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Oxygen Concentrator using Pressure Swing Adsorption Technology

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Abstract: An Oxygen concentrator is a devices designed to provide a constant and cost-effective supply of oxygen. Unlike traditional oxygen cylinders, they draw ambient air and employ advanced processes, such as pressure swing adsorption (PSA) or membrane technology, to extract and deliver highly concentrated oxygen to individuals with chronic respiratory conditions. This technology has revolutionized patient care, allowing many to receive oxygen therapy in the comfort of their homes, thus reducing the burden on healthcare facilities.

The compact and portable nature of oxygen concentrators ensures mobility and independence for patients, enhancing their quality of life. This has been particularly valuable during the COVID-19 pandemic, as concentrators played a vital role in providing oxygen to patients in makeshift healthcare settings and at home, alleviating the stress on overwhelmed healthcare systems.

Keywords: *Oxygen Therapy, RPSA Technology, Respiratory Equipments.*

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I. INTRODUCTION

An oxygen concentrator is a medical device designed to provide a concentrated oxygen to the patient such as chronic obstructive pulmonary disease (COPD), asthma, or other lung-related ailments. Unlike traditional oxygen tanks, which require refilling and can be cumbersome, oxygen concentrators extract oxygen from the surrounding air, purify it, and deliver it to the patient through a nasal cannula or mask. This technology has revolutionized the management of respiratory disorders, offering patients greater mobility and convenience while improving their overall quality of life. In this introduction, we will explore the essential functions, benefits, and applications of oxygen concentrators in the field of healthcare.

- *Introduction on PSA Technology:*

Pressure Swing Adsorption (PSA) Technology is a widely used process for gas separation and purification. It plays a important role in various industrial applications, most notably in the production of high purity gases such as nitrogen, oxygen, and hydrogen. PSA technology relies on the principle of selectively adsorbing specific gases on solid adsorbents under pressure, allowing for the separation of desired gases from gas mixtures. By cyclically changing the pressure, PSA systems can capture concentrate, and release gases of interest, making it an efficient and cost-effective method for gas separation. PSA technology finds extensive use in industries such as healthcare, electronics, and manufacturing, contributing significantly to the production of clean and pure gases that are essential for various processes and applications. The key advantage of PSA technology in oxygen concentrators is that it can provide a nearly constant source of high-purity oxygen without the need for heavy oxygen cylinders or frequent refills. This technology makes oxygen therapy more accessible and convenient for individuals with respiratory conditions, allowing them to lead a better quality of life.

II. METHODOLOGY

An oxygen concentrator works by taking in atmospheric air, then filtering out nitrogen and other gases, leaving behind concentrated oxygen. This process typically involves several stages, including air intake, compression, filtration, and delivery of oxygen enriched air to the user via a nasal cannula or mask. The key components include an air compressor, sieve beds filled with zeolite materials and electrical components. The compressor pressurizes ambient air, pushing it through the sieve beds where nitrogen is adsorbed, allowing oxygen to pass through. The purified oxygen is then delivered to the user while the trapped nitrogen is vented out.

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The electrical controls manage the operation of the concentrator.

➢ *Components:*

- *Compressor*:

An air compressor is a machine that takes ambient air from the surroundings and discharges it at a higher pressure. It is an application of a gas compressor and a pneumatic device that converts mechanical power into potential energy stored in compressed air. An air compressor creates 150 PSI pressure.

Fig 1 Air Compressor

- *Solenoid valve:*

Pneumatic solenoid valves are electromechanical devices that control the flow of air or process gas and are used for controlling pneumatic actuators such as cylinders, turbines (pneumatic motors), diaphragms, and tubes. Using actuators, they form auxiliary air circuits to control plant equipment.

Fig 2 Solenoid Valves

- *Selec 800XC Cyclic Timer*:

Cyclic timer is a product that can be used to periodically turn ON and OFF the device for stipulated time intervals. By using Cyclic timer you can operate device by stipulated time.

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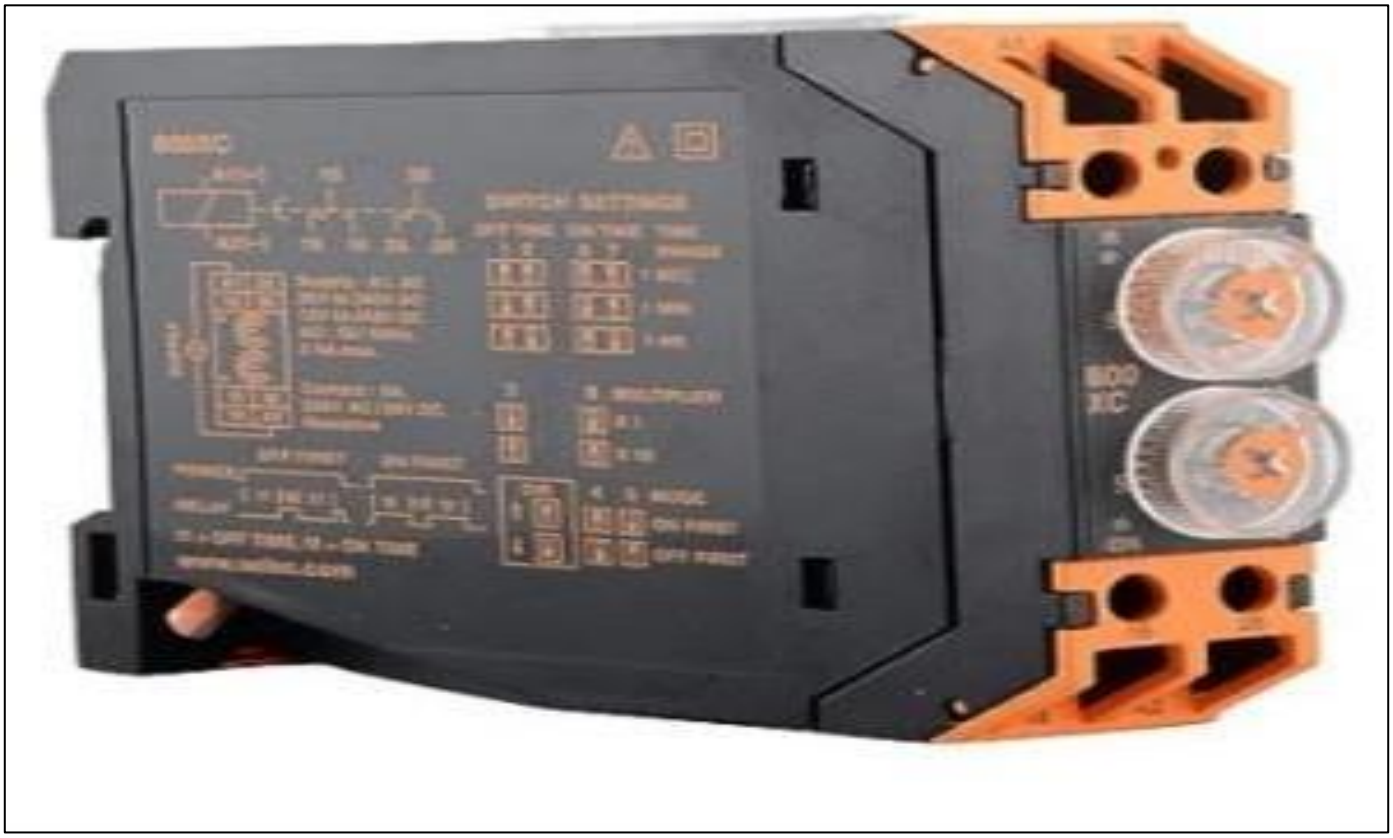

Fig 3 Selec 800XC Cyclic Timer

- *SMPS***:**
  Switched Mode Power Supply used for converting AC current intimate DC current. It is uses to operate compressor 12 volt.

Fig 4 SMPS

- *Charger:*
  24volt DC Charger is used to operate 6 solenoid valves which is equal to the operating capacity of solenoid valves i.e. 24volt. It is used to operate 6 solenoid valves.

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Fig 5 Charger

III. Flowchart

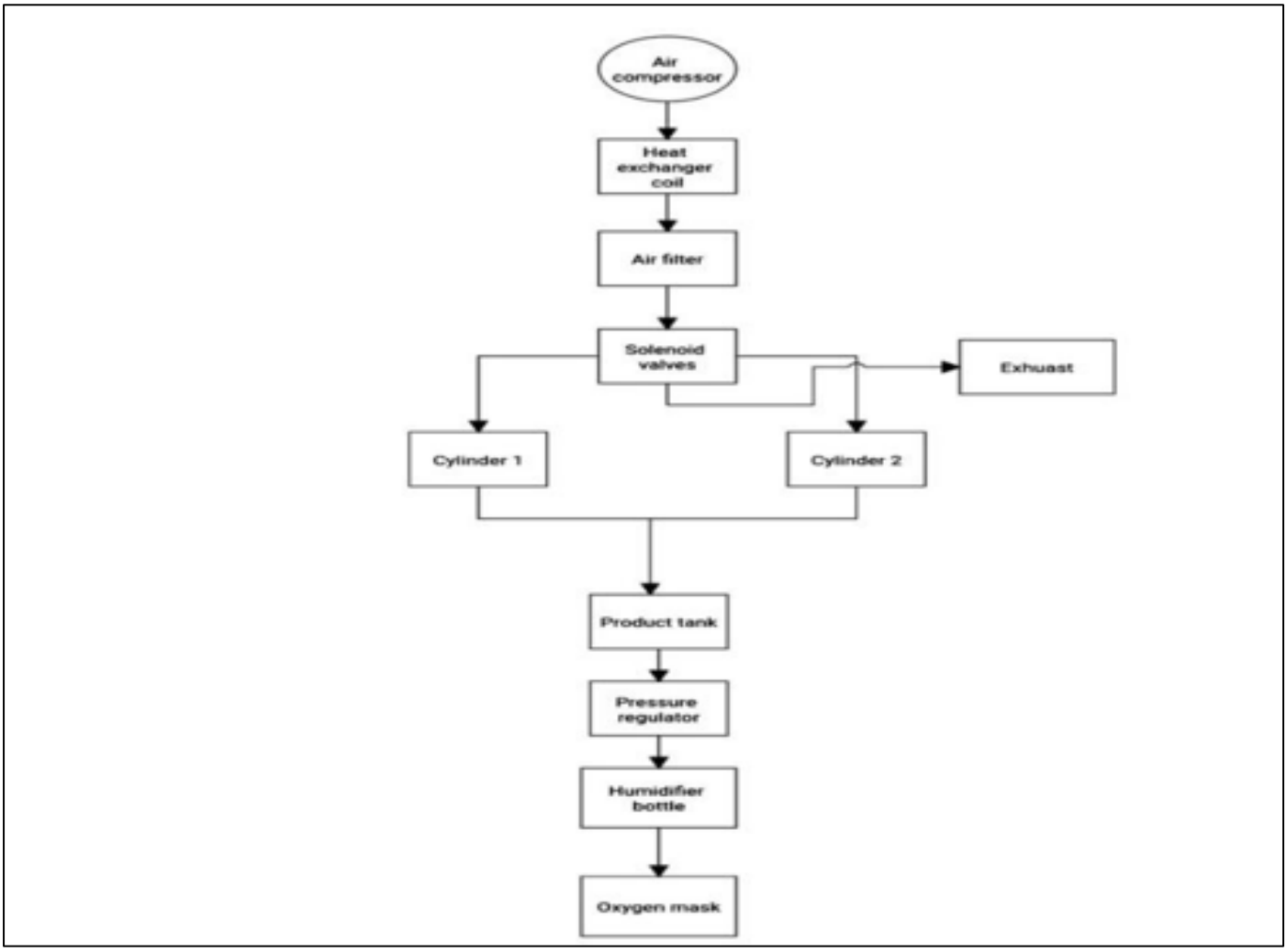

Fig 6 Flowchart

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An oxygen concentrator works on pressure swing adsorption technology. In the 1st step the air is compressed by the compressor at the pressure of 150 psi as the compressed air pressure increases, hence temperature of air is also increases to decrease the temperature of air it is passed through heat exchanger coil where the temperature of air being fall down then the compressed air is passed through air filter where dust particles are separated and the filtered air passes to the zeolite cylinders.

This system works on PSA technology in this technology there are two cylinders which contain molecular sieve called as 13X zeolite granules which are used to separate oxygen molecules from atmospheric air and separates nitrogen molecules. In this system there are six solenoid valves which works in sequential order.

In first step the compressed air is passes through 1st cylinder by opening 1,5 solenoid valve the air passed and separates nitrogen molecules and oxygen molecules are passed forward because the molecular size of oxygen i.e., 0.299 is less as compared to nitrogen i.e., 0.365 molecule. when the cylinder gets saturated then the valve 1,5 closed and the air passed through 2nd cylinder by opening 2,6 solenoid valve and the process is repeated. When the air passes through 1st cylinder V4 solenoid valve also open to depressurized cylinder 2 and the gasses are exhausted and V3 open when V2 and V6 valve are open. It's mean is that V1,V5 and V4 are works at the same time and V2,V6 and V3 open at same time.

Where,

V1,V5 and V2,V6 are inlet of cylinder 1 and cylinder 2 and;V3 and V4 are exhaust of cylinder1 and cylinder 2.

Table 1 Operation of 6 solenoid valves

Step	V1	V2	V3	V4	V5	V6
Pressurization	✓	✗	✗	✓	✗	✗
Adsorption	✓	✗	✗	✓	✓	✗
Blow down	✗	✓	✓	✗	✗	✗
Purge	✗	✓	✓	✗	✗	

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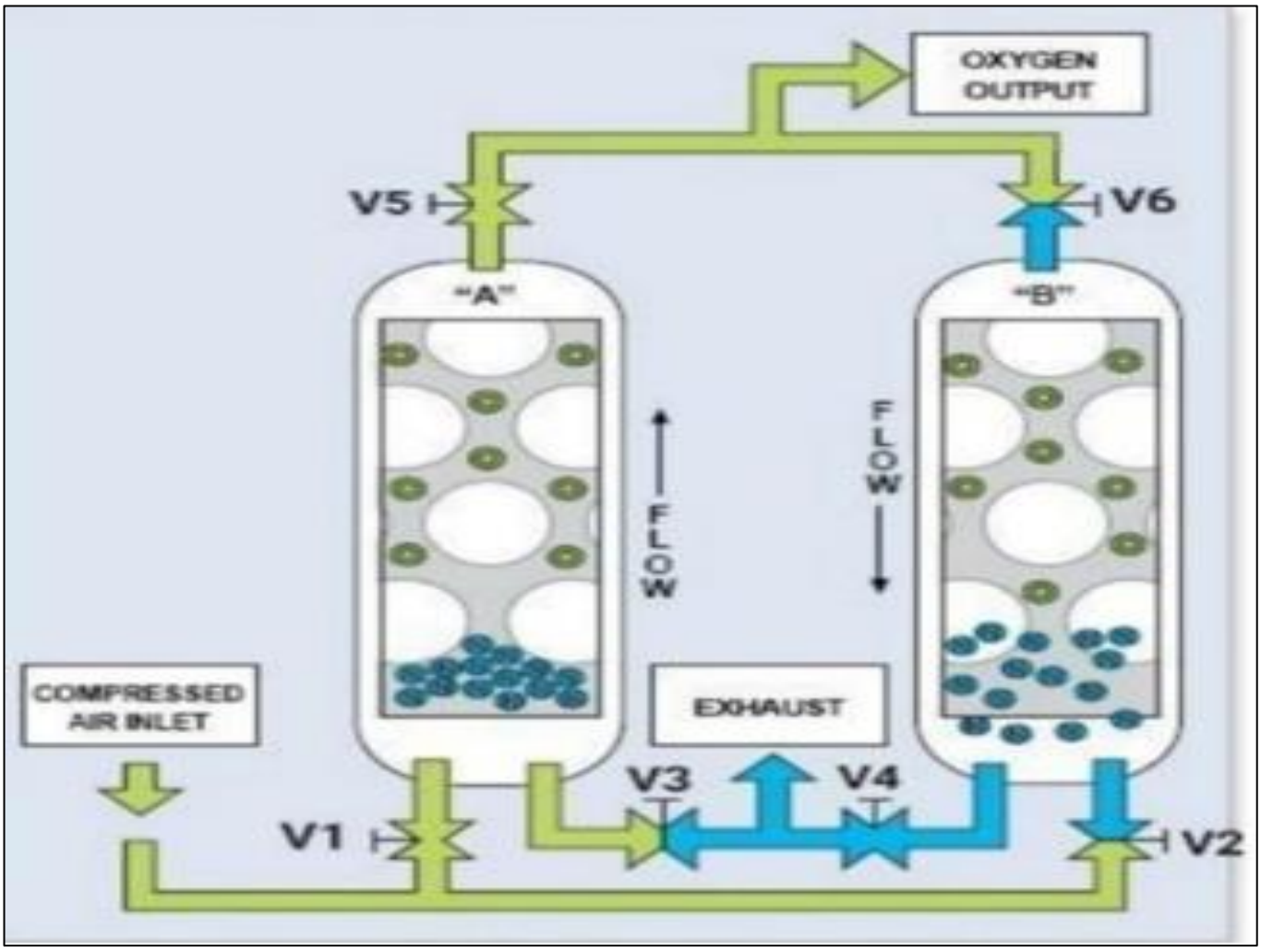

Fig 7 Valve Diagram

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Fig 8 Structural Diagram

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➢ *Applications:*
It is widely used in hospitals.

➢ *Advantages:*

- It continue supply of oxygen without the need refills.
- Oxygen concentrators are a cost-effective option for long-term oxygen therapy.

IV. RESULT

The result of using an oxygen concentrator is increased oxygen levels in the Patient's blood, which can improve their ability to breathe and alleviate symptoms of oxygen deficiency. It's efficiency 80-90% and has met the required standard for functionality and safety.

V. CONCLUSION

In conclusion, oxygen concentrators play a crucial role in providing medical oxygen therapy to individuals with respiratory conditions. They offer a convenient and cost-effective way to deliver concentrated oxygen, improving patients oxygen levels and quality of life. and it is made in low cost.

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