B.Tech. Fifth Semester (Chemical Engineering) (CGS)

10153 : Heat Transfer : 5 CH 01

P. Pages : 4 **AW - 3145**
Time : Three Hours Max. Marks : 80

Notes :
1. Answer **three** question from Section A and **three** question from Section B.
2. Assume suitable data wherever necessary.
3. Illustrate your answer necessary with the help of neat sketches.
4. Use of slide rule logarithmic tables, Steam tables, Moller's Chart, Drawing instrument, Thermodynamic table for moist air, Psychrometric Charts and Refrigeration charts is permitted.

SECTION – A

1. a) A pipe 100 mm ID & 8 mm thickness is carrying a steam at 170°C. The convective heat transfer coeffi. on the inner surface of pipe is $75\,W/m^2{}^\circ C$. The pipe is insulated by two layers of insulation. The first layer of insulation is 46 mm in thickness having thermal conductivity of $1.4\,W/m^\circ C$. The second layer of insulation is also 46 mm having thermal conductivity $0.46\,W/m^\circ C$. Ambient temperature = 33°C thermal conductivity of steam pipe $= 46\,W/m^\circ C$. The convective heat transfer coeffi. from the outer surface of pipe $12\,W/m^2{}^\circ C$. Calculate the heat loss per unit length of pipe. Also determine the interface temperature. **7**

b) Define the terms :

i) Economic thickness of insulation. **2**

ii) Critical thickness of insulation. **2**

iii) Extended surfaces. **3**

OR

2. a) Derive expression for temperature distribution under one dimensional steady state heat conduction for composite wall. **7**

b) A steam pipe of outer diameter 120 mm is covered with two layers of lagging inside layer 45 mm thick ($k = 0.08\,W/m^\circ C$) & outside layer 30 mm thick ($k = 0.12\,W/m^\circ C$). The pipe conveys steam at a pressure of 20 bar with 50°C super heat. From steam table temperature of steam $t_1 = 262.4^\circ C$. The outside temperature of lagging is 25°C. If the steam pipe is 30 m long determine – **7**
i) Heat lost per hour &
ii) Interface temperature of lagging.

3. a) Draw and discuss the temperature profile of parallel flow and countercurrent flow heat exchanger. **6**

b) Explain the following : 6

i) Reynold's Number

ii) Prandtl Number

iii) Grashoff Number.

c) Define the term convection. 1

OR

4. a) Ethylene glycol is to be heated from 20°C to 54°C in a tube having 50 mm I.D. The tube wall is maintained at a constant temperature of 85°C. The flow velocity through the tube is 2m/sec. the physical properties of E.G. at average temperature = 37°C are 9

$\rho = 1104\,kg/m^3$, $Cp = 2460\,J/kg\,k$

$\mu = 0.0107\,N-S/m^2$, $k = 0.255\,W/mk$,

$\mu_w = 0.0029\,N-S/m^2$

Calculate the length of heat exchanger tube.

b) Explain Wilson plot with significance. 4

5. a) What is mean by film condensation? Obtain an expression for following equation. 10

$$h_{av} = 0.943\left[\frac{k^3\rho_L(\rho_L-\rho_V).g.\lambda}{\mu.L(T_V-T_S)}\right]^{0.25}$$

valid for laminar flow in condensation film.

b) The effectiveness of counter flow heat exchanger is greater than parallel flow heat exchanger. Justify. 3

OR

6. a) A vertical plate 500 mm high & maintained at 30°C is exposed to saturated steam at atmospheric pressure calculate – 4

i) rate of heat transfer &

ii) the condensate rate per hour per meter of the plate width for film condensation.

Data :

$\rho = 980.3\,kg/m^3$, $k = 66.4\times10^{-2}\,W/m°C$

$\mu = 434\times10^{-6}\,kg/m.s$ & $\lambda = 2257\,kJ/kg$.

b) Calculate the heat transfer coefficient for fluid flowing through a tube having 40 mm I.D. at a rate of 5000 kg/hr. 9

Data :

$\mu = 0.004\,N.s/m^2$, $\rho = 1.07\,g/cm^3$

$sp.heat = 2.72\,kJ/kg.k$

$k = 0.256\,W/m.k$

Use Dittus – Boelter equation.

SECTION – B

7. a) The flow rates of hot & cold water stream through a parallel flow heat exchanger are 0.2 kg/s & 0.5 kg/s respectively. The inlet temperature on the hot & cold sides are 75°C & 20°C respectively. The exit temperature of hot water is 45°C. If the individual heat transfer coefficients on both sides are $650\,W/m^2{}^\circ C$. Calculate the area of the heat exchanger. **6**

b) A counter flow heat exchanger is employed to cool 0.55 kg/s $(C_p = 2.45\,kJ/kg^\circ C)$ of oil from 115°C to 40°C by the use of water. The inlet and outlet temperatures of cooling water are 15°C & 75°C respectively. Take $U = 1450\,W/m^2{}^\circ C$. Using NTU method, calculate the following – **8**

i) the mass flow rate of water.
ii) the effectiveness of the heat exchanger.
iii) The surface area required.

OR

8. a) Draw and discuss the working of plate type heat exchanger with the help of diagram. Mention the industrial applications of it. **9**

b) Discuss the different types of fouling in heat exchanger. **5**

9. a) 10000 kg/hr of solution containing 5% solute is to be concentrated to 25% solute. Steam is available at a temperature 135° C. Feed solution enters at 35° C. BPR of the solution is 5° C. Calculate - **7**

1) Water evaporated per hr.
2) Steam consumption per hr.
3) Steam economy
4) Heat Transfer area.

Data :
Sp. heat of water is 4180 J/kg k.
Latest heat of condensation = 2180 kJ/kg
Latent heat of vaporization = 2253 kJ/kg
$U = 2907\,W/m^2k$.

b) Define & Explain the term. **6**

i) Capacity of Evaporator.
ii) Economy of Evaporator.
iii) True Boiling point rise.

OR

10. a) Discuss the working and industrial applications of falling film evaporator with figure. **8**

b) Define the phenomenon boiling and explain pool boiling curve with neat diagram. 5

11. a) Define Radiation and give an expression for Net radiation exchange between black bodies separated by non - absorbing medium. 7

b) Explain the terms : 6

i) Emissivity.

ii) Total Emissive power

iii) Grey body

OR

12. a) Discuss the following laws of radiation. 6

i) Kirchhoff's Law

ii) Planck's Law.

b) Calculate the following for an industrial furnace in the form of a black body and emitting radiation at 3500° C. 7

i) Monochromatic emissive power at 1.2 μm length.

ii) Wavelength at which the emissions is maximum.

iii) Maximum Emissive Power.

iv) Total Emissive Power.

v) Total Emissive Power if it is assumed as a real surface with emissivity equal to 0.9.

****