°C and the wind is blowing across the pipe at velocity of 65 km/h **(8)**

(OR)

(b) (i) A 10 m long section of a 90 mm diameter horizontal hot water pipe passes through a large room whose temperature is 10°C, if the outer surface temperature of the pipe is 80°C. Determine the rate of heat loss from the pipe natural convection. **(8)**

(ii) Air flows through a long rectangular (30 cm height x 60 cm width) air conditioning duct maintains the outer duct surface temperature at 15°C. If the duct is maintained and exposed to air at 25°C. Calculate the heat gained by the duct per meter length assuming vertical side. **(8)**

11. (a) (i) Estimate the power required to boil water in a copper pan 0.35 m in diameter. The pan is maintained at 120°C by an electric heater. **(8)**

(ii) One hundred horizontal tubes of 1.27 cm diameter are arranged in a square array and exposed to steam at atmospheric pressure. Calculate the heat condensed per unit length of a tube, the tube wall temperature is 98°C. **(8)**

(OR)

(b) (i) Steam in the condenser of a power plant is to be condensed at a temperature of 30°C with cooling water nearby lake, which enters the tubes of the condenser at 14°C and leaves at 22°C. the surface area of the tubes is $45m^2$ and the overall heat transfer coefficient is 2100 W/m^2 K. Determine the mass flow rate of the cooling water needed and the rate of condensation of the steam in the condenser. **(8)**

(ii) Derive an expression for logarithmic mean temperature difference (LMTD) in case of counter flow heat exchangers and state the assumptions **(8)**

12. (a) (i) A thin aluminum sheet with an emissivity of 0.1 on both sides is placed between two large parallel plates that are maintained at uniform temperature T_1 = 800 K,T_2 = 500 K, ε_1=0.2, ε_2=0.7, determine the net rate of radiation heat transfer between the two plates per unit, surface area of the plates **(8)**

(ii) Determine the shape factors associated with an enclosure formed by two concentric spheres, as shown in Figure1 **(8)**

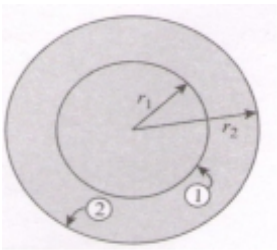

Figure 1

(OR)

(b) (i) Dry air at 27°C and 1 bar flows over a wet plate of 50 cm at 50 m/s. calculate the mass transfer coefficient of water vapour in air at the end of the plate. **(8)**

(ii) An open pan 20 cm in diameter and 8 cm deep contain water 25°C and is exposed to dry atmospheric air. if the rate of diffusion on water vapour is 5.54 x 10^{-4} kg/hr. Estimate diffusion coefficient of water in air. At 25°C, saturation pressure of water is 0.03165 bar **(8)**