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OXYGEN CONCENTRATION GENERATOR USING PSA

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Abstract: In the medical and healthcare fields, oxygen concentrators—also referred to as oxygen generators—are frequently used to provide oxygen for patients. Here, we create a home-made oxygen concentrator that uses a pneumatic supply to produce oxygen from ambient air. In order to construct this system, our machine uses pneumatic pressure, zeolite containers, a separate pressure vessel, pressure sensors, oxygen sensors, and leakage sensors. For the benefit of patients in COVID pandemic and other emergency scenarios, we successfully build an oxygen concentrator generator

IndexTerms **– PSA-Pressure Swing Adsorption, Zeolite, oxygen concentrator**

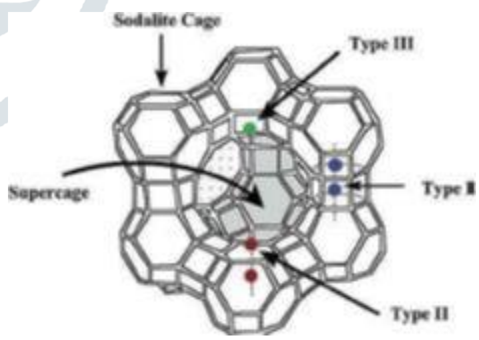
I. INTRODUCTION

At pressures exceeding 50 PSI, an oxygen concentrator generator generates pure oxygen at a rate of roughly 95%. The oxygen concentrator generator's viewpoint is excellent, and it operates flawlessly despite oxygen leaks. We have learned so much while working on it. We gained knowledge of the air-separation pipe, humidifier, and pressure regulator. solenoid valve, wire plug for an Arduino kit, a Malc cable, and an adapter. The pressure swing adsorption system (PSA) powers the oxygen concentrator generator. To provide patients 90–98% pure oxygen, it filters with ambient air. First, we turn on the compressor and attach the inlet pipe to the concentrator. The compressor is then turned on and adjusted at 50 to 140 PSI. We have an intake air regulator valve set at 50 PSI and an exit pressure regulator when ambient air enters the pressure regulator through the compressor.

In order to separate gas mixtures, pressure swing adsorption (PSA) has been used, for example, to collect carbon dioxide during the synthesis of ammonia and to purify hydrogen. Due to its straightforward operation, good performance at ambient temperatures, high regeneration rate, and low energy intensity, PSA is seen as an appealing method in terms of its high cost-effectiveness. By passing a gas mixture through a reactor that contains sorbent, gas molecules may be separated from the gas mixture in the PSA process under high pressure and low temperature. Once the pressure is reduced, the CO2 is fairly easily released from the adsorbent surface because the electrons between the adsorbent and adsorbate are not shared.

Using zeolites in medicine: oxygen concentrator

An oxygen concentrator is a machine that selectively removes nitrogen from a gas source, typically ambient air, to produce an oxygen-enriched product gas stream. They came about as a replacement for small cryogenic liquid oxygen systems or heavy high pressure oxygen cylinders, allowing patients receiving medical oxygen therapy to receive care in their own homes. Pressure swing adsorption (psa) technology is used by oxygen concentrators to release oxygen-enriched gas for usage by patients who need medical oxygen because their blood oxygen levels are low.



2.OBJECTIVES:

- Ongoing pressure and oxygen concentrator displays.
- Sound an alarm when an oxygen concentrator falls below 90%.
- Constant output flow to meet all oxygen demands.
- Sound an alarm if the output pressure is less than 3 bars/44 psi.
- To create an intermittent oxygen product flow PSA oxygen concentrator with the proper zeolite and operating parameters.
- To create a mathematical model for the internal gas adsorption analysis of the zeolite column that specifies the transport processes and adsorption kinetics.

3.METHODOLOGY:

The project's goal is to create an oxygen concentrator generator that generates medical-grade oxygen using Pressure Swing Adsorption (PSA) technology. Lithium 13X zeolite, which has an effective pore size of 10 Angstroms, is used to line the adsorption column. The process produces highly concentrated oxygen from ambient air by using the concept of selective adsorption of nitrogen over oxygen.

Materials required:

- Adsorption column filled with Lithium 13X zeolite
- Compressor
- Air dryer
- Oxygen storage tank
- Flow control valves
- Pressure Regulator
- Pressure sensors
- Oxygen purity monitor

Working :

Step 1: Ambient air is drawn into the system using a compressor. The compressed air is then directed to the air dryer to remove any moisture and impurities that can potentially damage the adsorption column.
Step 2: The dried and clean air is then directed to the adsorption column filled with Lithium 13X zeolite. The zeolite selectively adsorbs nitrogen from the air while allowing oxygen to pass through. The adsorption process is driven by the difference in adsorption capacity between nitrogen and oxygen.
Step 3: The oxygen-enriched air is directed to the oxygen storage tank through a flow control valve. The pressure of the tank is monitored using a pressure sensor, and the flow of oxygen is controlled to ensure that the tank pressure remains within the desired range.
Step 4: The oxygen purity is monitored using an oxygen purity monitor. The monitor continuously measures the percentage of oxygen in the output stream, and alarms are generated if the oxygen purity falls below the desired level.
Step 5: The oxygen is then dispensed to the patient through a flow control valve. The flow of oxygen is adjusted to meet the patient's oxygen demand, and the output pressure is monitored to ensure that it remains within the desired range.
Step 6: The nitrogen that is adsorbed by the zeolite is periodically purged from the adsorption column using a separate flow of compressed air. This process, known as the regeneration cycle, is necessary to ensure that the zeolite remains effective over an extended period.
Step 7: The entire process is controlled by a Programmable Logic Controller (PLC) that monitors the various parameters such as pressure, flow, and oxygen purity. The PLC provides an interface to the operator to set and adjust the system's parameters, and it also generates alarms if any parameter falls outside the desired range.

PSA System:

A variety of various types of valves and flow controls are included in the extremely sophisticated PSA apparatus used in these tests so that the user may create and regulate the cyclic process required for PSA. The 1/8 inch stainless steel tubing and fittings that link various kinds of valves and flow controllers make up the system as a whole. It is deliberately heavily instrumented in order to measure the physical changes taking place at various times in the process, which reveals how to fine-tune and enhance the process. Data on pressure, temperature, flow rate, and gas composition may all be gathered by the system. Preliminary experiments and PSA experiments are the two types of tests performed using the device.

PSA process 5 main stages:

- Filtered and dried compressed air with a nitrogen to oxygen ratio of 78% to 21% and less than 1% argon is used.
- Air flows through the molecular sieves, where zeolite absorbs nitrogen, raising the oxygen content to 97%.
- The oxygen generated from the molecular sieve is transported via the buffer tank by way of a multifunction block. Nitrogen is driven back outdoors after being silently discharged.
- While the second vessel assures oxygen generation, a portion of the oxygen created is used to assist one vessel's nitrogen desorption.
- A pneumatic and automated mechanism for balancing the containers provides constant oxygen flow.

Experimental details:

Finding the pressure drop in a segment of the system between two ports (P1 -P2) linked to the valve with the pressure transducer attached was the primary technique. This was carried out at flow rates (500–1950 standard cc/min) and pressures (vacuum–4 atm), which were within the range of PSA cycles anticipated for this project. Although the pressure drop was found to be insignificant, the appendix contains a summary of the pressure drops in some of the system's more pertinent sections. Several calibrations and ins trumpet zeroing were finished before any other testing could start. Utilising the vacuum pump connected near the oxygen storage tank, the pressure transducers were zeroed.

Main parts used in this project:

Arduino Uno:

Arduino Uno can be used to control the operation of an oxygen concentrator. An oxygen concentrator typically works by filtering nitrogen from the air to provide high concentration oxygen for therapeutic or medical purposes. With Arduino Uno, it is possible to automate the process of monitoring and regulating the oxygen concentration levels, as well as controlling the flow rate and other settings of the concentrator.

Relay:

A relay can be used in an oxygen concentrator to control the flow of electrical power to various components, such as the compressor and the control panel. By connecting the relay to a microcontroller or a control circuit, it is possible to turn on or off the power to these components in response to the signals from sensors or user input.

Air Compressor

A compressor is a critical component of an oxygen concentrator that compresses the ambient air and pushes it through the concentrator's sieve beds, where nitrogen is separated from oxygen, producing a high-purity oxygen stream. Compressors in oxygen concentrators can be of different types, including piston, diaphragm, or rotary vane compressors.

In terms of maintenance, compressors require regular cleaning, lubrication, and replacement of worn-out parts to ensure their optimal performance and longevity. Failure to maintain the compressor can result in reduced efficiency, increased noise, and potential safety hazards.

Flow Regulator

A flow regulator is a crucial component of an oxygen concentrator that allows for a controlled and safe delivery of oxygen to the patient or user. Oxygen concentrators can offer a dependable and efficient supply of therapeutic oxygen if the right type of flow regulator is used and the flow rate is regulated to the required level. The oxygen flow regulator generally consists of a dial or knob that may be turned to change the oxygen flow rate. A healthcare professional or the patient's demands can be taken into consideration while setting the flow rate, which is expressed in litres per minute (LPM).

Filtration Unit

A typical water filtration tank consists of a large tank or container that contains a filtering media, such as activated carbon, sand, or ceramic. As water passes through the media, impurities and contaminants are trapped and removed from the water, resulting in clean and safe drinking water

Adsorption Tank

It is a tank used to separate and purify gases from a mixture, based on their different adsorption characteristics. It is commonly used in various industrial applications to produce high-purity gases for different processes. Adsorption tank is saturated with the target gas, the pressure is reduced, and the adsorbent is desorbed, releasing the target gas in a concentrated form. The process then repeats, with the adsorbent being repressurized and the gas mixture being passed through again to adsorb more of the target gas.

Software Program :

This prototype was created using the Oxygen_Concentrator Arduino programme. The Arduino Uno must be uploaded with it. An open source programme called Arduino IDE is needed for this. Digital pins 2, 3, 4, 5, 6, and 7 are designated as outputs in the Arduino programme.

Main functions of Arduino code are explained below:

pinMode(): Sets the given pin's behaviour to be either an output or an input. For information on how the pins work, go to the digital pins explanation. They can also be used as PWM pins there.

Digital Write(): The voltage of the pin will be set to the appropriate value if it has been designated as an OUTPUT using pin Mode(): 5V (or 3.3V on 3.3V boards) for HIGH, and 0V (ground) for LOW.

Serial: used to communicate with a computer or other devices using the Arduino board. Every Arduino board has a serial port, sometimes referred to as a UART or USART, and some have several serial ports.

Begin(): sets the serial data transmission's data rate in bits per second (baud). Use one of these rates to communicate with the computer: 300, 600, 1200, 2400, 4800, 9600, 14400, 19200, 28800, 38400, 57600, or 115200. To connect with a component that needs a specific baud rate across pins 0 and 1, for example, you can provide different rates instead. **println():** prints data to the serial port as ASCII text that can be read by humans, followed by a carriage return.

delay(): It is used to pause the programme for the specified duration (six seconds in this case).

Construction:

Parts list	C1
Diodes 1N4007	1 K ohm Resistor
U1	C2
IC1	RL1-RL6
Q1-Q6	Jack 1
Indicator LED	L1-L6
D1-D10	R2 , R7
1000 uF Capacitor	Arduino processing board, Arduino uno
LED 1	R1
4.7 K ohm Resistor	7812 Voltage Regulator IC (12 Volts)

Volumetric efficiency:

Volumetric efficiency = Amount of oxygen ouput/Amount of air intake

=3.14(37.5)2*55/3.14 (27.5)2*120

=0.852*100

=85.2%

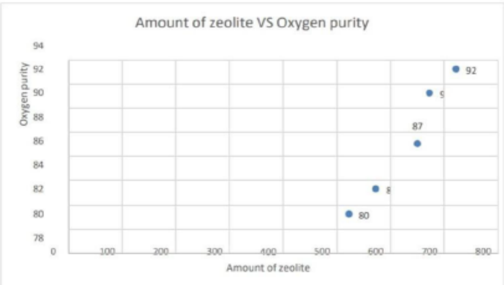
Power consumption:

Power =voltage*current

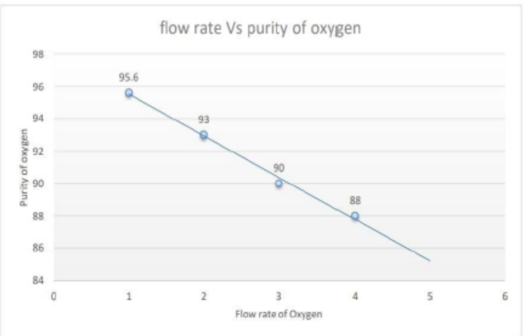
=230*1.39

=320watt

Graphs :



OXYGEN CONCENTRATOR GENERATOR USING PSA



Air Filter :

Length (l) =115mm

breadth(b) = 55mm

Area (a) = l*b = 115*55= 6325mm2

Air Tank :

Height(h) = 120mm Diameter (d) = 55mm

Radius (r) = 27.5mm

Volume (v) = 3.14 *r2*h=3.14*27.52*120=284955mm3

Compressor :

- Oil free compressor
- Pressure =2.5kgf/cm2
- Flow rate = 110 lpm

PROJECT OUTCOME

The goal of this project was to examine a pressure swing adsorption process utilizing a adsorbent for the application of oxygen generation and determine the efficiency of the process. As evidenced by the results and discussion chapter, there are numerous ways to operate a PSA process depending on what the process is designed for. This leads to the secondary goals of this project, which was to optimize for high recovery of oxygen and for the development of a fast, productive process. It was specifically of interest to investigate the kinetic limit of the adsorbent used. First, based on the ability of the adsorbent used in this process to maintain its efficiency when the feed gas velocity was increased to create 10 second cycles, it can be concluded that this material has a fast adsorption rate. All the cycles conducted were of the PSA/VSA hybrid kind. Future work could include a more in depth look at changing the adsorption pressure including operating the cycle as a pure VSA cycle or PSA cycle. Operating at higher adsorption pressures would require larger columns as the effects of the dead volume in the system are magnified at the higher adsorption pressures. Operating under VSA conditions would require another pump to pressurize the product gas in order to analyze it.

Conclusion

The prototype underwent rigorous testing, and the results were promising. The device was able to provide a continuous supply of oxygen at a concentration of 97%, which is more than the minimum requirement for medical oxygen. The device was also energy-efficient and required minimal maintenance, making it a cost-effective solution for delivering oxygen therapy.

The lithium-based oxygen concentrator using PSA technology has significant potential in the healthcare industry, particularly in areas with limited access to medical oxygen. This college project has demonstrated that it is possible to develop a portable and cost-effective device that can provide a continuous supply of oxygen using PSA technology.

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