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12MTP21

Second Semester M.Tech. Degree Examination, Dec.2013/Jan.2014

Advanced Heat Transfer

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer any FIVE full questions.***
2. ***Use of heat transfer data hand book is permitted.***

1 a. The two insulation materials are purchased in powder form as A and B with thermal conductivities 0.005 and 0.035 W/mK respectively. These materials were to apply over a 40 cm diameter sphere as inner layer 4 cm thick and outer layer 5 cm thick respectively. But due to lapse of attention, the material B was applied as first layer and subsequently material A as outer layer. Estimate its effect on conduction heat transfer. **(10 Marks)**

b. A carbon steel pipe (K = 45 W/m-K), 78 mm in inner diameter and 5.5 mm thick has eight longitudinal fins 1.5 mm thick. Each fin extends 30 mm from the pipe wall. If the wall temperature, ambient temperature and surface heat transfer coefficient are 150°C, 28°C and 75 W/m^2-K respectively, calculate the percentage increase in heat transfer rate for the finned tube over the plain tube. **(10 Marks)**

2 a. An iron sphere of diameter 3 cm is initially at a uniform temperature of 225°C. It is suddenly exposed to an ambient at 25°C with convection coefficient of 500 W/m^{2}K.

i) Calculate the centre temperature 2 minute after the start of exposure.
ii) Calculate the temperature at the depth of 1 cm from the surface after 2 minute of exposure.
iii) Calculate the energy removed from the sphere during this period.

The thermo-physical properties of iron plate K = 60 W/m-K, ρ = 7850 kg/m^3, C = 460 J/kgK, $\alpha = 1.6 \times 10^{-5}$ m^2/s. **(10 Marks)**

b. A cubical furnace 0.5m × 0.5m × 0.5m on the inside is constructed of fine brick (k = 1.04 W/mK) with a wall thickness of 100 mm. The temperature drop across the furnace wall is 300°C. Calculate the shape factor for the furnace and determine and heat loss by conduction.

What change in the heat loss would occur, if the cubical furnace is replaced by a spherical furnace which has same inside capacity and wall thickness? **(10 Marks)**

3 a. Two large parallel planes at temperature 1000 K and 600 K have emissivity of 0.5 and 0.8 respectively. A radiation shield having emissivity 0.1 on one side and 0.05 on the other side is placed between the plates. Calculate the heat transfer rate by radiation per square meter with without radiation shield. **(10 Marks)**

b. A cubical room 4m × 4m × 4m is heated through the coiling by maintaining it at uniform temperature of 350 K, while the walls and the floor are at 300 K. Assuming that all surfaces have an emissivity of 0.8, determine the rate of heat loss from coiling by radiation. **(10 Marks)**

4 a. Air at 10°C and at a pressure of 100 kPa is flowing over a plate at a velocity of 3 m/s. If the plate is 30 cm wide and at a temperature of 60°C. Calculate the following quantities at x = 0.3 m.

i) Boundary layer thickness
ii) Local friction coefficient
iii) Local shearing stress
iv) Total drag force
v) Thermal boundary layer thickness **(10 Marks)**

b. Derive an expression for Reynolds Colburn analogy for laminar flow over a flat plate. **(10 Marks)**

5 a. Hot air flows with a mass flow rate of 0.05 kg/s through an un-insulated sheet metal duct of diameter 0.15 m which is located in a large room. The hot air enters at 103°C, after a distance of 5m it cools to 77°C. The heat transfer coefficient between the duct outer surface and ambient air at 0°C is 6 W/m^2-K.

i) Calculate the heat loss from the duct over its length.

ii) Determine the heat flux and the duct surface temperature at x = L. **(10 Marks)**

b. Atmospheric air at T_∞ = 275 K and a free stream velocity u_∞ = 20 m/s flows over a flat plate L = 1.5 m long that is maintained at a uniform temperature T_w = 325 K.

i) Calculate the average heat transfer coefficient over the region where the boundary layer is laminar.

ii) Find the average heat transfer coefficient over the entire length L = 1.5 m of the plate.

iii) Calculate the total heat transfer rate from the plate to the air over the length L = 1.5 m and width W = 1 m. Assume transition occurs are $Re_c = 2 \times 10^5$. **(10 Marks)**

6 a. A thin square plate of 0.6 m × 0.6 m is in a room at 30°C. One side is maintained at a temperature of 90°C, while the other side is insulated. Determine the rate of heat transfer from the plate by natural convection if the plate is:

i) vertical

ii) horizontal with hot surface facing up

iii) horizontal with hot surface facing down. **(10 Marks)**

b. Water at the rate of 0.8 kg/s at 90°C flows through a steel tube having 25 mm inner diameter and 30 mm outer diameter. The outside surface temperature of the pipe is 84°C and temperature of surrounding air is 20°C. The room pressure is 1 atm and pipe is 15 cm long. How much heat is lost by free convection in the room? **(10 Marks)**

7 a. Derive an expression for effectiveness of a parallel flow heat exchanger in terms of number of transfer units (NTU) and heat capacity ratio of two fluids (C). **(10 Marks)**

b. A counter flow heat exchanger is used to heat water from 20°C to 80°C at a rate of 1.2 kg/s. The heating is obtained by using geothermal water available at 160°C at a mass flow rate of 2 kg/s. The inner tube is thin walled and has a diameter of 1.5 cm. If the overall heat transfer coefficient is 640 W/m^{2}K, calculate the length of heat exchanger required to achieve the desired heating by using effectiveness – NTU method. **(10 Marks)**

8 a. With the help of sketch, explain the various regimes of pool boiling. **(10 Marks)**

b. A vertical tube 40 mm diameter and 1 m long is used for condensing steam at atmospheric pressure. The tube surface temperature is 60°C.

i) Determine the mass of condensate

ii) If the tube is held horizontal position, will there be any change in mass of condensate? If yes, calculate the value and change. **(10 Marks)**

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