09/06/17

T2225 / T0515 HEAT TRANSFER

Sem V / CBSGS / Auto / HT / M-J-17

Q. P. Code : 600900

(3 Hours)

[TOTAL MARKS 80

Instructions:

1) Question **No-1** is compulsory.
2) Answer any **THREE** from the remaining **FIVE** questions.
3) Assume suitable data if necessary and state the same.

Q-1 Answer any 4 questions. [20]

a) What are the three modes of heat transfer? Define each with an appropriate example.

b) Define Fourier's Law of heat conduction, Newton's law of cooling and Stefan Boltzmann Law.

c) What do you mean by Fouling factor? What are the causes of fouling?

d) Define shape factor and write down the properties of shape factor.

e) How convection heat transfer occur? What are the differences between Natural Convection and Forced Convection.

Q-2 a) A steam pipe made of steel (K= 58W/m-K) has ID of 160mm and OD of 170mm. The saturated steam flowing through it is at 300°C, while the ambient air is at 50°C. It has two layers of insulation. The inner layer (k=0.17 W/m-K) is 30mm thick and the outer layer (k=0.023 W/mK) is 50mm thick. The heat transfer coefficient on inside and outside walls are 40W/m^{2}K and 5.8W/m^{2}K respectively. Find the rate of heat loss per unit length of the pipe. [8]

b) A brick (k= 1.3 W/mK) wall 0.15 m thick separates combustion gases in a furnace from the atmosphere air at 30°C. The outside surface temperature is 100°C while its emissivity is 0.8 and the heat transfer coefficient for the outer surface is 20W/m^{2}K. Find the inner surface temperature of the wall and total heat lost to surrounding by both convection and radiation per unit area. [6]

c) A 0.5 m^2 plane, grey, diffuse, opaque surface with absorptivity = 0.7 is maintained at 500°C. With an irradiation of 10000 W/m^2. Determine (i) the Absorbed energy (ii) Emitted Energy (iii) Total Energy leaving the surface per unit Area. Take Stefan Boltzmann constant as 5.67 x 10^{-8} w/m^2 K^4. [6]

Q-3 a) For lumped heat analysis with usual notations prove that $\frac{\theta}{\theta_o} = e^{-BiFo}$ [8]

b) An egg with mean diameter of 45mm and initially at 18°C is placed in a boiling water pan for 4.5 minutes and found to be boiled to the consumer's taste. For how long should a similar egg for the same consumer be boiled taken from a refrigerator at 4°C. Take the following properties for egg. Verify whether the Lumped heat capacity analysis can be used or not. [6]

K =10W/m°C, ρ=1200kg/m^3, Cp = 2 kJ/kg°C, and h = 100 W/m^2 °C.

c) Nitrogen gas at 0°C is flowing over a 1.2 m long , 2m wide plate maintained at 80°C with a velocity of 2.5 m/sec. properties of nitrogen, at film temperature, ρ=1.142kg/m^3, Cp=1.04 kJ/kg-K, kinematic viscosity (v) =15.63 x 10^{-6} m^2/sec and Conductivity(k) = 0.0262 W/m-K. Find the average heat transfer coefficient and total heat transfer from the plate. Take the correlation **Nu = 0.664 Re $^{1/2}$ Pr $^{1/3}$.** [6]

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Q-4 a) An incandescent lamp is approximated as a 75mm diameter sphere. The temperature of the glass bulb of a 60W lamp is 110°C when the ambient air is at 20°C. Estimate the heat transfer rate from the bulb surface by natural convection and by radiation if emissivity of the glass is 0.7. Properties of air at 65°C are $\mu = 2.03 \times 10^{-5}$ Ns/m^2, $\rho = 1.044$ Kg/m^3, Cp = 1007 J/kg-K, k= 0.02845 w/m-K, Pr = 0.7188. Use the correlation $Nu = 0.589\ Ra^{(1/4)}$ and $\sigma = 5.67 \times 10^{-8}$ w/m^{2}K^4. [8]

b) Derive the relation $Nu = C\ (Gr)^m \times (Pr)^n$ for Natural Convection by using Dimensional Analysis. [8]

c) What do you mean by critical thickness of insulation? State its significance. [4]

Q-5 a) Water (Cp=4.187 kJ/kg-K) is heated at the rate of 1.4 Kg/sec from 40°C to 70°C by an oil (Cp=1.9kJ/kg-K) entering at 110°C and leaving 60°C in a counter flow heat exchanger. If Uo is 350 W/m^2-K calculate the surface area required. [8]
Using the same entering fluid temperature and same oil flow rate, calculate the exit temperature of oil and water and the rate of heat transfer when the water flow rate is halved (50% of initial flow).

b) Derive the relation for LMTD in the case of a parallel flow heat exchanger from fundamentals. [6]

c) Three hollow thin walled cylinders having diameters 10 cm,20cm and 30 cm are arranged concentrically. The temperature of innermost and outermost cylindrical surfaces are 80 K and 280 K respectively. Assume vacuum between annular spaces, find the steady state temperature attained by the cylindrical surface having diameter of 20 cm. Take $\varepsilon 1 = \varepsilon 2 = \varepsilon 3 = 0.05$. [6]

Q-6 a) Draw a neat boiling curve showing all boiling regimes of water. [4]

b) Derive the governing differential equation for Fin of uniform cross section. [8]

c) State and prove reciprocity theorem. [8]

Auto

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