Sem IV / Mech / Heat & Mass Transfer / Dec-09

162 : 2nd-AExm.09-Mina

Con. 6000-09. (REVISED COURSE) SP-8498

(3 Hours) [Total Marks :100

N.B.: (1) Question No. 1 is **compulsory.**
(2) Answer any **four** out of remaining **six** questions.
(3) Make **suitable** assumption, if any.
(4) Use of **steam** table is **permitted**.

1. Solve any **four** :— 20
   (a) What are Fourier and Biot Numbers ? What is physical significance of these numbers ?
   (b) Explain the term hydrodynamic and thermal boundary layer.
   (c) Explain non dimensional numbers used in convection heat transfer.
   (d) What is black body ? How does it differ from a gray body ?

   (e) In a quenching process, a copper plate 3 mm thick is heated up to 400 °C and then exposed to an ambient at 25 °C, with the convection coefficient of 28 W/m^2K. Calculate the time required for the plate to reach the temperature of 50 °C. Take thermo physical properties as –
   $C = 380$ J/KgK, $\rho = 8800$ kg/m^3, $k = 385$ W/mK.
   (f) What is heat exchanger ? Where are they used ?

2. (a) Show that the thermal resistance offered by a spherical wall of uniform k is given by $-\frac{r_o - r_i}{4\,\pi\,k\,r_i\,r_o}$ 8
   (b) A standard cast iron pipe (inner diameter = 50 mm and outer diameter = 55 mm) is insulated with magnesium insulation (k = 0·02 W/mK). Temperature at the interface between the pipe and insulation is 300 °C. The allowable heat loss through the pipe is 600 W/m length of pipe and for the safety ; the temperature of the outside surface of insulation must not exceed 100 °C. 8
   Determine :—
   (i) Minimum thickness of insulation required and
   (ii) The temperature of inside surface of the pipe assuming its thermal conductivity 20 W/mK.
   (c) In wire and cables, why the thickness of insulation is always kept at critical thickness ? 4

3. (a) For transient heat conduction, with negligible internal resistance, with usual notations, show that :— 8
   $$\frac{\theta}{\theta_1} = \exp\,(-Bi\,Fo)$$
   State the assumption clearly.
   (b) A plate fin of 10 mm thickness and 80 mm length is dissipating heat from a surface at 190 °C. The fin is exposed to air at 25 °C with a convection coefficient of 22 W/m^2 K. If thermal conductivity of the fin material is 200 W/mK. Consider 1 m width of fin — 12
   (i) Determine the heat dissipation.
   (ii) To increase the heat dissipation, the following two alternatives have been suggested with the same material volume.
   (1) Split the fin into two fins of 5 mm thickness each. Length 80 mm.
   (2) Single fin 5 mm thick and 160 mm long.
   Which will be the better choice ?
   The fins may be considered short with tip insulated.

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4. (a) With the help of dimensional analysis method prove that for free convection :— **10**
$Nu = \text{constant} \times (Gr)^m \times (Pr)^n$

(b) Air at 27 °C is flowing across a tube with a velocity of 25 m/s. The tube could be either a square of 5 cm side or a circular cylinder of 5 cm diameter. Compare the rate of heat transfer in each case, if the tube surface is at 127 °C. **10**
Use $Nu = C\,(Re)^n\,(Pr)^{1/3}$
Where, C = 0·027, n = 0·805 for cylinder
C = 0·102, n = 0·675 for square tube.
Properties of air at 77 °C,
$\rho = 0{\cdot}955$ kg/m³, $K_{air} = 0{\cdot}03$ W/mK, $\nu = 20{\cdot}92 \times 10^{-6}$, $C_p = 1{\cdot}009$ kJ/kgK.

5. (a) Define intensity of radiation. What is a solid angle ? What is its unit ? **4**

(b) State and explain the reciprocity theorem. Derive the equation $A_1 F_{12} = A_2 F_{21}$. **10**

(c) An enclosure measures 1·5 m × 1·75 m with a height of 2 m. Under steady state equilibrium conditions, the wall and ceiling are maintained at 525 K and floor at 400 K. Determine the net radiation to floor. **6**
ε_1(emissivity of ceiling and wall) = 0·85
ε_2 (emissivity of floor) = 0·75
take $\sigma_b = 5{\cdot}67 \times 10^{-8}$ w/m² K⁴.

6. (a) Explain the terms :— Effectiveness, NTU and LMTD. **6**

(b) For a heat exchanger, derive an equation of overall heat transfer coefficient considering fouling factor. **8**

(c) Exhaust gases (C_p = 1·12 kJ/ kgK) flowing through a tubular heat exchanger at the rate of 1200 kg/hr are cooled from 400 °C to 120 °C. The cooling is affected by water (C_p = 4·18 kJ/kgK) that enters the system at 10 °C at the rate of 1500 kg/hr. If the overall heat transfer coefficient is 500 kJ/m²-hr-K, what heat exchanger area is required to handle the load for :— **6**
(i) parallel flow and
(ii) counter flow arrangement ?

7. (a) Explain equimolal counter diffusion and isothermal evaporation of water. **8**

(b) Air at 1 atm and 25 °C, containing small quantities of iodine, flows with a velocity of 6·2 m/s inside a 35 mm diameter tube. Calculate mass transfer coefficient for iodine. The thermo physical properties of air are :— **4**
$\nu = 15{\cdot}5 \times 10^{-6}$ m²/s, $D = 0{\cdot}82 \times 10^{-5}$ m²/s.
Use, $Sh = 0{\cdot}023\,(Re)^{0.83}\,(Sc)^{0.44}$

(c) Write short notes on any **two** of the following :— **8**
(i) Reynolds analogy
(ii) Various modes of heat transfer
(iii) Wien's displacement law and its use.