Energy crisis: the use of biomass as fuel, its emissions and CO_2 capture

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1.Introduction

International energy policy is evaluated in terms of meeting some social requirements such as energy and environmental security, sustainability, and energy equity, recognizing social justice as a fourth factor of great importance. Contrary to this meaning, the Russian invasion of Ukraine in February 2022 painfully exposed Europe's dependence on a geopolitical adversary. Energy is intimately intertwined with this conflict. Europe is determined to phase out Russian fossil fuel imports, while Russia, in turn, has cut off gas supplies to a number of countries [1]. The urgency of the global energy situation, coupled with the issue of this conflict, implies the need to devise new decarbonization policies that reduce and control GHG emissions before 2030. The recognition of energy equity and social justice among countries, should be key to transitions to durable and sustainable energy systems [2]. Biomass, composed of group of organic materials can be transformed into energy, considered as a potential renewable energy source. It is the third primary energy source after coal and hydrocarbons. Biomass can be converted into useful forms of energy by applying thermo-chemical and bio-chemical processes, in which thermo-chemical conversion technology finds its dominance due to high conversion efficiency. Sugarcane bagasse emits CO_2 during energy conversions and the gasification process. In Brazil and other Latin American countries, the use of biomass as a renewable source in the production of biofuels and bioelectricity has shown excellent results, being used in different industrial sectors. The sugar and ethanol industry has made the most of its resources, using sugarcane bagasse as fuel in the process and for energy generation, including selling energy to the power grids [4]. Several residues are obtained during the process of sugar extraction from sugarcane, such as bagasse, which is a fibrous and heterogeneous material. In the boilers of distilleries and industries the sugarcane bagasse is mainly used as a burned raw material. In the process only 9% of the bagasse is used in the production of alcohol or sugar, but its use as a residue as fuel is considered a sustainable alternative [5]. However, their emissions should be monitored and controlled, because bagasse burning is a critical source in greenhouse gas emissions such as CO_2. The work of Kazanc et al. [6] evaluated the emissions produced by burning sugarcane bagasse in O_2/N_2 and O_2/CO_2 ratios, the values of emissions in mole fraction were 15 to 18% CO_2, for coal burning, while the CO_2 emission for pure bagasse burning was between 0.6% and 1.4%, due to the lower concentration of carbon in the biomass. Rokni et al. [7] analyzed gas emissions from biomass burning mixed with coal. When mixing fossil fuel with renewable fuel, the total cost tends to decrease, but one should take some aspects into account, such as the availability and cost of coal to make this mixture of raw materials. The carbon dioxide emissions from burning the two types of coal were reduced in all mixtures with biomass and the most significant reduction for the biomass and bituminous coal mixtures resulting in a molar fraction of 9% of CO_2 in the outgoing effluent, for burning coal, 2.2% for corn husks and 5.5% for rice husks. The effective control of these emissions in industrial processes is necessary to achieve the emission reduction goals assumed by the different countries. The urgency to invest in research and technologies that can effectively capture CO_2 from stationary sources is highly important (Sumida, 2012). The most commonly used methods for controlling and capturing CO_2 are the wash column and the droplet separator. The absorption is the separation of gaseous compounds in which the target gas is selectively absorbed into a liquid. Several commercial gas technology separations rely on interactions between gases and pure liquids. Another separation method comprises a reaction between the target gas and a liquid solute (Bates et al. 2002; D'alessandro et al. 2010). However, the cost of absorbers is still relatively high because the flow rate of industrial flue gas is generally large, large-scale capture system and high system power consumption. In addition, the current materials that are used in these large gas flow applications form waste products that require careful handling and storage and the materials become unstable after heating, which limits regeneration (Creamer, Bin Gao, 2015). Historically, liquid adsorbents (e.g. NaOH, NH_4OH, KOH) have been used in industrial carbon capture due to the acidity of CO_2 gas (Y. Ji, et al., 2022 and W. Liu et al., 2022). The efficient sequestration of CO_2 is a challenge for the entire scientific community. There is an urgent need for public politics that encourage and provide support and incentives for control processes and legislation that include the reduction of emission levels. In relation to industrial processes and their anthropogenic emissions in which CO_2 emission is included, the great scientific and technological challenge is to find an economically applicable and efficient technology for the existing processes.

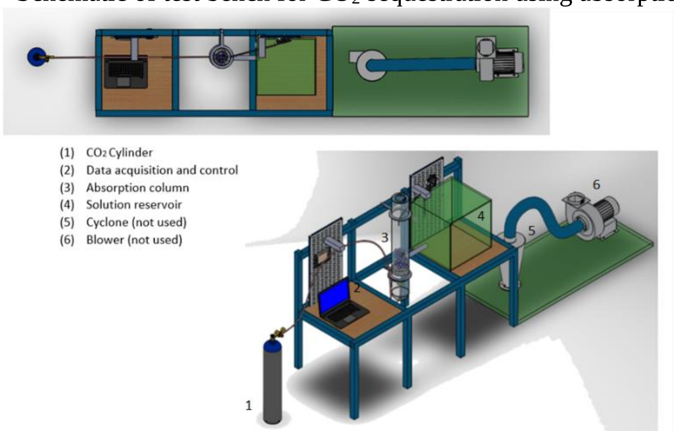
2.Objective: The main objective of this experimental study is to evaluate technologies developed in the laboratory that could mitigate industrial CO_2 emissions emitted by burning biomass used as fuel; To evaluate the effect of cleaning liquids on CO_2 absorption using an absorption column.

3.Methodology

3.1. Laboratory equipment to evaluate CO_2 emission and control.

The different materials obtained during the modification process will be evaluated at a laboratory level using a bubbling system of the CO_2 on the absorbent solution. Different parameters will be evaluated to measure the CO_2 absorption capacities such as pH, temperature, gas flow, absorbent concentration, etc. Figure 1 shows the experimental apparatus to be used on a laboratory scale to simulate the emission and capture of CO_2. In this equipment, the fluid flow, temperature, and pressure drop were be monitored and data collection automated. The absorption column where the gas containing carbon dioxide was bubbled into recirculating solutions of NaOH and CaO and other sequestrants in aqueous solution, in order to compare the results between approaches that could be mentioned due to their efficiency and cost. The absorption column has a diameter of 8.5 cm, with a packing height (3/8-inch Raschinh type plastic rings) of 26 cm. The collection efficiency was evaluated with CO_2 concentration measurements before and after the absorption column. The effects of gas velocity, liquid flow, CO_2 concentration were analyzed. Efficiency results were obtained by chemical analysis and a gas analyzer, Chemist 500, with gas measuring cells and insertion probe into the ducts for sampling was also used. Absorption without and with chemical reaction was analyzed. The flow rates of water (distilled) and liquid solutions (NaOH 0.1N) were 1.4; 1.8 and 2.0 L/min; the compressed air flow rate was 20 L/min and the CO_2 input flow rate was constant and equal to 6.0 L/min.

Figure 1 – Schematic of test bench for CO_2 sequestration using absorption column



4.Results

Preliminary results showed that for absorption without chemical reaction for water flow rates of 1.4, 1.8 and 2.0 L/min the efficiencies were low with values of 0.84, 0.79 and 0.32%, respectively. For the absorption with chemical reaction the NaOH solution flow rates of 1.4; 1.8 and 2.0 L/min the efficiencies were 12.62; 2.6 and 25.71, respectively. Some process improvements can be made to improve efficiencies, such as changing droplet nozzles and increasing liquid flow rates. Further tests with CaO solutions will be performed, as well as other liquid solutions.

5. Conclusion

Gas emissions should be monitored and controlled by the industries. New chemical compounds must be evaluated for the absorption and capture of CO_2, compounds that encourage control in industrial processes under cost conditions that encourage proper control.

6. References

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