USN

10ME63

Sixth Semester B.E. Degree Examination, Dec.2018/Jan.2019
Heat and Mass Transfer

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting at least TWO full questions from each part.***

PART – A

1 a. Explain boundary conditions of first, second and third kind. **(06 Marks)**

b. A furnace wall is made of three layers. First layer of insulation (K = 0.6 W/mK) 12cm thick. Its face is exposed to gases at 870°C with convection coefficient of 110W/m^{2}K. It is covered with a 10cm thick layer of fire bricks (110 W/mk) with a contact resistance of 2.6×10^{-4} m^{2}k/w between the first and second layer. The third layer is a plate of 10cm thickness (K = 4 W/mk) with a contact resistance between second and third layers of 1.5×10^{-4} m^{2}k/w. The plate is exposed to air at 30°C with convection coefficient of 15W/m^{2}K. Determine the heat flow rate. **(06 Marks)**

c. Derive 3D conduction equation in Cartesian coordinates. **(08 Marks)**

2 a. A copper pipe carrying the refrigerant at -20°C is 10mm in outer diameter and is exposed to ambient at 25°C with convective coefficient of 50W/m^{2}K. It is proposed to apply the insulation material having thermal conductivity of 0.5W/mK. Determine the thickness beyond which the heat gain will be reduced. Calculate the heat loss for 2.5mm and 7.5mm thick layer of insulation over 1m length. **(04 Marks)**

b. A very long 25mm diameter (K = 380W/mk) rod extends from a surface at 120°C. The temperature of surrounding air at 25°C and the heat transfer coefficient over the rod is 10W/m^{2}k, Calculate the heat loss from the rod. **(08 Marks)**

c. A plane wall of thickness L is made of material whose thermal conductivity varies with temperature according to the relation $K = K_0 (1 + BT)$, where K_0 is the fundamentals derive an expression for temperature distribution. **(08 Marks)**

3 a. What is lumped system analysis? Derive an expression for temperature distribution and rate of heat transfer in case of lumped system analysis. **(08 Marks)**

b. What is Biot number? What is its physical significance? **(04 Marks)**

c. An aluminium sphere weighing 6kg and initially at temperature of 350°C is immersed in a fluid at 30°C with convection coefficient of 60W/m^{2}K. Estimate the time required to cool the sphere to 100°C. Take the thermophysical properties as C = 900 J/kgK, ρ = 2700kg/m^3, K = 205 W/mK. **(08 Marks)**

4 a. Explain velocity and thermal boundary layer. **(06 Marks)**

b. Define Grashoff number. Explain the physical significance of Grashoff number. **(04 Marks)**

c. A hot plate 1m × 0.5m at 130°C is kept vertically in still air at 20°C. Find:

i) Heat transfer coefficient.

ii) Initial rate of cooling the plate in °C/min.

iii) Time required for cooling plate from 180°C to 80°C if the heat transfer is due to convection only.

Take mass of the plate as 20kg and C_p = 400J/kg K. Assume 0.5m side is vertical and convection takes place from both sides of the plate. **(10 Marks)**

PART – B

5 a. Derive an expression for forced convection heat transfer in terms of dimensionless parameters using dimensional analysis. **(10 Marks)**

b. Atmosphere air at 275K and free stream velocity of 20m/s flows over a long flat plate maintained at a uniform temperature of 325K, calculate:
   i) Average heat transfer coefficient over the region of laminar boundary layer.
   ii) Average heat transfer coefficient over the entire length of 1.5m.
   iii) Total heat transfer coefficient over the entire length of 1.5m. **(10 Marks)**

6 a. Derive an expression for LMTD for a parallel flow heat exchanger. **(10 Marks)**

b. 16.5 kg/s of the product at 650°C (C_p = 3.55 kJ/kg°C) in a chemical plant, are to be used to heat 20.5kg/s of the incoming fluid from 100°C (C_p = 4.2 kJ/kg°C). If the overall heat transfer coefficient is 0.95kW/m^2°C and the installed heat transfer surface is 44m^2, calculate the fluid outlet temperature for the counter flow arrangement. **(10 Marks)**

7 a. Explain the different regimes of pool boiling using an appropriate boiling curve. Indicate CHF (Critical Heat Flux) and Leiden frost points on it. **(10 Marks)**

b. State Fick's law of diffusion. **(03 Marks)**

c. A vertical plate 500mm high and maintained at 30°C is exposed to saturated steam at atmospheric pressure. Calculate the following:
   i) Rate of heat transfer.
   ii) Condensate rate/hr/m width of plate for film condensation.

Properties of water at mean film temperature are ρ = 980.3 kg/m^3, K = 66.4 × 10^{-2} W/m°C, μ = 434 × 10^{-6} kg/ms and h_{f_g} = 2257 kJ/kg.

Assume vapour density is small compared to that of condensate. **(07 Marks)**

8 a. Prove that the total emissive power of a black body is equal to π times the intensity of radiation. **(10 Marks)**

b. Two large parallel planes with emissivity of 0.6 are at 900K and 300K. A radiation shield with one side polished and having emissivity of 0.05, while the emissivity of other side is 0.4 is proposed to be used. Which side of the shield should face the hotter plate, if the temperature of shield is to be kept minimum? Justify your answer. **(10 Marks)**

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