**Q.P. Code : 25267**

**[Time: 3 Hours]** **[ Marks:80]**

Please check whether you have got the right question paper.

N.B:
1. Q. No. 1 is compulsory.
2. Attempt any Three out of remaining questions.
3. Assume suitable data if necessary and state it clearly.
4. Draw neat sketches wherever required.
5. Answer to the sub questions of individual question should be grouped & written together i.e one below the other.
6. Steam Tables would be provided.

1. Solve all sub questions:
   a) Derive for critical thickness for the insulation applied over hollow cylinder. **05**
   b) State the laws of radiation. **05**
   c) State (only) assumptions for Nusselt theory for condensation. **05**
   d) Explain thermal boundary layer in convection. **05**

2. a) A flat furnace wall is constructed of a 144 mm layer of Sil-o-cel brick having a thermal conductivity of 0.138 W/m K backed by a 229 mm layer of common brick having a thermal conductivity of 1.38 W/m K. The inside face temperature of the wall is 1033 K (760°C) and the outside face temperature is 349 K (76°C). Find the heat loss through the wall unit area and the temperature at the interface. Supposing that the contact between two brick layers is poor and that a contact resistance of 0.09 K/W is present, what would be the heat loss? **10**
   b) A steel pipe 25 mm internal diameter and 33 mm outer diameter and insulated with rock wool carries steam at 451 K (178°C). lf the surrounding air temperature is 294 K (21°C), Calculate the rate of' heat loss from one meter length of pipe. The thickness of insulation is 38mm.Thermal conductivities of steel and rock wool are 44.97 W/m K and 0.175 W/m K respectively. The inside and outside heat transfer coefficients are 5678 $W/m^2$ K and 11.36 $W/m^2$ K respectively. Contact resistance between the pipe and insulation may be neglected. **10**

3. a) For heat transfer by forced convection show that Nusselt number is function of Reynolds number and Prandtl number by dimensional analysis. **10**
   b) Derive design equation heat exchanger "$Q = U.A \Delta T_{1m}$". **10**

4. a) Calculate the total length of' a double pipe heat exchanger require to cool 5500 Kg/hr of ethylene glycol from 358 K (85°C) to 341K (68°C) using toluene as a cooling medium which flows in a counter current fashion Toluene enters at 303 K ($30^0$C) and leaves at 335 K ($62^0$C). **20**

   Data:

   Outer diameter or outer pipe = 70 mm
   Outer diameter of' inner pipe = 43 mm
   Wall thickness of both pipes = 3mm

**Turn Over**

Physical properties of two fluids at mean temperature are as given below:

| Property | Ethylene glycol | Toluene |
|---|---|---|
| Specific heat | 2.680 KJ/Kg. K | 1.80 KJ/Kg.K |
| Density | 1080 Kg/$m^3$ | 840 Kg/$m^3$ |
| Thermal conductivity | 0.248 W/m. K | 0.146 W/m. k |
| Viscosity | 3.4 x$10^{-3}$ Pa.sec | 4.4 x $10^{-4}$ Pa.sec |

Thermal conductivity of the pipe wall material is 46.52 W/mk and ethylene glycol is flowing through the inner pipe.

5. a) A 30cm long glass plate is hung vertically in the air at 300 K (27°C).The plate is maintained at 356 K ($77^0$C ). Calculate the average heat transfer coefficient for natural and force convection. Take free stream velocity of air 4m/s. **10**

Data: The properties of air at 325K are:

| | |
|---|---|
| $\beta$ | 3.77 x $10^{-3}$ $K^{-1}$ |
| $N_{pr}$ | 0.7 |
| Thermal conductivity | 0.02815 W/m. K |
| Kinematic Viscosity | 18.41 x $10^{-6}$ $m^2$/sec |

b) Dry steam at 373K ($100^0$C) condenses on the outside surface of a horizontal pipe of 25 mm outside diameter. The pipe surface is maintained at 357K (84°C) by circulating water through the pipe. Calculate the average/mean heat transfer coefficient, the heat transfer per unit length of the pipe and the condensate rate per unit length of the pipe. Data: The properties of the condensate at the film temperature of 350K arc: **10**

| | |
|---|---|
| Density | 974 Kg/$m^3$ |
| $\lambda$ | 2255 KJ/Kg |
| Thermal conductivity | 0.668 W/mK |
| Viscosity | 3.6 x $10^{-6}$ Ns/$m^2$ |

6. Write short note on (any four) **20**

a) Wilson plot
b) Boiling regimes in pool boiling
c) Unsteady state heat transfer with negligible internal resistance.
d) Extended surface for heat exchanger.
e) Significance or Biot Number and Fourier Number.

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