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Article

Gasification of Sugarcane Cutting Residues in the Capture of Carbon Dioxide by Simulation

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Abstract: The gasification of sugarcane cutting waste (RAC) is a process that occurs in a gasifier where the transformation of this raw material into a solid-state and a gasifying agent with a moderate calorific value occurs, thanks to the application of heat. Under restricted oxygen levels, we can say that several styles of air gasifiers, water vapor, oxygen, and hydrogen have a performance that can be analyzed and categorized by their performance to avoid damage to the environment. The objective of this article is based on the mathematical development of gasification of cane cutting waste; it was carried out as a transformation of the primary fuel into a stream of gases whose main components are CO_2 and H_2, which can be separated relatively easily by their concentrations, and available pressures and in some cases in their temperatures; which helped to identify the second-order reaction in the transformation and improvement of the process; applying to the optimization of development in the capture of carbon dioxide, contributing to the reduction of greenhouse gases.

Keywords: greenhouse; biomass; carbon dioxide; capture carbon dioxide; gasification

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Introduction

Global warming and climate change do consider the main points of attention globally. Carbon dioxide consider the main contributor and the point to take interactivity to correct this situation burning afflicts the Inactivity and its inhabitants. The burning of fossil fuels. Inactivity is their main source, of emission, being that in the daily life of their processes they indiscriminately release large amounts of this greenhouse gas into the atmosphere. Carbon Capture emissions this age technology are projected as an essential emission this situation given the capacity it has to contain emissions from their source CO_2 process

This study aims to simulate determining the process of for the gasification of determining sugarcane by using ware and determining its reaction kinetics. For which several simulation models will be raised and compared by estimating their reaction kinetics, then the model with the best kinetics will be reconfigured for its optimization in the capture of carbon dioxide.

Gasification

Gasification stores solid waste at high temperatures (approximately 600°C) in equipment that does not contain oxygen. Oxygen is kept in low proportions, i.e., absent to prevent accelerated combustion; instead, the carbon-containing base of agricultural residues for the sugarcane industry is broken down into syngas and a well-known solid such as

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slag, ash, or coal residue. Note that operations in oxygen-free conditions (advertised by many suppliers) are challenging to carry out during operations on a commercial scale. The synthesis gas is formed mainly of CO, H2, and CO2 (Cuadrat, 2012)(Velasco, 2017), with some pollutants all having a sufficient heat capacity to be burned and reformed in energy. Still, it requires determining advanced systems that help pollution. Many of these operational facilities fail to produce the necessary power to be economically profitable.(Forero et al., 2009) Certain bioproducts and many of their derivatives are from these methods comprising emissions of gases into the atmosphere; much slag is considered a form of solid waste, ash is the flywheels of air pollution control equipment (which requires exceptional management due to its toxicity), and liquid waste and wastewater.

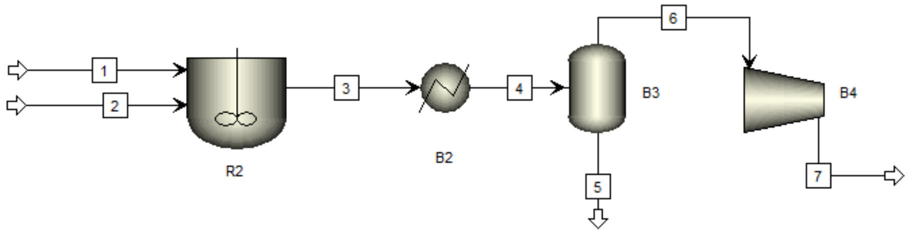

Figure 1. Gasification.

Capture Systems CO_2

The Global Carbon Capture and Storage Institute (GCI) (2020) defines it as "an emission reduction technology critical to meeting global improve and storage of is a novel important technology in the reduction of emissions in there of this greenhouse gas, with the potential to drastic considerably and positively in the fight against global wintoming CO_2 (Perez, 2016) (Saqline et al., 2021) (SaqPost-combustion1). This technique is applicable to large release points of gases with high content commonly coming from These such as power generation plants that use fossil fuels and industrial processes in generalCO_2 the (Moreno, 2019).

Error! Reference source not found. a basic diagram about a capture and storage system. This system basically consists of the capture or separation of the gases generated in combustion and / or various processes, for the production of a gas of highly rich concentration in , $CO_2CO_2CO_2$(Velasco et al., 2017) (Estrada & Zapata, 2004) which is subjected to compression, at pressures above , is transported, usually by pipeline lines or ships, depending on the specific requirements, to determine their subsequent use the production of dry ice in many food industries, they are properly stored in many geological structures in several oil tanker wells, depleted gases, saline aquifers, with ca practical for dissolution in salt, have been found in the deep ocean$200\ bar$ (Queijo, 2017).

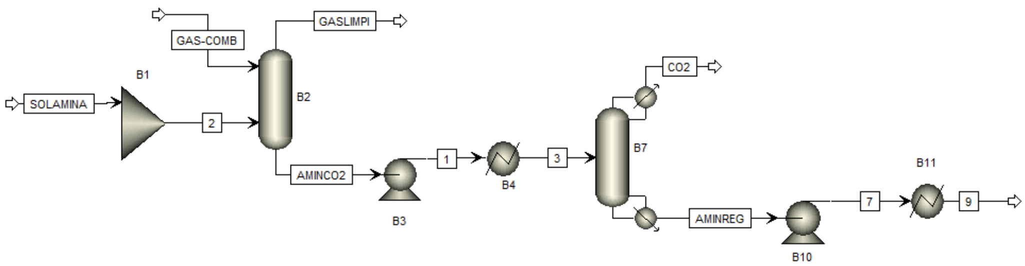

Figure 2. Basic Diagram of a capture and storage system.CO_2

Technologies for the capture of CO_2

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The question of the many countries before the reports of different climates are a product of the effect of CO_2 emissions provoked great interest in the research of technologies and optimization of capture, developing the most convenient processes immediately to implement in the energy industries, which are primarily responsible for almost half of the pollution of emissions of this gas in the European Union (Muñoz, 2019) (Forero et al., 2010).

The technical capacity to regroup CO_2 from the primary sources of emission was established; somehow, there are currently very few large-scale protests of this technology, first of all, because of the costs involved and, in most cases, the technologies are individual have not been accurate at the level they were intended. In this way, we can theoretically exceed the standard of emission capture; the current focus of research is on economically controlling the processes used today (Muñoz, 2019).

The technical side of this process goal is to produce a CO2-focused current that can be safely moved into storage. The technology is applied in 1st place in coal, lignite, mineral coal, and natural gas power plants; in addition, its continuous values give an advance to these sciences can expand its uses to all those areas where CO2 is released as a way to obtain energy (Muñoz, 2019).

At present, various capture technologies are being improved, at an experimental and commercial level, which can be classified depending on at what point in the process the degradation of the process itself is intervened and carried out. If the system acts by capturing the available fuel before the combustion process is completed, the process is known to be captured in pre-combustion; on the other hand, if it is captured in the chimney gases, that is, after the burning of the fuel, it is called post-combustion capture; and, when the technique focuses on the same combustion process, we speak of oxy-combustion capture CO_2 (Muñoz, 2019).

Materials and Methods

Equipment

The equipment used in the simulations were as follows:

RAC Gasification

- Reactor RCTR Rstoic
- Dry Flash2 Separator
- Reactor Yield
- Reactor Gibbs
- Split separator

CO_2 uptake

- Mixer
- Rad Frac Reactor (Absorb)
- Bomb
- Heat Exchanger
- Rad Frac reactor (stripper)
- Bomb
- Heat Exchanger
- Monoentanolamine Reagent (MEA)

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The methodology developed this project is based on bibliographic research with application of the aspen plus simulator because a wide variety of references were spectated and reviewed in as pacts such as chemical kinetics, gasification processes and capture of CO_2, as well as the consultation of different studies carried out in the application of these technologies. On the other hand, this research is also pig on holed as experimental, corresponding to this the simulation of the different scenarios and models proposed to determine the most relevant reaction kinetics.

This research work is based on the simulation of the experimental data obtained from the study carried out by Chatrattanawet and collaborators (2019), through its application in the Aspen Plus process modeling programs, in this way it is possible to perform treatment and analysis, as describing gasification simulation of the gasification process and co2 capture, from the biomass residues of the agricultural waster cane, base research a of next and last analysis exposed in (Ferreira et al., 2021) (Chatrattanawet et al., 2019). We also calculate the kinetic result set simulation model results of the simulation model. The Reconfiguration of the model was determined for the optimization of the gasification process and capture of CO_2.

Calculation of the Kinetic Model

The overall reaction of the RAC gasification process can be represented from cellulose, a constituent of a more significant proportion, according toEquation 1. The cellulose decomposition equation is considered with second-degree kinetics, taking into account its direct transformation into the products of interest of gasification without degradation of these or the formation of intermediate products.

Equation 1 Gasification process

$$1\,(C_6H_{10}O_5)_n \rightarrow 1\,CH_4 + 1\,CO_2 + 3\,CO + 3$$

The term corresponds to the variation of cellulose concentrations follows:

Equation 2 Kinetic calculus

$$\frac{dC_x}{,dt} = -k \cdot {C_x}^2$$

Where the term corresponds to the variation of the concentration of cellulose over time, referred to as the kinetic constant and the concentration of cellulose raised to its reaction order. This Equation $\frac{dC_x}{dt} - k{C_x}^2$Equation 3 can be manipulated and integrated between their respective initial and final limits of concentration and time, as follows:

Equation 3

$$\int_{C_{xo}}^{C_x} \frac{dC_x}{{dC_x}^2} = -\int_{t_o}^{t} k \cdot t$$

$$\frac{1}{C_{xo}} - \frac{1}{C_x} = -k \cdot t$$

This equation can be rearranged to agree with the shape of the equation of a line (), where it represents the time variable () and corresponds to the value of the slope () $y = m \cdot x + bxtkm$(Equation 4). Using this expression, the reaction kinetics for the previously proposed simulation models were determined.

Equation 4

$$\frac{1}{C_x} = k \cdot t + \frac{1}{C_{xo}}$$

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Table 1. Operating Conditions.

OPERATING CONDITIONS	
Flue gas temperature	40 oC
Flue gas pressure	1.5 bar
Total inflow	602874.4 kg/h
Co2 input flow	48319.4 kg/h
The temperature of the amine solution is 30% of its weight	40 oC
Inlet pressure amine solution	1.1bar
Inlet flow of the mine solution 30% of its weight	554555.5kg/h
Number of stages in the absorber	18
Pressure in the absorber (upper stage)	1.1bar
Flow ratio	13
Number of stages in the stripper	40
Reboiler energy	5x107 cal/s
Stripper pressure (upper stage)	2 bar
Discharge pressure	2 bar

The technique used to develop this research is the determination of the mathematical model with the help of the simulation of RAC gasification and CO_2 capture using the Aspen Plus VERSION 12.1 program.

Results and Discussions

The question that many ask is how much profitability has the gasification of RAC in countries like ours we can say that it is a way to obtain energy in rural places where we find that firewood and pellets are still used in some instances if you think about pollution because we have a CO2 capture system where we guarantee the minimum risk of decay analyzing we demonstrate in the capture a considerable reduction of the It ensures that the environment will not be affected in any way. The gasification process is optimized to the point where we have a meager percentage of ash.

It should be noted that (Muñoz, 2019) developed the following research where it indicated that the data of the agricultural residues of the sugarcane harvest (RAC), fundamentally we can compare the data of the leaves, can be a very efficient biofuel and of economic importance for the sugar mills, dedicated to the sustainable generation of electrical energy from cleaner and renewable biofuels.

The Gasification and Roasting of RAC can occur within the industrial facilities of many sugar mills, as long as they initially go through three basic processes: Drying, filtering, and chopping.

Table 2. Gasification data the average of the three simulations.

Gasification simulation		
Compound	**Molar Fraction**	**Mass Flow**
CELLULOSE	1.94E-22	3.56E-17
CO	0,373672851	11836,00044
CO2	0,124282313	6185,187033
H2O	0,003786774	77,14441267
H2	0,373731517	851,9586477
CH4	0,124526546	2259,098378
C	3.37E-66	4.58E-62

Another of the questions that we find a lot is whether the energy produced by the RAC will have the same performance and that if the energy produced is clean because we are a country that its energy base is fossil biofuels we highlight that the data we find in our gasification shows that it has the same performance it can be used in the same way however in (Golato et al., 2017) we highlight that in this work shows us the different renewable sources for the generation of electricity is constantly increasing in recent years biomass can be considered a renewable source for obtaining bio products and "clean" electrical energy for this, depending on the type of biomass, an adequate technology is necessary to convert biomass efficiently, and a promising alternative is gasification in this work, using the Simulation software Cycle Tempo 5.0 to solve balances of matter and energy, the potential for electricity generation in internal combustion engines from poor gas obtained by gasification of the main biomasses without substantial current use was evaluated: cane harvest waste and pruning and citrus renewal residues with these wastes, altogether, 1,229,208 tons on a dry basis per year, 774 GWh of electricity could be generated annually, 27% of the total electricity consumed in the province.

Table 3. CO_2 capture data.

SEPARATION DATA (CO_2)		
Compounds	**Mass flows (kg/h)**	**Molar fraction**
C2H7NO	43,375698	0,01063652
CO2	1024,34624	0,25118858
CO	58,3290986	0,01430337
H2	5.92E-06	1.45E-09
H2O	2877,01792	0,70549782
N2	0	0
CH4	0	0
H2S	70,4086294	0,01726549
COS	3,24480173	0,00079569
H3N	0,25488063	6.25E-05
CHN	1,01832761	0,00024971

It is also questioned because we do not use a fixed bed reactor in our gasification. We can also highlight that it was tried to do more simply and at the same time also practice demonstrating that if the conditions and the system are adapted, gasification can be carried out with optimal results, we find that in the research of (OECD / FAO, 2009) (OECD/FAO, 2009) the basic theory of the operation of the gasification process today is highlighted, gasification is considered an economically competitive, thermally efficient and environmentally friendly technology later, the following factors are analyzed and selected with criteria, comparing the raw material residues of the sugarcane harvest (RAC)

Energy recovery system internal combustion engine Gasifying agent air Plant production capacity 0.8 ton RAC /h plant design capacity 1-ton RAC/h Estimated synthesis gas production 2408 Nm 3 /h Type of gasifier Fixed bed- Downdraft synthesis gas obtained from biomass gasification is used for electric power generation by an internal combustion engine, in search of supplying the energy necessary for the operation of the plant and selling the remaining surplus at a price of U$S 150 per MWh (RenovAr Program) finally, the reasons why it is considered convenient to install a plant for the production of syngas within them are listed the low costs of the raw material, the development of local industry and the use of agricultural waste.

Table 4. CO_2 optimization data.

RECIRCULATING DATA (CO2 SEPARATION)		
Compounds	**Mass flows (kg/h)**	**Molar fraction**
C_2H_7No	155,816840	0,013358

CO_2	2798,521650	0,239925
CO	165,795452	0,014214
H_2	1.695754E-05	1.453818E-09
H_2O	8332,250643	0,714347
N_2	0	0
CH_4	0	0
H_2S	200,625294	0,017200
COS	9,385330	0,000804
H_3N	0,724457	6.210978E-05
CHN	1,019191	8.737819E-05

Conclusions

After running the model of the modeled gasification process, a conversion of the biomass corresponding to 93% of its feed is obtained and the formation of volatiles whose molar fraction 37% corresponds to a of and once waste and water have been eliminated. $H_2 12\% CH_4 37\% CO 12\% CO_2$

On the other hand, in the carbon dioxide capture process, a yield of up to one of sequestration of , with respect to the processed gas stream was obtained, and obtaining a final molar composition of the process output gases with of , of , of and of , with respect to its molar composition, for the best run.$45\% CO_2 39\% H_2 12\% CH_4 38\% CO 7\% CO_2$

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