International Journal of Interdisciplinary Innovative Research &Development (IJIIRD)

ISSN: 2456-236X

Vol. 03 Special Issue| 2019

Carbon Emissions Capturing Device

Simran Dhariwal[1], Monali Patil[2]

[1, 2,] *Department Of Mechanical Engineering, AgnelPolytechnic, Navi Mumbai, India*

ABSTRACT

Pollution is a vastly increasing global phenomenon. By volume dry air contains 78.09% nitrogen, 20.95% oxygen, 0.93% argon, 0.04% carbon dioxide, and small amounts of other gases. Air also contains a variable amount of water vapour, on average around 1% at sea level, and 0.4% over the entire atmosphere. The air also contains a small amount of pollutants such as particulate matter (PM10 and PM2.5), Ozone (O3), Nitrogen dioxide (NO2), Carbon monoxide(CO),Sulphur dioxide (SO2). The concentration of carbon dioxide and carbon monoxide has observed a massive hike in the past two decades.The concentration of such gasses is measured in parts per million (ppm) where the concentration of the gas is measured as a millionth part of oxygen present in the atmosphere. Over the past two decades, Co2 concentration levels have increased drastically.

In the year 1980 CO2 concentration was 330ppm and currently, the concentration is 410 ppm. Carbon dioxide is a greenhouse gas, which causes the greenhouse effect. Concentration of Co2 levels in enclosed or poor air quality zones are mostly around 800 to 1000 ppm. An increase in this level i.e above 2000ppm could cause human discomfort, increased heartrateandnausea.AlsoknownasCo2poisoning. The technology we used to reduce the concentration of pollutants was capturing of carbon emissions from the air itself. A technology namely Direct Air Capture. A technology which uses a capture solution which uses calcium hydroxide or any other hydroxide based solution .The idea is to not create further emissions but captured current pollutants and make solid use out of them. Our device is called carbon emissions capturing device (CECD) This technology has been developed by us which causes the carbon dioxide to be trapped by the capture solution expect the inlet pollutant gas is taken from the car's exhaust. With anincrease in population, production of automobiles and emissions from various industrial sources, carbon dioxide levels are bound to increase. Our focus is to reduce the automobile emission of pollutants like carbon monoxide, carbon dioxide and make useful products out of the newly obtained solution.

Keywords—CECD, PPM, pollutants, Direct Air Capture

1. INTRODUCTION

Capturing CO_2 from air is being proposed as a viable climate change mitigation technology. The capture of CO_2 from ambient air was commercialized in the 1950's as a pre-treatment for cryogenic air separation. In the 1960's, capture of CO_2 from air was considered as a feedstock for production of hydrocarbon fuels using mobile nuclear power plants.In the 1990's, Klaus Lackner explored the large-scale capture of CO_2 as a tool for managing climate risk, now commonly referred as direct air capture(DAC).

Carbon emission capturing device (CECD) involves a process of removing CO_2 directly from the vehicle's exhaust. Basically, CECD is a technology that processes the exhaust gases, removes CO_2 and purifies it. CECD involves a system in which the exhaust gases flow over a chemical sorbent that selectively removes CO_2. The CO_2 is then released as a concentrated stream for disposal or reuse while the sorbent is regenerated and the CO_2 depleted air is returned into the atmosphere. Nonetheless, CECD is one of the small strategies that lower the atmospheric concentration of CO_2.

The capture of CO_2 is a very enticing prospect. If it can be accomplished on a large enough scale, we have a practical approach to stabilize atmospheric CO_2 concentrations. CECD can help to address the impact of CO_2 buildup on global climate change. This technology can at best slow the rate of increased atmospheric CO_2 concentration. In contrast, the direct CO_2 capture from vehicle's exhaust offers the potential to be a truly carbon negative technology. The concentration of CO_2 in air and in stack gases from simple combustion sources (heaters, boilers, furnaces) is not high enough to make carbon dioxide recovery commercially feasible.

Producing carbon dioxide as a commercial product requires that it be recovered and purified from a relatively high-volume, CO_2-rich gas stream, generally a stream which is created as an unavoidable byproduct of a large scale chemical production process or some form of biological process. But the slightest of efforts can be made to decrease the pollutant concentration to improve air quality locally as well as globally. Hence, we have attempted to make a slightly more innovative and feasible way of reducing CO2 and COemissions.given environment. Various methods exist and are being developed and researched for the purpose of pollution reduction and prevention of climate change. By definition, climate change is a change in global or regional climate patterns, in particular a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels.

There are many climate forcing processes, but broadly speaking, they can be separated into internal and external types. External processes operate outside planet Earth, and includes changes in the global energy balance due to variations in the Earth'sorbit around the Sun, and changes in the amount of energy received from the Sun. Internal processes operate from within the Earth's climate system, and include changes in the global energy balance due to changes in ocean circulation or changes in the composition of the atmosphere. Other climate forcing processes include the impacts of large volcaniceruptions and collisions with meteorites. Our focus is to control the atmospheric parameter that controls the climate change cycle. Our mission is to reduce pollution caused by vehicles and eliminate any harmful exhaust gas present in the atmosphere. With an increase in the concentration of carbon monoxide and dioxide, we decided to target one of the emitting sources and make the maximum reduction in concentration ofpollutants

2. AIM

Pollution by definition is the most escalating crisis humanity is facing right now. A pollutant is a condition or substance that contaminates the atmosphere, surroundings, the water or the soil. Pollutants can be artificial substances, such as pesticides and PCBs, or naturally occurring substances, such as oil or carbon dioxide.

3. INSPIRATION

Klaus lackner is known as the pioneer of the carbon capture industry. He is a pioneer in carbon management and is the first to suggest capturing carbon dioxide from air in the context of addressing climate change.His current work includes the demonstrating and improving passive methods to remove carbon dioxide from the atmosphere, integrating air capture technology with applications for using carbon dioxide, exploring safe and permanent disposal options for carbon dioxide, and identifying opportunities for automation and scaling. His publications have been cited 5842 times as of November 12,2015.The main component of diesel exhaust, just as is the case with ambient air, is nitrogen (N2).

3.1 DAC

Companies like Clime works, Carbon engineering etc, use the technology known as DAC(direct air capture). Direct air capture (DAC) is the process of removing CO_2 directly from the ambient air (as opposed to from point sources). Combining direct air capture with carbon storage could act as a CO2 removal technology and as such would constitute a form of climateengineering if deployed at large scale.Wecan not only create negative carbon emissions but also mitigating the greenhouse effect. Storage of the captured carbon dioxide and then creating a market for co2 could benefit companies in carbon credit, but also, co2 can be sold to manufacturing companies that can use it for a wide range of applications, eg: welding, making fuel, c…. .Various institutions and organizations have worked on this technology for several years, Carnagiemellon university, Climeworks, Carbon Engineering, and we have finally achieved the capturing of carbon with the help of hydroxide based solutions. The main objective of DAC is to absorb 1% of the world's carbon emissions by2020.

3.2 CECD

Carbon emission capturing device is a carbon emission capturing technology which uses the source of emission as a car's exhaust. We have specifically targeted diesel vehicles Compared to the composition of air, the diesel exhaust gas contains increased concentrations of water vapor (H2O) and carbon dioxide (CO2)—the main combustion products. The concentrations of both H2O and CO2 can vary from a few percent, up to about 12% in diesel exhaust. These combustion products displace oxygen, the concentration of which can vary from a few percent, up to about 17% (compared to 21% in ambientair).

3.3. Objective of CECD

- To build a device which captures exhaust pollutants such as CO2 andCO
- To decrease the content of carbon and its oxides in theatmosphere
- To contribute in reducing the Global warming effect
- For increasing air quality in pollutionridden areas.

4. METHODOLOGY

4.1 Design of device

For designing the device we used various designs and searched the most efficient design. We simulated the gas flow in Analysis and determined the required geometry. It's geometry was very similar to that of a pipe reducer. So we did a market survey where we found reducers of 3" to 2". The material used was Mild Steel.The idea was to place this device in the car exhaust systems assembly. This is the outer casing of the device. the filtering arrangement is housed inside this assembly.

4.2 Constructional Details

4.2.1 Device

The Capture solution reservoir is placed above the device connected through a tube which would supply the solution to the filtering media. The exhaust gas flows over the filtering media. A ring is housed inside the reducer body which has a strainer welded to it. We have tested different filters with the exhaust flow and selected the Open cell polyeutherene compressed gas filter. The filter was specially requested by us to Delta Filters and separators. Below the assembly a storage device for the collection of the combined solution is placed. it is again connected with tubes. The combined solution is stored in the collection container.

4.2.2 CO2 Meter

Our CO2 measuring device consists of a CO2 gas sensing element , the mg811 sensor. To connect the sensor to the arduino board we used a Gas sensor PCB board. we used a simple LCD display 16*1. For the microcontroller we used the open source electronics prototyping platform, The Arduino Uno R3. We calibrated the sensor and coded it with the arduino board to shoe the Co2 spreading.

4.3 Working

Our device works on the principle of Capturing the flow of CO2 by means of a hydroxide based solution. Carbon monoxide can also captured by making it react it with a hydroxide based solution. For the capture solution we utilized calcium hydroxide. Calcium Hydroxide when reacts with Carbon Dioxide, it forms calcium carbonate and water.

$$Ca(OH)2 + CO2 = CaCO3 + H2O$$

Calcium Hydroxide when reacts with Carbon monoxide , it gives calciumformate.

$$Ca(OH)2 + CO = Ca(HCOO)2$$

The capturing of co2 depends upon the following parameters

- Flow rate of the exhaust gas coming from the outlet
- Temperature of the exhaust gas at the outlet
- Flow of capture solution
- Material of the casing
- Material of the filtering media
- Porosity of the filter

The specifications of the filter are given below:

- Air Permeability: Upto99%
- Tensile Strength: 50 to 200KPa
- Extensibility: 75% to250%
- Tear Strength: 3.5 to 10N/cm2
- Operating Temp: -50 to +70 degC
- Alkali Resistance:pH Range 5.0 to12.5
- Pores per Inch (ppi) 60ppi

The process of re-circulating the capture solution is tedious but possible. The collection tank can be heated up to a point where the decomposition reaction takes place. Calcium carbonate is strongly heated until it undergoes thermal decomposition to form calcium oxide and carbon dioxide. The calcium oxide (unslaked lime) is dissolved in water to form calcium hydroxide (limewater). Thus, the solution can be reused and it completes the cyclic process of capturing carbon emissions. These captured solutions can be used in their combined form or they can be separated to again obtain CO2gas.

4.4 Applications of CO2

Carbon dioxide in solid and in liquid form is used for refrigeration and cooling. It is used as an inert gas in chemical processes, in the storage of carbon powder and in fire extinguishers. Carbon dioxide is used on a large scale as a shield gas in MIG/MAG welding, where the gas protects the weld puddle against oxidation by the surrounding air. A mixture of argon and carbon dioxide is commonly used today to achieve a higher welding rate and reduce the need for post weld treatment.

4.4.1 Multi-Industry Uses for Carbon Dioxide (CO_2)

Carbon dioxide in solid and in liquid form is used for refrigeration and cooling. It is used as an inert gas in chemical processes, in the storage of carbon powder and in fire extinguishers.

4.4.2 Metals Industry

Carbon dioxide is used in the manufacture of casting molds to enhance their hardness.

4.4.3 Manufacturing and Construction Uses:

Carbon dioxide is used on a large scale as a shield gas in MIG/MAG welding, where the gas protects the weld puddle against oxidation by the surrounding air. A mixture of argon and carbon dioxide is commonly used today to achieve a higher welding rate and reduce the need for post weld treatment.

Dry ice pellets are used to replace sandblasting when removing paint from surfaces. It aids in reducing the cost of disposal and cleanup.

4.4.4 Chemicals, Pharmaceuticals and Petroleum Industry Uses

Argue quantities are used as a raw material in the chemical process industry, especially for methanol and urea production. Carbon dioxide is used in oil wells for oil extraction and to maintain pressure within a formation..When CO_2 is pumped into an oil well, it is partially dissolved into the oil, rendering it less viscous, allowing the oil to be extracted more easily from the Bedrock. Considerably more oil can be extracted from through this process.

4.4.5 Rubber and Plastics Industry Uses

Flash is removed from rubber objects by tumbling them with crushed dry ice in a rotating drum.

4.4.6 Food and Beverages Uses for Carbon Dioxide

Liquid or solid carbon dioxide is used for quick freezing, surface freezing, chilling and refrigeration in the transport of foods. In cryogenic tunnel and spiral freezers, high pressure liquid CO2 is injected through nozzles that convert it to a mixture of CO2 gas and dry ice "snow" that covers the surface of the food product. As it sublimates (goes directly from solid to gas states) refrigeration is transferred to the product. Carbon dioxide gas is used to carbonate soft drinks, beers and wine and to prevent fungal and bacterial growth. Liquid carbon dioxide is a good solvent for many organic compounds. It is used to de-caffeinate coffee. Carbon dioxide is used as an additive to oxygen for medical use as a respiration stimulant.

4.4.7 Applications of Calcium Carbonate

Calcium carbonate is the most widely used mineral in the paper, plastics, paints and coatings industries both as a filler – and due to its special white color - as a coating pigment. In the paper industry it is valued worldwide for its high brightness and light scattering characteristics, and is used as an inexpensive filler to make bright opaque paper. Filler is used at the wet-end of paper making machines, and calcium carbonate filler allows for the paper to be bright and smooth. As an extender, calcium carbonate can represent as much as 30% by weight in paints. Calcium carbonate also is used widely as filler in adhesives, and sealants.

5. ADVANTAGES

- CECD helps to address the impact of CO_2 buildup of global climate change.
- It slows the rate of increase in atmospheric CO_2concentration.
- Offers the potential to be a truly carbon negative technology.
- Is able to tackle distributed emissions from transportation and heating.
- This technology can compensate for any emitted CO_2 by capturing an equal amount of CO_2 at a different location and time.

6. LIMITATIONS

1. More energy is required to separate the $CO_2$from air than from a power plant because it is more dilute in CO_2 meaning that twice as much energy is required to remove the CO_2 emitted from a given amount of coal compared to the energy content of the coal.
2. The energy requirement of calcination step is prohibitively large.
3. Technology associated with the sorbent and sorbent recycling is tedious

7. FUTURE SCOPE

1. Sorbent costs will be lowered as air capture becomes adopted on a large-scale.
2. If given industrial support, CECD can give great benefit in carbon reduction.
3. Combined with possible carbon taxes on CO_2emitting industries, direct air capture could become part and parcel of industry of the future.
4. Since CECD units can be easily attached and detached it can be used with various other devices like:
    - Diesel generators
    - Sooty boilers
    - Furnaces
    - Heaters
    - Various Automobiles including HCVs

8. REFERENCE

[1] http://carbonengineering.com/media/
[2] https://www.who.int/airpollution/en/
[3] http://carbonengineering.com/wp-content/uploads/2017/06/CE-DAC-CCS-Comparison.pdf
[4] MG811 datasheet. https://chem.libretexts.org