53 (FPT 812) CADH

2013
(May)

CONCENTRATION AND DEHYDRATION OF FOODS

Paper : FPT 812

Full Marks : 100

Pass Marks : 30

Time : Three hours

The figures in the margin indicate full marks for the questions.

*Answer **any five** questions.*

1. *(a)* What is equilibrium moisture content and free moisture content? 2+2=4

   (b) What are *two* modes of transport of material through a membrane?

   Explain with the help of schematic drawing. 4

   (c) What is freezing concentration? What is the goal of freezing? 4

(d) Write down the importance of the Duhring's Plot and Enthalpy Concentration diagram. 4

(e) Derive the expression for *LMTD* in case of co-current and counter-curent heat exchanger. 4

2. (a) Explain with the help of a diagram a typical drying rate curve for constant drying conditions. How does drying in the constant rate period differ from drying in falling rate period. 10

(b) A batch of wet solid is to be dried from a moisture 0.38 kg H_2O /kg dry solid $\left(Critical\ rate = 1.51\ kg\ H_2O / hr.m^2\right)$ to 0.04 kg H_2O / kg dry solid. The weight of the dry solid is 399 kg dry solid and area 18.58 m^2 of top drying surface. Calculate the time for drying. 5

(c) A wet solid is to be dried from 80% to 5% mositure, wet basis, compute the moisture to be evaporated, per 1000 kg of dried product. 5

3 *(a)* Write down the importance of the following:

(i) Saturated steam in an evaporator.

(ii) Pressure effect in an evaporator.

3+3=6

(b) An evaporator is used to concentrate 4536 *kg/hr* of a 20% solution of NaOH in water entering at $60^{\circ}C$ to a product of 50% solids. The pressure of the saturated steam is used 172.4 *kpa* and the pressure in the vapor space of the evaporator is 11.7 *kpa*. The overall heat transfer coefficient is 1560 $w/m^2.k$. Calculate the steam used, the steam economy in *kg* vaporized/*kg* steam used, and the heating surface area in m^2. Use steam table if necessary. 14

4. *(a)* What is fouling of membrane? Explain the common mechanisms of fouling. 10

(b) What do you mean by the performance of a membrane ? 5

(c) Write down the defination of Specific heat, Sensible heat and Latent heat. 5

5. *(a)* Develop an enpression for the rate of heat transfer in hollow sphere of thermal conductivity K, inner and outer radious r_i and r_0 respectively, with the corresponding surface temperature T_i and T_0. 8

(b) A furnace wall is made up of 23 *cm* of fire brick, 7.5 *cm* of insulating brick and 8.9 *cm* of red brick. The temperature at the inner surface of the wall is $800^\circ C$ and that of the outer surface is $60^\circ C$. Average Thermal Conductivity Values of the three types of bricks, *i.e.* fire brick, insulating brick and the red brick are 1.04, 0.104 and 0.744 *kcal/ hr* $m^\circ C$ respectively. Neglecting resistance of points, calculate the temperature at interfaces between different kinds of bricks. 6

(c) The outside surface temperature of a pipe *(radius = 0.1m)* is 400 *k*. The pipe is losing heat to atmosphere, which is at 300 k. The film heat transfer co-efficient is $10\,W/m^2K$. To reduce the the rate of heat loss, the pipe is insulated by a 50 mm thick layer of asbestors $(K = 0.5\,W/mk)$. Calculate the percentage reduction in the rate of heat loss. 6

6. *(a)* Hot Water $\left(0.01\ m^3/\min\right)$ enters the tube side of a concurrent shell and tube heat enchanger at $80^\circ C$ and leaves at $50^\circ C$. Cold oil $\left(0.05\ m^3/\min\right)$ of density $800\ kg/m^3$ and specific heat of 2 *KJ/Kg.K.* enters at $20^\circ C$. Find out the LMTD in $^\circ C$. Assume water specific heat 4.18 *KJ/Kg.K.* 5

(b) In a 1-1 counter flow shell and tube heat exchanger, a process stream $(CP = 4.2\ KJ/Kg.K)$ is cooled from 450 to 350 *K* using water $(CP = 4.2\ KJ/Kg.K)$ at 300 *K*. The Process Stream flows on the shell-side at a rate of 1 *kg/sec* and the water on the tube-side at a rate of 5 *kg/sec.* If the heat transfer co-efficients on the shell and tube sides are 1000 $W/m^2.k$ and 1500 $W/m^2.k$ respectively, determine *(i)* the required heat transfer area *(ii)* by what factor will the required area change if the flow is concurrent ? 10

(c) An ice box has walls constructed of a 10 *cm* layer of cork-board contained between two wooden walls, each 2 *cm* thick. Find the rate of heat removal in $kcal/m^2$.hour if the inner wall surface is kept at $-10°C$, while the outer surface temperature is $30°C$. Find out the zone in the wall where the temperature is $20°C$. Thermal conductivities of cork-board and wood respectively are 0.035 and 0.09 *kcal/hr* $m°C$. 5

7. Write short notes on ***any four*** : $4 \times 5 = 20$

(i) Spray dryers

(ii) Bubble point method

(iii) Multiple effect evaporator

(iv) Overall heat transfer coefficient

(v) Critical insulation thickness

(vi) Capacity and Economy of a continuous single effect evaporator

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