Seat No. | | | | | | |

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Heat & Mass Transfer
(1010)

P. Pages : 4

Time : Three Hours **Max. Marks : 100**

Instructions to Candidates :

1. Do not write anything on question paper except Seat No.
2. Answersheet should be written with blue ink only. Graph or diagram should be drawn with the same pen being used for writing paper or black HB pencil.
3. Students should note, no supplement will be provided.
4. All question are compulsory. Solve **any two** bits from (a, b, c)
5. Use non-programmable calculator, steam table and heat transfer data book is allowed.
6. Neat diagram must be drawn if necessary.
7. Assume suitable data if necessary.

1. a) Prove that $\left(\frac{\partial^2 t}{\partial r^2} + \frac{1}{r}\frac{\partial t}{\partial r}\right) = 0$ by using three dimensional steady state heat conduction equation in cylindrical co-ordinates. **10**

b) 55kg per steam flowing through a convective steam superheater 35 (inner) / 45 (outer) dia. made up of steel (k = 38.5 w/m°C) The pressure of dry saturated steam at inlet of superheater is 120 bar. The temperature of steam leaving the super heater is 480°C. The heat transfer coefficient from gas to wall and from wall to steam are 82 w/m^2°C and 1120 w/m^2°C resp. If mean flue gases temperature is 920°C. Determine

i) Inner and outer heating area of superheater.

ii) Outer and inner overall Heat Transfer Coefficient. Take specific heat of steam is 1.92 kJ/kg°C. **10**

c) i) Prove that spherical surface temperature (wall) is

$$T_w = \frac{\dot{q}_g R}{3h} + T_f$$

where T_f = ambient temperature

T_w = spherical surface, surface temperature. **5**

ii) A cable of 10 mm outside is to be laid in an atmosphere of 25°C (ho = 12.5 w/m^2 deg) and its surface temperature is likely to be 75°C due to heat generated within it. How would the heat flow from the cable be affected if it is insulated with rubber having thermal conductivity k = 0.15 w/m. deg. **5**

2. a) A motor body is 360 mm in dia outside and 240 mm long. Its surface temperature should not exceed 55°C. When heat decipates 340 w longitudinal fins. of 15 mm thickness and 40 mm height are proposed the convection coefficient is 40 w/m^2°C. Determine the number of fins required atmospheric temperature is 30°C. Thermal conductivity is 40 w/m^2°C. **10**

b) An enclosure measure 1.5 m x 1.75 m with a height of 2m. Under steady state equilibrium conditions, the walls and ceiling are maintained at 525 k and floor at 400 k. Determine the net radiation to floor. **10**

E_1 (emissivity of ceiling and wall) = 0.85

E_2 (emissivity of floor) = 0.75

c) i) Define efficiency and effectiveness of fin and also derive what is the relation between them. **5**

ii) Explain Radiation shield and also derive the shield temperature is

$$T_3^4 = \frac{T_1^4 + T_2^4}{2} \text{ where}$$

T_1 & T_2 are plate temperature

T_3 is shield temperature **5**

3. a) A 3.5 kw plate heater 15cm x 30 cm is held vertically with larger side vertically in a water bath at 40°C make calculation for the steady state temperature attained by the heater. If heat transfer is only for convection. Use following co-relation.

$$N\mu = 0.15(Gr \cdot Pr)^{0.33}$$

$$\beta = 4.15 \times 10^{-4} /^\circ C$$

Properties of water $\rho = 977.8 kg/m^3$ $C_P = 4.187 kJ/kgk$,

$\nu = 0.415 \times 10^{-6} m^2/s$ $k = 0.667$ w/mk. **10**

b) A motor cycle cylinder consists of 10 fins, each 15 cm outside dia. and 7.5 cm inside dia. calculate the rate of heat dissipation from the cylinder fin when :

i) Motor cycle is stationary and

ii) Motor cycle is running at 60 km/hr. The atmospheric air is at 20°C and the average fin temperature is 480°C. The relevant thermophysical properties at the average temperature of 250°C are

$\rho = 0.674 \text{ kg/m}^3$ $C_P = 1038 \text{ J/kg k}$

$k = 0.427 \text{ w/mk}$ $P_r = 0.677$

$\nu = 40.61 \times 10^{-6} \text{m}^2/\text{s}$

$N\mu = 0.54 \ (Gr \cdot P_r)^{1/4}$ for laminar flow

$N\mu = 0.036 \ (Re)^{0.8} \ (Pr)^{0.33}$ for Turbulent flow. **10**

c) i) Explain Hydrodynamic boundary layer. **5**

ii) Explain Hydraulic diameter and How it is calculated for cylinder and square. **5**

4. a) Derive an expression for the E - NTU of a counter flow Heat exchanger if the product of mass and specific heat of hot fluid is less than cold fluid. **10**

b) Hot water having specific heat 4200 J/kg k flows through a heat exchanger at the rate of 4 kg/min. within an inlet temperature of 100°C. A cold fluid having a specific heat 2400 J/kg k flows in at a rate of 8 kg/min and with inlet temperature 20°C. Make calculation for the maximum possible effectiveness if the fluid flow conforms to :

i) Parallel flow:

ii) Counter flow arrangement **10**

c) i) Show the temperature variation along the length of a Heat exchanger when **5**
   a) Hot and cold fluids flow in same and opposite direction.
   b) Hot fluid as used for evaporating another liquid

ii) What is mean by fouling factor ? How does it affect the performance of a heat exchanger. **5**

5. a) Show that the total mass of water vapour diffused from a water column to the air passing over the water container is given by

$$(M_w)_{total} = \frac{DA}{GT} \frac{M_w P_t}{(x_2 - x_1)} \log_e \left(\frac{P_t - P_{w2}}{P_t - P_{w1}} \right)$$

D = diffusion coefficient, A = c/s area G = universal gas constant, T = absolute temperature M_w = molecular wt. of water vapour, $x_2 - x_1$ = height of container above water level P_t = total pressure, P_{w_1} & P_{w_2} = Partial pressure of water at water surface and top. **10**

b) Define : **10**

i) Mass fraction.

ii) Mole fraction

iii) Mass concentration

iv) Molar concentration

v) Mass transfer

c) The air pressure in a tyre tube of surface area 0.5 m^2 and wall thickness of 0.01m. is approximated to drop. from 2 bar to 1.99 bar in a period of 5 days. The solubility of air in rubber is 0.07 m^3 of air/m^3 of rubber at 1 bar. Estimate the diffusivity of air in rubber at the operating temperature of 300k. If the volume of air in the tube is 0.025 m^3. **10**

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