Sub: Heat Transfer operations.

(157)

Con. 2791–09. 22/1/10

VR–5169

(REVISED COURSE)

(3 Hours)

[Total Marks : 100

N.B. : (1) Question No. **1** is **compulsory**.
(2) Attempt any **four** questions out of the remaining questions.
(3) Assumptions made should be **clearly** stated and **justified**.
(4) **Figures** to the **right** indicate **full** marks.

1. (a) Derive the expression for heat transfer through furnace wall made of three different materials in series. Assume k_1, k_2, k_3 be the thermal conductivities of materials and X_1, X_2, X_3 be the respective thickness. h_i and h_o be the convective heat transfer coefficients for inside hot gas and ambient air respectively. Assume hot gas and ambient cold air temperatures T_i and T_o respectively. **10**

   (b) A exterior wall of a house may be approximated by a 100 mm layer of common brick (k = 0·7 W/mK) followed by a 40 mm layer of gypsum plaster (k = 0·065 W/mK). What thickness of lossely packed rock wool insulation (k = 0·065 W/mK) should be added to reduce the heat loss (or gain) through the wall by 80%. **10**

2. (a) An egg with mean diameter of 40 mm and initially at 20°C is placed in a boiling pan for 4 min and found to be boiled to the consumer's taste. For how long should a similar egg from same consumer be boiled when taken from a refrigerator at 5°C. Take following properties for egg. **8**
   K = 10 W/m°C, ρ = 1200 kg/m^3 C = 2 kJ/kg°C
   h(heat transfer coefft.) = 100 W/m^2°C.

   (b) Show that for heat transfer by convection Nussult number is a function of Prandtl number and Reynould number and Groshoff's number. Use dimension analysis method. **12**

3. (a) Air at 2 atm and 200°C is heated as it flows at a velocity of 12 m/sec through a tube with the diameter of 3 cm. A constant heat flux condition is maintained at the wall and the wall temperature is 20°C above the air temperature all along the length of the tube. Calculate – **10**
   (i) the heat transfer per unit length of the tube.
   (ii) the increase in bulk temperature of air over a and m length of tube.
   Properties of air at 200°C are
   P_r = 0·681 μ = 2·57 × 10^{-5} kg/ms.
   k = 0·0386 W/mK, C_p = 1·025 kJ/kg K.
   You may use –
   $Nu_d = 0{\cdot}023\ (R_{ed})^{0.8}\ (p_r)^{0.4}$.

   (b) (i) What is radiation shield ? **5**

   (ii) Derive Q with 'n' shield $= \left(\frac{1}{n+1}\right)$ Q without shield. **5**

[TURN OVER

4. 250 kg/hour of dry carbon dioxide at normal pressure is to be heated from 26°C to 100°C in a heat exchanger using steam at 1·7 atmosphere pressure. The gas is passed thro' copper tubes (2·54 cm O.D. and 0·124 m wall thickness) and inlet velocity is to be 6·1 m/sec. The mean specific heat of carbon dioxide over the temperature range may be taken as 0·204 cal/gm °C.
   (a) For gas-film coefficient use –
   $h = 2{\cdot}5\ G^{0{\cdot}8}$ where h – gas film coefficient in watt/m^2 °C
   G – mass velocity of gas in kg/m^2sec.
   (b) Take steam side film coefficient – $1{\cdot}13 \times 10^4$ W/m^2 °C.
   (c) Thermal conductivity of copper tube – 391 W/m °C.
   (d) Saturation temperature at 1·7 atm is 115·6 °C.
   How many tubes are required and what is their length ?

5. (a) In a heat exchanger, the capacity rates of the cold and hot fluids are 4197 W/k and 1889 W/k. If the effectiveness of the heat exchanger is 0·75 and difference in the inlet temperature of the two fluids is 100 k. What is the actual rate of heat transfer ? Also, if the number of transfer unit for the exchanger is 2·1 and overall heat transfer coefficient is 100 W/m^2k. Calculate the surface area of the exchanger.
   (b) 100 tubes of O.D. 12·5 mm are arranged horizontally in a square array and exposed to dry saturated steam at 1 atm abs. Estimate the mass rate of steam condensation per unit length of tubes for tube wall temperature of 98°C. (371 K).
   Data : The properties of condensate at film temperature of 99°C are –
   $\rho = 960$ kg/m^3, k = 0·68 W/mk, $\mu = 282 \times 10^{-6}$ kg/m sec.
   Saturation temperature of steam at 1 atm abs is 100°C and Latent heat of condensation is 2257 kJ/kg.

6. (a) Derive expression for calculating the areas and intermediate temperatures for tripple effect evaporator.
   (b) Explain in brief various feed arrangement used in multiple effect evaporator.

7. Write short notes on any **three** :–
   (a) Plate heat exchanger
   (b) Different regimes of boiling
   (c) Vapour Recompression in evaporator
   (d) Extended surfaces for heat transfer.

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