Automation of CO_2 Sequestration System

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Abstract:

The **Direct Air Capture (DAC)** system is an automated system that directly captures CO_2 from the atmosphere. This poster discusses the **beginning stages, design, and future of the DAC system**. Ambient air runs through a dehumidifier before being sent through an adsorption column. From the adsorption column, CO_2 is pushed to a heat exchanger and then to the cryogenic freezer where CO_2 is deposited. The experiment performed indicated that **automation for the DAC system is feasible and accurate**. The system accurately indicated a person's breath on the SCD sensor and controlled the flow of the system through pneumatic gas valves. This experiment provides a good starting point for the future construction and implementation of the DAC system in Polar regions.

Introduction

- In 2021, **37.14 billion metric tons of CO_2** have been emitted into the atmosphere. (Global Carbon Project)
- CO_2 molecules absorb infrared photons which increase the temperature of Earth. With the substantial increase in CO_2 emissions, the **Earth is warming up substantially** resulting in major environmental issues.
- One method for removing CO_2 calls for sequestration through **cryogenically freezing captured CO_2**. Perskin et al. did a study on the evaluation of the feasibility of precompression for direct atmospheric cryogenic capture and concluded that the **efficiency of a heat exchanger precooler is more effective and advantageous than the utilization of a precompression and turbine recovery in a DAC system**. We will continue this research and eventually put theory into practice.

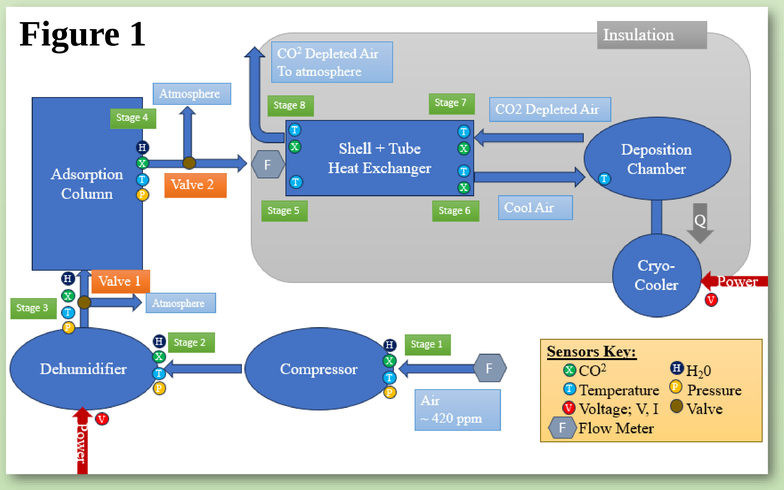
Materials and Methods

- The design of the whole DAC system is shown in **Figure 1**.
- Focus of this experiment is **Stage 1**, the preliminary stage, as shown in **Figure 2.** Data is collected in a classroom.

Preliminary Circuit Design:

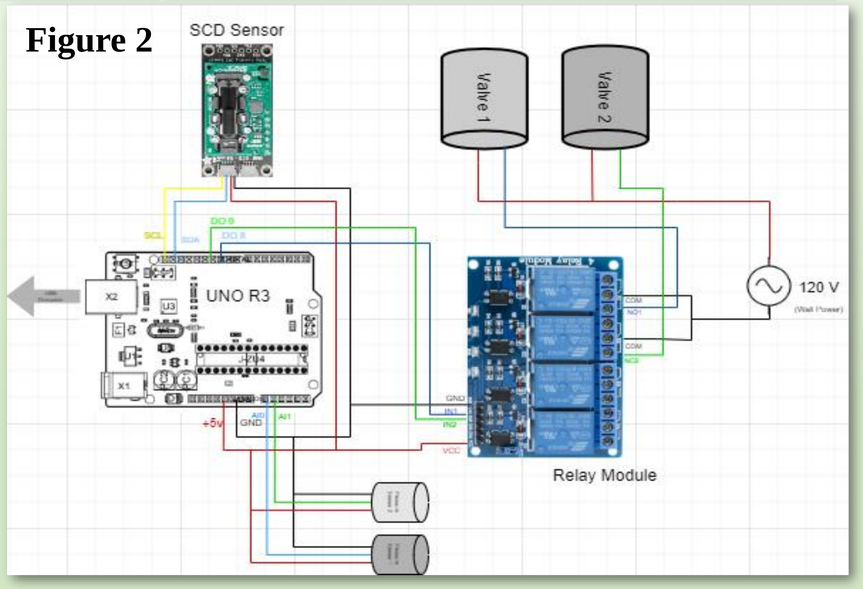
- Programming: Arduino software
- Hardware: UNO R3 microcontroller, SCD sensor, Relay module, Solenoid pneumatic gas valves
- The data is collected with Cool Term and analyzed in Microsoft Excel.

Figure 1

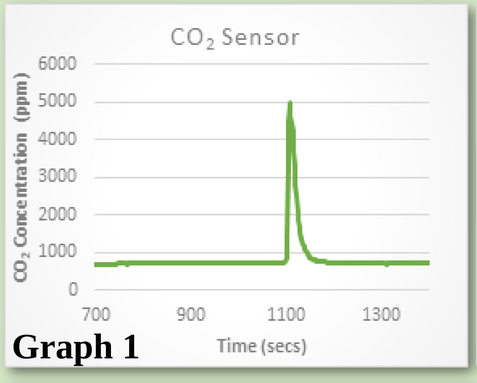


Preliminary Circuit

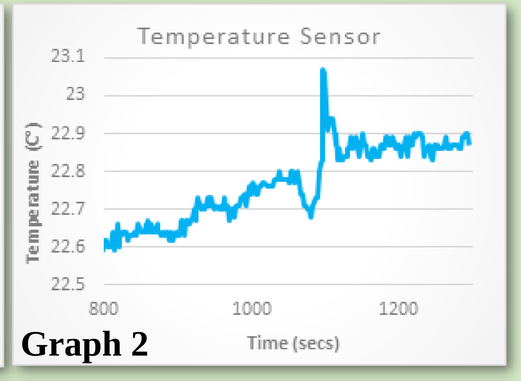
Figure 2



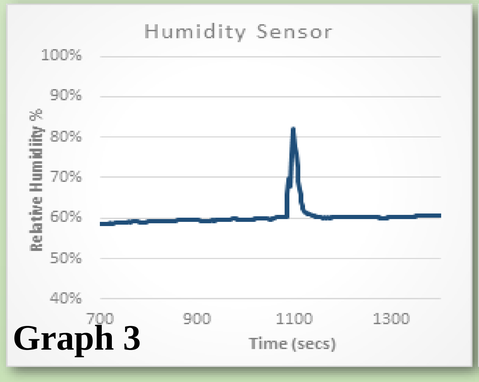
Results: Graphs



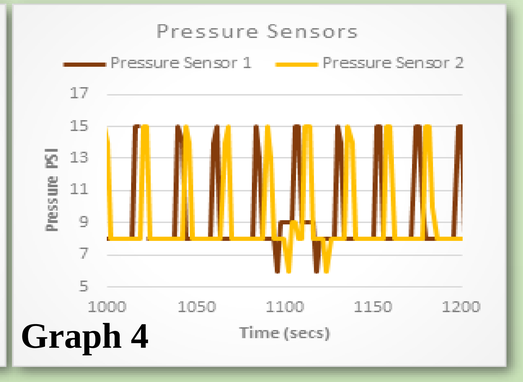
Graph 1



Graph 2



Graph 3



Graph 4

Results: Tables

SENSORS	CO_2 (PPM) ± 30 PPM + 3%	TEMP (°C) ± (0.4 °C + .023 X (T-25°C))	RELATIVE HUMIDITY (%) ± 3%	PRESSURE 1 (PSI) ± 2%	PRESSURE 2 (PSI) ± 2%
MEAN	753	22.6	65.8	9.16	9.17
HIGH PEAK	4970	23.1	81.4	15.0	15.0
LOW PEAK	688	22.4	52.3	6.00	6.00

Discussion

- The spikes in Graphs 1-3 indicate exactly when a person breathed onto the system (at 1,100 secs), meaning that the system **can accurately detect a change in the atmosphere at a specific time.**
- The pressure sensors need to be further researched as they seem to produce unexpected results and may be inaccurate.
- **Automation** in the DAC system is **feasible**.

Future Research

- The next step for the team is to build the physical system completely and put the theory into practice.
- Experiments to be further researched:
  - Additional adsorption column.
  - Energy consumption.
  - Flow rate.
  - Location: Artic/Antarctica.

A future endeavor for this project is a **large production system**, with multiple columns and cycles all fully automated. While this solution will not completely fix climate change, it is with great ambition to mitigate it.

References

- Global Carbon Project. (November 11, 2022). Annual carbon dioxide (CO_2) emissions worldwide from 1940 to 2022 (in billion metric tons) [Graph]. In Statista. Retrieved October 08, 2023, from https://www.statista.com/statistics/276 629/global-co2-emissions/
- Perskin, J. B., Traum, M. J., von Hippel, T., & Boetcher, S. K. S. (2022). On the feasibility of precompression for Direct Atmospheric Cryogenic Carbon Capture. Carbon Capture Science & Technology, 4. https://doi.org/10.1016/j.ccst.2022.100063