T.E (Chemical Engg.) (Sem-V) (Rev.) Dec, 2010
Sub: Heat Transfer Operations

.. 6396-10. **(REVISED COURSE)** **GT-9468**

(3 Hours) **[Total Marks : 100**

N.B.: (1) Question No. 1 is **compulsory.**
(2) Solve any **four** from **remaining**.
(3) Assume any **suitable** data, correlation if **required**.
(4) **Figures to right** indicates **full** marks.
(5) **All** questions carry **equal** marks.

1. Solve all subquestions :
   (a) Derive for critical thickness for trhe insulation applied over hallow cylinder. **5**
   (b) State (only) assumptions for Nussett theory for condensation. **5**
   (c) State the Laws of radiation. **5**
   (d) Derive for necessary relation between individual and overall heat transfer coefficients of hot and cold fluids flowing in double pipe heat exchanger. **5**

2. (a) A thick walled hallow cylinder heated inside by hot flue gas (individual heat transfer coefficient $h_i \frac{w}{m^2K}$) and is lagged by two different insulations of thermal conductivities K_1 and K_2 $\frac{w}{m\ K}$. The heat transfer takes place radially. The outside ambient air temperature is $h_o \frac{w}{m^2K}$. Derive the necessary derivation to estimate steady state heat loss. **10**
   (b) A hot gas at 325°C flows through a metal pipe of 10 cm O.D. and 3 mm thick. It is insulated with mineral wool for reducing the heat loss in such a way that the insulation surface temperature should not exceed 50°C. Determine the thickness of insulation required taking the following data :— **10**
   h_i = 25 w/m²·K, h_o = 10 w/m² K
   T_a (surrounding air temperature = 25 °C
   K (mineral pipe) = 40 w/mK
   K (mineral wool) = 0·045 w/mK.
   Also, calculate the loss of heat per meter length of pipe after putting the insulation.

3. (a) Using Dimensional Analysis, Derive Nussutt number is a function of Reynold number and Prandtl number in forced convection. **10**
   (b) Explain the design procedure for multiuple effect evaporators. **10**

4. (a) Find the heat transfer coefficient in case of a flow of 2000 kg/hr of a fluid in a single tube when mean bulb temperature is 80 °C. The properties of the fluid at this temperature are C_p = 2650 J/kgK, $\mu = 3{\cdot}92 \times 10^{-3}$ kg/m.s. and K = 0·227 w/mK. **10**
   If this fluid while passing thro' the tube is to be cooled from 100 °C to 60 °C in an arrangement of counter flow heat exchanger and coolent is water entering at a temperature of 10 °C flowing at a rate of 1500 kg/hr in the annular space outside the tube, calculate the necessary length of the trube neglecting the thickners of the tube and its thermal resistance. Take the hat transfer coefficient of outside water side 8500 w/m²K.
   Use $N_u = 0{\cdot}023\,(N_{Re})^{0.8}\,(N_{Pr})^{0.3}$

5. (a) Find the amount of heat transfered through an iron fin of thickness 5 mm heig[ht] 50 mm and width 100 cm. Also determine the temperature difference θ at the tip of fin, assuming atmospheric temperature of 28 °C. Assume the followings :

$K = 50$ w/mK, $h = 10$ w/m²K and $\theta_0 = 80$ °C. 10

(b) A composite wall consist of two place walls of 30 cm and 40 cm thick with an evacuted space in between. The conductivity of 30 cm wall is 1·5 w/mK and of 40 cm thick wall is 2 w/mK. The emissivities of the wall surfaces facing each other are 0·6 (30 cm wall) and 0·5 (40 cm wall). Find the steady state heat flux thro' the composite wall. The temperature of hot gas in contact with 30 cm wall is 250 °C and total heat transfer coefficient considering convection and radiation is 25 w/m²K. The temperature of air in contact with 40 cm wall is 30 °C. And total heat Transfer coefficient is 10 w/m²K. 10

6. (a) Determine the heat transfer per m² area of a brass plate at 125 °C submerged in water at atmospheric pressure. Also calculate the heat transfer coefficient of boiling when water is boiling at 100 °C. 10

Take the following properties of water at 100 °C.

$C_{p\ell} = 4254$, J/kg °C, $\mu_\ell = 0{\cdot}22 \times 10^{-3}$ kg/m.sec $\frac{kg}{m \cdot sec}$

$\rho_\ell = 934{\cdot}6$ kg/m³, $C_{sf} = 0{\cdot}006$

$\lambda_g = 2189$ kJ/kg. $P_{r\ell} = 1{\cdot}36$

$\rho_v = 1{\cdot}3$ kg/m³ $(\sigma)\ell_v = 535$ N/m

(Suffix ℓ represents water and v-steam)

(b) Steam at 100 °C is condensing on cylindrical drum having a diameter 20 cm and temperature of 90 °C. If drum is vertical how long must it be to condense 100 kg of steam per hour. 10

The properties of condensing water at mean temperature are given—

$\rho = 965$ kg/m³, $\mu = 0{\cdot}315 \times 10^{-3} \frac{kg}{m \cdot sec}$

$\lambda = 2270 \frac{kJ}{kg}$, $K = 0{\cdot}673 \frac{w}{mK}$

$\gamma = 0{\cdot}312 \times 10^{-6}$ m²/sec.

7. Write a short notes on any **four** :—
   - (a) Wilson plot 5
   - (b) Plate type Heat Exchanger 5
   - (c) Forward feed multiple effect evaorator 5
   - (d) Pool Boiling of saturated liquid 5
   - (e) Unsteady state heat Transfer with negligible internal resistance. 5