This question paper contains 4 printed pages.

3275 *Your Roll No.....*

B.Tech. (M) / IV

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Paper EME - 402 - HEAT TRANSFER

Time : 3 hours *Maximum Marks :70*

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt any five question.
Assume missing data suitably, if any.
Use of Heat Transfer Data Book is permitted.

1. a) A wall thickness L is made of material whose thermal conductivity varies with temperature as follows $k = k_0 T^2$. Find the expression for steady state conduction through the wall per unit area and mean thermal conductivity if two surfaces are maintained at temperatures T_1 and T_2.

   b) A reactor wall 400mm thick is made up an inner layer of fire brick (k = 0.84 w/mk) covered with a layer of insulation (k = 0.16 w/mk). The reactor operates at a temperature of 1425°C and the ambient temperature is 25°C. Determine thickness of firebrick and insulation which give minimum heat loss and calculate the heat loss presuming that the insulating material has a maximum temperature of 1250°C at the interface. *(5, 9)*

2 a) Define critical thickness of insulation. Derive the expression of critical thickness of insulation for sphere.

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b) A 100mm diameter of pipe is covered by two layers of lagging. The inside layer is 40mm thick and has a thermal conductivity of 0.07 w/mk. The outside layer is 25mm thick and has a thermal conductivity 0.08 w/mk. Another outside layer 25mm thick has a themal conductivity of 0.01 w/mk. The inside of pipe is maintained at 300°C and outside of lagging is maintained at30°C. If the pipe is 20m long, determine the heat loss per hour and interface temperature of lagging. *(4, 10)*

3 a) One end of the long rod is inserted into a furance and the other end projects into the surrounding air at 20°C. Under steady state conditions, the temperature of the rod measured at two points 100mm apart was formed to be 120°C and 100°C respectively. If the diameter of the rod is 25mm and thermal conductivity of Fin material is 120 w/mk, make the calculations for the surface heat transfer co-efficient.

b) Derive the expression for temperature distribution and maximum temperature in solid cylinder with uniform internal heat generation. *(8, 6)*

4 a) What is transient heat conduction ?

b) Define Biot number and fourier number. Explain their physical significance in transient heat conduction.

c) A 12mm diameter mild steel sphere (k = 42w/mk) is exposed to air at 27°C. Determine the time required to cool the sphere from 540°C and 90°C. Take

$h = 114 w/m^2k$. The relevant properties of mild steel are :

$\rho = 7800 kg/m^3$, $c = 475 J/Kg/C$, $\alpha = 0.043 m^2/hr$

(2, 5, 7)

5 a) State and explain the following laws relatings to themal radiation.

(i) Planck's law

(ii) Stefan Boltzman's law

(iii) Wien's displacement law

(iv) Kirchoff's law of radiaion.

b) Two circular disc of diameter 20cm each are placed 2m apart. Calculate the radiant heat exchange for these plates if these are maintained at 800°C and 300°C respectively and their corresponding emissivities are 0.3 and 0.5. *(8, 6)*

6 a) Air at 20°C and 1 bar flows over a flat plate of 40m/s. The plate is 1m long and is maintained at 60°C. Assuming unit depth calculate the heat transfer from the plate. The relevant properties of air are :

$\rho = 1.128 kg/m^3$, $c_p = 1.005$ KJ / Kg k,

$k = 0.0275$ w/mk , $\gamma = 16.96 \times 10^{-6} m^2/s$

$p_r = 0.699$

b) Determine the heat transfer rate by free convection from a plate 0.3 x 0.3m for which one surface is maintained at 110°C and other surface is insulated and exposed to air at 30°C if the plate is vertical. The relevant properties of air are :

$p_r = 0.694$, $\dot{\gamma} = 20.02 \times 10^{-6} m^2/s$, $k = 0.02966$ w/mk

(7, 7)

7 a) Explain the concept of LMTD method of Heat exchanger.

b) Define NTU and effectiveness of heat exchanger. What is fouling factor ?

c) A single pass counter flow shell and tube heat exchanger is used to heat water from 20°C to 80°C at the rate of 5kg/s using oil entering shell side at 150°C and leaving at 90°C. The overall heat transfer co-efficient is $400 w/m^2k$. Calculate heat transfer surface required. *(3, 4, 7)*

8. Explain the following :
   (i) Transient heat conduction.
   (ii) Thermal Boundary layer
   (iii) Nucleate Boiling and Film boiling. *14*