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

PROCESS DESCRIPTION

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.

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, \( G.y + L_1.x_1 = L.x + G_1.y_1 \)

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

\( G_1 = G = G_2 \)
\( L_1 = L = L_2 \)

MASS BALANCE (CONT’D)

• The equation becomes:

• \( G_y = L_x + G_y_1 - L_x_1 \)

• 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.

\[
\left( \frac{L_{\text{min}}}{G} \right) = \left( \frac{y_1 - y_2}{x_1 (\text{max}) - x_2} \right)
\]
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

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.

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
REFERENCES

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