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Absorption and Simulation of Carbon IV Oxide Recovery Plant with Monoethanolamine Solvent using Aspen HYSYS

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Abstract

Carbon IV Oxide (CO_2*) was extracted from a natural gas (NG) stream containing 8.7% carbon dioxide, 17.8% water, 73.4% nitrogen, 0.1886% oxygen, 0.0017% sulfur dioxide, and 0.0097% nitrox using monoethanolamine (MEA) solvent. The* CO_2 *is an acidic and greenhouse gas which may cause corrosion attacks on the pipelines, vessels and global warming when the concentration is accumulated appreciably, hence the need to free the natural gas from it. The process parameters were 500 tons per day flow rate,* 150^0C *temperature, and 101.6 kPa pressure. Using ASPEN HYSYS, an optimization and technical parameter study was conducted for a* CO_2 *recovery process from mixture of gas of a natural gas liquefaction plant at different percentage recoveries (75%, 80%, 85%, 90%, 95%, and 99%). The procedure was based on the use of MEA solutions in an absorption/desorption process. Recovering more* CO_2 *from the NG than was initially present is the aim. Deviations of 3% and 10% and root mean square error of 0.5 and 1.5 from the validation of the simulation result with plant data show that, in contrast to earlier research, the simulation using Aspen HYSYS of V8.8 was able to extract 99% of the 8.7%* CO_2 *from NG. The models showed that* CO_2 *recovery was possible once pumps were installed inside the facility. The simulation result further showed that the overall cost of the recovery* CO_2 *plant including the cost of utilities, was obtained to be $19.629m.*

***Keywords*: Simulation, Absorption, CO2 recovery, Monoethanolamine, Natural gas and Aspen HYSYS.**

1.0 Introduction:

Approximately 75% of carbon dioxide emissions produced by humans over the last 20 years have come from burning fossil fuels (IPCC, 2007; EE, 2014). This explains why the majority of attention in the fight against global warming is focused on CO_2. Greenhouse gases are those that allow sunlight to freely enter the atmosphere (Zhao *et al*., 2023; Henandez *et al*., 2022). Infrared radiation, which produces heat, is reflected back into space by a portion of the sunlight that reaches the Earth's surface.

Bruce *et al*., (2005) stated that this infrared radiation is absorbed by greenhouse gases, which keeps the heat in the atmosphere. When sunlight strikes the Earth's surface, some of it is reflected back into space as infrared radiation, which generates heat. Greenhouse gases absorb this infrared radiation and hold the heat in the atmosphere, claim. Other gases also play a role in global warming, but CO_2 is the gas of interest because, in comparison to other emission products, it contributes comparatively more (Henandez *et al*., 2022).

Depending on the carbon content of the fuel and the amount of excess air needed for combustion, the percentage of CO_2 in the flue gas produced by burning fossil fuels (coal, oil, and natural gas) in the presence of air can range from 3 to 15%, it takes a lot of money and energy to separate CO_2 from the other flue gases (mostly N_2) using chemical or physical methods (Andrzej & Miroslaw, 2015; Liquiang *et al*., 2016; Saha *et al*., 1993). Burning the fossil fuel in pure or enriched oxygen is an alternative; in this case, the flue gas will mostly consist of CO_2 and H_2O. The natural gas liquefaction facilities with carbon capture and storage (CCS) system integrated into the plant design are necessary for a liquefied natural gas (LNG) chain to achieve zero or nearly zero CO_2 emissions (Total Energy, 2022; Bariha *et al*., 2016).

For a very reasonable amount of CO_2 gas and other impurities to be removed from flue gas, simulation software like Aspen HYSYS is essential (Wosu *et al*., 2023a; Zhai, 2009; Wosu *et al*., 2024). Aspen HYSYS and other optimization software are applied in various studies to recover CO_2 gas from flue gas using various types of solvents, especially with 90% of the CO_2 in the flue gas could be extracted using Aspen Plus and monoethanolamine (MEA) as the solvent of conditions 50% exhaust gas recirculation, 1 bar of absorber pressure, 50°C flue gas temperature, and 35 weight percent amine concentration (Petrovic & Soltani, 2019). The use of Promax as a simulator and a 30% weight K_2CO_3 solution promoted with 3% weight diethanolamine (DEA) as an absorbent (Single *et al*., 2013) successfully captured H_2S and CO_2 of 2.2% and 4.7% initially present in the natural to a sweetened gas of 0.4ppmv and 19ppmv, respectively, which met the required specifications. Jiang *et al* in 2020 simulated and adsorbed CO_2 from dry flue gas with specifications of CCS as 95% CO_2 purity and 90% CO_2 recovery using zeolite 13X as an adsorbent. Artur (2014) conducted and simulated absorption-based CO_2 capture from dry flue gases saturated with water, a significant impurity, to achieve high purity of more than 90% and a recovery of more than 80%; and Patricia in 2016 optimized and captured CO_2 from flue gas through the use of MEA (fuel combustion).

There were several HYSYS designs and simulations run, especially one with MEA to capture about 98% CO_2 at 94.9% overall plant efficiency and a total cost of $19.63 million (Dadet *et al*., 2024).
A plant for 30 kilo tons per year of cumene from a natural gas field was simulated and designed for $3.004 million, while the acetone plant was designed and some of its units were simulated using isopropyl alcohol, at an overall cost of $7.792 million (Ojong *et al*., 2023). The natural gas TEG dehydration plant can also be designed using Aspen HYSYS as the simulation tool (Wosu *et al*., 2023b; Wosu & Ezeh, 2024; Wosu, 2024).

Since carbon dioxide is a highly inert molecule and that transforming the captured gas into useful products typically requires a significant amount of energy and the fact that oil is still a very affordable industrial feedstock because it can be used as a fuel and as a precursor to make other materials, like plastics, flue gas treatment becomes highly imperative through CO_2 capture technique.

The primary objective of the carbon recovery plant, which makes use of Aspen HYSYS simulation and MEA, is to recover CO_2 from flue gas. The entire complement of related units, including compressors, heat exchangers, absorber, stripper, and reboiler, is simulated as a CO_2 recovery unit using amine (Ojong *et al*., 2024b). The recovery will be carried out at different percentages in order to recover more (at least 98%) of the CO_2 from its initial content in the flue gas. This research utilized the Aspen HYSYS as the simulation tool for the design of the units of the CO2 recovery plant, bearing in mind the application of material and energy balance principles and validated with valued literatures.

2.0 Materials and Method

2.1 Materials

The research utilized the physiochemical data, including the process flow diagram depicted in Figure 1 and information on the composition of monoethanolamine (MEA), charts, and natural gas (NG) characterization.

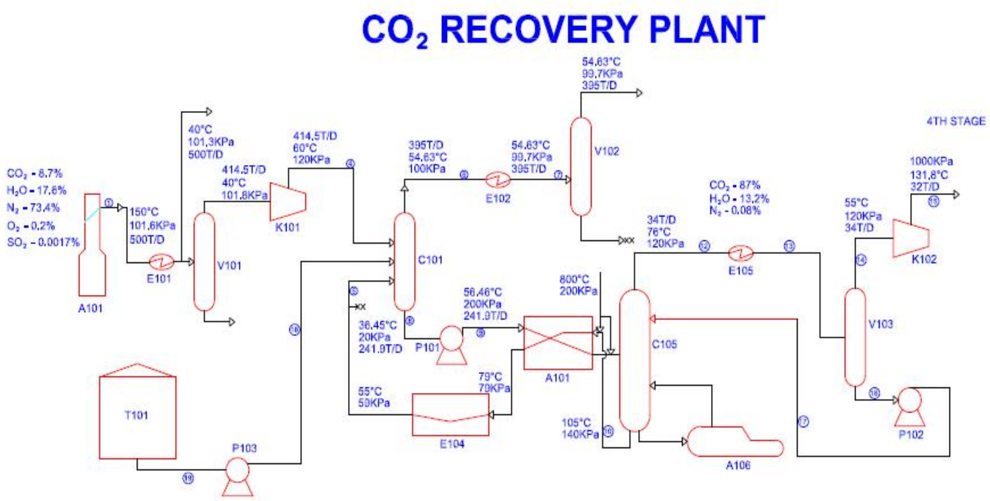

Figure 1: Process Flow Diagram for CO_2 Recovery (Dadet *et al.*, 2024)

Process Description. Figure 1 shows the CO_2 recovery procedure using MEA according to Dadet *et al.*, 2024, the CO_2 in natural gas (NG) enters the absorber, it comes into contact with an aqueous solution of MEA flowing counter currently to the NG stream. A weak base, CO_2, and a weak acid, MEA, combine exothermically to form a salt that dissolves in water. The absorber at the base of the column permits the `rich' MEA stream to exit. Before more heat is added to reverse the reaction, the lean MEA stream that leaves the stripper and enters a heat exchanger in order to be preheated. The CO_2 escapes through the top of the stripper column once it has been released from the MEA. The "lean" MEA is then recycled back into the absorber. The CO_2 is either liquefied at lower pressures using refrigeration systems, or compressed using a gas compressor to reach the desired pressure, and then pumped to the desired pressure. This is because the flow rate needed for a given recovery increases as the lean loading into the absorber increases. Finally, a low-temperature liquid carbon dioxide pump was considered in the analysis. Liquid pumps are far less expensive than gas compressors and require a lot less power to raise pressure, which is the basic tenet of the liquefaction approach.
To reduce the variable operation and maintenance costs of either CCS system requires integrating the most efficient and variable compression technology with the capture process or the power plant.

The researchers stated that after entering a cooler (E101), the flue gas from the turbine exhaust tank (A101) is cooled to roughly 40^0C by circulating water. The gas is then transported using a gas blower (K101) to make up for the pressure drop caused by the MEA absorber (C101) after being run through a knockout pot (V101) to extract water. The gas flow through the absorber (C101) is countercurrent to the absorbent, which is an aqueous MEA solution in which the carbon dioxide was absorbed. The CO_2 lean gas is passed through a water cooler prior to entering a recovery vessel in order to reduce solvent loss. Water and MEA droplets and vapour are collected in this vessel and recycled back into the absorber while the treated gas is released into the atmosphere. The rich solvent containing CO_2 is pumped to the top of a stripper via a lean/rich cross heat exchanger (E104). The CO_2 lean solution is then cooled after being heated to a temperature that is comparable to the stripper's operating temperature (80^0–100^0C).
The solvent is regenerated in the stripper column (C102) at temperatures between 100^0 and 105^0C and slightly atmospheric pressure. The lean solvent is pumped back to the absorber and its temperature is lowered to the absorber level using a lean/rich heat exchanger (E101) and cooler (E104).

The absorber was simulated at 110 kPa with a 20 kPa pressure drop using 22 equilibrium stages. A preliminary investigation into the minimum number of stages required revealed that 22 stages were more than sufficient for reaching equilibrium. Increasing the number did not result in a better or more detailed description of the absorption process. The stripper, which had an operating pressure of 150 kPa and a pressure drop of 20 kPa, required twenty equilibrium stages to be replicated.

2.2 Method

The research methodology involves the use of Aspen HYSYS (Aspen HYSYS 2006 Aspen1) to simulate the CO_2 recovery plant shown in Figure 1. In the simulation, CO_2 is extracted from a NG stream (refer to Table 1) in order to produce rich natural gas at lower energy and with very little acidic gas. NG composition, flow rate, and process conditions for the plant are as follows: 500.0 t/d, 101.6 kPa pressure, 150^0C temperature, and Table 1 shows the NG composition.

Table 1: Natural Gas Composition

Composition	N_2 + Ar	CO_2	H_2O	O_2	SO_2	Nox
Flue Gas (vol.%)	73.3	8.70	17.8	0.1886	0.0017	0.0097

Model Validation. The simulation Results were validated with plant data using error analysis based on percentage deviations and root mean square error (RMSE) as captured by works of [20] (see model 1) and [21] as depicted in model 2 respectively.

$$\text{RMSE} = \sqrt{\left(\frac{\text{model}-\text{plant/literature}}{\text{N}}\right)^2} \quad (1)$$

where, N is the number of iterations of model results

$$\text{Deviation} = \left|\frac{\text{Model result}-\text{Plant or Lit. data}}{\text{Plant or Literature data}}\right| \quad (2)$$

3.0 Results and Discussion

The presentation of the simulated process flow diagram (see Figure. 2) and the necessary HYSYS results of each unit of the recovery plant are displayed and discussed in Tables 1 to 12, and validated with literatures.

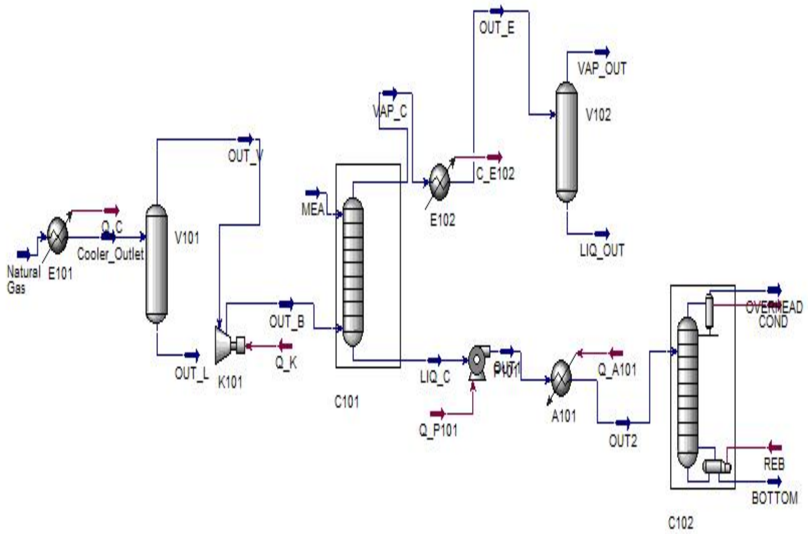

Figure 2: CO_2 Recovery Plant from Natural Gas with MEA Solvent using Aspen HYSYS Simulator

The process flow diagram for the CO_2 recovery plant from natural gas mixture with MEA is shown in Figure 2. The simulation was performed using Aspen HYSYS to achieve 99% recovery of the gas from the mixture.

3.1 Comparison between the Simulation Results and the Data from the Literature

The comparative analysis of HYSYS simulation results and data from literature is presented in Table 2.

Table 2. Validation of the Simulated Result with Literature Data

Literature Data	Literature Result	Simulated Result	Deviation (%)
[22]	96	99	3
RMSE	-	0.5	-
[23,12]	90	99	10
RMSE	-	1.5	-

As demonstrated, MEA was used to absorb CO_2 from the steam of the wet gas, yielding 99% of the NG from the 8.7% of CO_2 gas in the stream. Compared to works of (Simmonds *et al*., 2023; Vaccarelli *et al*., 2016 and Petrovic & Soltani, 2019). The percentage deviations were 3, 10 and 10 respectively, indicating that the absorption of CO_2 gas from the stream of gas mixture has an improvement from the literatures with the current study for a liquefaction plant. The root means square error computed gave minimal values of 0.5 and 1.5, a more refined result indicating better simulation process of the capture plant. This is because the work incorporated pump for the recovery plant, different from literatures and also the low MEA-CO_2 ratio usage, makes this process and the technique unique. The pumping process compresses the CO_2 process, raising pressure and lowering the energy and expense requirements for the comparison. Increased regeneration efficiency and a corresponding decrease in the need for thermal energy because of a lower MEA-CO_2 mole are consistent with the findings of Jiang *et al* in 2020.

3.2 HYSYS Simulation Results of the CO_2 Recovery Plant Units.

The HYSYS simulation results of the various CO2 recovery plant units are presented in the following sections.

3.2.1 HYSYS Design Specification for Cooler (E101) Unit

Table 3: HYSYS Design Specification for Cooler (E101)

Column Type	Heater as Exchanger	
Function	Reduce the temp. of the Lean/Rich gas	
Medium	Water	
Material Composition	Inlet	Output
CO2	0.0871	0.0871
H_2O	0.1761	0.1761
N_2	0.7346	0.7346
O_2	0.001886	0.002
SO_2	0.0002	0.0002
MEA	0.0000	0.0000
Operating Conditions		
Pressure	101.6kPa	101.3kPa
Temperature	150^0C	40^0C
Coolant Duty, Qc		809.71kW
Design Parameter		
Diameter	1.193m	
Height	1.789m	
Material	Stainless steel	
Total Cost	$1.5m	

Table 3 displays the recovery plant's cooler unit's HYSYS result. This outcome aids in the characterization of the flow characteristics as well as the determination of process parameters like pressure, temperature, and NG composition inside the unit.Essentially, the results provide the process conditions of the NG cooled in the cooler and the material compositions of the components (CO_2, H_2O, N_2, O_2, SO_2, and Monoethanolamine (MEA)) in the NG. 0.0871, 0.1761 and 0.7346 are the main visible compositions for the first three components while the rest of the components' compositions are negligible. The estimated total cost of $1.5m for the cooler unit is determined also by the Aspen HYSYS simulator.

3.2.2 HYSYS Design Specification for Exhaust Gas Liquid Knock out Vessel (V101)

Table 4: **HYSYS** Design Specification for Exhaust Gas Liquid Knock out Vessel (V101)

Column Type	Vertical Vessel of Shell Material	
Function	Separate the vapour components from liquid ones	
Medium	Water	
Material Composition	Inlet	Output
CO_2	0.0871	0.0764
H_2O	0.1761	0.0746
N_2	0.7346	0.644
O_2	0.001886	0.0022
SO_2	0.0002	0.0018
MEA	0.0000	0.0000
Operating Conditions		
Pressure	101.3kPa	100kPa
Temperature	40^0C	40^0C
Design Parameter		
Diameter	1.193m	
Height	1.789m	
Power input	0.642Kw	
Material	Stainless steel	
Purchase Cost	$111600	
Total Cost	$1.193m	

The composition of the CO_2 gas in the exhaust knocks out vessel decreases from 0.0871 to 0.0764, a percentage 89.06% absorbed in the vessel as indicated in the Aspen HYSYS (see Table 4). This is a good reason for the recovery plant as the knockout vessel aid the capturing of CO_2 also. The total cost of the knockout vessel using the HYSYS is $1.193m; which included purchased cost and other variable cost. The Aspen HYSYS was able to size this column to give dimensions of 1.193m and 1.789m respectively for diameter and height of column.

3.2.3 HYSYS Design Specification for Exhaust Gas Blower (K101)

Table 5: **HYSYS Design Specification for Exhaust Gas Blower (K101)**

Equipment	Exhaust Gas Blower	
Function	Compresses the gas to increase pressure	
Medium	Air	
Material Composition	Inlet	Output
CO_2	0.0978	0.0978
H_2O	0.0746	0.0746
N_2	0.8252	0.8252
O_2	0.0022	0.0022
SO_2	0.0002	0.0002
MEA	0.0000	0.0000
Operating Conditions		
Pressure	101.6kPa	120kPa
Temperature	40^0C	60^0C
Rating		
Efficiency,	0.75	
Power Consumed	32.241Kw	
Material	Stainless Steel	
Purchase Cost	$1000	
Total Cost	$1500	

The HYSYS result shown in Table 5 for the exhaust gas blower (K101) is essential in that it accounted for the increase in process conditions of 120kPa from 101.8kPa and 40^0C to 60^0C, suitable for absorption, though the composition remains the same for the blower inlet and outlet. The HYSYS simulator was able to cost the unit to a total of $1500 and of material type stainless steel. The unit acts as a compressor where the NG are boosted with more energy necessary for the next stage of separation.

3.2.4 HYSYS Design Specification for Absorber (C101) Column

Table 6: HYSYS Design Specification for Absorber (C101) Column

Column Type	Sieve trayed Column	Absorber Column
Function	Absorbed CO_2 from gas mixture with MEAmine.	
Medium	Water and Absorbent	
Material Composition	Inlet	Output
CO_2	0.0764	0.0624
H_2O	0.0746	0.0001
N_2	0.644	0.591
O_2	0.0022	0.002
SO_2	0.0018	0.0002
MEA	0.0000	0.0008
Operating Conditions		
Pressure	101.9kPa	101kPa
Temperature	40^0C	25.22^0C
Design Parameter		
Diameter	1.5m	
Height	12.5m	
Stages	25	
Material	Carbon steel	
Force	Counter current absorption	
Purchase Cost	$29000	
Total Cost	$183500	

The HYSYS simulation result of the absorber column gave 0.0624 mole fraction of CO_2 in the amine regenerator and 0.0008 mole fraction of the MEA in the regenerator unit as shown in Table 6. Apart from nitrogen gas which has the highest mole composition of 0.8913 (this is so because it is an inert gas), the composition of carbon dioxide is low in the amine regenerator inlet or the liquid exit of the absorber column indicating that more of the CO_2 is captured (93%) and removed from the NG. This implies that the main column for the CO_2 capture is the absorber unit and it is very essential for the recovery plant.

3.2.5 HYSYS Design Specification for Absorber Overhead Condenser (E102)

Table 7: HYSYS Design Specification for Absorber Overhead Condenser (E102)

Column Type	Cooler as exchanger	
Function	Reduce the pressure of the Lean/Rich gas	
Medium	Water	
Material Composition	Inlet	Output
CO_2	0.0624	0.0624
H_2O	0.0001	0.0001
N_2	0.591	0.591
O_2	0.002	0.002
SO_2	0.0002	0.0002
MEA	0.0008	0.0008
Operating Conditions		
Pressure	101.8kPa	101.3kPa
Temperature	54.63^0C	54.63^0C
Design Parameter		
Diameter	1.193m	
Height	1.789m	
Condenser Duty, Qc	254.69Kw	
Material	Stainless steel	
Purchase Cost	$1.35m	
Total Cost	$1.5m	

The Aspen HYSYS simulation result for the absorber overhead column is shown in Table 7.
The composition of the gases is retained after they are condensed and removed from the condenser at the absorber's exit. Similar to the cost of the cooler (E101), the absorber overhead condenser (E102) cost is same at conditions of condensing at 101.3kPa and 54.63^{0}C. The cost of E101 unit total is \$1.5m with a stainless-steel material used. The material selection is essential for such process so that it does not affect the composition of the components present in the units. The unit sizes are 1.193m and 1.789m respectively for diameter and height of the overhead absorber column.

3.2.6 HYSYS Design Specification for Absorber Overhead Knock Out Vessel (V102)

Table 8: HYSYS Design Specification for Absorber Overhead Knock Out Vessel (V102)

Column Type	**Vertical Vessel of Shell Material**	
Function	Separate the vapour components from liquid ones	
Medium	Water	
Material Composition	Liquid	Vapour
CO_2	0.0016	0.0004
H_2O	0.0098	0.0001
N_2	0.0003	0.7591
O_2	0.0000	0.002
SO_2	0.0001	0.0002
MEA	0.9882	0.0008
Operating Conditions		
Pressure	99.7kPa	99.7kPa
Temperature	54.83^{0}C	54.83^{0}C
Design Parameter		
Diameter	1.193m	
Height	1.789m	
Material	Carbon Steel	
Purchase Cost	\$111600	
Total Cost	\$1.193m	

The amine mixture from the knocked-out vessel of the absorber comprises of the 0.16% of CO_2 of the lean NG that enters the amine regenerator for separation using amine charge pump (P101). 93% of CO_2 of the 8.7% of it in the NG was knocked out in the absorber and taken at the exit of the absorber.
The remaining percentage of it (0.16%) is in the amine liquid solution taken to the next stage as shown in Table 8. The cost of the unit is carried out with HYSYS and gave total of \$1.5m. The process condition for the knocking process is at 99.7kPa and 54.83^{0}C.

3.2.7 HYSYS Design Specification for Pump (P101) and Turbine Exhaust Stack (A101)

Table 9: HYSYS Design Specification for Pump (P101) and Turbine Exhaust Stack (A101)

Column Type	**Mechanical Carbon Steel; Heating**	
Function	Moves fluids by mechanical action; Exchange Heat among Fluids	Heat the fluid to certain process conditions
Medium	Fluid	Fluid
Material Composition	P101	A101
CO_2	0.0007	0.0007

H_2O	0.1441	0.1441
N_2	0.0004	0.0004
O_2	0.0000	0.0000
SO_2	0.0000	0.0000
MEA	0.8549	0.8549
Operating Conditions		
Pressure	20kPa; 200kPa	200kPa
Temperature	36.45^0C; 56.46^0C	80^0C
Design Parameter		
Diameter	-	
Height	-	
Material	Carbon Steel	Stainless Steel
Purchase Cost	$1300	$50700
Total Cost	$1630	$60500

Table 9 displays the composition and process parameters of the liquid component from the absorber overhead knock out vessel in the turbine exhaust stack (A101) and amine charge pump (P101). The P101 pumped the liquid from the bottom of the absorber overhead knock out vessel to A101, increases the temperature and pressure from 36.45^0C and 20kPa to 56.46^0C and 200kPa respectively. The liquid in the exhaust stack maintains conditions of 54.83^0C and 99.7kPa necessary for separation in the amine regenerator (C102).

3.2.8 HYSYS Design Specification for Amine Regenerator (C102)

Table 10: HYSYS Design Specification for Amine Regenerator (C102)

Column Type	Trayed Column	
Function	Separates CO_2 from amine mixture.	
Medium	Water and MEA	
Material Composition	Overhead	Bottom
CO_2	0.0009	0.0000
H_2O	0.1767	0.0014
N_2	0.0005	0.0000
O_2	0.0000	0.0000
SO_2	0.0000	0.0000
MEA	0.8217	0.9986
Operating Conditions		
Pressure	120kPa	140kPa
Temperature	78^0C	105^0C
Design Parameter		
Diameter	1.5m	
Height	11m	
Stages	20	
Reboiler Heat, Q_R	26.433kW	
Condenser Load, Q_C	23Kw	
Material	Stainless steel	
Purchase Cost	$29000	
Total Cost	$183500	

Table 10 shows the compositions of the amine mixture and NG in the amine regenerator (C102), where the feed stream is made up of 0.8549 mol/mol of MEA and 0.0007 mol/mol of CO_2. About 77.78% of the amount of CO_2 that enters the regenerator are captured and taken off from the amine mixture, which implies that 0.124% of the 0.16% of CO_2 remaining in liquid product knocked out from the absorber knock out vessel is taken off from the C102. Therefore, about 0.036% of CO_2 gas remains in the liquid at the bottom;

this is very minimal and acceptable for the process. The absorbent is therefore regenerated back to the amine tank for re-use in the absorber column.

3.2.9 HYSYS Design Specification for Reflux Vessel (V103)

Table 11: HYSYS Design Specification for Reflux Vessel (V103)

Column Type	Vertical Vessel of Shell Material	
Function	Separate the vapour components from liquid ones	
Medium	Water	
Material Composition	Liquid	Vapour
CO_2	0.0004	0.0001
H_2O	0.1768	0.1638
N_2	0.0000	0.3779
O_2	0.0000	0.0021
SO_2	0.0000	0.0012
MEA	0.8228	0.0870
Operating Conditions		
Pressure	120kPa	120kPa
Temperature	55^0C	55^0C
Design Parameter		
Diameter	1.193m	
Height	1.789m	
Material	Stainless Steel	
Purchase Cost	$111600	
Total Cost	$1.193m	

The composition of the overhead and bottom components of the reflux vessel (V103) is shown in Table 11 indicates that the 0.0001mol/mol is the most fractional amount of CO_2 gas at the overhead of the V103 and 0.0004mol/mol is the fractional amount knocked from the gas component at the bottom of the vessel respectively. The HYSYS simulation result for the V103 shows that the MEA liquid constituted majorly the liquid component of the V103 with a mole composition of 0.8228 with very small amount of 0.087 of it at the top of the V103. This is the vessel that the remaining CO_2 gas is removed and taken off.

3.2.10 HYSYS Design Specification for CO_2 Blower (K102) and Reflux Pump (P102)

Table 12: HYSYS Design Specification for CO_2 Blower (K102) and Reflux Pump (P102)

Column Type	Compressor Industrial Air	
Function	**Dry the gas to increases pressure**	**Move the liquid to elevated position**
Medium	Air	
Material Composition	K102	P102
CO_2	0.0001	0.0004
H_2O	0.1638	0.1768
N_2	0.3779	0.0000
O_2	0.0021	0.0000

SO_2	0.0012	0.0000
MEA	0.0870	0.8228
Operating Conditions		
Pressure	120kPa; 1000kPa	120kPa
Temperature	55^0C; 131.8^0C	55^0C
Power Consumed	29.743kW	
Efficiency	0.75	-
Material	Stainless Steel	Stainless Steel
Purchase Cost	$1000	$1250
Total Cost	$1500	$1800

The HYSYS simulation result of the CO_2 blower (K102) and reflux pump (P102) is shown in Table 12 indicating that the composition of the CO_2 at the blower is far higher than that at the reflux pump. The costs of the K102 and P102 are $1500 and $1800 respectively. The process conditions for each unit are shown in Table 12. The capacity of the pump is 642W and that of the blower is 1611.35kW.

Conclusion

We were able to simulate the CO_2 recovery plant with monoethanolamine as absorbent using Aspen HYSYS to absorbed 0.99 of the 0.087 amount of CO_2 present in the natural gas mixture in other to produce a lean gas mixture. The essence is that the natural gas needs to be free from carbon (iv) oxide gas since it is a greenhouse gas when the concentration is accumulated and again as an acidic gas, corrosion of pipes during transportation and the vessels used for storage are attacked if not curb. The high amount recovered is due to use of pumps in the recovery process to increase efficiency and effectiveness, which results in successful recoveries. The deviations and root mean square error for the error analysis showed the effectiveness of the simulation package and the fluid since negligible values of 0.03, 0.1, and 0.5, 1.5 were obtained respectively.

Declarations

Authors Contribution

D. W, O.O.E, and W.C.O: Conceptualization, Methodology, Original draft preparation, Performed simulation work and writing.

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Nomenclature

IPCC - International Panel on Climate Change

MEA - Monoethanolamine

Q_C - Heat Duty

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