University of Technology
Chemical Engineering
Department
Final Examination
2015/2016

Subject :Equipment Design

Branch :Both Branches

Examiner: Dr.Riyadh Al Mukhtar

Class: Third
Time:3hours
Date :

الاجابة بالقلم الجاف

Attempt Four Questions Only

Q1 Numerate the types of heat transfer equipments and discus two in details

(25 mark)

Q2 A- Explain the anatomy of a chemical process

B- Draw the symbols of the following
Packed column , Fired heater, Drum , Autoclaves, Heat exchanger

(25 mark)

Q3) Design vertical gas –liquid separator at 35 C and 2 bar to separate mixture of air and water ,air flow rate 1000 kg/h and water flow rate 3250 kg/h ,then prepare a proper data sheet to the separator including pipe size connected to the equipment

Data: air density 1.4 kg/m^3 , water density 1100 kg/m^3

The gas – liquid separator without demister (25 mark)

Q4 Answer of the following

A- Explain the advantages of the globe valve and limitations in details

B- Define gas compressors and explain their types (25 mark)

Q5 The stripping section of a distillation column show below .Estimate the following

a- choose tray flow
b- Column Diameter
c-Down comer area ,down comer length
d- Weeping check

(25 marks)

Follow

Stripping **Section**	Liquid	Vapor
Volumetric flow kg / h	9000	5500
Density kg/m^3	900	2.0
Surface tension N/ m	30 E-3	

$$u_h = \frac{[K_2 - 0.90(25.4 - d_h)]}{(\rho_v)^{1/2}}$$

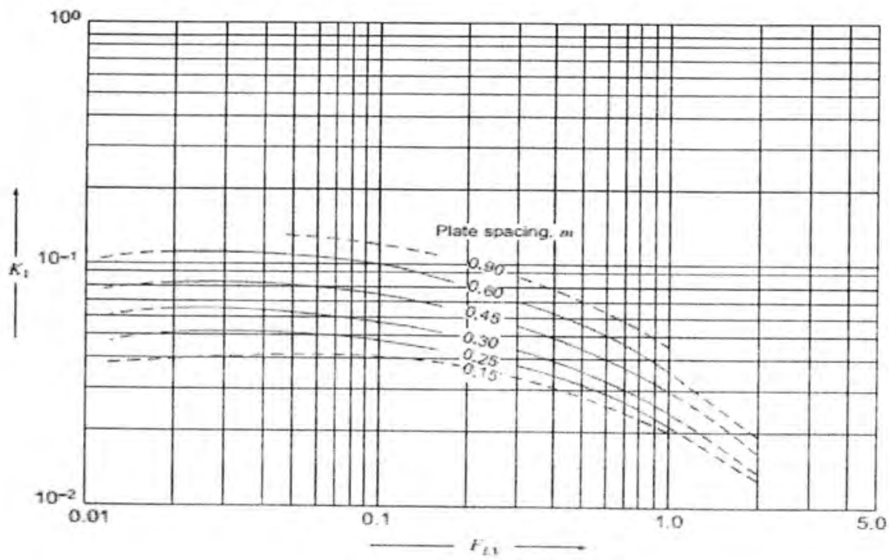
$$F_{LV} = \frac{L_w}{V_w}\sqrt{\frac{\rho_v}{\rho_L}}$$

Hole: Active Area	Multiply K_1 by
0.10	1.0
0.08	0.9
0.06	0.8

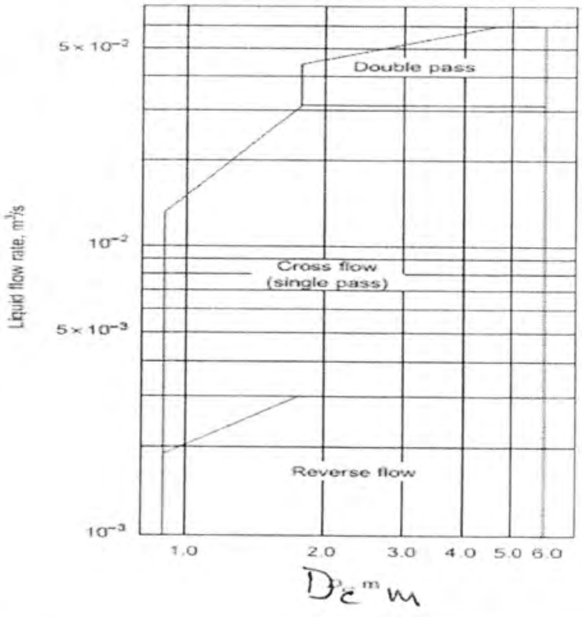
$$u_f = K_1\sqrt{\frac{\rho_L - \rho_v}{\rho_v}}$$

$$h_{ow} = 750\left[\frac{L_w}{\rho_L l_w}\right]^{2/3}$$

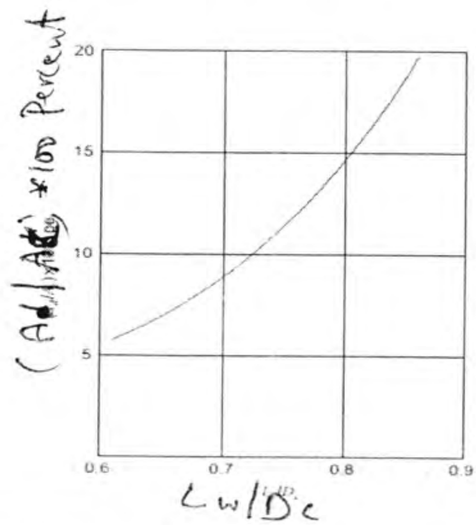
Liquid surface tension 0.02 N/m. for other surface tensions, σ, multiply the value of K_1 by $[\sigma/0.02]^{0.2}$.



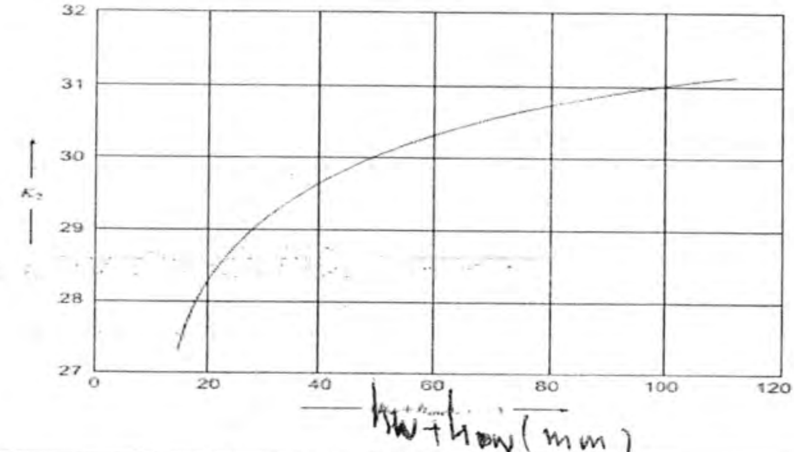
Flooding velocity, sieve plates.



Selection of liquid-flow arrangement.



Relation between downcomer area and weir length.



Weep-point correlation (Eduljee, 1959).

Q1 Heat Transfer Equipments

The transfer of heat to and from process fluid is an essential part of most chemical processes

There are many types of heat transfer Equipments
1- Double pipe exchanger
2- Air Cooled Exchangers
3- Direct Contact heat Exchanger
4- Shell and tube Exchangers
5- plate Heat Exchangers
6- Fired heaters - furnaces and boilers
7- Heat transfer to vessels
Jacket , Coil

يتم اختيار اي نوعية لما موجود في الفراغ الكافي

I Double pipe Exchangers
It is simple and cheap., it is a concentric pipe arrangment. it is only used for small heat transfer area.

Hair Pin are another types of double pipe heat exchangers, it is formed by inserting one or more U tube into two pipe section welded to a large flanged,

Direct Contact heat Exchangers

Hot and cold streams are brought into contact without any separating wall.

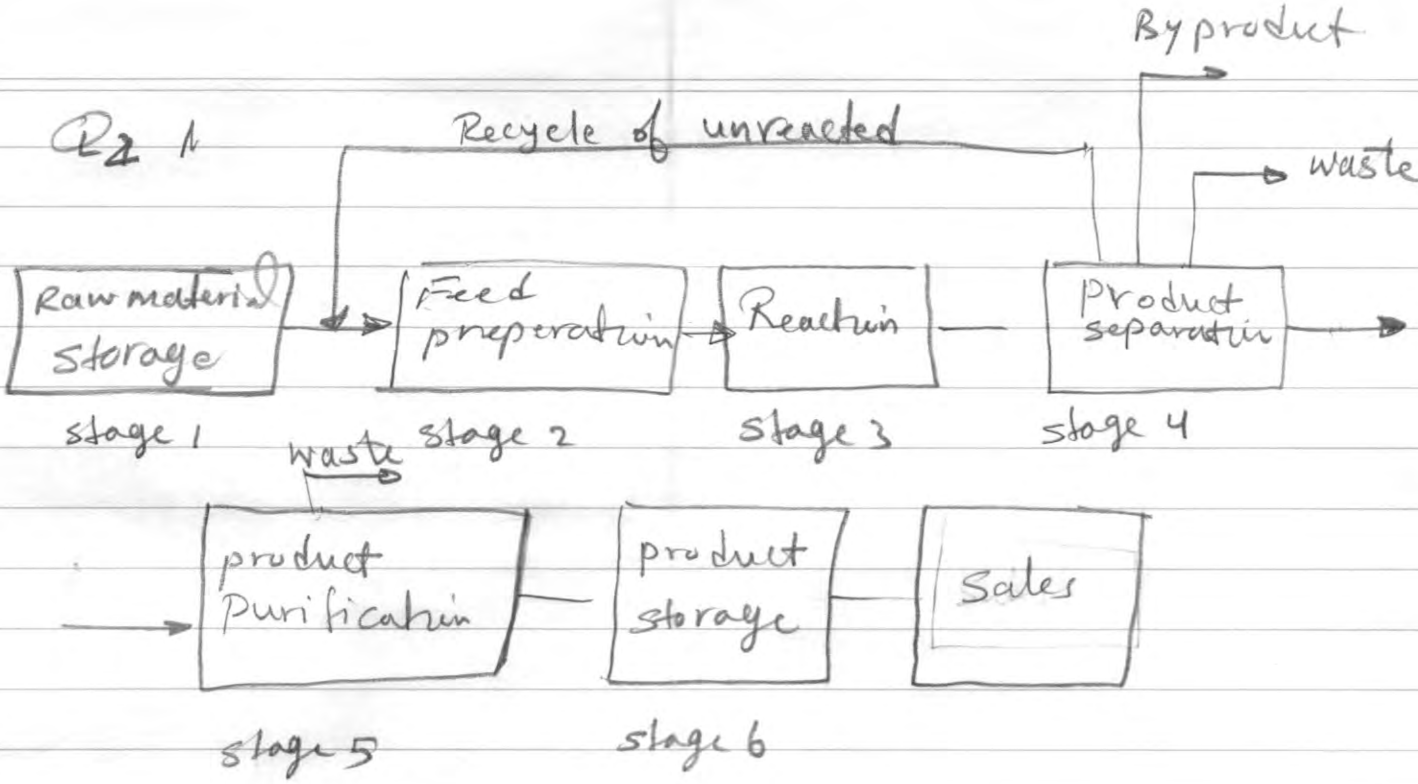
Advantages :-

1- High rates of heat transfer are achieved
2- The equipment is simple and clean
3- It may use for heavily fouling fluids and liquid containing solids
4- The size of the exchangers is not critical

Application

It is applied when the process stream and coolant are compatible, cooling towers, reactor off gas, quenching

Q2 1



1- Raw material storage
some provision will have to made to hold several days or weeks

2- Feed preparation
Some purification, and preparation of raw material will be nessary befor to be fed to reaction Stage

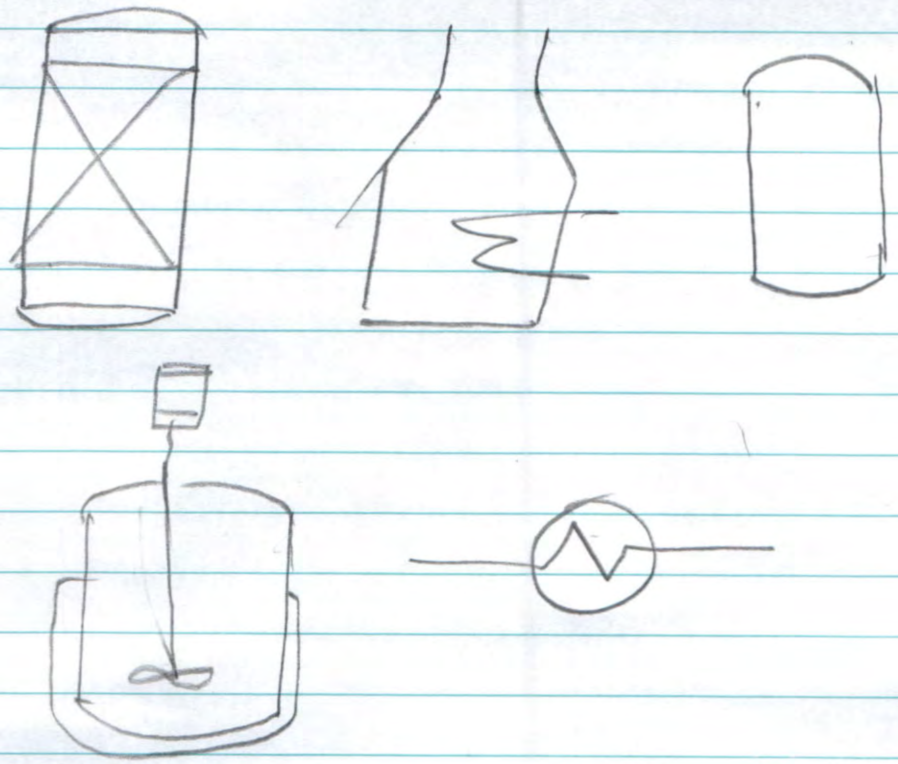
3 - Reactor
The reaction stage is the heart of a chemical manufacre Process

4- Product Separation
products and by products are separated from any unreacted material

5 - Purification: The main product need Purification to meet the product specifications

6 - Product Storage: Provision for product Packing and transport is needed

Q2 B



Q3 gas - liquid Separator Vertical

$$U_t = 0.07\sqrt{\frac{1100-1.4}{1.4}} = 1.96 \text{ m/s}$$

No demister $U_s = 1.96 \times 0.15 = 0.29$ m/s

Vap vol flowrate $= \frac{1000}{3600 \times 1.4} = 0.198$ m^3/s

$A = \frac{0.198}{0.29} = 0.684$ m^2 $\Rightarrow$ D $= 0.93$ m $\simeq 0.95$

Liquid flowrate $= \frac{3250}{3600 \times 1100} = 0.00082$ m^3/s

Take 10 min $= 0.00082 \times 60 \times 10 = 0.49$ m^3

Liquid height $= \frac{0.49}{0.684} = 0.71$ m $\simeq$ 72 cm

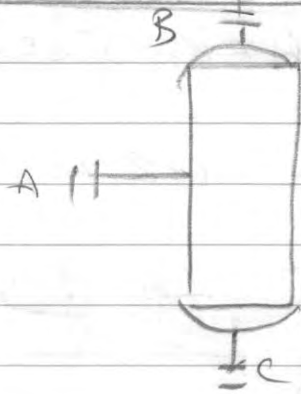
Connection pipes:

vap pipes outlet $= \frac{0.198}{15} = 0.0132$ m^2 $\Rightarrow$ d $= 0.129$ m $= 12.9$ cm $\simeq$ 5"

Liquid pipe outlet $= \frac{0.00082}{1} = 0.00082$ m^2 $\Rightarrow$ d $= 0.03$ m $\simeq 3.2$ cm $\simeq$ 1 1/2

Twophase pipes = 6"

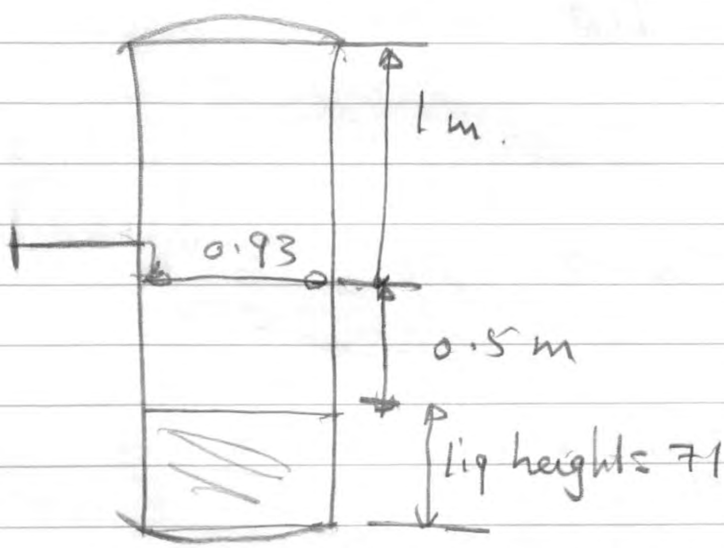
Chemical Eng	Gas_liq. Sep.



Diam m	0.93		A	Feed inlet
Height m	2.2		B	vap. outlet
Press bar	2		C	liq outlet
Temp C^{0}	35			
Fluid water Air				
mat. of Con	CS			

Design By

No demister

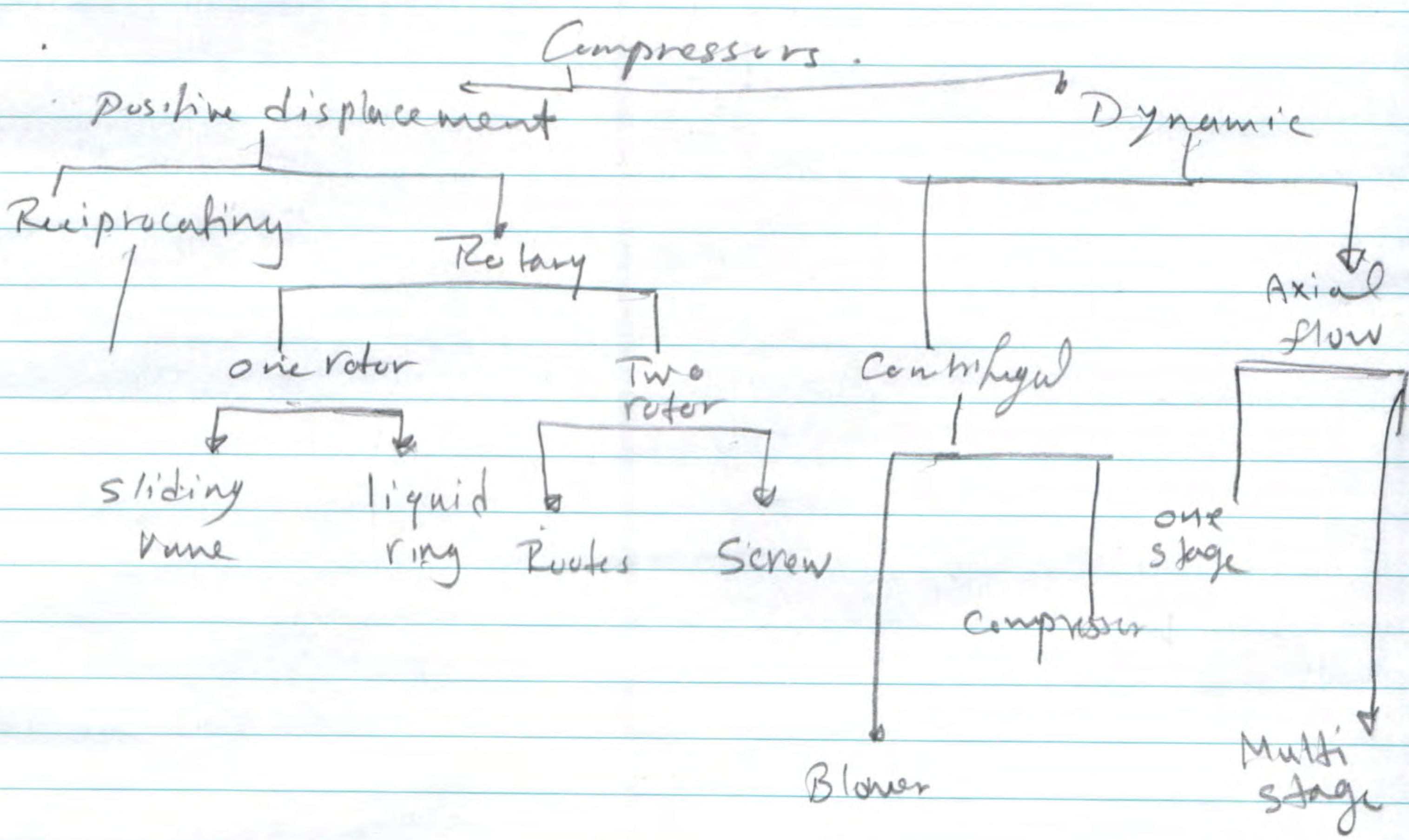


Total height 2.2 m

Q 4 B

Gas Compressor is a mechanical device that increases the pressure of a gas by reducing it's volume. compressors are similar to pumps. both increase the pressure on a fluid.

The are classified as



Distillation Coulumn.

$$F_{lv} = \frac{L_w}{V_w}\sqrt{\frac{\rho_v}{\rho_L}} = \frac{9000}{5500}\sqrt{\frac{2.0}{900}} = 0.0771$$

From Fig $K_1 = 8.5\times10^{-2}$

K_1 correction $= K_1\left(\frac{30}{20}\right)^{0.2}$

$= 9.2\times10^{-2}$

Assumption:
Tray spacing = 0.5 m
Down comer = 12%
weir height = 50 mm

$$u_f = 9.2\times10^{-2}\sqrt{\frac{900-2.0}{2}} = 1.9\ m/s \text{ flooding}$$

$u_f = 1.9 * 0.85 = 1.61$

vap. vol. flowrate $= \frac{5500}{3600\times2.0} = 0.763\ m^3/s$

Net area $= \frac{0.763}{1.61} = 0.402\ m^2$

$A_c = \frac{0.402}{0.88} = 0.54\ m^2 \rightarrow D_c = 0.83\ m$

From Fig. at liquid flowrate 2.7×10^{-3} → cross flow

$A_d = 0.54\times0.12 = 0.064\ m^2$

$A_n = 0.54 - 0.064 = 0.476\ m^2$

$A_a = 0.54 - 2(0.064) = 0.412\ m^2$

$A_h = 0.0412$ (10%)

$l_w = 0.76\times0.83$ from fig $= 0.630\ m$

$L_w = \frac{9000}{3600} = 2.5\ kg/s$

$$h_{ow} = 750\left(\frac{L_w}{\rho_L l_w}\right)^{2/3} = 750\left[\frac{2.5}{900\times0.577}\right]^{2/3} = 22.14\ mm.$$

$$h_{ow\,min}\ 70\% = 750\left[\frac{2.5 * 0.7}{900 * 0.577}\right]^{2/3}$$

$$= 17.5$$

$$h_o + h_{ow} = 50 + 17.5 = 67.5$$

from fig = $K_2 = 30.5$

$$U_{h_{min}} = \frac{30.5 - 0.9(25.4 - 5)}{(2)^{1/2}} = 8.58$$

$$U_h = \frac{0.763 * 0.7}{0.0412} = 12.9 \text{ m/s} \quad O.K$$

Weeping. ~~check~~ K