

GUJARAT TECHNOLOGICAL UNIVERSITY**BE - SEMESTER-VI • EXAMINATION – SUMMER 2013****Subject Code: 160503****Date: 28-05-2013****Subject Name: Process Equipment Design I****Time: 10.30 am - 01.00 pm****Total Marks: 70****Instructions:**

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

- Q-1 1-2 shell and tube heat exchanger is used to cool methanol condensate from 95 °C to 40°C. Flow rate of methanol is 100000 kg/h. Brackish water is used as coolant with temperature rise from 25 °C to 40 °C. 14

Property	Methanol	Brackish Water
Heat Capacity, kJ/kg °C	2.84	4.2
Density, kg/m ³	750	995
Viscosity, mNs/m ²	0.34	0.8
Thermal conductivity, W/m °C	0.19	0.59

Choose 20mm od, 16 mm id, 4.88 m long cupro-nickle tubes with triangular pitch $P_t=1.25d_o$.

Based on overall heat transfer coefficient 600 W/m²°C, Calculate

- (1) Number of tubes
- (2) Shell Diameter
- (3) Tube side heat transfer coefficient. (Take brackish water in tubes).

K_1 and n_1 for tube bundle diameter: (For triangular pitch $p_t=1.25d_o$)

No of tube side passes	1	2	4	6	8
K_1	0.319	0.249	0.175	0.0743	0.0365
n_1	2.142	2.207	2.285	2.499	2.675

Heat transfer coefficient for tube side: for $Re > 4000$

$$Nu = 0.023 Re^{0.8} Pr^{0.33} (\mu/\mu_w)^{0.14}$$

- Q-2 A A centrifugal pump is drawing water from an overhead tank, exposed to atmosphere. Vertical distance between free surface of liquid in the tank and centre line of the pump is 10 m. Capacity of centrifugal pump is 10000 kg/h. Maximum operating temperature is 50 °C. Vapor pressure of water at 50 °C is 92.51 torr. Total length of suction pipe 10.5 m, having two 90 ° elbows. Material of pipe is carbon steel. Density of water = 1000 kg/m³, Viscosity of water = 0.558 cP. K-Value for 90°elbow is 0.75 07

For the velocity of water in suction line 1 m/s, Determine

- (1) The size of suction pipe
- (2) Total frictional pressure drop in suction line
- (3) (NPSH)_A of centrifugal pump.

Pressure drop

$$\frac{\Delta P}{L} = \frac{2fV^2\rho}{g_c D_t}$$

Where $f = 0.0394 Re^{-0.16}$ for turbulent flow.

B Explain in brief Tinkers Flow Model for shell and tube heat exchanger 07

OR

B Write a brief note on selection between horizontal and vertical condenser. 07

Q-3 A sieve tray tower is used for the distillation of acetic acid-water system. 14
Maximum feed flow rate is 12000 kg/h and turn down ratio is 70%. Following data are available for this column.

Feed composition: 54.55% acetic acid and 45.45% water (by mole)

Mole fraction of water: In distillate $x_D=0.9302$, In Residue $x_W= 1.666 \times 10^{-4}$

$q=1.272$

Reflux ratio $R=4.2$, Number of theoretical stages required = 25

Tray spacing = 0.45 m, hole diameter = 5 mm.

weir height = 50 mm, weir length $l_w = 0.77 D_i$.

Property	Top	Bottom
Vapor density, kg/m^3	0.6823	2.8368
Liquid density, kg/m^3	967.97	1000
Surface tension, N/m	55.5×10^{-3}	21.34×10^{-3}

Based on 85% flooding condition, Calculate

(1) Tower diameter required at top and bottom.

(2) Check weeping for enriching section. (top section)

Consider down comer area is 12% of column cross section and hole area is 10% of active area.

Flooding velocity

$$V_f = C_f \left(\frac{\sigma}{0.02} \right)^{0.02} \left(\frac{\rho_L - \rho_V}{\rho_V} \right)^{0.5}$$

Weep point velocity

$$V_{hmin} = \frac{K - 0.9(25.4 - d_h)}{\sqrt{\rho_V}}$$

Where K is constant can be taken from the following table

$h_w + h_{ow}$, mm	20	40	60	80	100
K	28.3	29.6	30.3	30.75	31

OR

Q-3 A What is the function of down comers in tray column? Discuss the different types of down comers used in industry in brief. 04

B Discuss and explain various parameters to be considered for selection of trays in tray type distillation column. 05

C Discuss the design of plate type heat exchanger. 05

Q-4 A Discuss various applications of liquid-liquid extraction in process industry. 05

B Write a brief note on packings used for packed bed absorption. 06

C Explain the functions of liquid redistributor and hold down plate in absorber. 03

OR

Q-4 A For separation of dimethylformamide (DMF) from its dilute solution in water, counter current liquid-liquid extraction is used. Methylene chloride is solvent. DMF-water solution flow rate is 1000 kg/h and contains 20% DMF by mass. DMF is reduced to 1% in the final raffinate. Determine the minimum amount of solvent used.
Phase equilibria equation is given by $y = 0.5555x$ at 25 °C where y and x are mass fractions of solute. 10

B Write a short note on selection of equipment for distillation. 04

Q-5 A Discuss the criteria for selection of various absorption equipments. 07

B Discuss the effect of parameters in the process design of equipment. 07

1. Baffle spacing in shell and tube heat exchanger
2. Tray spacing in tray column
3. Wear length on tray column

OR

Q-5 A Predict the fractional solute removal and pressure drop in a venturi scrubber based on the following data. 10

Volumetric flow rate of boiler flue gas = 24000 Nm³/h

Discharge pressure of the gas from venturi = atmospheric

Temperature of the gas = 80 ñ 90 °C

SO₂ concentration in boiler flue gas = 4000 ppm

Solvent = 1% lime solution

Solvent to gas ratio = 1.4 L/m³

Throat velocity of gas phase = 100 m/s

Average molar mass of flue gas = 29.48 kg/kmole

Density of 1% lime solution = 1012.5 kg/m³

Density of gas = $\rho_G = 0.99 \text{ kg/m}^3$

Assume $N_G = 1$

Equilibrium mass of SO₂ per 100 mass of H₂O = 0.035

Equilibrium constant for physical absorption at 50 °C and 1 atm $m = 40.63$

$$\text{fractional solute removal} = \frac{y_1 - y_2}{y_1} = \frac{\eta(1 - m x_2/y_2)}{\left(1 + \frac{mG_m}{L_m}\right)}$$

Pressure drop across the venturi scrubber

$$\Delta P = 2.584 \times 10^{-3} V_G^2 \rho_G A_{th}^{0.133} (L/G)^{0.78}$$

B Discuss the various locations for pressure taps in orifice meter. Also state advantages and disadvantages of orifice meter. 04

Figure1: Flooding constant correlation

Figure 2: F_t , MTD correction factor for 1 pass shell and two or more passes of tubes.