Registration No. : | | | | | | | | | | |

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B. Tech

PCCH 4301

Fifth Semester Regular Examination – 2014

HEAT TRANSFER

BRANCH : CHEM

QUESTION CODE : H 128

Full Marks – 70

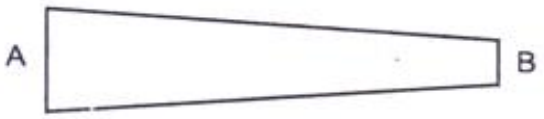
Time : 3 Hours

*Answer Question No. **1** which is compulsory and any **five** from the rest.*
The figures in the right-hand margin indicate marks.
Assume suitable notations and any missing data wherever necessary.

1. Answer the following questions : 2 ×10

(a) What is Widdmann and Franz Law ?

(b) In the following figure if the areas of surface A and B are 20 and 10 m^2 respectively and the heat flux at face A is 5 W/m^2. Find the heat flux at surface B.



(c) What is lumped system analysis ?

(d) Draw the shape of the thermal boundary layer when a hot fluid flows through a pipe.

(e) What is the % of baffle window for a 25% cut segmental baffle ?

(f) For a heat exchanger which value is more : Outside overall heat transfer coefficient or inside overall heat transfer coefficient. Justify your answer.

(g) If 8 inch is the ID of a shell, then what is the minimum baffle spacing ?

(h) If the number of passes in the tube side is doubled then how many times the heat transfer coefficient will increase and justify your answer.

P.T.O.

(i) What is Tube Plugging in an evaporator ?

(j) Write the type of evaporator and type of feeding used for concentrating viscous solution.

2. Two layers of a composite cylinder of inner diameter 15 cm and outer diameter 30 cm has moderate volumetric rates of heat generation 100 KW/m^3 and 40 KW/m^3 in the inner and outer layer respectively. The thicknesses of two layers are equal. The temperature at the inside surface (r_i = 0.075 m) of the assembly is 100 ^{0}C and that at the outside surface (r_o = 0.15 m) is 200 ^{0}C. Thermal conductivities of the materials are K_1 = 30 W/m^{0}C for the inner layer and K_2 = 10 W/m^{0}C for the outer layer. Determine :

(a) The temperature distributions in the individual layers. 7

(b) The maximum temperature in the cylinder and the radial position at which it occurs. 3

3. (a) Under what condition does the fin efficiency become nearly 100% ? 2

(b) An electric motor drives a centrifugal pump which circulates a hot liquid metal at 480 °C. The motor is coupled to the pump impeller by a horizontal steel shaft (k = 32 w/m°C) 25 mm in diameter. If the ambient air temperature is 20 °C, the temperature of the motor is limited to a maximum value of 55 °C and the heat transfer coefficient between the steel shaft and the ambient air is 14.8 w/m^2.°C, what length of shaft should be specified between the motor and the pump assuming that the end of the shaft is insulated. 8

4. (a) In a counter flow double pipe heat exchanger the hot fluid temperature drops from 73 °C to 68 °C and cold fluid temperature rises from 30 °C to 35 °C. Calculate the amount of heat transfer with an overall heat transfer coefficient of 537 w/m^2.°C and heat transfer area of 3 m^2. 3

(b) A counter flow heat exchanger is employed to cool 0.55 kg/sec (C_p = 2.45 kJ/kg.°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 and 75 °C, respectively.

The overall heat transfer coefficient is expected to be 1450 $W/m^2.°C$. Using NTU method, calculate the following :

(i) Effectiveness of heat exchanger,

(ii) The surface area required, and

(iii) The mass flow rate of water. 3+2+2

5. (a) What is the effect of presence of non-condensable gas on condensation ? 2

(b) A vertical flat plate is 600 m in height and is exposed to steam at atmospheric pressure. If the surface of the plate is maintained at 60 °C, then calculate the total heat transfer rate and rate of steam condensation. 8

Data : Saturation steam temperature = 100 °C

Latent heat of vaporization = 2257 kJ/kg

$\rho_v = 0.596$ kg/m^3.

The properties of saturated vapour at the mean film temperature are :

$\mu = 355.3 \times 10\text{-}6$ Ns/m^2

$\rho = 971.8$ kg/m^3

$k = 67.413 \times 10\text{-}2$ W/m.°C.

6. (a) What is radiation shape factor ? 2

(b) A well insulated hemispherical furnace of radius 1 m. Find the self view factor of the curved surface. 3

(c) The inner sphere of a dewar flask is 30cm diameter and outer sphere is 36 cm diameter. Both spheres are coated for which emissivity to 0.05. Determine the rate at which liquid oxygen (latent heat = 5.12 Kcal/kg) would evaporate at –183 °C when the outer sphere temperature is 20 °C. Assume that the other modes of heat transfer are absent. 5

7. A single effect evaporator with 11 m^2 of heating surface is used to concentrate NaOH solution from 10% to 50 % solids, the feed being 2200 kg/hr. The feed enters at 49 °C and has a specific heat of 0.8 Kcal/kg.°C. The pressure in the vapour space is 10 cm Hg absolute. 900 kg/hr of steam of 101.7 °C are used.

Calculate :

(a) Apparent overall heat transfer coefficient,

(b) Coefficient corrected for boiling point elevation and hydrostatic head if the liquid depth is 1.83 m. Boiling point of 50% NaOH solution = 86.7 °C. 5

8. Write short notes on any two : 5×2

(a) Multiple effect evaporators

(b) Dimensional analysis for forced convection

(c) Thermal boundary Layer

(d) Critical thickness of insulation