Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VI (NEW) EXAMINATION – SUMMER 2023

Subject Code:2160503 Date:06-07-2023

Subject Name:Process Equipment Design -I

Time:10:30 AM TO 01:30 PM Total Marks:70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

			MARKS
Q.1	**(a)**	Write Fanning or Darcy equation which relates pressure drop and pipe diameter.	**03**
	(b)	Discuss about pressure drop in Fittings and Valves.	**04**
	(c)	Hexane at 400 C is pumped through the system at the rate of 10 m3/hr. The tank is at atmospheric pressure. Pressure at the end of the discharge pipe is 400 kPa g. The discharge is 4.5 m above the pump center line while the suction lift is 1 m above the the level of the liquid in the tank. The friction loss in the suction line is 4 kPa and that in the discharge line is 40 kPa. The mechanical efficiency of the pump is 65%. The density of hexane is 650 kg/m3 and its vapour pressure at 400 C is 35 kPa. Calculate (a) (NPSH)A and (b) power required by centrifugal pump.	**07**
Q.2	**(a)**	Discuss about fluid allocation criteria for shell & tube heat exchanger.	**03**
	(b)	How to calculate bundle diameter for triangular pitch and square pitch for various tube side passes.	**04**
	(c)	Discuss the selection of cooling medium or heating medium.	**07**
		OR	
	(c)	Calculation of shell side pressure drop for shell & tube heat exchanger for no phase change and condenser.	**07**
Q.3		Design shell & tube horizontal condensor for condensation of 36500 kg/hr ethanol at 0.32 kgf/cm^{2}g by cooling water at 32^{0}C. The condensing temp. at this pressure is 88 ^{0}C. The dirt factors of both shell & tube side is 2000 kcal/hr m^{2}C. Assume that allowable pressure drop on both the side is within limit. Assume the tube o.d. of 19.05 mm and 23.81 mm triangular pitch. Tube wall thickness to be taken as 1.65 mm. Assume isothermal condensation. Properties for ethanol: Latent heat of condensation: 216 kcal/kg Thermal conductivity : 0.119 kcal/hr m C Liquid density : 789 kg/m^3 Liquid viscosity: 0.43 cP Vapor viscosity: 0.012 cP Thermal conductivity of tube metal = 39 kcal/hr m C Condensation coefficient is to be calculated as: $$h_c = 0.95k_c\left[\frac{\rho_c(\rho_c-\rho_v)g}{\mu_c\Gamma}\right]^{1/3}(N_R)^{-1/6}\ \text{kcal/hrm}^2\text{C}$$ Where, kc = condensate thermal conductivity, kcal/hrmC	**14**

[P.T.O.]

ρ_c = condensate density, kg/m^3
ρ_v = vapor density, kg/m^3
μ_c = condensate viscosity, kg/m-s
Γ = tube loading, condensate flow per unit length of tube, kg/m-s
N_R = (2/3)rd of maximum tubes in central row.

Water side coefficient is calculated as:

$$h_i = \frac{4200(1.35+0.02t)}{d_i^{0.2}} u_t^{0.8} x0.86 \quad \text{kcal/hr m}^2\text{C}$$

t = water side average temperature, ^{0}C
di = inside diameter 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
k1	0.319	0.249	0.175	0.0743	0.0365
n1	2.142	2.207	2.285	2.499	2.675

OR

Q.3 **(a)** Discuss the selection criteria of solvent for Gas absorption. **07**

(b) Discuss desirable properties for choice of solvent for liquid liquid extraction. **07**

Q.4 If 80 kg of a solution of acetic acid and water containing 28% acid is to be extracted counter currently with 90 kg pure isopropyl ether at 20 ^{0}C. The aqueous raffinate is to be extracted down to 2 percent acetic acid. How many theoretical stages will be required and what will the extract composition be? **14**

The equilibrium data at 20 ^{0}C are listed below:

Mass % in Raffinate			Mass% in Extract		
Acetic acid	Water	Isopropyl ether	Acetic acid	Water	Isopropyl ether
0.69	98.1	1.2	0.18	0.5	99.3
1.41	97.1	1.5	0.37	0.7	98.9
2.89	95.5	1.6	0.79	0.8	98.4
6.42	91.7	1.9	1.93	1.0	97.1
13.3	84.4	2.3	4.82	1.9	93.3
25.5	71.1	3.4	11.4	3.9	84.7
36.7	58.9	4.4	21.6	6.9	71.5
44.3	45.1	10.6	31.1	10.8	58.1
46.4	37.1	16.5	36.2	15.1	48.7

OR

Q.4 **(a)** Discuss advantage and limitations of plate type heat exchangers. **03**

(b) Discuss about Tinker's flow model. **04**

(c) Discuss in detail about heat transfer in Thermosyphon reboiler. **07**

Q.5 Discuss in detail about FUG method for multi component distillation. **14**

OR

Q.5 Discuss design procedure for Absorption tower for finding the height (Cornell's method) and diameter of column. Discuss in brief the types of packing. **14**

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