

GUJARAT TECHNOLOGICAL UNIVERSITY**BE - SEMESTER-VII (NEW) EXAMINATION – SUMMER 2022****Subject Code:3170502****Date:03/06/2022****Subject Name:Process Equipment Design****Time:02:30 PM TO 05:00 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.

- Q.1** (a) Define: 1. The capacity of pump 2. NPSH 3. Schedule number **03**
 (b) What are the functions of baffles in shell and tube heat exchangers? Discuss in brief types of baffles. **04**
 (c) Discuss with a neat sketch the pressure taps in the orifice meter. **07**
- Q.2** (a) Give the full name for TEMA, BEM, and HTRI in the context of shell and tube heat exchangers. **03**
 (b) State the advantages and disadvantages of plate-type heat exchangers. **04**
 (c) Benzene at 37.8 °C is pumped through the system at a rate of 9.09 m³/h with the help of a centrifugal pump. The reservoir is at atmospheric pressure. Pressure at the end of a discharge line is 345 kPa g. The discharge head is 3.05 m and the pump suction head is 1.22 m above the level of liquid in the reservoir. The friction loss in the suction line is 3.45 kPa and that in the discharge line is 37.9 kPa. The mechanical efficiency of the pump is 0.6. The density of benzene is 865 kg/m³ and its vapor pressure at 37.8 °C is 26.2 kPa. Calculate (i) (NPSH)_A (ii) Power required by a centrifugal pump. **07**
- OR**
- (c) A three-stage reciprocating compressor is used to compress 306 Sm³/h of methane from 0.95 atm a to 61.3 atm a. The inlet temperature is 26.7 °C. Specific heat ratio of methane, $k = 1.31$. Calculate the power required for compression, if mechanical efficiency is 80% and discharge temperature of gas after 1st stage. **07**
- Q.3** (a) What is the significance of the temperature correction factor? How to calculate? **03**
 (b) Discuss the downcomer design in the tray column. **04**
 (c) Explain the design steps to calculate the tower diameter of the packed bed absorption column. **07**
- OR**
- Q.3** (a) Discuss the types of flooding in a distillation column. **03**
 (b) Discuss the criteria of selection between kettle type reboiler and thermosyphon reboiler. **04**
 (c) Discuss the significance of following in a packed bed tower design. **07**
 1. Flooding velocity 2. Minimum wetting rate 3. The minimum amount of solvent required.
- Q.4** (a) What is the function of packing support? Explain in brief its types. **03**
 (b) In the design of vertical thermosyphon Reboiler recirculation ratio is determined via trial and error calculation. Discuss how to find or fix the recirculation ratio in case if $\Delta P_{av} \gg \Delta P_t$ **04**

- (c) The feed and product composition for distillation column is given as below. **07**
Determine the number of theoretical stages required for $R=3$, by FUG method. The design equations are provided below. Take $\alpha_{LK} = 2.567$, $R_m=1.4509$

Component	Feed	Distillate	Residue
n-butane	37	95	16.3
iso-pentane	32	05	41.6
n-pentane	21	--	28.5
n-hexane	10	--	13.6

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

$$f(N) = \frac{N-N_m}{N+1} = 1 - \exp \left[\left(\frac{1+54.4\varphi}{11+117.2\varphi} \right) \left(\frac{\varphi-1}{\varphi^{0.5}} \right) \right] \quad ; \quad \varphi = \frac{R-R_m}{R+1}$$

OR

- Q.4** (a) With an example explain the guideline to choose the material of construction for any pressure vessel. **03**
(b) Compare the various types of trays for tray columns. **04**
(c) What is design pressure? Explain various methods to calculate the thickness of cylindrical pressure vessels **07**

- Q.5** (a) Calculate tube side and shell side heat transfer coefficient for the design of a 1-2 shell-and-tube exchanger for the following duty. What modifications are required to do for design? **14**

20,000 kg/h of kerosene (42° API) leaves the base of a kerosene side-stripping column at 200°C and is to be cooled to 90°C by exchange with 70,000 kg/h light crude oil (34° API) coming from storage at 40°C. The kerosene enters the exchanger at a pressure of 5 bar and the crude oil at 6.5 bar. A pressure drop of 0.8 bar is permissible on both streams. Allowance should be made for fouling by including a fouling factor of $0.0003 \text{ (W/m}^2 \text{ }^\circ\text{C)}^{-1}$ on the crude stream and $0.0002 \text{ (W/m}^2 \text{ }^\circ\text{C)}^{-1}$ on the kerosene stream.

Property	kerosene	light crude oil
Specific heat, kJ/kg K	2.47	2.01
Density	730	820
Thermal conductivity	0.132	0.134
Viscosity	0.43	3.2

k_1 and n_1 for tube bundle diameter: (For triangular pitch $pt=1.25dO$)

No of the 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

Crude is taken through the tubes and the kerosene in the shell. Use 19.05 mm (3/4 inch) outside diameter, 14.83 mm inside diameter, 5 m Long tubes on a triangular pitch (pitch/dia. = 1.25). Assumed value of the overall heat transfer coefficient is $300 \text{ W/m}^2 \text{ }^\circ\text{C}$ for calculation.

OR

- Q.5** (a) Define and explain the significance of joint efficiency factor and maximum allowable stress. **03**
(b) Write a short note on types of heads and their applications. **04**
(c) Discuss the design steps to calculate the number of theoretical stages in binary distillation column. **07**

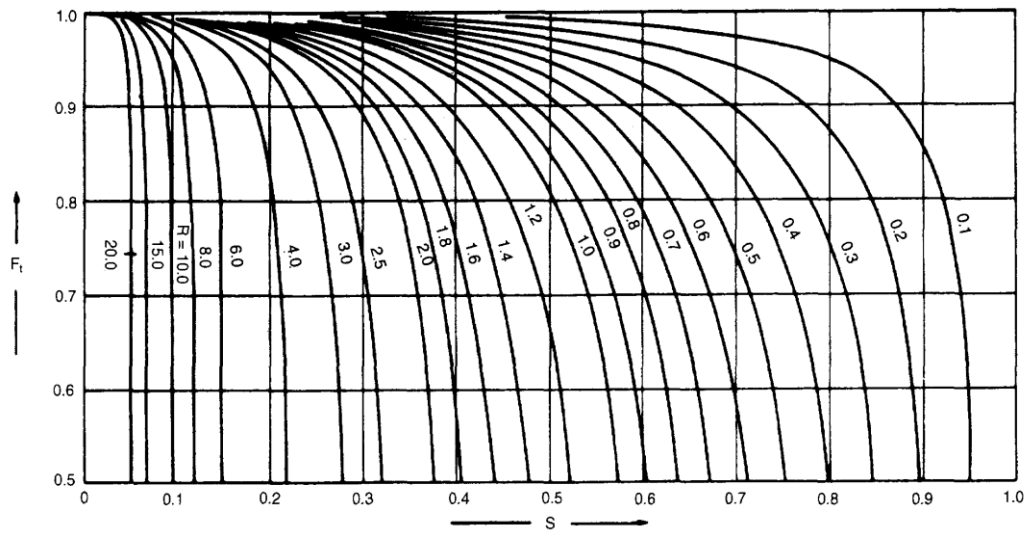


Figure1: Temperature correction factor for one pass shell and two ore more passes of tubes.