T.E (MECHANICAL ENGG) (SEM V) (CBSGS)
Heat Transfer

10th December, 2014
2.30 pm to 5.30 pm

Mechanical/Automobile

QP Code : 14964

(3 Hours) **[Total Marks : 80**

Instructions:

1) Question No 1 is compulsory
2) Answer any 3 from the remaining.
3) Assume suitable data if necessary.

Q-1 Answer any 4 questions. 20

a) A rectangular slab (k = 10 W/m-K) of thickness 15 cm and inside temperature of 400°C is insulated by a materials of thickness 10 cm (K = 30W/m-K). The ambient air is at 28°C and the outside convective heat transfer coefficient is 15 W/m^{2}K. Determine the steady state heat transfer per unit surface area and the temperature of outside surface of the slab and the insulation.

b) In an oil cooler, oil (m=2500kg/hr and C_p = 1.9 kJ/kg-K)) at 160°C is cooled by water(m=1500 kg/hr and C_p =4.187 kJ/kg-K) entering at 35°C. Determine Capacity ratio, NTU and effectiveness if the overall heat transfer coefficient is 300 W/m^{2}K. Assume parallel flow.

c) A pipe, 2cm diameter, at 40°C is placed in (i) an air flow at 50°C with h = 20W/m^{2}K OR in (ii) water at 30°C with h = 70W/m^{2}K. Find the heat transfer per unit length of the pipe and comment on the results in both cases.

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

e) What is the mode of heat transfer in Vacuum? Define absorptivity, reflectivity and transmissivity.

Q-2 a) Water (mass = 1.4 kg/s , C_p = 4.187KJ/kg-K) is heated from 40°C to 70°C by an oil (mass =2 kg/sec, C_p =1.9 KJ/kg-K) entering at 110 °C in a counter flow heat exchanger. If overall heat transfer coefficient is 350 W/m^{2}K, calculate the surface area required. 10

b) Derive the temperature profile equation for a cylindrical system from the general differential equation stating the assumptions for one dimensional steady state heat transfer. 10

Q-3 a) A steel pipe of OD 0.15m lies 2m vertically and 8m horizontally in a large room with an ambient temperature of 30°C. The pipe surface is at 250°C and has an emissivity of 0.6. Estimate the total heat loss (due to convection and radiation) from the pipe to the atmosphere. Properties at film temperature : ν =27.8 x 10^{-6} m^2/s, k =0.035 W/mK, Pr =0.684. 10
[Take Nu =0.13 (Gr.Pr)$^{1/3}$ if the flow is turbulent OR Nu =0.53 (Gr.Pr)$^{1/4}$ if the flow is Laminar.]

b) What is lumped system analysis? When is it applicable? 4

c) Draw a neat boiling curve for water and mark the different regions. 6

Q-4 a) A furnace door, 1.5 m high and 1m wide is insulated from inside and has an outer surface temperature of 70°C. If the surrounding ambient air is at 30°C calculate steady state heat loss from the door. Take the properties from at film temperature 50°C are ρ= 1.093Kg.m^3, v =17.95 x 10-6 m^2/s, Pr =0.698 Cp = = 1.005J/kg-K, use the correlation Nu =0.13 (Ra)$^{1/3}$ 10

b) A longitudinal copper fin (k=380W/m-K) 600 mm long and 5 mm diamet 6

is exposed to an air stream at 20°C. The convective heat transfer coefficient is 20 W/m^2-K. If the fin base temperature is is 150°C, determine the rate of heat transfer and Fin efficiency.

c) How a radiation network is is constructed between two grey surfaces exchanging radiant heat energy? 4

Q-5 a) With the help of Buckingham π-theorem show that for a forced convection $Nu = C\,Re^m\,Pr^n$. 8

b) An 8 cm diameter Orange, approximately spherical in shape, undergoes ripening process and generates 5000W/m^{3}of energy. If the external surface of the orange is at 6.5°C calculate the temperature at the center and also find the heat flow from the outer surface. Take k =0.22W/m-K for the orange. Assume steady state heat transfer. 6

c) A 3.2 mm stainless steel wire, 30 cm long has a voltage of 10 Volt impressed on it. The outer surface temperature of the wire is maintained at 93°C. Calculate the center temperature of the wire. Take resistivity (ρ) of the wire as 70×10^{-8} ohm-m and the thermal conductivity as 22.5 W/mK. 6

Q-6 a) 10 mm OD pipe carries a cryogenic fluid at 80K. This pipe is encased by another pipe of 15mm OD, and the space between them is evacuated. The outer pipe is at 280K. Emissivity of inner and outer surfaces is 0.2 and 0.3 respectively. (i) Determine the radiant heat flow rate over a pipe length of 5m. (ii)If a radiation shield of diameter 12mm and emissivity 0.05 on both sides is placed between the pipes, determine the percentage reduction in heat flow. (iii) What is the equilibrium temperature of the shield? 10

b) A spherical tank, 1 m in diameter is maintained at a temperature of 120°C and exposed to a convection environment with h = 25W/m^2-K and temperature of ambient is 15°C. What thickness of urethane foam ($k = 20 \times 10^{-3}$ W/m-K) should be added to ensure that the outer temperature of the insulation does not exceed 40°C? What percentage reduction in heat loss results from installing this insulation? 6

c) Define effectiveness and NTU of a heat exchanger. 4

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