RADMAN SANA'T CO.
CONSULTING ENGINEERS

Instructions manual

Gas Absorption and Desorption unit

The packed tower is a well-established application of immobilized (fixed film) cells. A vertical cylindrical column is packed with pieces of coke, aggregate, or plastic. Initially both medium and cells are fed into the top of the packed bed

The packed tower system, also called a "packed column," consists of the following elements:

- A tower, usually cylindrical, usually constructed of steel and coated as needed to prevent corrosion or other form of destruction
- Packing to promote intimate contact between molecules of target pollutants and the liquid absorbent
- A reservoir, usually at the bottom to the tower, to serve as a wet well for the pump
- A pump to transfer liquid absorbent from the reservoir to the top of tower
- Air compressor for adding air in to the packed tower and up through the packing
- A support floor, highly perforated, to perform several functions: holding the packing above the reservoir so as to provide a space for incoming gas (influent) to distribute itself evenly across the cross-section of the tower; serving as an inlet device to promote even application of the influent gas to the bottom of the column of packing; and allowing the liquid absorbent to readily drain away from the packing

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.

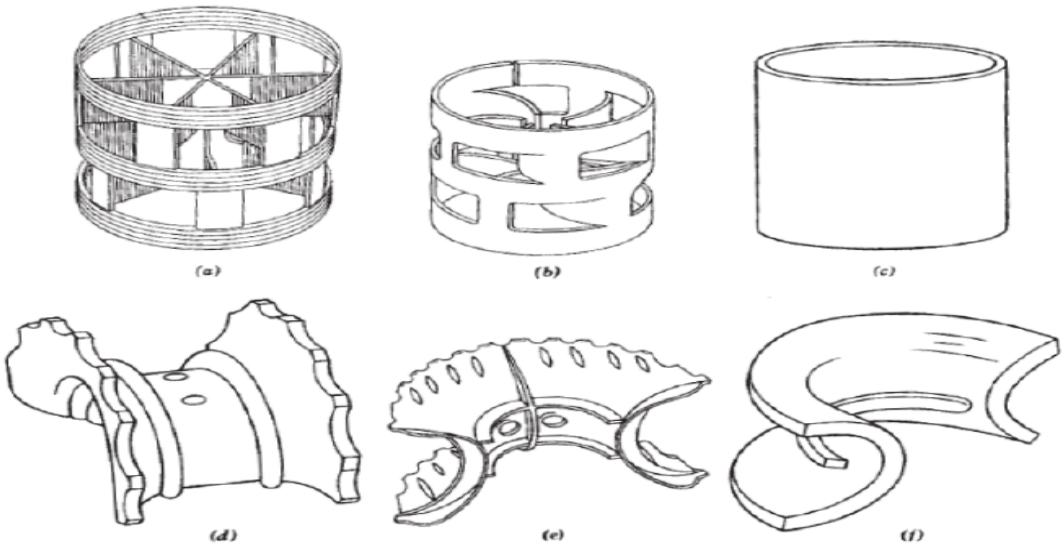

Fig1. Random packing: (a) plastic pall rings. (b) metal pall rings (Metal Hypac). (c) Raschig rings. (d) Intalox saddles. (e) Intalox saddles of plastic. (f) Intalox saddles

A description of the operation of the packed tower is as follows. The liquid absorbent is pumped continuously from the reservoir to the spray distribution system. After being applied evenly over the top surface of the packing material, the liquid absorbent flows slowly down over the surfaces of the packing. As the gas stream, which has entered the tower in the space between the reservoir and the bottom of the packing, flows up through the packing, substances that can dissolve in the liquid do so These substances have thus been removed from the gas stream, which continues its upward flow and exits the tower at the top. Excess moisture in the form of aerosol-size droplets or larger are trapped by the demister as the gas stream passes through.

The chemical mechanism of absorption is that of dissolution. In a gas stream treatment system that employs absorption as the treatment technology, the stream of gas to be discharged to the air or recycled for reuse is brought into intimate contact with a liquid. Substances dissolve into the liquid and are thus removed from the gas stream. In some cases the removed substance changes in character; in other cases it does not. Either way, the removed substances have been converted from an air pollutant to a potential water pollutant and must be dealt with further. Absorption systems, then, are not complete as treatment systems in themselves but are components of treatment systems.

The primary purpose of absorption equipment is first to contain the pollutants and then to maximize the opportunity for pollutants to move from the gas phase to the liquid phase. This purpose is accomplished by maximizing the surface area of the liquid absorbent and causing the gas stream to move past as much of the liquid surface as possible. Time of contact, of course, is a major parameter.

Where the target pollutants are highly soluble in water, the liquid absorbent can be water. However, it is the usual case that a chemical substance present in the liquid absorbent readily

reacts with the target pollutant to form a product that is either highly soluble in the liquid absorbent or forms a precipitate. For instance, sulfur dioxide, a gas at ambient temperatures, can be removed from a stream of air by contacting it with a solution of sodium hydroxide. Soluble sodium sulfate will quickly form and remain in the liquid. As another example, a stream of air containing silver sulfate in aerosol form can be contacted with an aqueous solution of sodium chloride. Insoluble silver chloride will form and remain suspended in the liquid until it is removed by an additional treatment step.

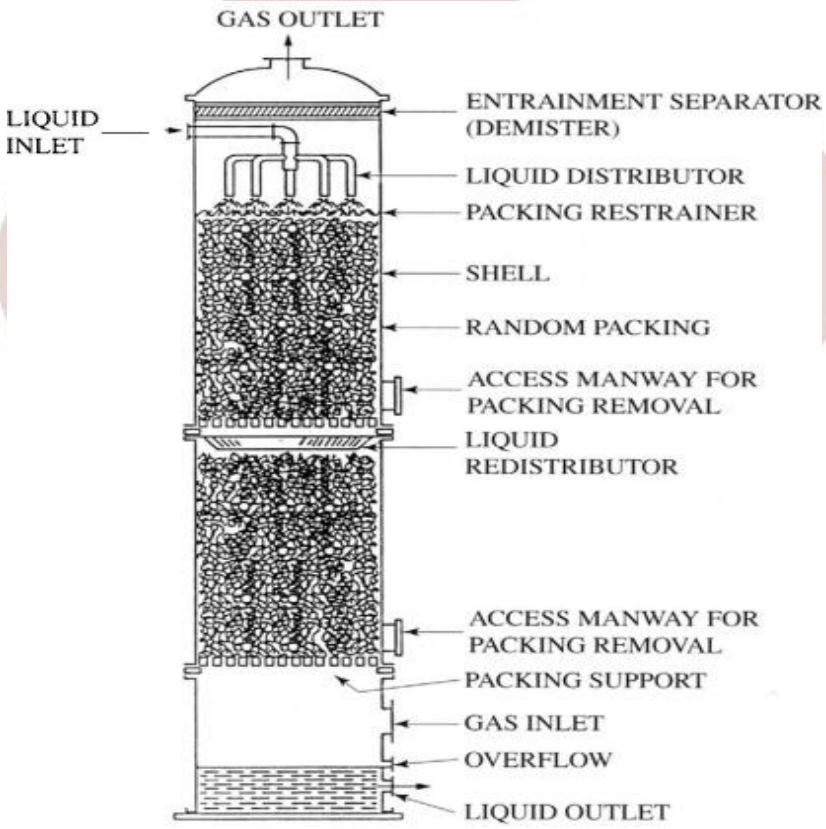

Fig 2. Gas absorption and Desorption unit

Packed tower advantages:

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 far 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%.

Assume two phases LG they are Insoluble And are used for liquid and gas, respectively, mass transfer It takes place from phase G to L. The transition component is component A and the other components are not transferable.

The lower part of the tower with subtitles 1 and top of the tower with subtitles 2 Has been specified

$Gs = G_1 - G_1y_1 = G_1(1 - y_1)$ moles(input) per unit time:G_1

moles(input) in phase G without component A:Gs

$Y_1 = (y_1G_1)/(G_1-y_1G_1)=y_1 /(1-y_1)$

mol fraction A at input phase G :y1

ratio mol A at input phase G :Y1

moles(input) per unit time :L2

mol fraction A at input phase L :x2

moles(input) in phase Lwithout component A :Ls

$L_S=L_2(1-x_2)$

ratio mol A at input phase L :X2

$X_2=x_2/(1-x_2)$

$$G_s = G(1-y) \qquad X = \frac{x}{1-x} \qquad Y = \frac{y}{1-y}$$

$$x = \frac{X}{1+X} \qquad L_s = L(1-x) \qquad y = \frac{y}{1-y}$$

We write the molar fraction balance of component A on the whole system:

$G_1y_1+L_2x_2=G_2y_2+L_1x_1$

Molar balance for the transferred component

$$G_S = G_1 - G_1 y_1 \rightarrow G_1 = \frac{G_s}{1-y_1}$$

$$L_s = L_1(1-x_1) \rightarrow L_1 = \frac{L_s}{1-x_1}$$

$$G_s = G_2(1-y_2) \rightarrow G_2 = \frac{G_s}{1-y_2}$$

$$L_s = L_2(1-x_2) \rightarrow L_2 = \frac{L_s}{1-x_2}$$

$$G_s\frac{y_1}{1-y_1} + L_s\frac{x_2}{1-x_2} = G_s\frac{y_2}{1-y_2} + L_s\frac{x_1}{1-x_1}$$

$$G_sY_1 + L_sX_2 = G_sY_2 + L_sX_1 \rightarrow G_s(Y_1-Y_2) = L_s(X_1-X_2)$$

$$\frac{Y_1-Y_2}{X_1-X_2} = \frac{L_s}{G_s}$$

The above equation is called the operating line equation of the whole operating that Connect the points (Y1 X1) to (Y2 X2) and slope is LS/GS By drawing the operating line and the equilibrium curve in XY In the form of a drawing or Computational method (solution including operating line and equilibrium curve in terms of XY, can be Found unknown.

In the absorption operation of mass transfer from phase G to L. Y2> Y1 and the operating line at the top of The equilibrium curve.

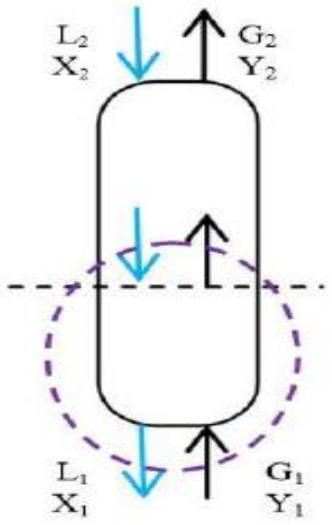

Fig3. Absorption of CO2

Absorption of CO_2 process

In the process of CO2 absorption, after the absorption of some CO2 by water, the amount of CO2 in the input and output can be compared . To determinate the amount of CO2 in the exist gas stream Gas glass is used In this way, a certain volume of NaOH with a certain molarity is poured into the gas glass. At each stage of the test, the glass is connected to the air outlet hose. The reactions performed during these steps are as follows:

$$NaOH + CO_2 \rightarrow NaHCO_3$$

$$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$$

In the ammonia desorption experiment , because of ammonia bases property, in a gas glass of HCl solution with a certain molarity Is used. The following reactions occur during this experiment:

$$NH_3 + H_2O \rightarrow NH_4OH$$

$$NH_4OH + HCl \rightarrow NH_4Cl + H_2O$$

After this reaction NH_4Cl to NH_3 and HCL Decomposed and neutralized if the reaction is balanced.

$$NH_4Cl \rightarrow NH_3 + HCl$$

Volumetric Titration

There are different types of titration with different methods and purposes, and the most common types of qualitative titration are acid-base titration and oxidation and reduction.

Acid–base Titration

Acid-base titration is related to the neutralization of acid and base when mixed with a solvent It means determining the concentration of an acid or base by neutralizing it with the help of another known base or acid. This method helps to quantify the concentration of an unknown acid or base solution. In this method, a neutralization reaction between acids and base and knowledge of how these materials with certain compound reaction .must be used. This method is based on measuring the exact volume of a solution In this method, a solution of a certain concentration, called a standard solution, It is located inside the port. And a solution of unknown concentration called an unknown solution It is located inside the erlen. The standard solution is added drop wise to the unknown solution until the reaction is complete The point at which the acid-base reaction is complete is called the end point Various methods are used to indicate the completion of a reaction, the most famous of which is the use of chemical indicator. The unknown solution is acidic or the base uses different indicators, the most common of which are phenolphthalein, methyl orange, and bromomethyl blue.

Unit Description

This unit includes a packed bed tower with the necessary part for storing solutions, feed pump and temperature measurement. The main part of the tower are:

Feed storage tank

Feed pump

Heater(2 kw at 220 volt)

Glass absorption desorption column consisting of 3 parts of 70 cm

Product tank for solution

Air Rotameter

Rotameter CO2 on the gauge CO2 (on cylinder)

Liquid rotameter

Thermocouple

instrumentation

Air compressor

Also valves that are installed in the unit according to PID:

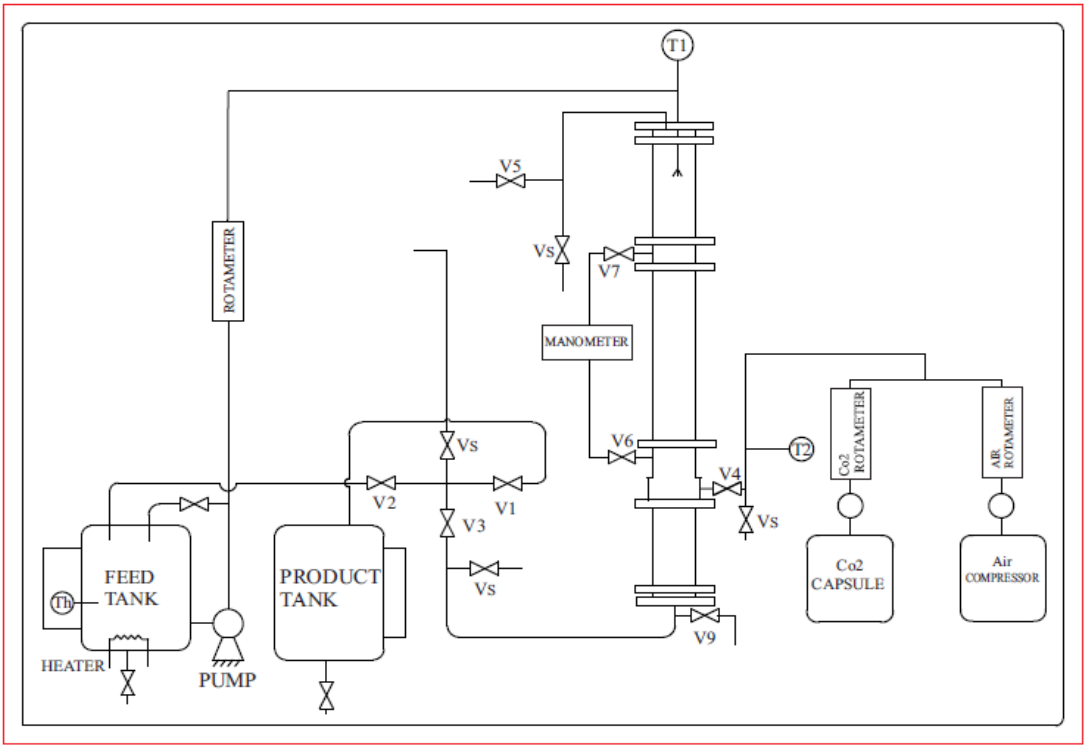

Fig 4. PID Unit

Experiment 1: Investigation of dry pressure drop along the packed tower

In this experiment, the aim is to investigate the changes in dry pressure in the packed tower in terms of mass flow of gas passing through the tower. Adjust the air flow and pressure simultaneously using an air compressor and regulator. for inlet air to column, Close valve V_s and open valve V_4 With the help of the regulator, set the air pressure to 1 bar and adjust the air flow to the minimum. After a few moments, write down the difference between the high and low pressure of the tower in a table Then find and record the pressure

difference in different flow rates while setting the Pressure gauge to fixed (1bar) and Then draw and analyze the pressure difference diagram in terms of flow at constant pressure.

Experiment 2: Flooding

In this experiment, we investigate the flooding when water and air are countercurrent in the tower. Adjust the air flow and pressure simultaneously with an air rotameter and regulator. To enter air to tower, close valve Vs and open valve V4. For example, set the air pressure to 1 bar and start from the minimum flow and increase the flow. Set the main power switch to ON and turn on the pump. adjust the liquid flow to a certain amount, for example, 100 liters per hour with valve 2. First, wait for the liquid to flow into the tower. Make sure the V1 valve is closed and the V2 valve is open so that the liquid reaches the bottom of the tower and returns to the feed tank. note the pressure drop. Then, without changing the flow rate, at a constant flow rate liquid, increase the air flow and record the pressure drop again. As the air flow increases, the liquid in the tower begins to collect and turns into a continuous phase in the tower, or the same flood is observed. During the test, make sure that the liquid collected at the bottom of the tower does not increase in sight glass. You can use the V3 valve to adjust the height of the liquid. Repeat this test in the other two flow rate and record the results.

Experiment 3: Continuous ammonia desorption process in a packed tower at ambient temperature

In this experiment, the aim is to investigate the separation of ammonia from water in a continuously packed tower by titration of samples with a solution of hydrochloric acid 0.1 N. First, prepare 250cc, 0.1 N acid solution using 1 N hydrochloric acid in laboratory and fill the burette.

Drain the tower with V9 valve and then close the valve. Fill the feed tank to about 20 liters with water and add about 300 cc of ammonia in the laboratory to the feed tank. Be very careful when transferring ammonia from the glasstank to the feed tank. Be sure about the feed tank closure to prevent evaporating ammonia
First, take a sample of the feed and titrate it with N0.1 acid. Use phenolphthalein for titration and continue until it reaches the colorless border. Open the valve (valve v2) for control flow and turn on the pump. Wait for the feed distribution from the top of the tower into the tower. Direct the air flow to the tower with the V4 valve and the regulator as the feed enters the tower. be careful the air flow rate according to the second experiment should be adjusted to about 70 to 80% of the confidence flow (flood flow). To prevent ammonia air from entering the laboratory area, open valve Vs and direct the hose connected to this valve out of the laboratory area . In this experiment, adjust the height liquid of the bottom tower with the V3 valve to a level of about 50 cm. Sampling the product at ten minute intervals and titrate it. After reaching the steady state, record the results in the table. During the experiment, you can observe and record the temperature of different parts of the tower.

Experiment 4 :Continuous process of ammonia desorption in packed tower with high temperature

In this experiment, the aim is to investigate the effect of feed temperature on the rate of ammonia separation in the desorption tower. First, set the maximum temperature of the heater installed in the feed tank to 45 degrees of Celsius and turn on the heater. To change the feed temperature, use the temperature display controller switch. Then titrate the product samples as in the third experiment and write down the result of the stable state in the table. Record the temperature of different parts of the tower in a steady state. Repeat this experiment for number favorable temperatures and observe the effect of increasing the temperature on the ammonia separation rate.

Experiment 5: Continuous process of CO2 absorption in a packed tower at ambient temperature

In this experiment same as, like the second test, first check that the feed tank has about 20 liters of water. Then turn on the main pump switch from the panel. adjust the air flow with air rotameter, set the air flow to about 24 LPM and do not change during the test. After adjusting the flow, wait for the liquid to reach the top of the tower and distribute from the top of the tower. Open the CO2 gas cylinder valve and adjust the flow rate about 12 LPM using the regulator of CO2 gas cylinder. Wait a while for the system to reach stable conditions. Now fill the cleaning bottles washing with 0.1 N NaOH (caustic) solution. Connect it to the Vs valve to the gas so that the exhaust gas from the tower passes through the bottles washing caustic with 0.1 N NaOH (caustic) solution for 2 minutes. Then drain the liquid inside bottles washing caustic and titrate it and get its normality. If the normality of the NaOH solution is zero, reduce the passage time of the gas through the bottles washing

caustic. Repeat the same experiment with different water flows. At the end of the experiment, open the drain valve at the bottom of the tower and the drain valve to open the product tank and feed tank to drain the entire route. At each flow rate, record it , duration, and normality changes of the gas solution.

Experiment 6: Continuous process of CO2 absorption in packed tower with high temperature

In this experiment, the aim is to investigate the effect of feed temperature on CO_2 absorption in tower. To change the feed temperature in this experiment, similar to Experiment 4, turn on the heater installed in the feed tank and set the desired feed temperature using the temperature display controller and wait until the measured temperature on the controller reaches the desired value. Then titrate the product samples at the bottom of the tower as in the third experiment and record the result in the steady state in the table. Record the temperature of different parts of the tower in a steady state. Repeat this experiment for different temperatures and observe the effect of increasing temperature on CO_2 absorption. At the end of the tests, turn off the pump and close the air valves. Drain the product and feed tank through the installed valves and wash the feed tank with a little water. Turn off the electrical panel and disconnect the mains.

Be sure to allow 15 minutes between each test

Important:

Fixed valve V5 to make testing easier