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06ME65

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 book is permitted.

PART – A

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

b. Derive the general 3-dimensional conduction equation in Cartesian co-ordinates, with a figure **(08 Marks)**

c. Determine the heat transfer through the composite wall shown in Fig.Q.1(c). Take the thermal conductivities of A, B, C D and E as 50, 10, 6.7, 20 and 30 W/mK respectively. Assume 1-D heat transfer. **(06 Marks)**

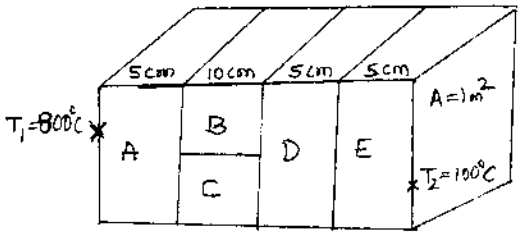

Fig.Q.1(c)

2 a. A steel pipeline (K = 50 W/mK) of ID 100mm and OD of 110mm is to be covered with two layers of insulation each having a thickness of 50mm. The thermal conductivity of first material in 0.06 W/mK and that of second insulation material in 0.12 W/mK. Calculate the heat loss per metre length of pipe and the interface temperatures between the two layers of insulation when the temperature of the inside steel pipe surface is 250°C and that of the outside surface of insulation in 50°C. If the second insulation material in placed first, what is the percentage increase or decrease of heat loss. **(10 Marks)**

b. A plate fin of 8mm thickness of 60mm length is used on a wall at 200°C. Thermal conductivity of fin is 210 W/mK. Convective heat transfer coefficient in $25 W/m^{2^\circ}K$. Surrounding air temperature is 35°C. Determine: i) Heat flow from fin; ii) If the same fin is split into 4mm thick fins determine the heat flow from the fins. Assume short fin end insulated conditions. Take width as 1m. **(10 Marks)**

3 a. An egg with a mean diameter of 4cm and initially at 25°C is placed in a boiling water pan for 4 min and found to be boiled to the consumers taste. For how long should a similar egg for the same consumer be boiled when taken from a refrigerator at 5°C. Assume following properties for egg. K = 12 W/mK, h = 125 W/mK, C(specific heat) = 2 kJ/kg K, $\rho = 1250 kg/m^3$. Treat egg as a sphere. **(10 Marks)**

b. On a hot summer day a concrete highway may reach a temperature of 55°C. Suppose that a stream of water in directed on the highway so that the surface temperature is suddenly lowered to 35°C. How long will it take to cool the concrete to 45°C at a depth of 5cm from the surface? Assume the following properties K = 1.279 W/mK $\alpha = 1.77 \times 10^{-3} m^2/h$. Assume semi-infinite said. **(10 Marks)**

4 a. With a sketch explain: i) Velocity boundary layer ii) Thermal boundary layer. **(10 Marks)**

b. A large vertical plate 4.0m high is maintained at 60°C and exposed to atmospheric air at 10°C. Calculate the heat transfer rate if plate is 10m wide. **(10 Marks)**

PART – B

5 a. Air at 27°C and at atmospheric pressure flows over a flat plate, at a speed of 2m/s. The plate is maintained at 93°C. Calculate the heat transfer rate per unit width of plate assuming the length of plate along the flow of air as 2 mts. **(10 Marks)**

b. Air stream at 27°C moving at 0.3 m/s across 100W incandescent bulb glowing at 127°C. If the bulb is approximated by a 60mm diameter sphere, estimate the heat transfer rate and the percentage of power lost due to convection. Use the following correlation $N_D = 0.37\ Re_D^{0.6}$ **(10 Marks)**

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

b. Saturated steam at 120°C is condensing on outer tube surface of a single pass parallel HE. The heat transfer coefficient is 1800 W/m^2K. Determine the surface area of heat exchanger which can heat 1000 kg/hr of water from 20°C to 90°C. Also calculate rate of condensation of steam. Assume $C_{pc} = 4186$ J/kg K and $h_{fg} = 2200$ kJ/kg. **(10 Marks)**

7 a. Differentiate between the following:

i) Nucleate boiling and film boiling.

ii) Sub-cooled boiling and saturated boiling.

iii) Film wise condensation and drop wise condensation. **(09 Marks)**

b. Dry saturated steam at a pressure of 2.45 bar condenses on the surface of a vertical tube of height 1m. The tube surface temperature is kept at 117°C. Estimate the thickness of condensate film and the local heat transfer coefficient at a distance of 0.2m from the upper end of tube. **(11 Marks)**

8 a. Emissivities of two large parallel plates maintained at 800°C and 300°C are 0.3 and 0.5 respectively. Find the net radiant heat exchange per square metre for these plates. **(06 Marks)**

b. State and explain Kirchoff's law. **(06 Marks)**

c. Explain the following:

i) Emissivity

ii) Monochromatic emissive power

iii) Gray surface

iv) Black surface. **(08 Marks)**

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