Process Simulation, Literature Review and Sensitivity Comparison of CO_2 Capture Using ProMax 5.0

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Abstract

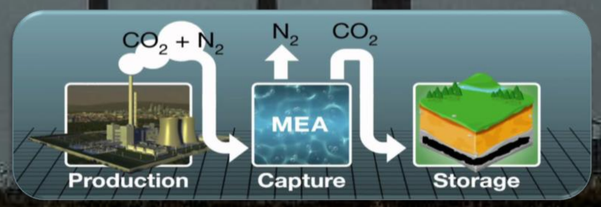
The project is cover rate-based process simulation on ProMax 5.0 and analyze the amount of CO_2 captured from the wet gas feed with the percentage of CO_2 11.5% mole fraction at 115 degrees Celsius and 1 atm. The CO_2 is captured by single solvent mono-ethanolamine (MEA) at 15-40% wt.

Background

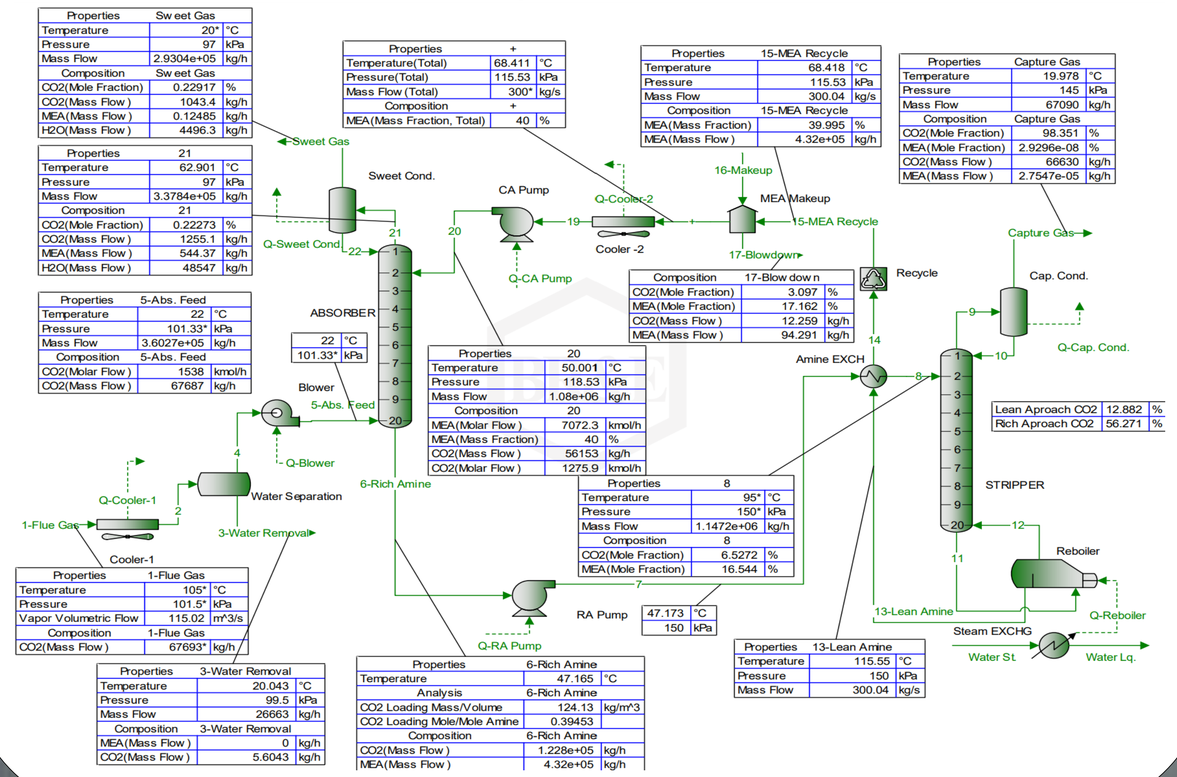
Global warming is one of the biggest challenges of our time. Our climate is experiencing increase in the average temperature across the globe now more than ever. This phenomenon occurs when the sun's heat is trapped inside the Earth's atmosphere which is caused by greenhouse gases as they absorb the sun's energy and keep it inside the Earth's atmosphere. Since the industrial revolution, climatic changes occur more frequently due to the use and combustion of fossil fuels in its various forms which lead to increase in greenhouse gases emissions such as carbon dioxide.

Motivation

Since renewable energy sources are still far from being fully effective alternatives to fossil fuels, one of the solutions to tackle the climate change issue is to reduce or eliminate the outflow of carbon dioxide into the atmosphere using a CO_2 Capture process.



Design & Process



Properties	Sweet Gas	
Temperature	20*	°C
Pressure	97	kPa
Mass Flow	2.9304e+05	kg/h
Composition	Sweet Gas	
CO2(Mole Fraction)	0.22917	%
CO2(Mass Flow)	1043.4	kg/h
MEA(Mass Flow)	0.12485	kg/h
H2O(Mass Flow)	4496.3	kg/h

Properties	+	
Temperature(Total)	68.411	°C
Pressure(Total)	115.53	kPa
Mass Flow (Total)	300*	kg/s
Composition	+	
MEA(Mass Fraction, Total)	40	%

Properties	15-MEA Recycle	
Temperature	68.418	°C
Pressure	115.53	kPa
Mass Flow	300.04	kg/s
Composition	15-MEA Recycle	
MEA(Mass Fraction)	39.995	%
MEA(Mass Flow)	4.32e+05	kg/h

Properties	Capture Gas	
Temperature	19.978	°C
Pressure	145	kPa
Mass Flow	67090	kg/h
Composition	Capture Gas	
CO2(Mole Fraction)	98.351	%
MEA(Mole Fraction)	2.9296e-08	%
CO2(Mass Flow)	66630	kg/h
MEA(Mass Flow)	2.7547e-05	kg/h

Properties	21	
Temperature	62.901	°C
Pressure	97	kPa
Mass Flow	3.3784e+05	kg/h
Composition	21	
CO2(Mole Fraction)	0.22273	%
CO2(Mass Flow)	1255.1	kg/h
MEA(Mass Flow)	544.37	kg/h
H2O(Mass Flow)	48547	kg/h

Composition	17-Blow dow n	
CO2(Mole Fraction)	3.097	%
MEA(Mole Fraction)	17.162	%
CO2(Mass Flow)	12.259	kg/h
MEA(Mass Flow)	94.291	kg/h

Properties	5-Abs. Feed	
Temperature	22	°C
Pressure	101.33*	kPa
Mass Flow	3.6027e+05	kg/h
Composition	5-Abs. Feed	
CO2(Molar Flow)	1538	kmol/h
CO2(Mass Flow)	67687	kg/h

22	°C
101.33*	kPa

Properties	20	
Temperature	50.001	°C
Pressure	118.53	kPa
Mass Flow	1.08e+06	kg/h
Composition	20	
MEA(Molar Flow)	7072.3	kmol/h
MEA(Mass Fraction)	40	%
CO2(Mass Flow)	56153	kg/h
CO2(Molar Flow)	1275.9	kmol/h

Properties	8	
Temperature	95*	°C
Pressure	150*	kPa
Mass Flow	1.1472e+06	kg/h
Composition	8	
CO2(Mole Fraction)	6.5272	%
MEA(Mole Fraction)	16.544	%

47.173	°C
150	kPa

Properties	1-Flue Gas	
Temperature	105*	°C
Pressure	101.5*	kPa
Vapor Volumetric Flow	115.02	m^3/s
Composition	1-Flue Gas	
CO2(Mass Flow)	67693*	kg/h

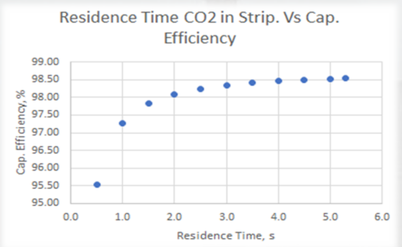
Properties	3-Water Removal	
Temperature	20.043	°C
Pressure	99.5	kPa
Mass Flow	26663	kg/h
Composition	3-Water Removal	
MEA(Mass Flow)	0	kg/h
CO2(Mass Flow)	5.6043	kg/h

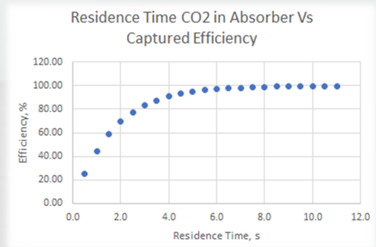
Properties	6-Rich Amine	
Temperature	47.165	°C
Analysis	6-Rich Amine	
CO2 Loading Mass/Volume	124.13	kg/m^3
CO2 Loading Mole/Mole Amine	0.39453	
Composition	6-Rich Amine	
CO2(Mass Flow)	1.228e+05	kg/h
MEA(Mass Flow)	4.32e+05	kg/h

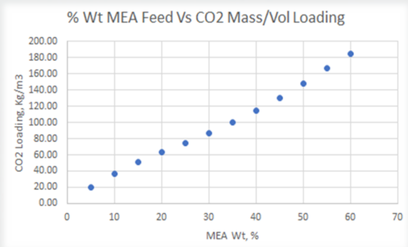
Properties	13-Lean Amine	
Temperature	115.55	°C
Pressure	150	kPa
Mass Flow	300.04	kg/s

Lean Aproach CO2	12.882	%
Rich Aproach CO2	56.271	%

Results







Project Objectives

- To design a packing/tray column for the CO_2 capturing process.
- Use advanced computational approach to simulate the CO_2 capturing process and estimate its efficiency.
- To capture more than 90% of the CO_2 entered.
- To achieve higher than 95% purity in the final CO_2 product.

Conclusions/Recommendations

Objectives of the project are met as CO_2 Capture efficiency achieved is 98.4% and CO_2 product purity reached 98.35%. To reach capture efficiency of 95% or higher, the reboiler heat duty is required to be at least 350GJ/h. Tray columns, the length between the poles, and other factors such as the use of water instead of ethanol can help in more motivated results as well as the use of different contractors such as tray column, packed column, and spray contractors would alter the results.

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