B.TECH. SEM -V MECHANICAL 2014 COURSE (CBCS) : WINTER - 2017

SUBJECT: HEAT & MASS TRANSFER

Day : **Thursday** Time : **02.30 PM TO 05.30 PM**

Date : **18/01/2018** Max. Marks: 60

W-2017-2160

N.B.:

1) All questions are **COMPULSORY**.
2) Figures to the right indicate **FULL** marks.
3) Use of non-programmable **CALCULATOR** is allowed.
4) Assume suitable data if necessary.

Q.1 Explain the concepts of thermal resistance and conductance. A square plate heater (size 10 cm × 10 cm) is inserted between two slabs. Slab 'A' is 2 cm thick (k = 40 W/mK) and Slab 'B' is 1 cm thick (k = 0.2 W/mK). The outside heat transfer coefficient on 'A' and 'B' side are 200 W/m^2k and 25 W/m^2K respectively. The temperature of surrounding air is 26^0C. If rating of heater is 3 KW. Find: **[10]**

i) Maximum temperature of the system.

ii) Outer surface temperature of both slabs.

OR

Explain variation of thermal conductivity in solids and liquids with temperature giving out reasons. A steel tube with 4 cm ID and 6 cm OD (k = 38 W/mK) is covered with an insulation covering of thickness 16 mm (k = 0. W/mK), a hot gas at temperature of 500^0C with convective heat transfer coefficient of 300 W/m^2k flows inside the tube. The outer surface of insulation is exposed to cold air at -5^0C with h = 20 $W/m^2\ ^0C$. Calculate heat flow rate from the pipe and the interface temperature between steel and insulation.

Q.2 Explain the critical radius of insulation. A metal slab of 2 cm thickness (k = 25 W/mK) generates internal heat energy at a uniform rate of 10^8 W/m^3. One face of this slab is insulated and other face is maintained at 300^0C due to its exposure to a fluid. Determine maximum temperature in the slab and its location. Also find out total heat flow out from the slab. **[10]**

OR

"While insulating a small diameter electric conductor, aim was to increase the heat transfer rate. However it was found on measurement that heat transfer rate was in fact decreases." Justify.

A plate having a thickness of 0.45 cm has an internal heat generation of 220 Mw/m^3 and a thermal conductivity of 25 W/mK. One side of the plate is insulated and the other side is maintained at 100^0C. Calculate maximum temperature in the plate. What is the temperature at the center of the plate?

Q.3 Explain significance of Biot and Fourier Number. **[10]**

An electric motor 200 mm long dissipating heat at a rate of 300 W is required to be fitted with plate fins radially outwords so that motor surface temperature dues not exceed 60^0C. Plate fins are 15 mm thick of 50 mm length with k = 40 W/m^0C. Motor is exposed to atmosphere at 25^0C with convective heat transfer coefficient of 20 W/m^2K. Determine number of fins required neglecting convection from tip of fins. Ignore heat convection from unfinned area of motor's outer surface.

P.T.O.

OR

Explain the significance of time constant for a thermocouple. Derive the expression for heat flow through an infinitely long solid cylinder with internal heat generation.

Q.4 Explain the concept of hydraulic boundary layer with neat sketch. A circular disc of diameter 30 cm is exposed to air at 293 K. If the disc is maintained at 393 K, estimate the heat transfer rate from it, when: **[10]**

i) Disc is kept horizontal (Take characteristics length = Area / perimeter).

ii) Disc is kept vertical for air at 70^0C, K = 0.03 w/mk, pr = 0.697, $v = 2.07 \times 10^{-6}$ m^2/s use the following correlations:

$Nu = 0.14 (R_a)^{0.334}$ for surface facing upward

$Nu = 0.27 (R_a)^{0.25}$ for surface facing downward

$Ny = 0.59 (Gr\ Pr)^{0.25}$ for vertical surface.

OR

Explain with neat sketches the natural convection flow patterns. Water flow at the rate of 4500 kg/hr and is heated from 20^0C to 50^0C by passing through a square duct of 20 mm × 20 mm. The duct is heated by condensing steam at 100^0C on its outer surface. Find the length of the duct required. Take properties of water

Density = 990 kg/m^3, $\mu = 7.6 \times 10^{-4}$ kg/m^3, C_p = 4.17 kJ/kgK, K = 0.62 W/m^0C conductivity of duct material = 24 W/m/K.

Use : $Nu = 0.023 (Re)^{0.8} (Pr)^{0.4}$ for turbulent flow

$Nu = 4.36$ for laminar flow.

Q.5 Explain with sketch the pool boiling with typical pool boiling curve. A thin aluminium sheet with an emissivity of 0.1 for both surfaces is placed between two very large parallel plates that are maintained at uniform temperature of T_1 = 800 K and T_2 = 600 K and have emissivities $\epsilon_1 = 0.2$ and $\epsilon_2 = 0.7$ respectively. Determine the net rate of radiation heat transfer in w/m^2 and compare it with the heat transfer rate without shield. **[10]**

OR

Explain the concepts of Radiosity and Irradiation. Discuss the relation between intensity of radiation and emissive power.

Q.6 Derive the expression for LMTD for parallel flow heat exchanger. Also give the detailed classification of heat exchangers. **[10]**

OR

Explain the analogy of heat and mass transfer. A heat exchanger with counter flow arrangement has a overall heat transfer coefficient of 400 W/m^2K, based on outer surface area of 100 m^2. Find the outlet temperature of hot and cold fluids from the data as follows:

	Hot fluid	**Cold fluid**
Inlet temperature (^{0}C)	600	80
Mass flow rate (kg / min)	800	1000
Specific heat (J / kgK)	3000	4200

* * * *