Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VI • EXAMINATION – WINTER 2013

Subject Code: 160503 **Date: 02-12-2013**

Subject Name: Process Equipment Design - I

Time: 02:30 pm to 05:30 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)** Define NPSH and explain process design of pump. **07**

(b) Discuss the process design of Orifice meter. **07**

Q.2 **(a)** Explain Tinker's flow model. Give procedure for calculation of pressure drop for Shell side for condenser **07**

(b) Discuss the design procedure for Kettle type Reboiler. **07**

OR

(b) Hexane at 40^0 C is pumped through the system at the rate of 10 m^3/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 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/m^3 and its vapour pressure at 40^0 C is 35 kPa. Calculate power required by centrifugal pump. **07**

Q.3 Design shell and tube horizontal condensor for condensation of 46000 kg/hr n-propanol at 0.25 kgf/cm^2g by cooling water at 32^0C. The condensing temp. at this pressure is 81.2 ^{0}C. The dirt factors of both shell and tube side is 2000 kcal/hr m^2C. 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. **14**

Properties for n-propanol:

Latent heat of condensation: 158 kcal/kg

Thermal conductivity : 0.14 kcal/hr m C

Liquid density : 800 kg/m^3

Liquid viscosity: 0.62 cP Vapor viscosity: 0.01 cP

Assume thermal conductivity of tube metal = 39 kcal/hr mC

Condensation coefficient is to be calculated as:

$$h_c = 0.95 k_c \left[\frac{\rho_c(\rho_c - \rho_v) g}{\mu_c \Gamma} \right]^{1/3} (N_R)^{-1/6} \text{ kcal/hrm}^2\text{C}$$

Where, kc = condensate thermal conductivity, kcal/hr mC

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
k_1	0.319	0.249	0.175	0.0743	0.0365
n_1	2.142	2.207	2.285	2.499	2.675

OR

Q.3 50000 kg/hr ethanol liquid is to be cooled from 85^0 C to 50^0 C in gasketed plate heat exchanger. Operating pressure at the inlet of heat exchanger is 2 atm g. Cooling water is available at 32^0 C, is used as a cooling medium. Design the suitable plate heat exchanger. Assume the temperature correction factor to be 0.97. Select the effective plate width 0.5 m and effective plate length 1.5 m having plate thickness 1 mm. Take gap between successive plate to be 3 mm. Assume the constant to be a=0.65, b= 0.4 and c=0.26. **14**

Take density of ethanol = 775 kg/m^3 and viscosity to be 0.6 cP Thermal conductivity of ethanol = 0.147 W/(m.^{0}C) and sp. heat = 2.84 KJ/Kg K

Take density of water = 1000 kg/m^3 and viscosity to be 0.8 cP Thermal conductivity of water = 0.62 W/(m.^{0}C) and sp. heat = 4.186 KJ/Kg K.

Assume the fouling coefficient of water and ethanol to be 10000 w/(m^2.^{0}C)

Assume plate material to be titanium with thermal conductivity = 21 W/(m.^{0}C)

Start the design assuming U = 1500 W/m^2 K and finalize after one trial only the area required as per 10% excess area. Pressure drop calculation is not required.

Q.4 1000 kg moles/hr of an ethanol propanol mixture containing 65 mole % ethanol is to be separated in a continuous plate column operating at 1 atm total pressure. The desired terminal composition in units of mole fraction of ethanol are: x_D=0.92 and x_w=0.07. The feed is a saturated vapor and total condenser is used. When reflux ratio is twice the minimum reflux ratio. Find the number of theoretical plates required for this distillation column using Mc- Cabe Thiele method. Relative volatility of ethanol propanol system may be taken as 2.20. **14**

OR

Q.4 Explain process design of Falling film absorber for exothermic absorption of gases like HCl and NH_3 in water. Indicate the advantage of Falling film absorber over Packed tower type absorber. **14**

Q.5 **(a)** Discuss criteria for choice of solvent for liquid-liquid extraction. **07**

(b) Discuss process design of settlers or decanters. **07**

OR

Q.5 **(a)** Discuss the design of counter current multistage extractor. **07**

(b) Discuss process design of Thermosyphon reboiler. **07**

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