RADMAN SANA'T CO.
CONSULTING ENGINEERS

Instructions manual

Packed Batch Distillation Column

Aim:

In aim of this unit is to study packed distillation tower . we have mixture of ethanol-water at various temperature. Ethanol concentration in samples is measured by hydrometer.

Packed bed

In chemical processing, a packed bed is a hollow tube, pipe, or other vessel that is filled with a packing material. The packing can be randomly filled with small objects like Raschig rings or else it can be a specifically designed structured packing. Packed beds may also contain catalyst particles or adsorbents such as zeolite pellets, granular activated carbon, etc.

The purpose of a packed bed is typically to improve contact between two phases in a chemical or similar process. Packed beds can be used in a chemical reactor, a distillation process, or a scrubber,

Packed column

In industry, a packed column is a type of packed bed used to perform separation processes, such as absorption, stripping, and distillation . A packed column is a pressure vessel that has a packed section. Columns used in certain types of chromatography consisting of a tube filled with packing material can also be called packed columns and their structure has similarities to packed beds.

Column structure: random and stacked packed columns

The column can be filled with random dumped packing (creating a random packed column) or with structured packing sections, which are arranged or stacked (creating a stacked packed column). In the column, liquids tend to wet the surface of the packing and the vapors pass across this wetted surface, where mass transfer takes place. Packing material can be used instead of trays to improve separation in distillation columns. Packing offers the advantage of a lower pressure drop across the column (when compared to plates or trays), which is beneficial while operating under vacuum. Differently shaped packing materials have different surface areas and void space between the packing. Both of these factors affect packing performance.

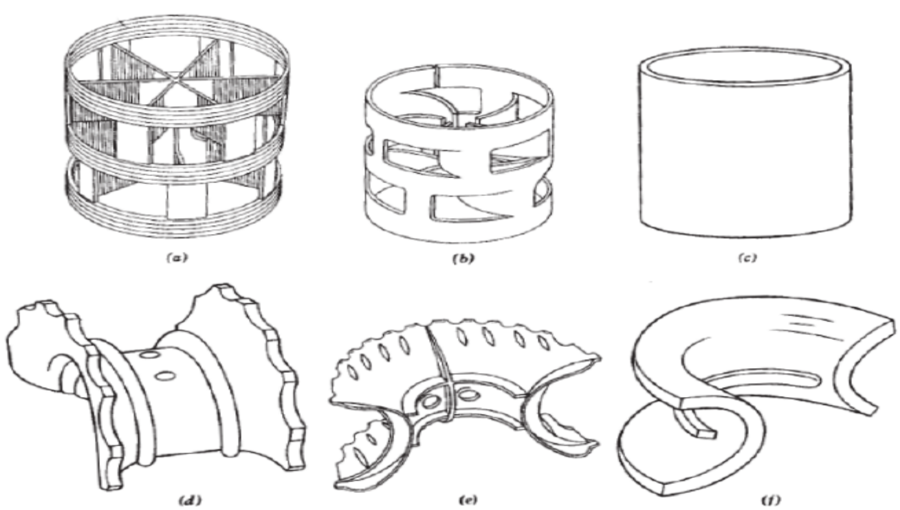

Fig1. Random packing: (a) plastic pall rings. (b) metal pall rings (Metal Hypac). (c) Raschig rings. (d) Intalox saddles. (e) Intalox saddles of plastic. (f) Intalox saddles

Liquid and vapor distribution (vapor to liquid ratio)

Another factor in performance, in addition to the packing shape and surface area, is the liquid and vapor distribution that enters the packed bed. The number of theoretical stages required to make a given separation is calculated using a specific vapor to liquid ratio. If the liquid and vapor are not evenly distributed across the superficial tower area as it enters the packed bed, the liquid to vapor ratio will not be correct and the required separation will not be achieved. The packing will appear to not be working properly. The height equivalent to a theoretical plate (HETP) will be greater than expected. These columns can contain liquid distributors and redistributors which help to distribute the liquid evenly over a section of packing, increasing the efficiency of the mass transfer. The design of the liquid distributors used to introduce the feed and reflux to a packed bed is critical to making the packing perform at maximum efficiency.

Working principle of packed tower

Liquid enters from tower top and is evenly distributed onto tower packings through liquid distributors and then flow down along the packing surface. The gas enters from tower bottom and distributed evenly through gas distributor device. The gas raises up against the liquid path through void of tower packing. The gas and liquid will contact on the packing surface for mass transfer.

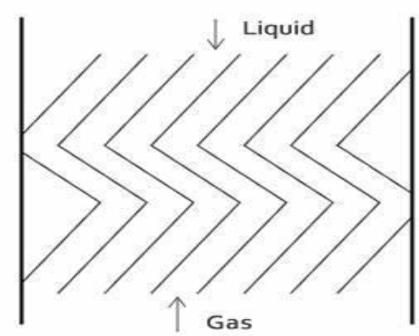

Fig2. Packing Tower working principle

packed tower working principle

The Ergun equation can be used to predict the pressure drop along the length of a packed bed given the fluid velocity, the packing size, and the viscosity and density of the fluid.

The Ergun equation, while reliable for systems on the surface of the earth, is unreliable for predicting the behavior of systems in microgravity. Experiments are currently underway aboard the International Space Station to collect data and develop reliable models for on orbit packed bed reactors.

Types of packing

Column packing for industrial separation processes is produced from various materials and is supplied in multifarious shapes and sizes. It may be dumped at random or stacked in regular geometric patterns, and it must ensure a large area of contact between the gas and the liquid phases and a uniform phase distribution.

The analysis and design of packed columns for thermal separation processes can be difficult in many cases. This applies not only to the actual scale-up of laboratory and pilot plant results but also to the uncertainty involved in many cases by the procedures adopted.

Column packing with a high volumetric efficiency obviously necessitates excellent hydro dynamic design and surfaces that greatly promote separation. A quantity to which the performance parameters are usually related is the ratio a of the surface area of the packing to the volume of the column.

$$a = \frac{\mathrm{Ap}}{\mathrm{Vc}}$$

The effective void fraction or porosity 8 in a bed of packing depends on the surface area Ap of the packing and the thickness of the basic material, which is usually in the form of sheet metal, metal foil, or plastics film.

and the effective void fraction of the bed, by:

$$\varepsilon = \frac{Vc - Vp}{\mathrm{Vc}}$$

$$\varepsilon \geq 1 - \frac{1}{2} as$$

Features of packed tower

- **Large production capacity**. The working principle of plate tower and packed tower is different. The rising gas in the plate tower passing though the liquid layer to achieve the mass transfer. The open area on the tower plate is 7% to 10%. In the packed tower, the rising gas and flowing down liquid contacts and achieve the mass transfer. The open area of tower packing is above 50% So the production capacity of packed tower is more superior than the plate tower in the unit sectional area.
- **High separating efficiency**. As we all know, most of the filtering operation in the tower is under atmospheric pressure and vacuum pressure. In these condition, the filtering efficiency of packed tower is much higher than the plate tower.
- **Low pressure drop**. The packed tower has higher void age, so the pressure drop is lower than the plate tower. In the normal condition, the pressure drop of plate tower is about 0.4–1.1 kPa per unit theoretical stage while the packed tower is about 0.01–0.27 kPa. The low pressure drop can not only save the operating cost, but also save energy. It is very suitable for the heat sensitive material separating.
- **Low liquid hold-up quantity**. Liquid hold-up quantity refers to the liquid quantity on the packing surface, internals and plates. The liquid hold-up quantity of packed tower is less than 6% while the plate tower is higher to 8-12%.

Applications of packed tower

Packed tower is widely used in the industrial application : such as pharmacy, coal mine, petroleum, chemical engineering.

- Separating.
- Filtering.
- Vacuum distillation.
- Purifying.

Device description

This unit consist of one glass column . The column have an inner diameter and height of 5 and 60 cm, respectively. The boiler with 2 kw heater, two thermocouples T1 and T2, which show the temperature of liquid and steam inside the boiler, respectively. Four thermocouples (T3 to T6) are installed along the tower and show the temperature distribution inside the tower. T7 measures the steam temperature inside the condenser. The condenser at the top of the tower has an effective surface area of about 200 cm^2 . And is cooled with cold water. Cold water flow rate can be adjusted with a rotameter and the inlet and outlet water temperature is measured by two thermocouples 01 and 02. The directions in this condenser are counter-current and the reflux rate of the tower can be adjusted by the pump. The product is also collected in the storage tank by another pump.

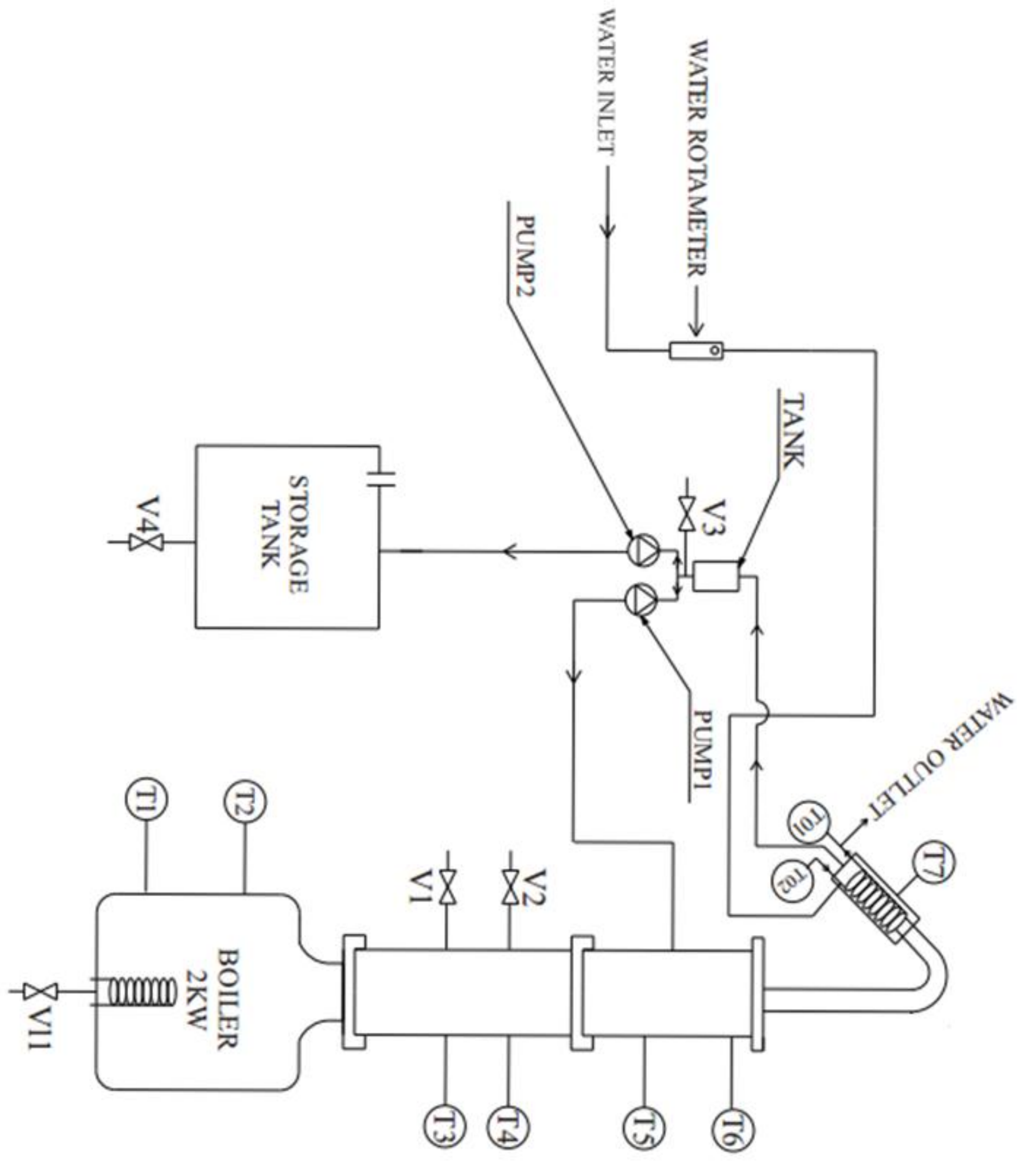

Fig3. PID Unit

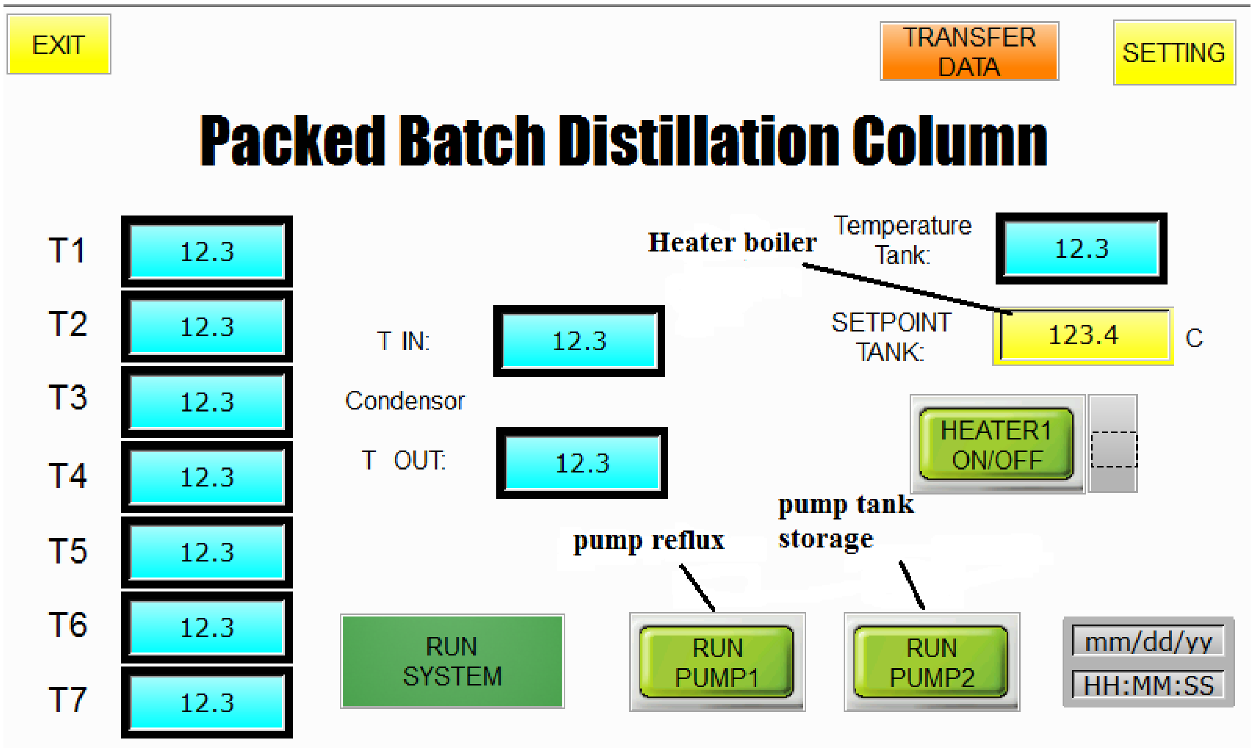

Fig4. Touch Panel Unit

To record data in the Set up -in part on the device, put the flash memory and at the end of the work for record data press TRANSFER DATA on the touch panel then the data is available as an Excel file.

Experimental

1. Prepare solution of 4 litter 10% (volume of ethanol) and fill it in the boiler tank. the alcohol content of the sample measure with a hydrometer.
2. Open the condenser water and adjusting flow rate of water by rotameter.
3. Turn on the heater on 90°C. Allow the system to accumulate a significant amount of liquid in the glass tank after condenser.
4. Note that the unit must operate in total reflux conditions.

5. Wait for the steam to enter the condenser and liquefy
6. Write down the necessary information about the condition of the tower and the condenser in three steps, 5 minutes apart
7. After reaching steady state, read the temperature values along the tower.
8. Now the ratio of liquid returned to the system can be changed Using the P1 peristaltic pump, adjust the reflux to a specified value On these pumps, an adjusting screw is installed, which is pumped by placing a certain flow mark on each line .sampled after the system is steady state.
9. allow the system 4 or 5 minutes to reaches steady state.
10. Write down the necessary information about the condition of the tower and the condenser
11. Finally close all valves and turn off the heater.
12. After cooling the set-up , turn off the cold water of condenser

Peristaltic pump

A peristaltic pump is a type of positive displacement pump used for pumping a variety of fluids. The fluid is contained within a flexible tube fitted inside a circular pump casing. As the rotor turns, the part of the tube under compression is pinched closed thus forcing the fluid to be pumped to move through the tube.

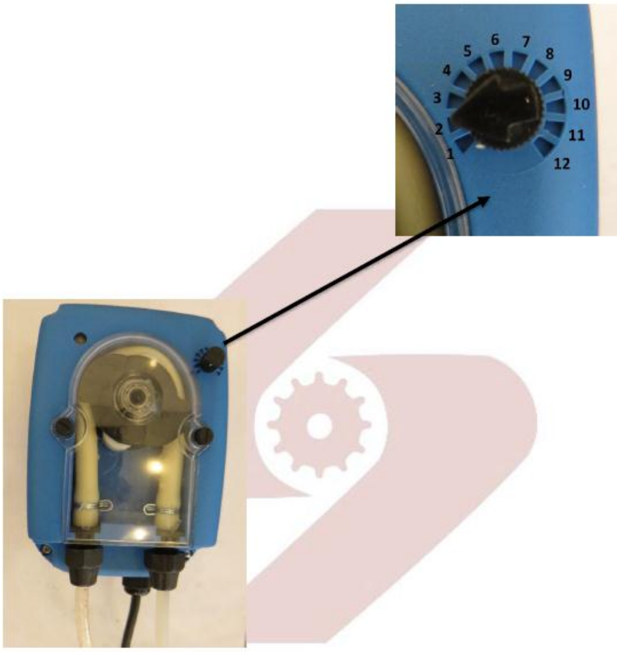

Fig5. Peristaltic pump

point	Flow rate(LPH)
2	0.94
3	1
4	1.5
5	1.8
6	2.4
7	2.9
8	3.2
9	5.5
10	7
11	8
12	9

Calculation:

$T_{3:}$(℃)vapor outlet of reboiler

$T_{6:}$(℃)vapor inlet to condenser

xw= concentration ethanol top of the tower

xd= concentration ethanol top of the tower

$HETP=K1*G^{K2}*D^{K3}*H^{(1/3)}[(\alpha av\ \mu^{L}av)/(\rho^{L}av)]$

K_1	K_2	K_3	αav	D(ft)	H(ft)
2.1	-0.37	1.24	Relative volatility	Tower diameter	Tower height

$\alpha av=(\alpha_{BO}\ \alpha_{up})^{1/2}$

$\alpha_{up=}$ Volatility top of the tower

$\alpha_{BO=}$ Volatility bottom of the tower

$\mu^{L}av$= viscosity(liquid)

$\rho^{L}av$= Density(liquid)

Q=V/T Ib/hr Flow rate

M Ib/Ibm Molecular weight

G=Q/M (Ibm/hr) mass flow(vapor)

H=NTU*HETP

NTU=H/HETP