

GUJARAT TECHNOLOGICAL UNIVERSITY**BE - SEMESTER-VI • EXAMINATION – WINTER • 2014****Subject Code: 160503****Date: 01-12-2014****Subject Name: Process Equipment Design I****Time: 02:30 pm - 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.

- Q.1 (A)** Determine the minimum and maximum flow rate of water at 40 °C in rotameter **09**
of the given dimensions.

Viscosity of water at 40 °C = 0.7 cP

Density of water at 40 °C = 992.2 kg/m³

Float material = Stainless steel

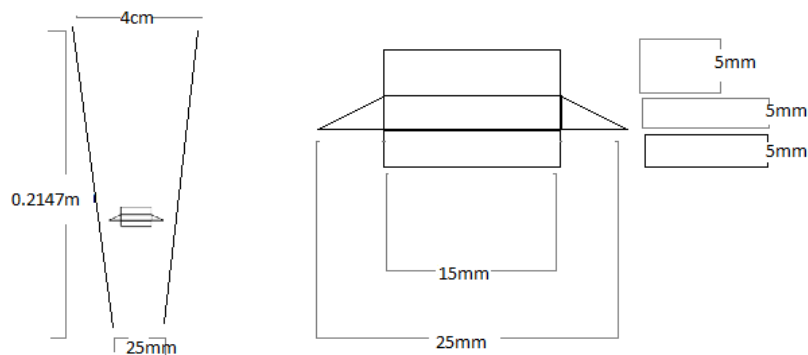
Density of stainless steel = 8000 kg/m³

Float is made from stainless steel plate of 2 mm thickness.

 $C_d = 0.775$

Angle made by tapered tube with vertical plane is 2 degree.

Mass flow rate through rotameter:



$$q_m = C_D A_2 \sqrt{\frac{2gV_f(\rho_f - \rho)\rho}{A_f \left[1 - \left(A_2/A_1 \right)^2 \right]}}$$

- (B)** Write a brief note on Fluid allocation in shell and tube heat exchanger. **05**
- Q.2 (A)** Discuss the criteria of selection among the different types of trays used in tray tower. **07**
- (B)** 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 reservoir. The friction loss in 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 (a) (NPSH)_A (b) Power required by centrifugal pump **07**

OR

- (B) 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 is 1.31. Calculate (a) Power required for compression, if mechanical efficiency is 80% and (b) discharge temperature of gas after 1st stage.

Power required in a single stage:

$$P_0 = 2.78 * 10^{-4} \left(\frac{k}{k-1} \right) q_{v1} p_1 \left[\left(\frac{p_2}{p_1} \right)^{\frac{k-1}{k}} - 1 \right]$$

- Q.3** Lube oil is to be cooled from 65°C to 45°C by using cooling water in shell and tube heat exchanger. **14**

Lube oil flow rate : 450 L/min

Density of lube oil : 869 kg/m³

Specific heat of lube oil: 2.1413 kJ/kg°C

Thermal conductivity of lube oil : 0.13 W/m°C

Viscosity of lube oil : 15 cP

Cooling water inlet temp. : 35°C

Cooling water outlet temp. : 39°C

Specific heat of water : 4.1868 kJ/kg°C

Viscosity of water : 0.73 cP

Thermal conductivity of water : 0.628 W/m°C

Density of Water = 993.32 kg/m³

Specification of fixed tube sheet heat exchanger:

Shell inside diameter : 418 mm , Tube O.D. : 15.875 mm

Type of baffle : 25% segmental, Tube I.D. : 13.3858 mm

Baffle spacing : 83.6 mm, Tube length : 3.048 m

Tube pitch : 1.25d_o

Type of tube arrangement : Triangular,

Nos. of tube side passes : 4,

LMTD correction factor : 0.95

Assume Overall heat transfer Coefficient = 400 W/m² °C.

Fixed tube sheet type shell and tube heat exchanger is used for this duty. Take lube oil on shell side and water on tube side.

Calculate (1) Number of tubes (2) tube side heat transfer coefficient (3) shell side heat transfer coefficient.

Use following correlation:

shell side heat transfer coefficient.

$$\frac{h_o d_s}{k} = J_h R_s P_r^{1/3}$$

Where

$$J_h = 10^X$$

$$X = 0.48856 \log_{10} R_s - 2.82393$$

$$d_s = \frac{1.1}{d_o} (P t^2 - 0.907 d_o^2)$$

Tube Side Heat Transfer coefficient:

$$Nu = 0.023 Re^{0.8} P_r^{0.33}$$

OR

- Q.3 (A)** State the functions of the followings in shell and tube heat exchanger. **07**
 (1) Baffles (2) tie rods (3) spacers (4) Tube sheet (5) sealing strips
- (B)** Discuss the desirable solvent properties required in liquid-liquid extraction. **07**
- Q.4 (A)** Explain the detail steps to calculate the tower diameter in distillation column. **07**
 Also discuss to check weeping in the tray column.

- (B) Discuss the industrial applications of Liquid Liquid Extraction. **07**
- OR
- Q.4 (A)** 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 6% by volume of acetone is passed through the scrubber. The mixture contains 1400 m³/hr of air. The scrubber is required to absorb 98% of the acetone. **10**
- At 25° C vapor pressure of acetone = 228.416 torr
Calculate Minimum amount of solvent required for above specified separation.
- (B)** Discuss the advantages and disadvantages of Vacuum Distillation. **04**
- Q.5 (A)** Explain the various flow pattern of liquid in column with neat sketch. **07**
- (B)** Discuss the process design of settlers. **07**
- Q.5 (A)** Explain the Tinkers flow model for shell and tube heat exchanger. **07**
- (B)** Write a brief note on NPSH for centrifugal pumps. **07**
