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10ME63

Sixth Semester B.E. Degree Examination, June/July 2015
Heat and Mass Transfer

Time: 3 hrs. Max. Marks:100

Note: ***1. Answer any FIVE full questions, selecting atleast TWO questions from each part.***
2. Use of heat transfer data hand book permitted.

PART – A

1 a. State the laws governing three basic modes of heat transfer. **(06 Marks)**

b. A furnace has a composite wall constructed of a refractory material for the inside layer and an insulating material on the outside. The total wall thickness is limited to 60 cms. The mean temperature of the gases within the furnace is 850°C, the external air temperature is 30°C and the temperature of the interface of the two materials of the furnace wall is 500°C. The thermal conductivities of refractory and insulating materials are 2 and 0.2 W/m–K respectively. The coefficients of heat transfer between the gases and refractory surface is 200 W/m^2-k and between outside surface and atmosphere is 40 W/m^2-k. Find :
i) The required thickness of each material
ii) The rate of heat loss. **(08 Marks)**

c. A small electric heating application uses 1.82 mm diameter wire with 0.71 mm think insulation. K (insulation) = 0.118 W/m-K, and h_0 = 34.1 W/m^2-k. Determine the critical thickness of insulation for this case and change in heat transfer rate if critical thickness was used. Assume the temperature difference between surface of wire and surrounding air remain unchanged. **(06 Marks)**

2 a. Derive an expression for the temperature distribution for a short fin of uniform cross section without insulated tip starting from fundamental energy balance equation. **(10 Marks)**

b. Determine the amount of heat transferred through an iron fin of thickness 5mm, height 50 mm and width 100 cms. Also determine the temperature of the centre of the fin end of the tip of fin. Assuming atmospheric temperature of 28°C. Take K = 50 W/m – K, h = 10 W/m^2 – K, Base fin temperature = 108°C. **(10 Marks)**

3 a. Explain physical significance of :
i) Biot number
ii) Fourier numbers. **(04 Marks)**

b. A steel ball of 5 cm diameter at 450°C is suddenly placed in a controlled environment of 100°C. Considering the following data, find the time required for the ball to attain a temperature of 150°C.
c_p = 450 J/kg-K, k = 35 W/m-K, h = 10 W/m^2 – K, ρ = 8000 kg/m^3. **(06 Marks)**

c. A long 15 cm diameter cylindrical shaft made of SS 314 (k = 14.9 W/m-k, ρ = 7900 kg/m^3) allowed to cool slowly in a chamber of 150°C with an average heat transfer coefficient of 85 W/m^2 – K. Determine :
i) Temperature of the centre of the shaft 25 minutes after the start of cooling process.
ii) Surface temperature at that time
iii) Heat transfer/unit length of shaft during this time period. **(10 Marks)**

4 a. Explain the significance of following non dimensional numbers :
i) Prandtl number
ii) Grashoff number
iii) Nusselt number. **(06 Marks)**

b. A steam pipe 5 cm in diameter is lagged with insulating material of 2.5 cm thick. The surface temperature is 80°C and emissivity of the insulating material surface is 0.93. Find the total heat loss from 10 m length of pipe considering the heat loss by natural convection and radiation. The temperature of the air surrounding the pipe is 20°C. Also find the overall heat transfer co-efficient. **(08 Marks)**

c. A hot plate 1 m × 0.5 m at 130°C is kept vertically in still air at 20°C. Find :
i) heat transfer co-efficient ii) heat lost to surroundings. **(06 Marks)**

PART – B

5 a. For flow over flat plate, discuss concepts of velocity and thermal boundary layer with sketches. **(04 Marks)**

b. Air at a free stream temperature T_∞ and velocity U_∞ flows over a flat plate maintained at a constant temperature T_w. Dimensions of the flat plate is 50 cm × 25 cm. Compare the heat transfer co-efficient when the flow direction is along 50 cm side and 25 cm side. Assume laminar flow over entire plate. **(06 Marks)**

c. Hot air at atmospheric pressure and 80°C enters an 8 m long uninsulated square duct of cross section 0.2m × 0.2 m that passes through the attic of a house at a rate at 0.15 m^3/s. The duct is observed to be nearly isothermal at 60°C. Determine the exit temperature of the air and the rate of heat loss from the duct to the attic space. **(10 Marks)**

6 a. Derive an expression for LMTD for counter flow heat exchanger. State the assumptions made. **(10 Marks)**

b. 8000 kg/hr of air at 105°C is cooled by passing it through a counter flow heat exchanger. Find the exit temperature of air if water enters at 15°C and flows at a rate of 7500 kg/hr. The heat exchanger has heat transfer area equal to 20 m^2 and the overall heat transfer co-efficient corresponding to this area is 145 W/m^2- k. Take C_p of air = 1 kJ/kg – K and that of water (C_{pw}) = 4.18 kJ/kg – K. **(10 Marks)**

7 a. With a neat diagram, explain the typical boiling curve for water at 1 atm pressure. **(08 Marks)**

b. State and explain Fick's law of diffusion. **(04 Marks)**

c. A tube of 15 mm outside diameter and 1.5 m long is used for condensing steam at 40 KPa. Calculate the average heat transfer coefficient when the tube is : i) horizontal ii) vertical and its surface temperature is mentioned at 50°C. **(08 Marks)**

8 a. Explain briefly concept of black body with an example. **(02 Marks)**

b. State and explain :
i) Planck's law
ii) Kirchoff's law
iii) Wiens displacement law
iv) Lambert's cosine law. **(08 Marks)**

c. Two parallel plates, each of 4 m^2 area, are large compared to a gap of 5 mm separating them. One plate has a temperature of 800 K and surface emissivity of 0.6, while the other has a temperature of 300 K and a surface emissivity of 0.9. Find the net energy exchange by radiation between them. If a polished metal sheet of surface emissivity 0.1 on both sides is now located centrally between the two plates, what will be its steady state temperature? How the heat transfer would be altered? Neglect the convection and edge effects if any. Comment upon the significance of this exercise. **(10 Marks)**

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