Enrolment No./Seat No_____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE- SEMESTER–VII (NEW) EXAMINATION – WINTER 2024

Subject Code:3170502 Date:07-12-2024

Subject Name: Process Equipment Design

Time:10:30 AM TO 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.**
4. **Simple and non-programmable scientific calculators are allowed.**

MARKS

Q.1 **(a)** Explain the effect of baffle cut and baffle spacing on shell side heat transfer coefficient in a shell and tube heat exchanger. **03**

(b) Explain concept of NPSH in pumping system. Distinguish between $(NPSH)_A$ and $(NPSH)_R$. If $(NPSH)_A$ is less than $(NPSH)_R$, then suggest corrective action to make $(NPSH)_A$ greater than $(NPSH)_R$. **04**

(c) Estimate minimum reflux ratio and minimum number of ideal stages needed for the butane-pentane splitter defined by the compositions given in table below. The column is operated at a pressure of 8.3 bar. The feed is at its boiling point. Top and bottom temperatures are 65 ^oC and 120 ^oC respectively. **07**

Component	Feed, kmol/hr	Distillate, kmol/hr	Bottom, kmol/hr
Propane	5	5	?
i-Butane	15	15	?
n-Butane	25	24	?
i-Pentane	20	?	19
n-Pentane	35	?	35

Relative volatilities at top and bottom are listed in table below.

Component	Top	Bottom
Propane	5.5	4.5
i-Butane	2.7	2.5
n-Butane	2.1	2
i-Pentane	1	1
n-Pentane	0.84	0.85

Useful equations for calculation,

$$\sum \frac{\alpha_i x_{id}}{\alpha_i - \vartheta} = R_m + 1$$

$$\sum \frac{\alpha_i z_{if}}{\alpha_i - \vartheta} = 1 - q$$

$$N_m = \frac{log\left[\left(\frac{x_{LK}}{x_{HK}}\right)_d \left(\frac{x_{HK}}{x_{LK}}\right)_b\right]}{log\alpha_{LK}}$$

Q.2 **(a)** Appreciate/criticize the following sentence with appropriate argument. **03**
"Superheated steam is preferred over saturated steam as a heating medium due to its higher heat transfer coefficient."

(b) Discuss merits and demerits of air cooled heat exchanger over water cooled heat exchanger. **04**

(c) Lube-oil (flowrate 450 L/min) is to be cooled from 65 ^{o}C to 45 ^{o}C with the cooling water. Calculate, **07**

(i) flow rate of cooling water.

(ii) tube side heat transfer coefficient.

Use following data for calculation purpose.

4-1 pass shell and tube heat exchanger

Shell side fluid = lube-oil, Tube side fluid = cooling water

Cooling water inlet temperature = 35 ^{o}C

Cooling water outlet temperature = 39 ^{o}C

Assume value of overall heat transfer coefficient of 400 W/m^2.^{o}C.

Tube length = 10 ft

Tube outside diameter = 15.875 mm

Tube inside diameter = 13.3858 mm

LMTD correction factor = 0.95

Property	Lube-oil	Cooling water
Density, kg/m^3	869	993.328
Viscosity, cP	15	0.73
Specific heat, kJ/kg.^{o}C	2.1413	4.1868
Thermal conductivity, W/m.^{o}C	0.13	0.628

Useful equation for calculation,

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

OR

(c) Discuss step-wise design procedure for horizontal condenser (condensation taking on shell side). Assume that vapor is saturated vapour and no phase change occurs for tube side fluid. **07**

Q.3 **(a)** Discuss the criteria for fluid allocation in shell and tube heat exchange. **03**

(b) Explain Tinker's flow model with a neat diagram. **04**

(c) In design of vertical thermosyohon Reboiler recirculation ratio is determined via trial and error calculation. In calculation, one of the following hypothetical conditions arises for the assumed value of recirculation ratio. **07**

(i) $\Delta P_{av} \approx \Delta P_t$

(ii) $\Delta P_{av} >> \Delta P_t$

(iii) $\Delta P_{av} < \Delta P_t$

Discuss how to find or fix the recirculation ratio in each of the above condition.

OR

Q.3 **(a)** Discuss merits and demerits of U-tube heat exchanger over floating head heat exchanger. **03**

(b) Discuss criteria of selection between horizontal and vertical condenser. **04**

(c) Discuss stepwise design procedure for kettle type reboiler. **07**

Q.4 **(a)** Discuss the effect of reflux ratio on fixed, operating and total cost of distillation column. **03**

(b) Discuss selection criteria for operating pressure in a distillation column. **04**

(c) Differentiate between jet flooding and downcomer flooding. Discuss stepwise procedure to calculate pressure drop in a sieve tray distillation column. **07**

OR

Q.4 **(a)** Define: (1) Light key component, (2) Minimum reflux ratio, and (3) Non-key component **03**

(b) Discuss selection criteria between tray and packed tower for distillation operation. **04**

(c) Discuss the design steps to calculate the number of theoretical stages in binary distillation column. **07**

Q.5	**(a)**	Explain the function of liquid distributors, liquid re-distributor and packing support in packed tower absorber.	**03**
	(b)	Differentiate between operating pressure and design pressure from mechanical design perspective.	**04**
	(c)	1. Discuss about five standard types of pressure taps for orifice meter. 2. State advantages and disadvantages of orifice meter over venturi meter.	**07**

OR

Q.5	**(a)**	Define: (1) Design stress, (2) Corrosion Allowance, and (3) Welding Joint efficiency factor.	**03**
	(b)	Discuss about radiography test in detail.	**04**
	(c)	Explain use of baffles, tie rods, spacers, tube side pass partition plate, shell side pass partition plate, tube sheet and expansion joints in shell and tube heat exchanger.	**07**

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