Time : 3 Hours **Marks: 80**

Note: - (1) Question No. 1 is compulsory
(2) Answer any Three out of reaming Five
(3) Make suitable assumption, if necessary

Q1. Solve any Five **(5*4)**

a) A steam pipe is insulated to reduce the heat loss. However, the measurement reveals that the rate of heat lost has increased instead of decreasing .Can you comment why?

b) How does a fin enhance heat transfer at a surface? What are the various types of fins? List the assumptions made while analyzing the heat flow from a finned surface.

c) What is lump system analysis? What are the assumptions made in the lumped system analysis and when is it applicable?

d) When heat transfer through a fluid layers is by conduction and when it is by convection? For what case, the rate of heat transfer is higher?

e) What are the limitations of LMTD method? How is Effective – NTU method superior to LMTD method?

f) State and explain Wien's displacement law.

Q.2 a) A thermocouple junction of spherical form is 8 mm diameter. **(10)**
Properties of the material are:
$C = 420$ J/kg-K, $\rho = 8000$ kg/m^3, $k = 40$ W/m-K and $h = 40$ W/m^{2}K.
This junction is initially at 40°C and inserted in a stream of hot air at 300°C.
Find:
(i) Time constant of the thermocouple
(ii) The thermocouple is taken out from the hot air after 10 seconds and kept in air at 30°C. Assuming the heat transfer coefficient in air 10 W/m^2 K, find the temperature attained by the junction 20 seconds after removing from hot air.

b) Derive Fourier's differential equation in the Cartesian Co-ordinate. **(10)**

Q.3 a) A refrigerated truck is moving on a highway at 90 km/h in a desert area where the ambient air temperature is 50°C. the body of the truck may be considered as a rectangular box measuring 10 m (Length) × 4 m (Width) × 3 m (Height). Assuming that the boundary layer on the four walls is turbulent, the heat transfer takes place only for the four surfaces and the wall surface of the truck is maintained at 10°C. Neglecting heat transferred from the front and back and assuming the flow to be parallel to 10 m long side, Calculate the following: **(10)**

1. The heat loss from the four surfaces,
2. The power required to overcome the resistance acting on the four surfaces.

Use the equation: $Nu = 0.036(Re)^{0.8}(Pr)^{0.33}$ if $Re_L > 1\times10^5$

The properties of air at 30°C :

$\rho = 1.165$ kg/m^3; $Cp = 1.005$ kJ/kgK; $k = 0.02673$ W/m-K; $\nu = 16\times10^{-6}$ m^2/s; $Pr = 0.701$

b) For transient heat conduction, with negligible internal resistance, with usual notations, show that: $\frac{\theta}{\theta_o} = \exp\left(-B_i . F_o\right)$ Also state the significations of 'B_i' and 'F_o'. **(10)**

Q.4 a) Two stroke motor cycle cylinder consists of 15 fins. If the outside and inside diameters of each fin are 200 mm and 100 mm respectively, the average fin surface temperature 475°C and atmospheric air temperature is 25°C, calculate the heat transfer rate from the fins for the following cases. **(10)**

(i) When the motor cycle is stationary

(ii) When the motor cycle is running at the speed of 60 km/h

The fin may be idealized as single horizontal flat plate of the same area. Use significant length

L = 0.9D to calculate Gr and Re.

Use equation $Nu = 0.54(Gr \times Pr)^{0.25}$ if nature of flow is laminar i.e. $Gr.Pr < 10^9$ and

$Nu = 0.036(Re)^{0.8} \times (Pr)^{0.33}$ if nature of flow is turbulent.

The properties if air at 250°C:

k= 0.04266 W/m-K; $\nu = 40.61 \times 10^{-6}$ m^2/s; Pr = 0.677

b) Derive an expression for the effectiveness of a parallel flow heat exchanger in terms of the number of transfer units, NTU, and the capacity ratio C_{min}/C_{max}. **(10)**

Q.5 a) A parallel flow heat exchanger has hot and cold water streams running through it and has the following data: **(10)**

Mass flow rates of hot and cold water are 10 kg/min and 25 kg/min respectively. Inlet and outlet temperatures of hot water are 70°C and 50°C respectively. Inlet temperature of cold water is 25°C. Individual heat transfer coefficient on both sides = 60 W/m^{2}K. Calculate:

(i) Area of heat exchange,

(ii) Exit temperatures of hot and cold fluids if hot water flow rate is doubled.

b) Define Shape factor and discuss its properties. Derive an expression for shape factor for **(10)**

(i) Hemispherical shape of radius R (ii) Two concentric cylinders.

Q.6 a) Consider two large parallel plates one at $T_1 = 727$°C with emissivity $\varepsilon_1 = 0.8$ and other at $T_2 = 227$°C with emissivity $\varepsilon_2 = 0.4$. An aluminum radiation shield with an emissivity $\varepsilon_s = 0.05$ on both side is placed between the plates. Calculate the percentage reduction in heat transfer rate between two plates as a result of the shield. **(10)**

Use $\sigma = 5.67 \times 10^{-8}$ W/m^{2}K^4

b) Write short note on any **two** of the following **(10)**

i) Heisler Charts.

ii) Boiling curves and various regimes of boiling.

iii) Heat Pipe.

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