

GUJARAT TECHNOLOGICAL UNIVERSITY
B. E. - SEMESTER – VI • EXAMINATION – WINTER 2012

Subject code: 160503**Date: 04/01/2013****Subject Name: Process Equipment Design - I****Time: 02.30 pm - 05.00 pm****Total Marks: 70****Instructions:**

1. Attempt any five questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.

- Q.1 (a)** Discuss about various criteria of selection between horizontal condenser and vertical condenser. **07**
- (b)** Discuss in detail about criteria of selection and advantages and disadvantages of kettle type reboiler and thermosyphon reboiler. **07**

- Q.2 (a)** Discuss criteria of selection among different types of trays used in tray tower. **07**
- (b)** Explain flooding and channeling in packed tower to be used for counter current contact between gas and liquid. **07**

OR

- (b)** Explain the method for determining minimum reflux ratio for binary distillation. **07**

- Q.3** Determine minimum reflux ratio, minimum number of theoretical stages required, optimum reflux ratio and theoretical stages required for desired separation for following system by FUG method. Feed flow rate is 70 kmol/hr and feed is saturated liquid. Composition of distillation column streams and average relative volatilities of all components of feed are as follows. **14**

Mole %

Component	α_{avg}	Feed	Distillate	Residue
Benzene	8.96	2.2	22.8	0
Toluene	2.8407	7.4	72.2	0.5
Ethyl Benzene	1	43.4	5.0	47.5
Styrene	0.6506	47	0	52

Toluene is light key and ethyl benzene is heavy key component.

Gilliland co relation.

$$N - N_m / N + 1 = 1 - \exp \left(\left(1 + 54.4\psi / 11 + 117.2 \psi \right) * (\psi - 1 / \psi^{0.5}) \right)$$

$$\text{Where } \psi = R - R_m / R + 1$$

OR

- Q.3** Acetic acid is to be separated from a process stream containing 80 % acetic acid and 20 % Water (by mass) by continuous distillation column at atmospheric pressure. **14**

Concentration of water in bottom product (pure acetic acid) should not be greater than 50 ppm. Top product (distillate) contains 80% water and 20% acetic acid (by mass). The feed is liquid at 30⁰ C. estimate the number of theoretical stages required both graphically and empirically. Vapor liquid equilibrium data are as follows.

Mole fraction of water in liquid, x	Mole fraction of water in vapor, y
0	0
0.1881	0.3063
0.3084	0.4467
0.4498	0.5973
0.5195	0.6580
0.5824	0.7112
0.6750	0.7797
0.7261	0.8239
0.7951	0.8671
0.8556	0.9042
0.8787	0.9186
0.9134	0.9409
0.9578	0.9708
1	1

Assume $q=1.272$ take $R = 2R_m$

Q.4 Design shell and tube heat condenser for condensation of **14**

46000 kg/hr n- propanol at 0.25 kgf/cm² g by cooling water at 32⁰ C. The dirt factor of both shell and tube side is 2000 kcal/hr m² C. Assume that allowable pressure drop on both the side is within limit. Assume the tube o.d. of 19.5 mm and 23.81 mm triangular pitch. Tube wall thickness to be taken as 1.65 mm. assumes isothermal condensation.

Properties of n-propanol.

Latent heat of condensation : 158 kcal/kg

Thermal conductivity : 0.14 kcal/hr m C

Liquid density : 800 kg/m³

Liquid viscosity : 0.62 cP

Vapor viscosity : 0.01 cP

Condensation co efficient is to be calculated as:

$$h_c = 0.95 k_c (\rho_c (\rho_c - \rho_v) g / \mu_c r) (N g)^{-1/6} \text{ kcal/ hr m}^2 \text{ C}$$

where

k_c = condensate thermal conductivity, kcal/hr m C

ρ_c = condensate density, kg/m³

ρ_v = vapor density, kg/m³

μ_c = condensate viscosity , kg / ms

r = tube loading, condensate flow per unit length of tube, kg/ms

$N_R = (2/3)^{\text{rd}}$ of maximum tube in central row.

Water side coefficient is calculated as:

$$h_i = 4200 (1.35 + 0.02t) / d_i^{0.2} u_t^{0.8} \times 0.86 \text{ kcal/ hr m}^2 \text{ C}$$

t = waterside average temperature, ⁰C

d_i = i.d. of tube, mm
 u_t = tube side velocity, m/sec

for triangular pitch, constants for bundle diameter are as :

No of passes	1	2	4	6	8
K_1	0.318	0.249	0.175	0.0743	0.0365
N_1	2.142	2.207	2.285	2.499	2.675

OR

- Q.4** Explain Tinker's flow model. Give procedure for calculation of pressure drop for shell side and tube side for condenser.
- Q.5** Design a scrubber for absorbing acetone vapor from air acetone vapor mixture by using water as a pure solvent. The temperature in scrubber is 25°C and scrubbing is isothermal. Operating pressure of scrubber is near atmospheric. A mixture of air with acetone vapor containing 5% by volume of acetone is passed through the scrubber. The mixture contains 1500 m³/hr of air. The scrubber is required to absorb 96% of the acetone. At 25°C vapor pressure of acetone = 228.416 torr
 Actual amount of solvent is 1.5 times the minimum as per minimum wetting rate (MWR)
 Assume $K_F = 0.17$, $K_p = 170\text{ m}^{-1}$ and
 actual velocity = 66 % of flooding velocity
 take pressure drop /m of packing height = 66 mm H₂O / m of packing
 for 25 mm polypropylene pall rings $a_t = 205\text{ m}^2/\text{m}^3$
 calculate tower diameter at top and bottom and N_{TOG}

OR

- Q.5** It is proposed to pump 5000 kg/hr of acetic acid at 129.5°C and 1.4 atm (ab) pressure from the reboiler of a distillation column to a hold up tank without cooling. If the friction loss in the line between the reboiler and pump is 8 kPa and the density of acetic acid is 1048 kg/m³, how far above the pump must the liquid level in the reboiler be maintained to give a net positive suction head of 2.5 m ? Friction loss in discharge line is 40 kPa. Maximum liquid level of acetic acid above the discharge point is 5m. Pump efficiency is 60%. Calculate the power required to drive the pump.
