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International Journal of Current Research
Vol. 8, Issue, 11, pp.42165-42173, November, 2016

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

EXPERIMENTAL STUDY ON CARBON DIOXIDE ABSORPTION BY CAUSTIC POTASH

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ARTICLE INFO

Article History:
Received 24th August, 2016
Received in revised form
04th September, 2016
Accepted 21st October, 2016
Published online 30th November, 2016

Key words:

Carbon dioxide, Caustic potash (KOH),
Absorption, Plate column,
Post-combustion, Mass transfer.

ABSTRACT

As there has been a tremendous rise of atmospheric greenhouse gases, there is a threat to the climate which in turn shows the effect on the living creatures. To overcome these problems, some scientists these days are finding ways to scrub the key pollutant, carbon dioxide (CO_2), right out of the air. The increase in atmospheric carbon dioxide has attracted international attention due to its impact on global climate. Countries below poverty line release much less atmospheric carbon compared to richer countries in the terms of industrial emissions. The Kyoto protocol was thus established to prevent further increase in atmospheric CO_2. Therefore a post combustion capture technique can be employed to capture carbon from already existed and new power plants. There are various sources of CO_2 emission, but the major source is power plants and hence the retention of carbon dioxide into aqueous potassium hydroxide solution using plate absorption column is a reliable method to reduce carbon emissions to an extent. The CO_2 gas absorbs readily at room temperatures into potassium hydroxide solution. Potassium hydroxide gives 40% efficiency of removing CO_2.This paper gives an overview of post combustion capture of chemical absorption by caustic potash(potassium hydroxide).

Citation: Salur. Divya and Rachakonda. Srikanth, 2016. "Experimental study on carbon dioxide absorption by caustic potash", *International Journal of Current Research*, 8, (11), 42165-42173.

INTRODUCTION

In many ways, carbon dioxide has been mischaracterized because of its association with greenhouses and global warming. But in fact carbon dioxide is a naturally occurring gas with many useful functions. From carbonated drinks, to fire extinguishers. But more importantly, carbon dioxide is essential for life on our planet, because it is required for photosynthesis that plants utilize to convert energy into the food we eat. While carbon dioxide is not a harm, it can be unsafe in high concentrations or encased situations where it uproots oxygen. In any case, in the outside, carbon dioxide scatters rapidly, making it an improbable danger to general well being. Post combustion carbon capture is the technology that can be retrofitted to already existing and new power plants. post-combustion capture is the most flexible furthermore, the best adjusted to the necessities of power plant operators. The Post capture process with its inventive dissolvable recovering framework is the most benign alternative among the distinctive post-combustion capture solutions offered on the market. This is because of the extraordinary properties of the dissolvable utilized. The solvent used is typically potassium hydroxide bind with CO_2. The solvent-Co_2 combination is separated from the rest of the exhaust gas and heated. The heat drives off relatively pure Co_2 which is ready for compression. The decision between utilization of plate column or a packed column for a given mass exchange operation ought to, hypothetically, be founded on a subtle element cost investigation of the two sorts of contacts. Be that as it may, the choice can be made on the premise of a subjective investigation of relative preferences and inconveniences, dispensing with the requirement for a point by point cost examination.

Which are:

I. Due to fluid scattering troubles in packed columns, the outline of plate segment is extensively more dependable.
II. Plate columns can be intended to handle wide ranges fluid rates without flooding.
III. In the event that the operation includes fluids that contain scattered solids, utilization of a plate column is favoured on the grounds that the plates are more available for cleaning.
IV. For non-frothing frameworks the plate column is favoured.
V. In the event that occasional cleaning is required, manholes will be accommodated cleaning. In packed columns, packing must be evacuated before cleaning.

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VI. From huge column heights, weight of the packed column is more than plate column.
VII. Plan data for plate column is more promptly accessible and more dependable than that for packed column.
VIII. At the point when temperature change is included, packing might be harmed.

As my framework is non frothing so I am going to utilize plate section.

Need to capture carbon

For a huge number of years, the generation of nurseries gases was controlled by the common frameworks of the planet. Gases would be consumed and radiated at a genuinely enduring rate. Temperatures, in the interim, were kept up at a level that upheld life around the globe. The environmental agency describes this as "an exercise in careful control". People changed the exercise in careful control starting in the second 50% of the 1700s, toward the begin of the industrial revolution. Since that time we have included nursery gasses, basically CO_2 in the air at a consistently expanding rate, catching that warmth and warming the planet. Atmospheric concentrations of co_2 have been steadily rising, from approximately 315 ppm in 1959 to a current atmospheric average of approximately 385 ppm. Current projections to continue to rise to as much as 500 - 1000 ppm by the year 2100.

Overview of capturing techniques

CO_2 capture:

This phase of the procedure includes isolating the co_2 from the smoke and exhaust (for the most part water vapor and nitrogen) emitted during combustion. The high capital expense of implementing capture technologies implies that they are most appropriate for plants that create a high volume of concentrated co_2 discharges, for example, power stations or energy intensive industrial sites like refineries, concrete processing plants, petrochemical plants, steelworks and fertilizer factories.

Primarily there are three methods to capture carbon dioxide

- Pre combustion capture
- Oxyfuel combustion capture
- Post combustion capture

Pre combustion capture

In precombustion capture, before combustion starts, the carbon content of the fuel is reduced so as to obtain a stream of pure CO_2 upon combustion. Precombustion technique can be used to produce hydrogen or generate electricity or both.

The fuel bound carbon is initially reacted with a mixture of oxygen and steam. Carbon monoxide and hydrogen are mainly produced which is called as synthesis gas or syngas. Two additional processing units are required to capture CO_2 from syngas. Carbon monoxide is converted to CO_2 in shift reactor and separated out from the hydrogen. The CO_2 thus obtained is compressed and then stored and Hydrogen rich gas is used for power generation.

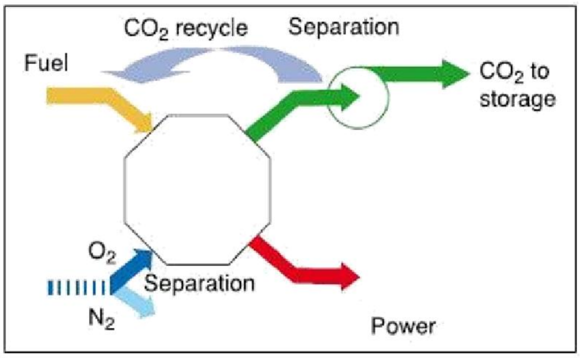


Figure 1. Schematic of pre-combustion capture

Advantages

Both the combustion of H_2 and heat recovered in the flue gas by means of a gadget called a Heat Recovery Steam Generator are utilized to produce power. The high pressure of CO_2 makes a capture artificially good.

Disadvantages

The crucial disadvantage of pre-combustion capture is that the technology can be used only in new power plants, as the capture process must be an integral part of the combustion process. On the off chance that any progression in the process fails. The plant might need to shut down. Plants might encounter nourish issues as well as corrosion due to snags. Furthermore, pre-combustion capture technology is not as advanced as post-combustion capture and is more expensive.

Oxyfuel combustion

In oxyfuel combustion, the combustion air is replaced by oxygen. Thus, the concentration of CO_2 in flue gas is increased by using pure or enriched oxygen (O_2) instead of air for combustion, either in a boiler or in the gas turbine.

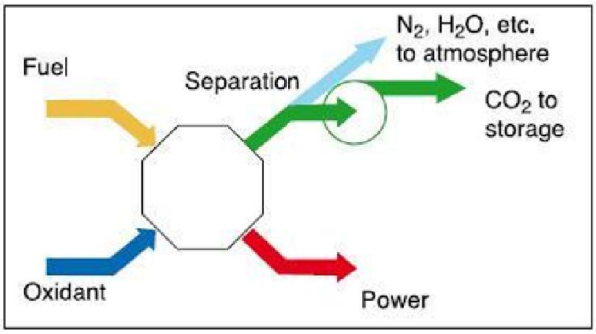


Figure 2. Schematic of Oxy-fuel combustion

In this approach oxygen will be produced by various methods such as cryogenic air separation. In the oxyfuel combustion procedures, the mass nitrogen is expelled from the air before ignition. The subsequent combustion products will have co_2 content up to around 90 for every penny (dry premise). The vent gas polluting influences (presently O_2, N_2, and Ar) might be uprooted by decreasing the flue gas (at moderate weight) to a temperature at which the co_2 and impurities do not. Oxyfuel combustion might be utilized with strong energizes, for example, coal, petroleum coke, and biomass, and also fluid and vaporous fill.

Advantages

The advantage of this methodology is that the vent gas contains just CO_2 and watervapour. Subsequently, the co_2 partition is an improved procedure which is accomplished by a cooling process in a heat exchanger for consolidating the water vapor.

Disadvantages

Oxyfuel capture plants are either just as or more costly as to maintain than traditional power plants. With this technology a new plant's efficiency will be decreased. Research on manufacture, transportation, and handling of pure oxygen must still be done before oxyfuel capture may be implemented on a large scale.

Post combustion capture

Post combustion capture expels co_2 from the vent gas after the fossil fuel has been burned. More than 95% of the coal-fired plants in the world use coal combustion technology. Around 33% of this limit worldwide is under 10 years of age. Introducing Post Combustion Capture on these plants is vital to evade the most exceedingly awful effects of environmental change. Post combustion capture means capturing CO_2 from the flue gas of power plants in order to significantly reduce the power plants CO_2 emissions.

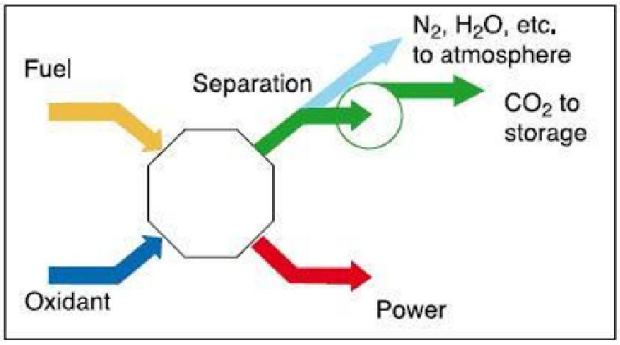


Figure 3. Schematic of Post-combustion capture

The exhaust goes through a compound dissolvable that binds the CO_2. The remaining exhaust is discharged into the environment, while the CO_2 is isolated from the solvent in a partition unit (called a stripper), and what remains is a pure stream of CO_2 that can be stored. One of the upsides of post-combustion capture is that can be relatively fit easily, on already existing emission sources, and it works on any kind of large stationary source, including industrial emissions. With the present solvents and technology post-combustion capture units can remove over 90 percent of the CO_2 from the flue gas. It is the foremost technology for gas fired power plants, neither the oxycombustion nor precombustion are well suited for gas plants.

Other methods to capture carbon

A number of methods exist for the post-combustion capture of CO_2 from flue gases. These include:

- Chemical absorption
- Adsorption
- Membrane separation
- Hydrate based separation
- Cryogenic separation

Chemical absorption

Chemical absorption at present is the most preferred option for post-combustion capture of CO_2. The liquid media can be aqueous alkanolamines, or other solutions such as chilled liquid ammonia, $K2CO_3$ solution and KOH solution. This mainly consist of an absorber and a desorber or stripper column. In the absorber, a reversible chemical reaction takes place between CO_2 and an aqueous solvent. This helps in the absorption process.

Adsorption technique

In contrast to absorption processes which use a liquid absorbent, a solid Sorbent is used to bind the CO_2 on its surfaces. (Lee, 2012) Large specific surface area, high selectivity and high regeneration ability are the main criteria for Sorbent selection. Typical Sorbents include molecular sieves, activated carbon, zeolites, calcium oxides, hydrotalcites and lithium zirconate.

Membrane seperation

Membranes can be used to allow only CO_2 to pass through, while excluding other components of the flue gas. The most important part of this process is the membrane which is made of a composite polymer of which a thin selective layer is bonded to a thicker, non-selective and low-cost layer that provides mechanical support to the membrane. This method has also been used to separate other gases such as O_2 from N_2, and CO_2 from natural gas.

Hydrate based separation

Hydrate-based CO_2 Separation is a new technology by which the exhaust gas containing CO_2 is exposed to water under high pressure forming hydrates. The CO_2 in the exhaust gas is selectively engaged in the cages of hydrate and is separated from other gases. The mechanism is based on the differences of phase equilibrium of CO_2 with other gases, where CO_2 can form hydrates easier than other gases such as N_2.

Cryogenic distillation

Cryogenic distillation is a gas separation process using distillation at very low temperature and high pressure, which is similar to other conventional distillation processes except that it is used to separate components of gaseous mixture (due to their different boiling points) instead of liquid.

Post combustion capture performance

The process is straight forward :

The flue gas from a power plant, or an industrial plant, enters a scrubbing tank.A liquid solvent is also added to this tank, and this solvent reacts with CO_2, but not with the other components of flue gas, like nitrogen. The nitrogen gas flows through the tank and leave an at the top of the tank. The liquid solvent, which has reacted with the co_2 leaves at the bottom of the tank. Typical solvents are chemical compounds like amines, ammonia, hydroxides are dissolved in water. These solvents cannot be stored or transported together with the co$_2$ because they are hazardous and expensive. The solvents are therefore regenerated so that they can be reused.In the regeneration tank the solvent-CO_2 mixture is heated, and the bonds between solvent and CO_2 are broken. The CO_2 is then released and leaves the top of the regeneration tank as gas. The pure amine leaves the bottom of the tank and is recirculated to the scrubber tank.

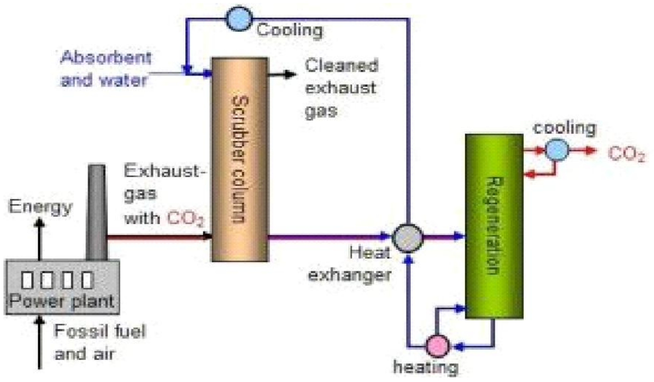


Figure 4. Process flow diagram of post-combustion capture

- Each of these techniques has its advantages and disadvantages.In theory post combustion capture can be applied to any power plant burning any carbon-based fuel,so it can be retrofitted to the world's thousands of existing power plants.
- Precombustion and oxyfuel both alter the fuel before it enters the station and are more suitable for newly built plants.
- Postcombustion is the best option for cleaning up the plants we have already; precombustion and oxyfuel could help us build clean plants in future.

Gas Seperation Processes

There are numerous approaches to perform seperation of gases. such as:

- Distillation,
- Absorption,
- Stripping and
- Extraction.

Distillation

(a) Flash Distillation

Flash Distillation is one of the easiest seperation procedures to be utilized in a chemical plant. The principle reason of flash distillation is that a portion of a fluid feed stream vaporizes in flash chamber or a vapor sustain gathers. Vapor-fluid equilibrium will bring about the vapor stage and the fluid stage to have diverse compositions. The more buoyant part of the mixture will make out of a bigger segment of the vapor. This straightforward seperation is simple but difficult to make yet does not result in expansive degrees of separation.

(b) Column Distillation:

Column Distillation are the most broadly utilized seperation procedure utilized in chemical industries, representing roughly 85% of all seperations. Distillation processes in columns comprise of numerous plates that each demonstration their own equilibrium conditions. Lege columns can perform complete seperation of binate and additionally more unpredictable multi-composised mixtures.

Absorption

Another seperation procedure utilized as a part of industry is absorption, which is utilized to remove a solute from a gas stream. It performs this by contacting the gas blend with a fluid dissolvable that immediately absorbs the obnoxious components from the gas stream, refining the gas stream. There are five noteworthy apparatus used for absorption in industrial application. These five equipments are venturi scrubbers, packed columns, plate (or tray) columns, film absorbers and spray towers.

(a) Packed column vs Plate column

Plate column absorbers and packed column absorbers have high efficiencies for the removal of an undesirable solute in the gas stream. The prime disservice a plate column has when contrasted with a packed tower is the weight drop. The pressure drop in a packed column is for the most part low, while in the middle of every plate of a plate column pressure drop can be quite large. However the preferences inherent to plate columns turn out to be clear when one needs the solvent to have a high concentration of the component to be expelled from the gas stream. This is most critical for the situation where there is a low concentration of the component in the gas stream and the determination expresses the solvent must contain a high concentration of that component. For this situation the flow rate of the dissolvable (solvent) may not be sufficiently high for a packed column, however in a plate column the dissolvable (solvent) flow rate can be close to zero for operation.

(b) Venturi scrubber Vs Spray tower

In both spray tower and venturi scrubber sprinkler systems (nozzles) are employeded to deliver small solvent droplets. These little droplets increase the surface zone of the fluid to gas contact taking into account the most extreme measure of mass exchange to happen between the gas blend and the fluid. The real contrast between the two sprinkler systems (nozzles) is the design and kind of nozzles

(c) Film absorber

The film absorber is for the most part utilized as a part of the situation where the heat of absorption must be removed. The film absorber works by sending the gas and dissolvable (solvent) through a heat exchanger where the dissolvable (solvent) makes a thin film on the walls of the tubes and the gas moves through the inside taking into account solute transfer.

Stripping

This procedure isolates solutes from solvents (frequently after absorption, to purify the solvent with the goal that it can be reused to a safeguard). Stripping will rely on upon the vapor and fluid stream rates, and in addition the temperature and pressure of the column. There is a temperature drop down the section, so columns for the most part have either an increased operating temperature or decreased operated pressure.

Extraction

Fluid extraction is a procedure for components with overlapping boiling points. The procedure requires a solvent with the end goal that a portion of the parts of the mixture are solvent, and after that the components will be isolated in view of this solvability in the fluid. This procedure can work at direct temperatures and pressures, so is not very high energy intensive.

Solvents used for carbondioxide capture

Carbondioxide absorption by amines

CO_2 capture is basically done by absorption with aqueous alkanolamines. These amines are bases which react with acid species. The alcohol groups enable them to be soluble in water. The first alkanolamines to be used industrially was Monoethanolamine (MEA). They may categorized into primary , secondary , tertiary types according to the number of organic groups that are attached to the alkaline nitrogen .These varieties of amines have different reaction mechanism, reaction products and the heat of reaction. Primary and secondary amines usually react faster than tertiary amines with higher heat of absorption in these amines. While the advantage of fast reacting amine solvent is a smaller absorber, the main difficulty is the energy required to regenerate the solvent. As a result a proper solvent must be selected. Several works are being carried out to develop mixed solvents so as to make this procedure more effective.

Carbon dioxide absorption by potassium hydroxide

Carbon dioxide forms a powerless acid when it dissolves in water, carbonic acid:

$$CO_2 + H_2O \rightarrow H_2CO_3$$

This then joins with potassium hydroxide in a acid/base response:

$$H_2CO_3 + KOH \rightarrow KHCO_3 + H_2O$$

The outcome is potassium bicarbonate and water. At the point when an answer of KOH is utilized as a part of titrations, it must be titrated itself to decide its careful fixation. This is on account of it is always absorbing CO_2 and loosing its quality as a base. (Ross E. Dugas, 2009)

Carbon dioxide absorption by sodium hydroxide

Zeman and Lackner outlined a specific method of air capture. First, CO_2 is absorbed by an alkaline NaOH solution to produce dissolved sodium carbonate. The absorption reaction is a gas liquid reaction, strongly exothermic, here:

$2NaOH(aq) + CO_2(g) \rightarrow Na_2CO_3(aq) + H_2O$

$Na_2CO_3(aq) + Ca(OH)_2(s) \rightarrow 2NaOH(aq) + CaCO_3(s)$

(Rochelle *et al.*, 2001)

Carbon dioxide absorption by lithium hydroxide

It reacts with carbon dioxide to make lithium carbonate

$2\ LiOH(s) + 2\ H_2O(g) \rightarrow 2\ LiOH{\cdot}H_2O(s)$

$2\ LiOH{\cdot}H_2O(s) + CO_2(g) \rightarrow Li_2CO_3(s) + 3\ H_2O(g)$

The net reaction being:

$2LiOH(s) + CO_2(g) \rightarrow Li_2CO_3(s) + H_2O(g)$

Lithium peroxide can also be used as it absorbs more CO_2 per unit weight with the added advantage of releasing oxygen.

Carbondioxide Absorption Into ‘ Caustic potash’

Formula: KOH

Molar Mass:56.1

Potassium hydroxide is also termed as ‘Caustic Potash’. Carbon dioxide forms a powerless acid when it dissolves in water, carbonic acid:

$CO_2 + H_2CO_3 \rightarrow$ H2CO3

This then joins with potassium hydroxide in a acid/base response:

$H_2CO_3 + KOH \rightarrow KHCO_3$

The outcome is potassium bicarbonate and water. At the point when an answer of KOH is utilized as a part of titrations, it must be titrated itself to decide its careful fixation. This is on account of it is always absorbing CO_2 and loosing its quality as a base. Potassium hydroxide KOH is a unscented, destructive, colourless, luscious crystalline solid. It promptly assimilates water and carbon dioxide from air. KOH has a decent solvency in water, 49.4% wt at 0°C, its solvation is exceedingly exothermic. It additionally breaks up in methyl liquor (35.5% wt at 28°C), ethanol (27.9% wt at 28°C). Potassium hydroxide frames stable mono-, di-and tetrahydrates (see table underneath):

Compound	KOH*H20	KOH*2H20	KOH*4H20
Dissolving point ‘c’	150	33	-33.5
Dissolvability in water g/100g (c)	147.0 (60c) 311.5 (150c)	117.4 (25c)	-------

Anhydrous potassium hydroxide exists in two crystalline changes. Monoclinic alteration is steady underneath 247°C, at higher temperature KOH has a NaCl-like cube grid. Potassium hydroxide is a "heavy base", alongside different soluble bases, for example, sodium hydroxide, lithium hydroxide, calcium hydroxide. Strong KOH viciously responds with mineral acids (balance response) to shape salts. It likewise promptly joins with their anhydrides (acidic oxides SO_2, CO_2, NO2 and others) to give comparing salts. Hence, association with carbon dioxide results in potassium hydrocarbonate.

Plate absorption column has been setup for following the process. The feed to the column is aqueous potassium hydroxide solution, carbondioxide gas. Aqueos potassium hydroxide solution flows downward through the column via gravity. While the carbondioxide gas flows upward. These two phases come in contact inspite of bubble caps, holes and valves that fill the area of the plates. Carbondioxide gas moves to the higher plate through these devices. While the potassium hydroxide solution move to the lower plate through a downcomer. Therefore a phase change occurs and mass transfer takes place by absorption of carbondioxide in to potassium hydroxide solution.The fluid is gathered to the base of the section while the gas is gathered to the top.

Equipment Mechanism

Figure 5. Overlook of Plate Absorption Column

Experimental Procedure

Aqueous potassium hydroxide solution of 0.1N,0.05N.0.15N were prepared and their initial concentrations were taken by titrating with oxalic acid. There initial concentrations were as 0.04292,0.07726,0.12019. The solution has been run through plate absorption column and accordingly readings were taken for different flow rates .According to absorption rate(r_a) and gas flow rate(r_g) a total of 3 experiments were conducted. The range of gas flow rate and liquid flow rate in this work were 0.5-1.5L/Min and 5-30L/Min respectively. The input gas concentrations were 15% respectively.While R was in the range of 2.62% - 4.94%.

STEP1: Finding out weight of KOH solution to be taken
Normality = wt / eq.wt * 1000 / vol of solution
For 0.1N = wt / 63.03 * 1000/5000
= 28.05grms
For 0.05N= 14.025grms
For 0.15N = 42.075gms

STEP2: Finding out the concentration of aqueous potassium hydroxide before fed into the plate absorption column for 0.05N
INITIALCONCENTRATION:
0.05N = (0.1010 * 8.3) / 20 = 0.04191
Therefore initial concentration = 0.04191

STEP3: Finding out the concentration of aqueous potassium hydroxide solution at different flow rates after running in plate absorption column.
At flowrate 5: (0.1010 * 4.1) / 20 = 0.02070
At flowrate 15: (0.1010 * 2.9) / 20 = 0.01464
At flowrate 30: (0.1010 * 3.4) / 20 = 0.01717
Therefore final concentrations for 0.05N solution at flow rates 5,15,30 are 0.02070, 0.01464, 0.01717

STEP4: Finding out carbondioxide absorption efficiency
Carbondioxide absorption efficiency = (initial- final) / initial * 100
CO_2 absorption efficiency at flowrate 5:
(0.04191 – 0.02070) / 0.04191 = 0.5060 * 100
= 50.60%

CO_2 absorption efficiency at flowrate 15: (0.04191 – 0.00959) / 0.04191 = 0.7717 * 100
= 77.17%
CO_2 absorption efficiency at flowrate 30: (0.04191 – 0.01717) / 0.04191 = 0.5903 * 100
=59.03%

RESULTS AND DISCUSSION

TRIAL 1. Obtained results for 0.05N solution (PRESSURE: 5lb/in ; EQUIPMENT RUNNING TIME: 20mnts)

SOL. INLET (LPH	CO_2 (LPM)	AIR (LPM)	SOL. OUTLET (LPH)
5	0.5	2.83	0.6
10	1	5.7	12
15	1.5	8.5	18.3
20	0.5	2.83	18.6
25	1	5.7	20.4
30	1.5	8.5	24

Carbondioxide Absorption efficiency is equal to 61.18%
Initial Concentration = 0.04292N
Final Concentration = 0.01666N
Carbondioxide Absorption efficiency = {(Initial Concentration – Final Concentration) / Initial Concentration} * 100
Therefore Carbondioxide absorption efficiency is equal to 61.18%

Minimum work of seperation

Consider 1 mole of gas containing 15% CO_2 and 85% N_2. We'll assume separation at 298k and assume 61.18% capture of CO_2

$$W_{min} = W_{flue\ gas} – W_{CO2} – W_{N2}$$

$$Wmin,_{flue\ gas} = -RT\ \{ (n_{CO2} / (n_{CO2} + n_{N2}))\ \ln (n_{CO2} / (n_{CO2} + n_{N2})) + (n_{N2} / (n_{CO2} + n_{N2}))\ \ln (n_{N2} / (n_{CO2}+ n_{N2}))\}$$

= -(0.298) (0.8314) { (0.15 / (0.15 + 0.85)) ln (0.15 / (0.15 + 0.85)) + (0.85 / (0.15 + 0.85)) ln (0.85 / (0.15+ 0.85)}
= (0.2477) { (0.15) ln(0.15) + 0.85 ln(0.85) }
= (0.2477) { (0.15) (1.897) + (0.85) (0.162) }
= 0.105kJ/gmol FG
Wmin,co_2= 0, Since it is a pure stream
Wmin,n_2 = -(0.298) (0.8314) { (0.015 / (0.015 + 0.85)) ln (0.015 / (0.015 + 0.85)) + (0.85 / (0.015 + 0.85)) ln (0.85 / (0.015+ 0.85)}
= (0.2477) { (0.865) ln(0.865) + 0.982 ln(0.982) }
= (0.2477) { (0.15) (1.897) + (0.85) (0.162) }
= (0.2477) {0.1431}
Wmin,n_2= 0.036kJ/gmol stream
Wmin,n_2 = 0.036 * 0.6118 gmol stream/gmol FG
= 0.022
Wmin = 0.105 – 0.022
= 0.083 kJ/gmol FG
Since 61.18% CO_2 is captured i.e.,
0.6118 * 0.15 = 0.09177gmol CO_2 / gmol flue gas
Wmin, normalised = 0.905 kJ/gmol CO_2
Wmin,normalized = 0.000251 kWh/gmol CO_2 (Anusha Kodandaraman, thesis, june 2010)

TRIAL-2. Obtained results for 0.1N solution (PRESSURE: 5lb/in ; EQUIPMENT RUNNING TIME: 20mnts)

SOL. INLET (LPH)	CO_2 (LPM)	AIR (LPM)	SOL. OUTLET (LPH)
5	0.5	2.83	6
10	1	5.7	9
15	1.5	8.5	10.2
20	0.5	2.83	24
25	1	5.7	24.6
30	1.5	8.5	6.6

Carbondioxide Absorption efficiency is equal to 58%

Minimum work of seperation

Consider 1 mole of gas containing 15% CO_2 and 85% N_2. We'll assume separation at 298k and assume 58% capture of CO_2

$W_{min} = W_{flue\ gas} – W_{CO2} – W_{N2}$
Wmin,$_{flue\ gas}$ = -RT { (n_{CO2} / (n_{CO2} + n_{N2})) ln (n_{CO2} / (n_{CO2} + n_{N2})) + (n_{N2} / (n_{CO2} + n_{N2})) ln (n_{N2} / (n_{CO2}+ n_{N2}))}
= -(0.298) (0.8314) { (0.15 / (0.15 + 0.85)) ln (0.15 / (0.15 + 0.85)) + (0.85 / (0.15 + 0.85)) ln (0.85 / (0.15+ 0.85)}
= (0.2477) { (0.15) ln(0.15) + 0.85 ln(0.85) }
= (0.2477) { (0.15) (1.897) + (0.85) (0.162) }
= 0.105kJ/gmol FG
Wmin,co_2 = 0, Since it is a pure stream
Wmin,n_2 = -(0.298) (0.8314) { (0.015 / (0.015 + 0.85)) ln (0.015 / (0.015 + 0.85)) + (0.85 / (0.015 + 0.85)) ln (0.85 / (0.015+ 0.85)}
= (0.2477) { (0.865) ln(0.865) + 0.982 ln(0.982) }
= (0.2477) { (0.15) (1.897) + (0.85) (0.162) }
= (0.2477) {0.1431}
Wmin,n_2 = 0.036kJ/gmol stream
Wmin,n_2 = 0.036 * 0.58 gmol stream/gmol FG
= 0.021
Wmin = 0.105 – 0.021
= 0.084 kJ/gmol FG
Since 58% CO_2 is captured i.e.,
0.58 * 0.15 = 0.087gmol CO_2 / gmol flue gas
Wmin, normalised = 0.965 kJ/gmol CO_2
Wmin, normalized = 0.000268 kWh/gmol CO_2 (Anusha Kodandaraman, thesis, june 2010)

TRIAL-3. Obtained results for 0.15N solution (PRESSURE: 5lb/in ; EQUIPMENT RUNNING TIME: 20mnts)

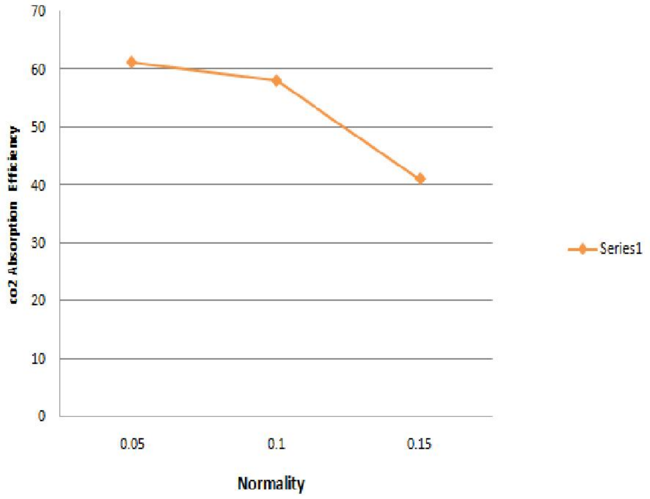
SOL. INLET (LPH)	CO_2 (LPM)	AIR (LPM)	SOL. OUTLET (LPH)
5	0.5	2.83	4.8
10	1	5.7	12
15	1.5	8.5	12
20	0.5	2.83	16.8
25	1	5.7	30
30	1.5	8.5	33

Carbondioxide Absorption efficiency is equal to 41%

Minimum work of separation

Consider 1 mole of gas containing 15% CO_2 and 85% N_2. We'll assume separation at 298k and assume 41% capture of CO_2

$W_{min} = W_{flue\ gas} – W_{CO2} – W_{N2}$
Wmin,$_{flue\ gas}$ = -RT { (n_{CO2} / (n_{CO2} + n_{N2})) ln (n_{CO2} / (n_{CO2} + n_{N2})) + (n_{N2} / (n_{CO2} + n_{N2})) ln (n_{N2} / (n_{CO2}+ n_{N2}))}
= -(0.298) (0.8314) { (0.15 / (0.15 + 0.85)) ln (0.15 / (0.15 + 0.85)) + (0.85 / (0.15 + 0.85)) ln (0.85 / (0.15+ 0.85)}
= (0.2477) { (0.15) ln(0.15) + 0.85 ln(0.85) }
= (0.2477) { (0.15) (1.897) + (0.85) (0.162) }
= 0.105kJ/gmol FG
Wmin,co_2 = 0, Since it is a pure stream
Wmin,n_2 = -(0.298) (0.8314) { (0.015 / (0.015 + 0.85)) ln (0.015 / (0.015 + 0.85)) + (0.85 / (0.015 + 0.85)) ln (0.85 / (0.015+ 0.85)}
= (0.2477) { (0.865) ln(0.865) + 0.982 ln(0.982) }
= (0.2477) { (0.15) (1.897) + (0.85) (0.162) }
= (0.2477) {0.1431}
Wmin,n_2 = 0.036kJ/gmol stream
Wmin,n_2 = 0.036 * 0.41 gmol stream/gmol FG
= 0.015
Wmin = 0.105 – 0.015
= 0.09 kJ/gmol FG
Since 41% CO_2 is captured i.e.,
0.41 * 0.15 = 0.062gmol CO_2 / gmol flue gas
Wmin, normalised = 1.451 kJ/gmol CO_2
Wmin, normalized = 0.000403 kWh/gmol CO_2 (Anusha Kodandaraman, thesis, june 2010)



Graph Showing Normality Vs CO_2 Absorption Efficiency

From graph we observe CO_2 absorption efficiency varies with normality and flowrate. Therefore the experimental analysis gave 77.17% carbondioxide absorption efficiency by pottasium hydroxide solution in a plate absorption column.

TRIAL-4. Finding concentration of aqueous solution of 0.5N solution before and after running the equipment for 1mnt

Conc. Bfr running	Flow rate	Co_2	Air	Sol. outlet	Conc. aftr run	%
0.04191	5	0.5	2.83	12.6	0.02020	50.60
0.04191	15	1.5	8.5	6.6	0.01464	77.17
0.04191	30	1.5	8.5	18.6	0.01717	59.31

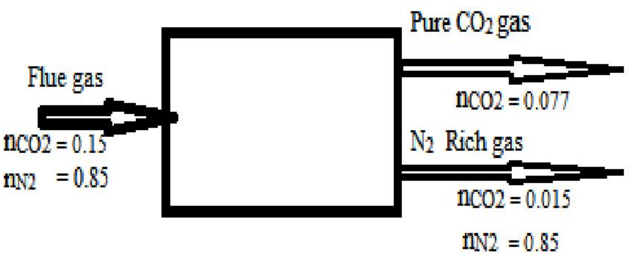
Therefore after several trials highest CO_2 absorption efficiency was as 77.17%

Initial Concentration = 0.04192N
Final Concentration = 0.01464N

Carbondioxide Absorption efficiency = {(Initial Concentration – Final Concentration) / Initial Concentration} * 100

Therefore Carbondioxide absorption efficiency is equal to 77%.

Consider 1mole of gas containing 15% CO_2 and 85% N_2. We'll assume separation at 298k and 77% capture of CO_2.



Minimum work of seperation

$W_{min} = W_{flue\ gas} – W_{CO2} – W_{N2}$
$Wmin,_{flue\ gas} = -RT\ \{ (n_{CO2} / (n_{CO2} + n_{N2})) \ln (n_{CO2} / (n_{CO2} + n_{N2})) + (n_{N2} / (n_{CO2} + n_{N2})) \ln (n_{N2} / (n_{CO2}+ n_{N2})\}$
$= -(0.298)\ (0.8314)\ \{ (0.15 / (0.15 + 0.85)) \ln (0.15 / (0.15 + 0.85)) + (0.85 / (0.15 + 0.85)) \ln (0.85 / (0.15+ 0.85)\}$
$= (0.2477)\ \{ (0.15) \ln(0.15) + 0.85 \ln(0.85) \}$
$= (0.2477)\ \{ (0.15)\ (1.897) + (0.85)\ (0.162) \}$
$= 0.105$kJ/gmol FG
$Wmin,co_2 = 0$, Since it is a pure stream
$Wmin,n_2 = -(0.298)\ (0.8314)\ \{ (0.015 / (0.015 + 0.85)) \ln (0.015 / (0.015 + 0.85)) + (0.85 / (0.015 + 0.85)) \ln (0.85 / (0.015+ 0.85)\}$
$= (0.2477)\ \{ (0.865) \ln(0.865) + 0.982 \ln(0.982) \}$
$= (0.2477)\ \{ (0.15)\ (1.897) + (0.85)\ (0.162) \}$
$= (0.2477)\ \{0.1431\}$
$Wmin,n_2 =$ 0.036kJ/gmol stream
$Wmin,n_2 = 0.036 * 0.77$ gmol stream/gmol FG
$= 0.028$
$Wmin = 0.105 – 0.028$
$= 0.077$ kJ/gmol FG
Since 77% CO_2 is captured i.e.,
$0.77 * 0.15 = 0.116$gmol CO_2 / gmol flue gas
Wmin, normalised = 0.664 kJ/gmol CO_2
Wmin, normalised = 0.000184 kWh/gmol CO_2

If we are assuming complete combustion of CO_2.Hence $W_{N2} = 0$, Since the stream is pure and Wmin = 0.859 kJ/gmol FG
=0.000238 kWh/gmol CO_2 (Anusha Kodandaraman, thesis, june 2010)

Conclusion

The advantages of post combustion capture to absorb carbon by aqueous potassium hydroxide were discussed in this paper. It is hoped that with the continuing studies conducted worldwide currently, the challenges related to absorption process can be overcome, and that co_2 Capture projects can be integrated and materialized in the industrial process.

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