1T01425 - T.E.(MECHANICAL)(Sem V) (Choice Based) / 32603 - Heat Transfer

(Time: 3 Hours) **[Total Marks: 80]**

N.B.: (1) Question no.1 is **Compulsory**.
(2) Attempt any **THREE** from question no.2 to 6.
(3) Figure to right indicates marks for that individual question.
(4) Assume suitable data if necessary with justification.

1 Answer any **Five** questions :- **20**

a) Explain Thermal contact resistance & Thermal network resistance.
b) Explain Initial and Boundary conditions.
c) What is Efficiency and Effectiveness of fin?
d) Explain non-dimensional number used in convection heat transfer.
e) Define Shape factor and write down the properties of shape factor.
f) Explain construction and working of Heat Pipe.

2 (a) An electrical cable of 20mm diameter at a surface temperature of 70^0C is insulated with rubber, which is exposed to atmosphere at 30^0C. Calculate the most economical thickness of rubber insulation (k = 0.175 W/m K).Also calculate the percentage increase in heat dissipation and percentage increase in current carrying capacity when most economical thickness is provided.Take convective heat transfer coefficient (h_o) = 9.3 W/m^{2}K.Assume that the surface temperature of the cable and outside convective heat transfer coefficient without insulation are same as those in insulated condition. **10**

(b) Consider two very long cylinder rods of the same diameter but of different materials. One end of the rod is attached to a base surface maintained at 100^0C, while the surfaces of rods are exposed to ambient air at 20^0C. It is observed that, the temperatures of the rods were equal to the position x_A= 0.15m & x_B = 0.075m, where 'x' is measured from the base surfaces. If the thermal conductivity of rod A is k_A = 72 W/mK. Determine thermal conductivity of rod B. **10**

3 (a) A two shell and four tube pass heat exchanger is used to heat glycerin from 20^0C to 50^0C by hot water, which enters thin wall 20mm diameter tube at 80^0C and leaves at 40^0C. The total length of the tube in the heat exchanger is 60 m. The convection coefficient on shell side is 25 W/m^{2}K and that on tube side is 160 W/m^{2}K. Calculate rate of heat transfer in the heat exchangers for clean surfaces of tubes. **08**

Refer Figure 1.

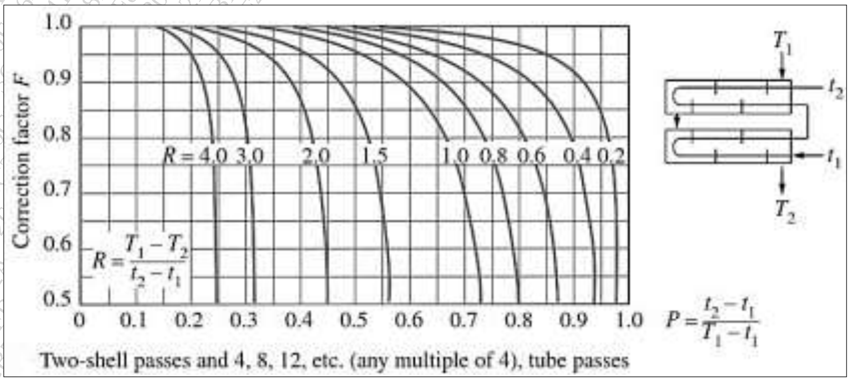

Figure 1: Correction factor graph

(b) A flat plate 1m wide and 1.5m long is maintained at 90^0C in air with free stream temperature of 10^0C flowing along 1.5m side of plate. Determine the velocity of the air required to have a rate of energy dissipated as 3.75kW. Consider convection is on both sides of plate. **08**

Use relation:

$Nu_L = 0.664\, Re^{1/2}\, Pr^{1/3}$ for laminar flow

$Nu_L = [0.036\, Re^{0.8} - 836]\, Pr^{1/3}$ for turbulent flow

Take properties of air at 50^0C are:

$\rho = 1.0877$ kg/m^3, $\mu = 2.029 \times 10^{-5}$ kg/ms, $k_f = 0.028$ W/mK

Pr = 0.703, $C_p = 1.007$ kJ/kg.K

(c) What is Critical thickness of Insulation, for cylinder and sphere, its significance **04**

4 (a) A furnace wall is made of three layers. First layer is of insulation (k = 0.6 W/m K), 12cm thick. Its face is exposed to gases at 870^0C with convection coefficient of 110 W/m^{2}K. It is covered with (backed with), a 10cm thick layer of fire brick (k = 0.8 W/m K) with a contact resistance of 2.6×10^{-4}K/W between first and second layer. The third layer is a plate of 10cm thickness (k = 4 W/m K) with a contact resistance between second and third layer of 1.5×10^{-4} K/W. The plate is exposed to air at 30^0C with convection coefficient of 15 W/m^{2}K. Determine the heat flow rate and overall heat transfer coefficient. **08**

Assume area of wall surface =1m^2

(b) Explain Buckingham – π theorem **06**

(c) For Lumped system analysis with usual notation, **06**

Prove that $\frac{\theta}{\theta_0} = e^{-Bi\,Fo}$

5 (a) Consider a rectangular plate 0.2m x 0.4m is maintained at a uniform temperature of 80^0C. It is placed in atmospheric air at 24^0C. Compare the heat transfer rates from the plate for the following case **08**

Case i) When the vertical height is 0.2m

Case ii) When the vertical height is 0.4m

Use: $Nu_L = 0.59\,(Gr.Pr)^{1/4}$

Take properties of air at 325K are as follows:

$\nu = 1.822 \times 10^{-5}$ m^2/s, Pr = 0.703, $K_{air} = 0.02814$ W/m K

(b) Starting from basic derive an expression for effectiveness of parallel flow heat exchanger in terms of NTU and capacity ratio. **12**

6 (a) Write short note on (Any two) **10**

i) Numerical methods in heat transfer

ii) Hydrodynamic and Thermal boundary layer

iii) Intensity of radiation & Solid angle

(b) Two large parallel planes with emissivity 0.6 are at 900K and 600K. 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 to face the hotter plane, if the temperature of shield is to be kept minimum? Justify your answer. **10**
