

Model Examination - October 2013
Seventh Semester - Chemical Engineering

CH 2407 – Process Equipment Design II

Time: Three hours

Maximum: 100 marks

Answer ALL Questions

Part A (5 x 2 = 10 marks)

1. Draw the front and rear views of 1-4 shell and tube pass partition arrangements.
2. Pressure drop estimation on the shell side of a shell and tube heat exchanger is found to be higher than the allowable limit. How would you change the design so as to reduce the pressure drop?
3. How do you specify the dimensions of a tube?
4. What is the typical percentage of '*area of central down-take*' in comparison to the '*total cross sectional area of all the tubes*' in a standard calandria evaporator?
5. What type of support is used for (i) horizontal shell and tube heat exchanger, (ii) bubble-cap distillation column.

Part B (20 marks)

6. Write down the steps involved in designing the following equipment. (5)
7. Make suitable calculations to show that the given design is satisfactory. (15)

Part C (50 marks)

8. Draw to scale the suitable views of the equipment, mark the salient parts, and dimensions.

Question for Part B & Part C

Packed Bed Ceramic Absorber

A **packed bed ceramic absorber** of 2 feet inner diameter, 13 feet height, 1.125 inch thickness shell is available in a plant. Tower sections are stack-packed with ceramic cross-partition rings of 0.75 inch nominal size. Other dimensions of absorber are given below.

Details of column

Vapor Inlet section

Height of inlet section = 30inch

Inside diameter of vapor inlet nozzle = 6inch

Inside diameter of liquid outlet nozzle = 2inch

Top Cover section

Overall height = 7inch

Hemispherical end, with liquid inlet (2inch ID) at the center
and vapor outlet (6inch ID) at a side

Intermediate sections

Between inlet and cover sections, there are *three* intermediate sections of height 40inch each.

Various sections of column are connected by bell and spigot joint.

Vapor distribution plate:

- It is holding 6 risers each of 5inch ID and 7inch height. Raisers have vertical slots of 2inch high 0.25 inch wide on their sides with spacing of 0.5 inch.
- Vapor distribution plates also have large number of holes of 0.25 inch diameter on 0.5 inch triangular pitch
- The inside rim near the top of the inlet section is holding the vapor distribution plate.

Liquid distribution plate:

- The inside rim near the top of the top-intermediate section is holding the liquid distribution plate.

Liquid re-distribution plate:

- There is a liquid redistribution plate at the middle intermediate section

ΔP allowed in the column = 42 mm water per meter of packing height.

Packing factor (F_p) for stacked cross-partition ring of size $\frac{3}{4}$ inch is = 1500 m^{-1}

(a) Check whether the above absorber is suitable for the following duty, in terms of height and diameter.

The carbon dioxide issuing out of a fermenter at a flow rate of 13 kg/min contains 0.0025 mole fraction of ethanol, which has to be reduced to 0.0001 mole fraction by scrubbing with water in a countercurrent packed tower.

Equilibrium relationship: (in mole fraction units)

$$y = 1.07 x$$

Absorption factor is to be maintained at 1.5

Density of liquid = 1000 kg/m³

Viscosity of liquid = 0.001 kg/m.s

Density of gas = 1.84 kg/m³

For cross-partition rings of size ¾ inch, for the gas-liquid system, H_{IG} = 0.27 m; and H_{IL} = 0.23 m.

(b) And draw:

- (i) Sectional elevation of packed bed absorber assembly
- (ii) Detailed drawing of liquid distributor (plan and elevation)
- (iii) Detailed drawing of gas injection support plate (plan and elevation)

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