Paper / Subject Code: 31403 / Heat Transfer

TE/Sem V/ CBCGS/ AUTO/ MJ2019/ 21-05-2019

Duration: 3 Hours **Max Marks: 80**

Note:

i) Question no.1 is compulsory.
ii) Attempt any **THREE** from question no. 2 to 6.
iii) Assume suitable data whenever necessary.

Q1) Solve any **Four** **20**

a) A refrigerator stands in a room where the air temperature is 30 ^{0}C. The surface temperature on the outside of the refrigerator is 25 ^{0}C. The sides are 30 mm thick and have an equivalent thermal conductivity of 0.1 W/m K. The heat transfer coefficient on the outside is 10 W/m^{2}K. Assuming one dimensional conduction through the sides, calculate the net heat flow per m^2 and the surface temperature on the inside.

b) Define and explain physical significance of Reynolds and Nusselt number.

c) Explain Fin efficiency and Fin effectiveness. Explain in brief factors affecting fin effectiveness.

d) Exhaust gases (C_P=1.12 kJ/kg ^{0}C) flowing through a tubular heat exchanger at the rate of 1000 Kg/hr are cooled from 300 ^{0}C to 120 ^{0}C. The cooling is affected by water (C_p= 4.18 kJ/Kg ^{0}C) that enters the system at 20 ^{0}C at the rate of 1200 Kg/hr. If the overall heat transfer coefficient is 140 W/m^2 K, what heat exchanger area is required to handle the load for parallel flow arrangement?

e) Define intensity of radiation. What is solid angle? Explain.

Q2) a) Derive general equation of heat conduction in Cartesian coordinate system and reduce it to all three forms. **10**

b) Air at atmospheric pressure and 20 ^{0}C flows with 5 m/s velocity through main duct of an air conditioning system. The duct is rectangular in cross-section and measures 40 cm x 80 cm. Determine heat loss per meter length of duct corresponding to unit temperature difference. The relevant thermo-physical properties of air are **10**

$\nu = 15 \times 10^{-6}$ m^2/s , $\alpha = 7.7 \times 10^{-6}$ m^2/hr , k = 0.026 W/m K

Use Dittus Boelter correlation : $Nu = 0.023 \times (Re)^{0.8} \times (Pr)^{0.4}$

Q3) a) Water flows at the rate of 65 kg/min through a double pipe counter flow heat exchanger. Water is heated from 50°C to75°C by oil flowing through the tube. The specific heat of oil is 1.780 kJ/kg K. The oil enters at 115°C and leaves at 70°C. The overall heat transfer co-efficient is 340 W/m^2 K. Calculate the following **8**

(i) Heat exchanger area
(ii) Rate of heat transfer

Use LMTD method.

b) The following data pertains to the junction of a thermocouple wire used to measure the temperature of a gas stream : 6

ρ = 8500 Kg/m^3 ; C_p = 325 J/kg K ; k = 40 W/m K and the heat transfer coefficient between the junction and gas h = 215 W/m^2 K.

If thermocouple junction can be approximated as 1 mm diameter sphere, determine how long it will take for the thermocouple to read 99 percent of the initial temperature difference?

c) Define the following terms: (i) Absorptivity (ii) Reflectivity (iii) Transmissivity. (iv) Emissivity. Explain Kirchoff's law. 6

Q4) a) A rod of 10 mm diameter and 70 mm length with thermal conductivity 15 W/m K protrudes from a surface at 180 ^{0}C. The rod is exposed to air at 30 ^{0}C with a convection coefficient of 25 W/m^2 K. How does the heat flow from this rod get affected if the same material volume is used for two fins of the same length? Assume short fin with end insulated. 8

b) In which mode of heat transfer is the convection heat transfer coefficient usually higher, natural convection or forced convection? Why? 4

c) Derive an expression for LMTD for parallel flow type heat exchanger. 8

Q5) a) Determine the radiant heat exchange in W/m^2 between two large parallel steel plates of emissivities 0.8 and 0.5 held at temperatures of 1000 K and 500 K respectively, if a thin copper plate of emissivity 0.1 is introduced as a radiation shield between the two plates. 10

Take σ = 5.67 x 10^{-8} W/m^2 K^4

b) What do you mean by critical thickness of insulation? State its importance. Derive an expression for critical radius of insulation for sphere of thermal conductivity k and outside film coefficient h_0. 10

Q6) a) Draw a neat boiling curve for water showing different regions of boiling. Explain each regime in brief. 6

b) Estimate the heat transfer from a 40W incandescent bulb at 125 ^{0}C to 25 ^{0}C in quiescent air. Approximate the bulb as a 50 mm diameter sphere. What percent of power is lost by free convection? The appropriate correlation for the convection coefficient is 8

$$Nu = 0.60 \times (Gr\, Pr)^{0.25}$$

The thermo-physical properties of air at mean film temperature are : ν = 20.55 x 10^{-6} m^2/s ,

k = 0.03 W/m K , Pr = 0.693

c) A 250 x 250 mm ingot casting, 1.5 m high and at 1025 K temperature, is stripped from its mold. The casting is made to stand on end on the floor of a large foundry whose wall, floor and roof can be assumed to be at 300 K temperature. Make calculation for the rate of radiant heat interchange between the casting and the room. The casting material has an emissivity of 0.85. 6

Take σ = 5.67 x 10^{-8} W/m^2 K^4
