GAS ABSORPTION (PACKED COLUMN AND TRAY TOWERS)

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PRESENTATION OUTLINE

- Unit process Description
- Basic mass and energy balance equations
- Basic design and operating principles
- Uses of gas absorption
- Limitations of gas absorption
- Applications of gas absorption in industries
- Differences with other unit operations

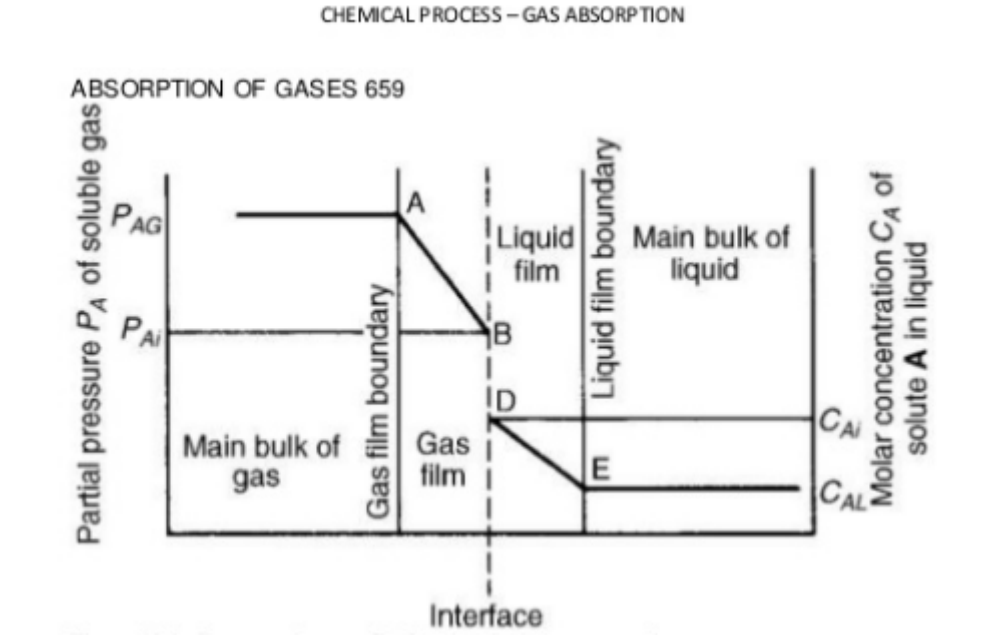
PROCESS DESCRIPTION

- Gas absorption also known as scrubbing is an operation in which a gas mixture is contacted with a liquid for the purpose of preferentially dissolving one or more components of the gas and to provide a solution of them in the liquid.
- Molecular diffusion- It requires the mass transfer of the gas components from the gas phase to the liquid phase.

CHOICE OF SOLVENT

- Gas solubility- should be high in order to increase rate of absorption and decrease amount of solvent needed.
- Volatility-solvent should have low vapor pressure to reduce loss of solvent in the gas leaving the absorption column
- Solvent should be non-toxic, non-flammable and chemically stable
- The materials of construction for the equipment should not be too expensive

TWO-FILM THEORY



Society, 2021. *Absorption process*. [online] Slideshare.net. Available at: <https://www.slideshare.net/RamiHawrami/absorption-process> [Accessed 9 February 2021].

PROCESS DESCRIPTION

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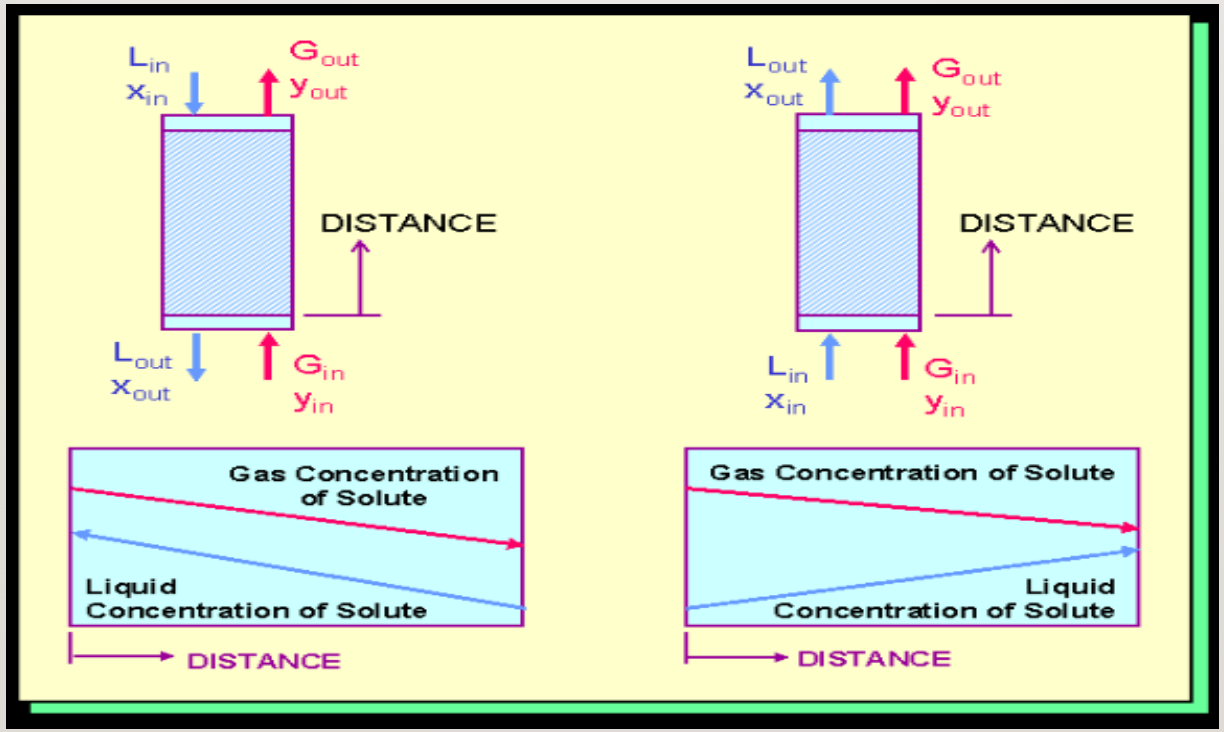
CHEMICAL & PHYSICAL GAS ABSORPTION

- There are two types of gas absorption: chemical and physical absorption.
- Chemical gas absorption- reaction between the absorbent and solute. Examples include using NaOH as an absorbent to dissolve acid gas, dissolving CO2 and H2S in aqueous solution of MEA.
- Physical absorption- No significant chemical reactions between the absorbent and solute. Examples include almost all gas absorptions that use water or hydrocarbon oils as absorbent.

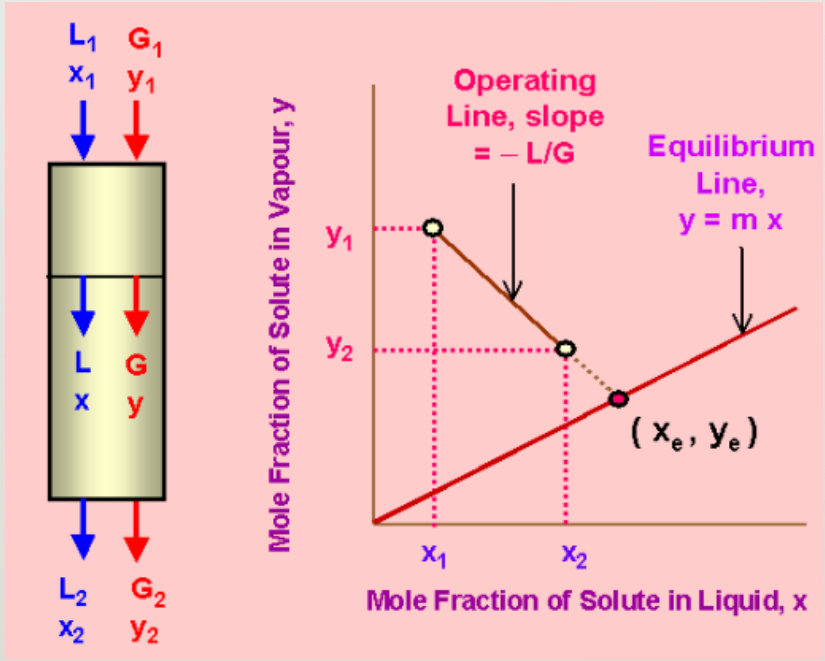
CO-CURRENT AND COUNTER-CURRENT GAS ABSORPTION



Separationprocesses.com. 2021. *Figure115*. [online] Available at: <http://www.separationprocesses.com/Absorption/Fig115.htm> [Accessed 5 February 2021].

CO-CURRENT GAS ABSORPTION

- The gas and liquid are both introduced from the same side of the column
- The operating line has a negative slope
- It is rarely used in industries as it is less efficient than counter-current.
- It requires an infinitely tall column to produce liquid and gas streams at equilibrium



Separationprocesses.com. 2021. *Co-Current Gas Absorption*. [online] Available at: <http://www.separationprocesses.com/Absorption/GA_Chp03b.htm> [Accessed 9 February 2021].

COUNTER-CURRENT GAS ABSORPTION

- The gas is introduced from the bottom while the liquid is introduced from the top.
- As we gradually move up the column, the gas component (A) is continuously transferred from the gas phase to the liquid phase.
- Moving up the column, there's a decrease in total gas flowrate and a decrease in concentration of A in the gas phase.
- Moving down the column, there's an increase in total liquid flowrate and an increase in concentration of A in the liquid phase

MASS BALANCE OF COUNTER-CURRENT GAS ABSORPTION

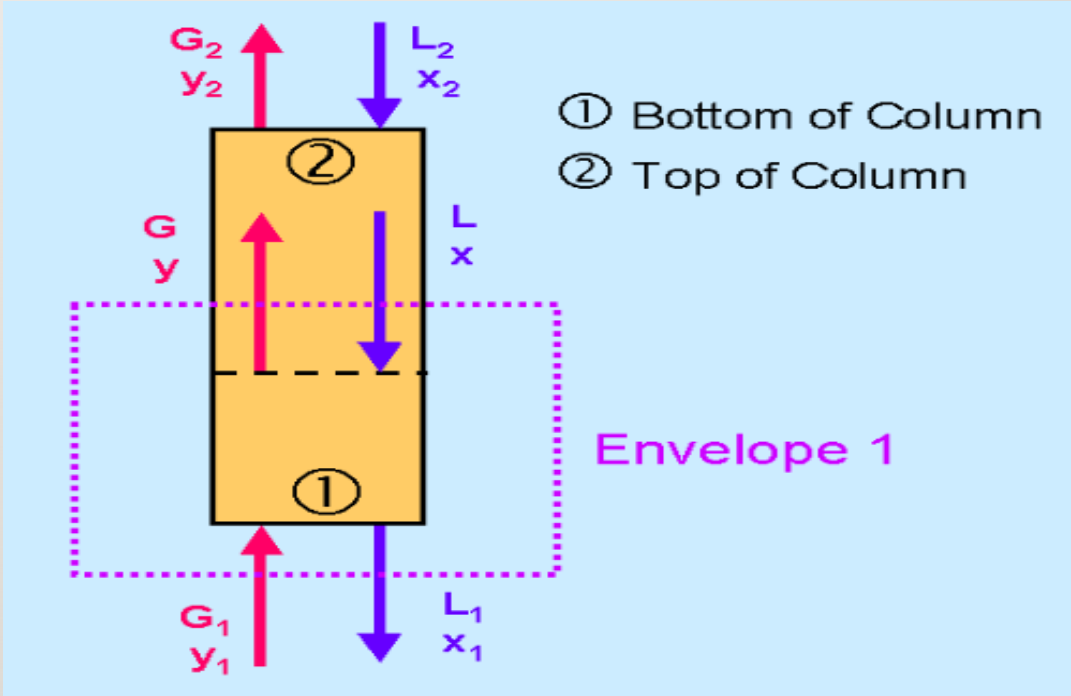
Assuming steady state : mass in =mass out

Thus, G.y + L1.x1 = L.x + G1.y1

For dilute systems, the solute content is relatively small compared to the absorbent and non-soluble inert, so constant flowrate is assumed.

G1=G=G2

L1=L=L2



Separationprocesses.com. 2021. *Counter-Current Gas Absorption*. [online] Available at: <http://www.separationprocesses.com/Absorption/GA_Chp03a.htm> [Accessed 9 February 2021].

MASS BALANCE (CONT'D)

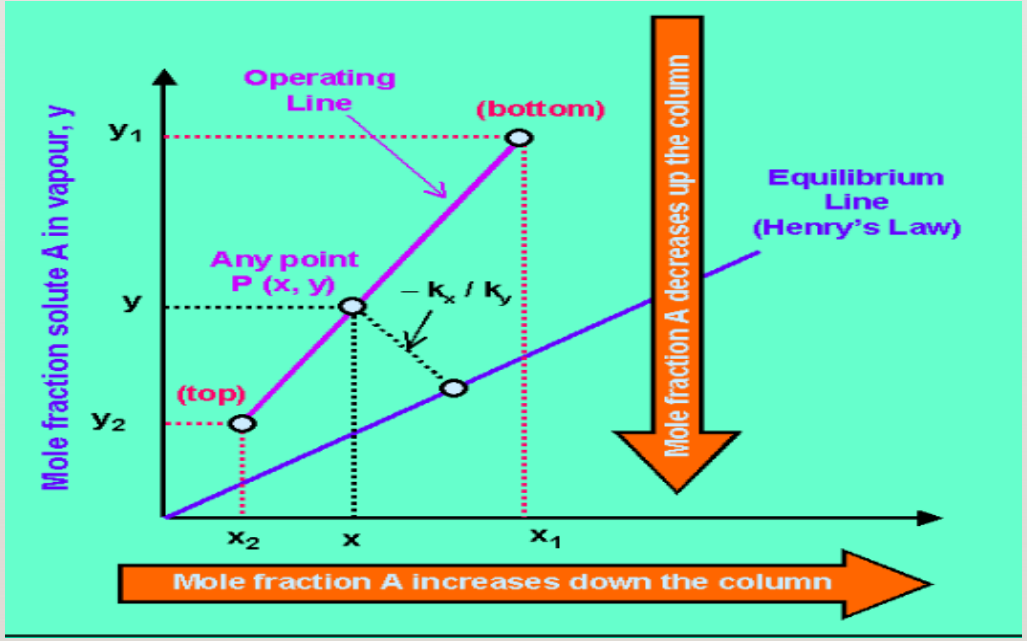
- The equation becomes:
- Gy=Lx +Gy1-Lx1
- Rearranging, we get

$$y = \left(\frac{L}{G}\right) x + \left(\frac{G y_1 - L x_1}{G}\right)$$

- This is the equation of the operating line with gradient (L/G), the liquid to gas ratio.

$$\left(\frac{L_{min}}{G}\right) = \left(\frac{y_1 - y_2}{x_{1\,(max)} - x_2}\right)$$

DETERMINATION OF MINIMUM LIQUID RATE

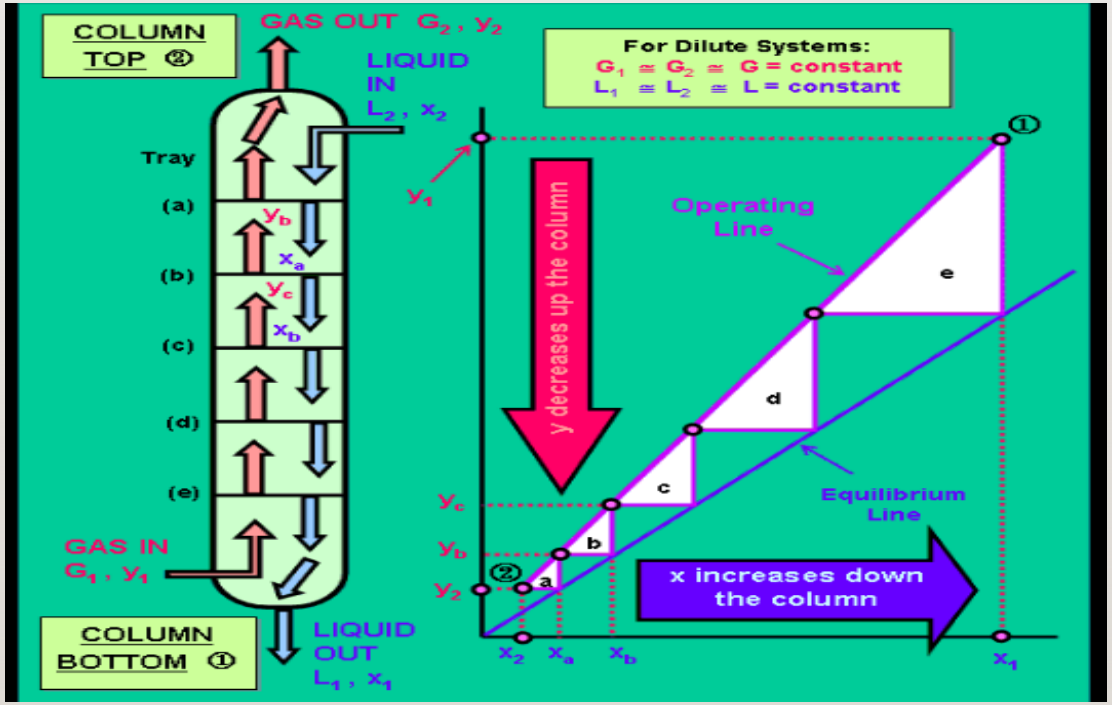


Separationprocesses.com. 2021. *Figure121*. [online] Available at: <http://www.separationprocesses.com/Absorption/Fig121.htm> [Accessed 9 February 2021].

FACTORS TO BE CONSIDERED IN DESIGNING AN ABSORPTION COLUMN

- Minimum Liquid Flow Rate
- Gas Flow Rate
- Loading Point
- Flooding Point
- Pressure Drop Along Transfer Units in the column
- Optimum operating condition for the packed column is located between the loading point & the flooding point
- Diameter and Height of Column (Number of Transfer Units, Height of Transfer Units)

DETERMINATION OF NUMBER OF STAGES

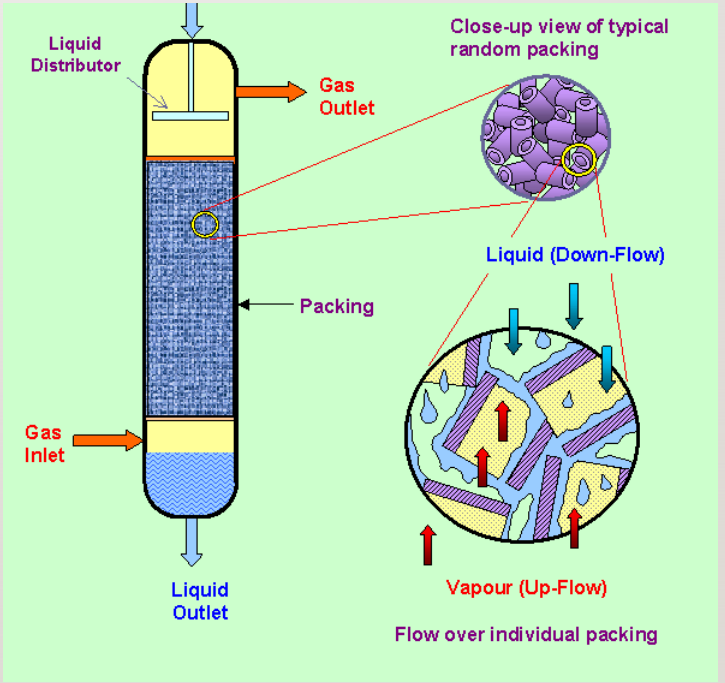


Separationprocesses.com. 2021. *Figure137*. [online] Available at: <http://www.separationprocesses.com/Absorption/Fig137.htm> [Accessed 9 February 2021].

PACKED BEDS

The gas-liquid contact in a packed bed is continuous and not stage-wise as in a plate column

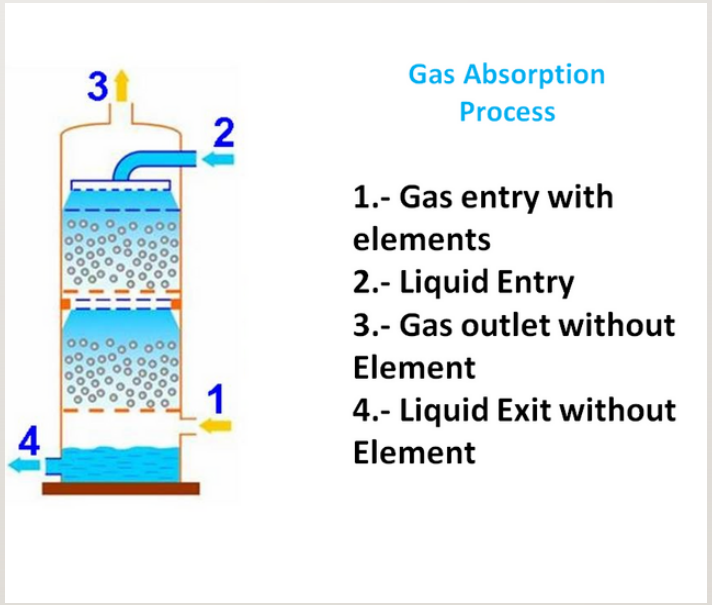
The performance of a packed bed is very dependent on the maintenance of good liquid and gas distribution over the packed bed



Separationprocesses.com. 2021. *Figure130*. [online] Available at: <http://www.separationprocesses.com/Absorption/Fig130.htm> [Accessed 9 February 2021].

TRAY TOWERS

The plate towers are vertical cylinders in which the liquid and the gas come into contact in the form of plates in different stages



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DIFFERENCES BETWEEN PACKED COLUMNS AND TRAY TOWERS

- There's lower pressure drop in packed columns than in tray towers
- Less liquid entrainment in packed columns than in tray towers
- Lower residence time in packed columns than in tray towers
- Tray columns are easier to clean than packed beds
- Tray columns have lower liquid rates and require more stages than an equivalent packed column

USES OF GAS ABSORPTION

- Co2 capture
- Removing pollutants from gases
- Recover valuable gases

LIMITATIONS OF GAS ABSORPTION

- Gas solubility
- Temperature of both the gas and the solvent
- Flooding of the column
- Corrosiveness of the solvent to be used

INDUSTRIAL APPLICATIONS OF GAS ABSORPTION

- Refineries to separate gas components
- For scrubbing in chemical industries
- Control of emissions of pollutants to the atmosphere, retaining polluting substances such as sulfur, chlorinated and fluorinated compounds; said control is based on the elimination of sulfur dioxide from combustion gases with aqueous solutions of sodium hydroxyl and the elimination of nitrogenous oxide with solutions of oxidizing agents.
- Recovery of gaseous stream products for production purposes

DIFFERENCES BETWEEN GAS ABSORPTION & DISTILLATION

GAS ABSORPTION

- Used to separate components present in a gas mixture
- Liquid is used for separation of gas mixtures
- Degree of separation depends on the selection of solvent and solubility of gas

DISTILLATION

- Used to separate components present in a liquid mixture
- Thermal heat is used for separation
- Separation depends on volatilities of the components present in the liquid mixture

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