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CM-701-CBGS

B.Tech., VII Semester

Examination, December 2020

Choice Based Grading System (CBGS)

Process Equipment Design-II

Time : Three Hours

Maximum Marks : 70

Note: i) Attempt any four questions.
ii) All questions carry equal marks.
iii) Draw neat sketch and assume suitable data wherever you required.
iv) Use of Design data book is permitted in the examination hall.

1. a) Explain the function of the following parts for the shell and tube heat exchanger.
   i) Baffles ii) Tie rods
   iii) Spacers iv) Expansion joint
   v) Tube side pass partition vi) Tube sheet
   vii) Support
   b) Explain Tube Arrangements and Tube-Sheet Layout

2. a) Discuss how fouling in heat exchangers represents a major source of performance degradation.
   b) A one shell-pass, two tube-pass heat exchanger cools 0.403 kg/s of methanol from 47°C to 7°C on the shell side. The coolant is 2.2 kg/s of Freon 12, entering the tubes at –33°C, with U = 538 W/m^{2}K. A colleague suggests that this arrangement wastes Freon. She thinks you could do almost as well if you cut the Freon flow rate all the way down to 0.8 kg/s. Calculate the new methanol outlet temperature that would result from this flow rate, and evaluate her suggestion.

3. a) What is the mechanism involved in the natural circulation evaporators?

   b) A salt solution is concentrated from 5 to 40% in weight of salt. For this reason, 15,000 kg/h of the diluted solution are fed to a double-effect evaporator that operates under backward feed. The steam used in the first effect is saturated at 2.5 atm, maintaining the evaporation chamber of the second effect at a pressure of 0.20 atm. If feed is at 22°C, calculate:

      i) steam flow rate needed and economy of the system;
      ii) heating area of each effect;
      iii) temperatures and pressures of the different evaporation and condensation chambers.

      Data: consider that only the 40% salt solution produces a boiling point rise of 7°C. The specific heat of the salt solutions can be calculated by the expression: $Cp = 4.18 - 3.34\ X$ kJ/(kg·°C), where X is the mass fraction of salt in the solution. The global heat transfer coefficients of the first and second effect are, respectively, 1860 and 1280 W/(m^2 °C). Specific heat of water vapor is 2.1 kJ/(kg·°C).

4. a) Explain the importance of Vapor-Liquid Equilibrium (VLE) relationship to the distillation process.

   b) Methanol water solution containing 50% by weight methanol at 26°C is to be continuously rectified at 1 standard atm pressure at a rate of 5000 Kg/h to provide a distillate containing 95% methanol by weight and a residue containing 1% methanol by weight. The feed enters at boiling point. The relative volatility is 3.2 and the reflux ratio is 1.5 times the minimum. If the overall efficiency is 75%. Design a suitable sieve tray distillation column by calculating its number of plates, height, diameter and pressure drop. Also sketch the tray with all the design details.

5. a) Write a brief note on various designs of packing supports and liquid distributors.

   b) It is desired to use the combustion gases from an oil fraction in a drying process. It was observed that the mixture of gases, after eliminating steam, contains 6% of SO_2 and 94% of dry air on a molar basis. In order to remove the SO_2, 453.6 kg/h of the gas mixture are fed to a tower packed with Raschig rings of 1 in. The column works at 50% of its flooding rate, using a water flow two times the minimum flow required to carry out the desired operation in an infinite height column. The column works under isothermal conditions at 30°C and 1 atm of pressure. If it is desired that the gas stream leaving the column not exceed 0.1% molar of SO_2, determine the diameter and the height of the column.

   Data: equilibrium data at 30°C:

P_{SO2}(mm Hg)	0.6	1.7	4.7	8.1	11.8	19.7	36.0	52.0	79
C_{SO2} kg SO_2 /100 kg H_2O	0.02	0.05	0.10	0.15	0.20	0.30	0.50	0.70	1

   The individual mass transfer coefficients can be calculated from the equations:

$$\left(K_y a\right) = 0.1G^{0.776}.L^{0.2}\ \frac{Kmols}{h.m^3.mol.fraction}$$

$$\left(K_x a\right) = 0.65L^{0.82}\ \frac{Kmols}{h.m^3.mol.fraction}$$

   where G and L are the mass flux of the gas and liquid streams, respectively, expressed in kg/(h.m^2). Properties of the liquid stream: density = 944.4 kg/m^3; viscosity = 1 m Pa·s.

6. a) How do you design a vapor-liquid separator or a flash drum?

b) Size a kettle reboiler to transfer 43.3 (10^6) btu/hr o vaporize a hydrocarbon mixture at 170 psia using steam available at 395°F. The critical pressure of this liquid is 434 psia and it has a boiling range of 60°F . The boiling temperature is 330°F. Design the reboiler using ¾ in OD tubes on 1.125 in square pitch.
Data:
Latent heat of liquid 144 btu / lb_m
Liquid density 41 lb_m/ft^3

7. a) Explain drying times for various drying rate models.
b) The rotary drier forms an important part of the plant. The drier has a capability of removing about 60% of the water entering the feed. The drier is a counter current drier, with air as the heating medium. The RH of the air entering is 10%. The air entering is heated to a temperature of 156°C. The slurry is fed into the drier at a temperature of 80°C.
Feed to the drier:
Water in feed = 1722.38 lb/Hr
Dry Solid in feed = 68205.51 lb/Hr
Water Content in Product = 688.94 lb/Hr
Water removed by the drier = 1033.44 lb/Hr
Condition of inlet air:
Ambient temperature of air = 30°C
RH = 10%
Wet bulb temperature = 22°C
Humidity WG = 0.002 lb water/lb dry air.
Inlet temperature of air = 156°C
Calculate the Diameter, Length, RPM and Number of Flights of the drie

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