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10ME63

Sixth Semester B.E. Degree Examination, Aug./Sept.2020
Heat and Mass Transfer

Time: 3 hrs. Max. Marks:100

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

PART – A

1 a. Explain the three types of boundary conditions used in conduction heat transfer with examples. **(06 Marks)**

b. Derive an expression for the temperature distribution and the rate of heat transfer for a hollow cylinder. **(08 Marks)**

c. A hollow sphere is made of steel of thermal conductivity 40W/m°C. It is heated by means of coil of resistance 100Ω which causes current of 5amps, the coil is located inside the hollow space at the center. The outer surface area of sphere is 0.2m^2 white the sphere weights 32kgs, assuming density of the material of the sphere to be 8gms/cc. Find the temperature difference between outer and inner surfaces. **(06 Marks)**

2 a. Derive an expression for critical thickness of insulation put on an electrical cable. **(06 Marks)**

b. A small electric heating application uses wire of 2mm diameter with 0.8mm thick insulation (K = 0.12W/m°C). The heat transfer coefficient on the insulated surface is 35W/m^2°C. Determine the critical thickness of insulation in this case and percentage change in the heat transfer rate if the critical thickness is used, assuming the temperature difference between the surface of the wire and surrounding air remain unchanged. **(06 Marks)**

c. Two rods A and B of the same length and diameter protrude from a surface at 120°C and are exposed to air at 25°C. The temperatures measured at the end of the rods are 50°C and 75°C. If thermal conductivity of material A is 20W/m°C. Calculate the thermal conductivity of material B. Adopt the condition of a fin insulated at the tip. **(08 Marks)**

3 a. Derive an expression for temperature distribution in a lumped system and show the nature of graph of temperature variation Vs dimensionless parameter. **(10 Marks)**

b. A metallic sphere of radius 10mm is initially at a uniform temperature of 400°C. It is heat treated by first cooling it in air (h = 10W/m^{2}K) at 20°C until its central temperature reaches 335°C. It is then quenched in a water bath at 20°C with h = 6000W/^{2}K until the center of the sphere cools from 335° to 50°C. Compute the time required for cooling in air and water for the following physical properties of the sphere. ρ = 300kg/m^3, C = 1000J/kgK, K = 20W/mK, $\alpha = 6.66 \times 10^{-6}$m^2/s. Also calculate the surface temperature at the end of cooling in water. **(10 Marks)**

4 a. Explain briefly with sketches:
i) Velocity boundary layer thickness
ii) Thermal boundary layer thickness. **(08 Marks)**

b. A thin 80cm long and 8cm wide horizontal plate is maintained at a temperature of 130°C in a large tank full of water at 70°C. Estimate the rate of heat input into the plate necessary to maintain the temperature of 130°C. **(12 Marks)**

PART – B

5 a. With the help of dimensional analysis derive expression which relates Reynolds number, Nusselt number and Prandtl number. **(10 Marks)**

b. The main trunk duct of an air conditioning system is rectangular in cross section (400 × 800mm) and has air at atmosphere pressure and at 20°C flowing with a velocity of 7m/s. Estimate the heat leakage per meter length per unit temperature difference. The relevant physical properties of air are: $\nu = 15.06 \times 10^{-6} m^2/s$ $\alpha = 7.71 \times 10^{-2} m^2/s$ K = 0.0259W/mK. **(10 Marks)**

6 a. Derive an expression for LMTD of a parallel flow heat exchanger, state the assumptions made. **(10 Marks)**

b. Exhaust gases (CP = 1.12kJ/kg°) flowing through a tubular heat exchanger at the rate of 1200kg/hr are cooled from 400°C to 120°C. The cooling is affected by water (CP = 4.18kJ/kgK) that enters the system at 10°C at the rate of 1500kg/hr. If the overall heat transfer coefficient is $500 kg/m^2hr°$. What heat exchanger area is required to handle the load for i) Parallel flow and ii) Counter flow arrangement. **(10 Marks)**

7 a. Sketch and explain boiling curve. **(06 Marks)**

b. State and explain Ficks law of diffusion. **(04 Marks)**

c. The outer surface of a vertical tube which is of length 1.25m and outer diameter 50mm is exposed is saturated steam at atmospheric pressure. If the tube surface is maintained at 80°C by the flow of cooling water through it, determine the rate of heat transfer to the coolent and the rate at which steam is condensed at the tube surface. **(10 Marks)**

8 a. State and explain the following:

i) Stefan – Boltzman law
ii) Kirchoif's law
iii) Planck's law
iv) Wien's displacement law
v) Lamber's cosine law **(10 Marks)**

b. A thermos flask has a double walled bottle and the space between the walls is evacuated so as to reduce the heat flow. The bottle surfaces are silver plated and the emissivity of each surface is 0.025. If the contents of the bottle are 375K, find the rate of heat loss from the thermo battle to the ambient air at 300K. What thickness of cork (K = 0.03W/m°) would be required if the same insulating effect is to be achieved by the use of cork? **(10 Marks)**

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