Government College of Engineering, Jalgaon
(An Autonomous Institute of Government of Maharashtra)

A Project Report

OXYGEN CONCENTRATOR

Under the Course (IN411U) Project Phase I

Submitted by

Final Year B. Tech. (Instrumentation)

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Under the Guidance of

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GOVERNMENT COLLEGE OF ENGINEERING, JALGAON

(An Autonomous Institute of Government of Maharashtra)

2021-2022

(The College is affiliated to the North Maharashtra University, Jalgaon)

GOVERNMENT COLLEGE OF ENGINEERING, JALGAON.

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CERTIFICATE

This is to certify that below mentioned students of L.Y. BTech. (Instrumentation) have successfully completed the project entitled, **"OXYGEN CONCENTRATOR"**, under the course (IN459U) Project Phase II this report, which is being submitted here with for the award of B. Tech (Instrumentation) is the result of the work completed by **Project Members** under my supervision and guidance within the four walls of the institute and the same has not been submitted elsewhere for the award of any degree.

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DECLARATION

I hereby declare that the project entitled, **"OXYGEN CONCENTRATOR"** was carried out and written by us under the guidance of SHIRISH ADAM, Professor, Department of Instrumentation Engineering, Government College of Engineering, Jalgaon. This work has not been previously formed the basis for the award of any degree or diploma or certificate nor has been submitted elsewhere for the award of any degree or diploma.

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Place: Jalgaon
Date:

ACKNOWLEDGEMENT

In the accomplishment of this project successfully, many people have best owned upon us their blessing and the heart pledged support, this time we are utilized to thank all the people who have been concerned with this project.

Primarily, we would like to thank our teachers for their endless support, kindness, and understanding in completion of this project with success. Then we would like to thank our (Project Phase I & II) Guide SHIRISH ADAM, whose valuable guidance has been the ones that helped us patch this project and make it full proof success. His suggestion and his instruction have served as the major contributor towards the completion of the project.

Then we would like to thank our parents and friends who have helped us with their valuable suggestion and guidance has been very helpful in various phases for the completion of the project.

Last but not the least we would like to thank our classmates who have helped us a lot for completion of this project.

ABSTRACT

Oxygen concentrators are also known as oxygen generators are widely used in medical, healthcare industry to generate oxygen for patients. Oxygen concentrators were invented in the 1970's and are used for oxygen generation from atmospheric air in a variety of industries ever since.

The development of a DIY oxygen concentrator to generate oxygen from atmospheric air using pneumatic supply is implemented in this project. This machine makes use of pneumatic pressure along with zeolite vessels and separate silica crystal pressure vessel along with pressure gauge, oxygen sensors to produce medical grade oxygen.

Firstly, use of atmospheric air through an external compressor to drive air through the system by valves. The valves drive air through Air filter which removes most of the moisture and oil from air and it is silica gel based. Then atmospheric nitrogen (N2) passes through zeolite bed which imposes a quadruple positive charge on oxygen and nitrogen molecules and the oxygen and other gases are lest free to move and nitrogen gets trapped into the zeolite bed.

Then the oxygen rich air is driven through the second pressure vessel. The separated nitrogen (N2) is then flushed out through another valve. Monitoring of leakages is simultaneously done because concentrated oxygen is highly combustible.

Then the oxygen rich air is passed in second pressure vessel and thus, supplied to patient on a regulated basis or supplied to the ventilator as required. The pressure sensor and valves work in coordination to achieve the desired output. The pressure and oxygen content of generated air is parallelly displayed to keep track. The entire system is run by a microcontroller (Arduino) to ensure smooth operation.

Thus, Successful development of an oxygen concentrator generator is done in this project to assist patients in COVID 19 pandemic and other emergency situations.

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Chapter 1

Introduction

1.1 Preamble:

Due to the concern over the lack of oxygen supplies in low- and middle-income countries, especially in regard to the treatment of pneumonia in children and covid 19 patients, an indigenously designed oxygen concentrator, which ensures high-purity oxygen supply, is being developed. Some organizations are designing and developing, affordable portable oxygen concentrator and are going to manufacturing it for supply to various hospitals in the country.

Oxygen saturation levels of patients have been a major challenge in the treatment of COVID 19, especially in the second wave. Indian medical device manufacturers and indigenous automation companies took this challenge up and came up with innovative designs of ventilators, portable respiratory aids, and related devices.

Indian Biomedical Skill Consortium (IBSC) has developed a 5L and 10L portable medical grade oxygen concentrators based on Pressure swing adsorption (PSA) technology in India with an oxygen purity of above 96% at a pressure of 5-15 psi. Pressure swing adsorption technology separates single gases from a gas mixture. PSA is a non-cryogenic air separation (near ambient temperature separation process) process that is commonly used in commercial practice. These two parameters are most critical for patients suffering from COVID or other respiratory problems.

1.2 Need of System:

Medical grade oxygen is necessary for treatment of covid 19, hypoxemia, chronic obstructive pulmonary disease, chronic bronchitis and pneumonia.

Normally factory-made oxygen is transported using cylinders or pipeline but due to lack of infrastructure in many cities it is time taking business. It is very hard maintaining the chain of demand and supply of oxygen in hospitals, hard to predict or get data of which hospital required how much quantity of oxygen. Sometimes due to lack of information oxygen won't get deliver to a patient who is in critical conditions or more than required quantity of oxygen get delivered to wrong location.

During the situation analysis it was found that oxygen was not always available in four out of five district hospital paediatric wards visited. Health workers did not know when or how to administer oxygen to children. Oxygen cylinders were only provided to central hospitals and district hospitals operate rooms, as they are expensive and difficult to deliver due to poor roads conditions.

Due to this various factors Oxygen Concentration System is needed and thus Oxygen Concentrator produce oxygen in current time and can be stored in tank or directly use by patient as per requirements it is lite weight so easy in transportation, maintenance is cheap, and every one can offered it for treatment.

1.3 Scope of the work:

To produce pure oxygen from ambient air at small scales, several adsorbent technologies based on pressure swing adsorption (PSA) have been commercialized. Therefore, a majority of (Medical-grade Oxygen Concentrator) MOCs rely on a PSA process with a nitrogen-selective adsorbent.

For medical use, depending on the condition of end-use patients and whether the patient is at rest or active, the required specifications of oxygen product could vary both in terms of flow rate and purity. In addition, the same oxygen concentrator unit can be used for several different patients in a hospital setting. Therefore, it is desirable to design a flexible and modular PSA process that can rapidly switch between different operating regimes for on-demand oxygen production while fulfilling different product specifications. To meet the time-varying oxygen demand, we envision a cyber-physical system (CPS) within which the blood oxygen concentration of a patient suffering from a lung condition is constantly monitored, and necessary actions to modify the operation of MOC are taken in real-time.

The components used in this MOCs are reusable and food grade. example zeolite canisters are water filter canisters which are recyclable so will reduce some carbon emissions.

India is a major producer of zeolite and for air filtration we use silica gel crystals which is also environment friendly and easily available in different quality.

Every component of MOC is replaceable and, we can verify which component is not working by analysing data from sensors and valves.

We can provide details on MOCs and how they are useful in treatment of several conditions and how to build your own oxygen concentrator at home, test it is working properly and you use it for emergency under doctors' guidance.

1.4 Purpose of the Project:

Purpose of this project is to supply medical grade oxygen to the patients who are in critical condition, example. Patient of covid 19, who needs continuous supply of oxygen, in villages and highly crowded cities it is not possible to provide oxygen to every single patient.

Generally, oxygen is produced by chemical oxidation or electrolysis in a domestic setting.

The oxygen produced by factories is hard to transport to village area or it is time taking, so this portable oxygen concentrator will supply 95% pure oxygen to patients, this method is cheap and is for personal use, there is no problem of oxygen shortage because this uses natural air to filter oxygen from it by using zeolite which is easily available in market and generally made locally in India.

Components used for this project are easily available as well as cost effective and quality of oxygen is automatically adjusted by microcontroller and if oxygen goes below 86% percent it is displayed on the given screen.

1.5 Motivation of the project:

Medical oxygen is a critical component in the treatment of COVID affected patients. A shortage of medical oxygen at hospitals in many parts of the country in the wake of the ongoing second wave of COVID-19 infections has caused multiple deaths across country.

Increased Demand by States while Uttar Pradesh doubled its requirement forecast to 800 MT from 400 MT earlier, Delhi said it would need 700 MT as of April 20, a 133% increase from the 300 MT it had previously sought.

Oxygen concentrators are a suitable and favourable option for administering point of-care oxygen in developing-country settings, especially where cylinders and piped systems are inappropriate or unavailable. Even where oxygen supplies are available at health facilities, patient access may be limited due to missing accessories, inadequate electricity and a shortage of trained staff.

Hypoxaemia is easily treated with oxygen, which is included in the WHO Model list of essential medicines and is perhaps the only medicine with no alternative agent. Having a reliable oxygen supply is necessary for the care of seriously ill patients to improve the probability of survival. It is important to ensure that potentially life-saving oxygen equipment is available and included in health planning budgets.

Despite the evidence of the importance of oxygen and the existence of appropriate oxygen supply technologies, utilization has been limited by inadequate maintenance, training, selection and procurement of high-quality devices. Many hypoxaemia patients in low-resource settings (LRS) still do not receive oxygen, thus improving access to oxygen therapy should be a priority. Recognizing the need to increase the availability of appropriate, safe and reliable oxygen concentrators.

1.6 Organization of the project: -

Oxygen concentrators are an attractive solution since they use atmospheric air freely available in unlimited quantities in our surroundings as their input and they are relatively safe. They do not involve cryogenic liquefaction of oxygen as is done with cylinders, so this cuts out huge engineering hassle and makes their design quite simple and tractable. The method involves passing air through a bed of grains called artificial zeolites.

The nitrogen is adsorbed into zeolite molecules and most (but not all) oxygen is allowed to pass through. Assuming all nitrogen in the air passing through the zeolite is adsorbed, for every 100 litters of air pumped through the bed, we remove 78.1 litters of nitrogen and are left with almost (not all) 21 litters of oxygen and less than a litter of other rare gases. Therefore, the 21.9 litters of gas exiting the zeolite bed contains (21/21.9) x100 = ~ 95.6% of oxygen, which meets medical grade specifications. The crucial point is the assumption that all the nitrogen in the air is being removed by the zeolite bed, and most of the effort goes into ensuring that.

The design below is scalable from portable units for individual use that are commercially sold to larger installations that some hospitals use to produce their own medical grade oxygen. What changes from the portable to institution-scale systems is the compressor size and the quantity of zeolite needed for concentrated oxygen production Otherwise, the process, which is shown in the flowchart below (Figure 1) is identical between the two scales.

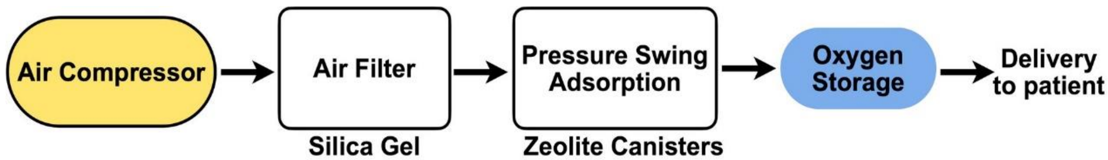

Figure 1. Process flow of OC

The basic process requires an air compressor that pumps air at a pressure above the standard atmospheric pressure through an air filter. The air then passes through a chamber containing the zeolite crystals that remove nitrogen, and out comes medical grade oxygen that is stored in a tank before being supplied to patients. Now we get into the specifics of each step in the above process.

Chapter 2

Background study/literature Review

1. First Generation: Joseph priestly, an English chemist who discovered the oxygen molecule in 1774, published his findings three years before Scheele's. That being said, Scheele is still recognized as being the first man to even figure out what oxygen is. [1]

2. Second Generation: From there, it took a little under 100 years for scientists and doctors to understand how to use oxygen to help those with varying illnesses and diseases. In 1885, the first ever recorded use of oxygen was documented for a medical purpose. This medical procedure was to treat a patient with pneumonia. This revolutionary treatment was administered and pioneered by Dr. George Holtz apple. [1,2]

3. Third Generation: At the turn of the twentieth century, a nasal catheter was used as the connection between the oxygen and the patient. It wasn't, however, until 1917 that jonscotthaldane invented the gas mask to protect and treat soldiers who had been affected by dangerous chlorine gasses during the first world war. [1]

4. Fourth Generation: Oxygen was mainly being used in hospitals to treat patients with a variety of respiratory issues. It wasn't until the 1950"s that the first form of portable medical oxygen therapy was invented. This portable oxygen was used strictly in ambulances and on the scene of medical emergencies. [1,2]

5. Fifth Generation: The 1970"s was revolutionary for medical grade oxygen therapy advancements. Finally, you could own your own oxygen therapy unit in your home. Over the next 30 years, oxygen concentrators began to shrink, due to the demand by younger and more active oxygen therapy patients who wanted smaller and more mobile machines. With these medical advancements came more knowledge on oxygen and various respiratory diseases. [1,3,4]

6. Sixth Generation: Presently, oxygen concentrators are small enough to fit in a purse, bring bike riding, or even store under your seat on an airplane! Nowadays, some concentrators can weigh less than 3 pounds, others have over 10 hours of battery life, and some home units have an oxygen output upwards of 10,000 ml per minute. [1,3,4,5]

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Concluding remarks:

In pandemic situations like war, covid-19, the clinical specialists will always be challenged to provide advanced healthcare support to preserve human life. The modern medical system can provide highest standards of healthcare in such pandemics by giving mobility and modularity. The portable oxygen concentrator is one of the best examples of a modern medical system which is evidence based, highly recommended and time tested. It provides very economical and easily applicable solution to oxygen shortage such as this project.

Chapter 3

Problem statement

"Lack of Oxygen supply during covid for household usage at affordable rate"

To survive, we need oxygen going from our lungs to the cells in our body. Sometimes the amount of oxygen in our blood can fall below normal levels. Asthma, lung cancer, chronic obstructive pulmonary disease (COPD), the flu, and COVID-19 are some of the health issues that may cause oxygen levels to drop. When the levels are too low, we may need to take extra oxygen, known as oxygen therapy.

One way to get extra oxygen into the body is by using an oxygen concentrator. Oxygen concentrators are medical devices required to be sold and used only with a prescription.

The air intake of humans contains approximately 21% oxygen, 78.1% nitrogen, and trace amounts of other rare gases. Medical grade oxygen consists of 95% or more oxygen. From this project on preparing, one's own makeshift intensive care unit (ICU) for a patient with serious COVID-19, the essential part of such an isolation unit is primarily the oxygen supply.

Engineers are neither medically trained nor are qualified to make any intelligent remarks on the various oxygen concentrators in the market or otherwise. But given the shortage of medical grade oxygen, reverting back to past was needed, to when many people needed a decent quantity of pure oxygen but lacked the funds for it. The design presented below is a reconstruction of that past effort.

3.1 Project Objective:

- To design and manufacture an oxygen concentrator which will differentiate the nitrogen from atmospheric air, leaving an enriched oxygen gas.
- To optimize cost and size of an oxygen generator by making it portable.

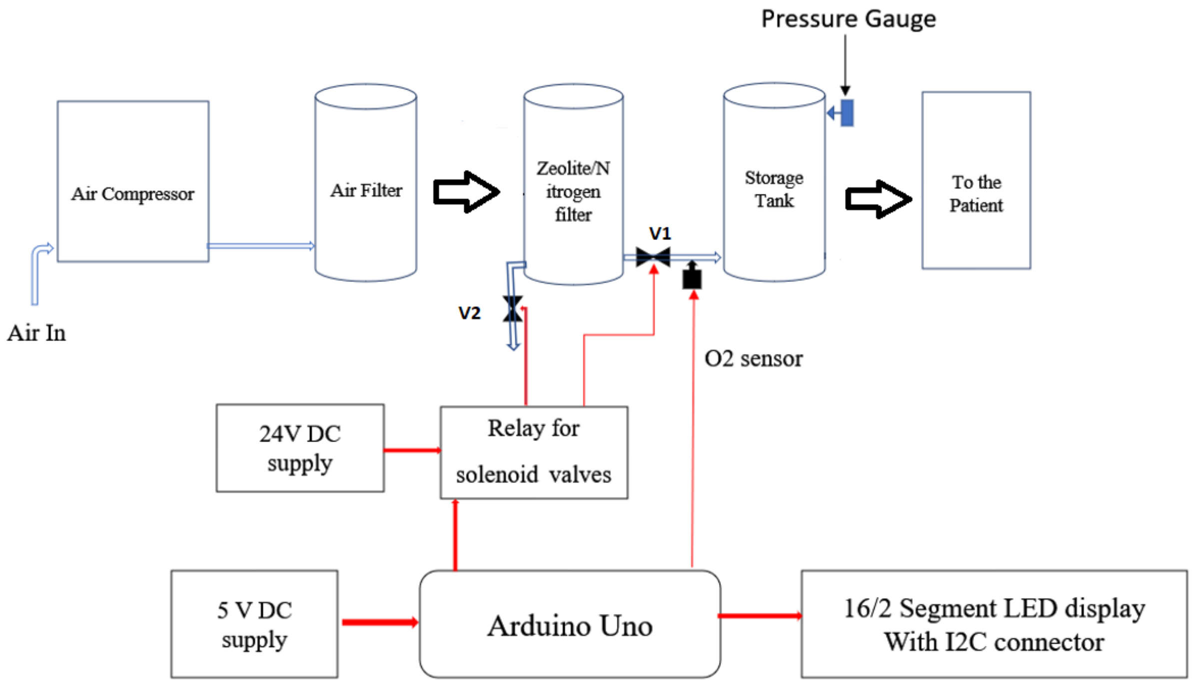

Figure 2. Block Diagram of Oxygen Concentrator

- **Air Compressor-** Air compressors work by forcing atmospheric air under pressure to create potential energy that can be transferred to the filters. Just like an open balloon, the pressure builds up when the compressed air is deliberately released, converting the potential energy into usable kinetic energy.
- **Air Filter-** It filters the moisture from the atmospheric air and also unwanted sustances from the compressed air to the canister.

- **Zeolite Filter-** This simple mechanism works by taking in oxygen through air compressor. The air is blown over zeolite filters where nitrogen, carbon dioxide, and traces of moisture are adsorbed. This leaves behind oxygen-enriched gas that is then released directly for the patient to use in real-time.
- **Solenoid valves-** A solenoid valve is an electrically controlled valve. The valve features a solenoid, which is an electric coil with a movable ferromagnetic core (plunger) in its centre. In the rest position, the plunger closes off a small orifice. An electric current through the coil creates a magnetic field. The magnetic field exerts an upwards force on the plunger opening the orifice. This is the basic principle that is used to open and close solenoid valves.
- **Relay-** A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. The switch may have any number of contacts in multiple contact forms, such as make contacts, break contacts, or combinations thereof.
- **Arduino Uno**- Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards ('shields') or breadboards (for prototyping) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs. The microcontrollers can be programmed using the C and C++ programming languages, using a standard API which is also known as the Arduino language, inspired by the Processing language and used with a modified version of the Processing IDE.
- **Led Display-** An LCD is an electronic display module that uses liquid crystal to produce a visible image. The 16×2 LCD display is a very basic module commonly used in DIYs and circuits. The 16×2 translates to a display 16 characters per line in 2 such lines. In this LCD each character is displayed in a 5×7pixel matrix.
- **Power supply-** The Power supply used in this project is a 5v volt supply for the Arduino, breadboard, and display. Another supply used here is a 12 volt battery system for 12-volt solenoid valves.
- **Oxygen sensor-** The oxygen sensor detects the output oxygen from the valves and gives the output on the lcd display.

3.2 Contribution to Society, Concern for Environment:

- Contribution to Society-

Since April 2021, India is witnessing a severe outbreak of the COVID-19 pandemic. The massive surge in cases has overwhelmed the healthcare infrastructure of the country. Many of the COVID-19 patients urgently require oxygen support to survive. But due to an extraordinary upsurge in demand, there is an acute shortage of medical oxygen and oxygen cylinders everywhere. The scarcity of oxygen cylinders has also pushed up the demand for oxygen concentrators.

Right now, oxygen concentrators are among the most sought-after devices for oxygen therapy in home isolation.

According to pulmonologists, only mild to moderately ill patients with oxygen saturation levels between 90% to 94% should use an oxygen concentrator under medical guidance. Patients with oxygen saturation levels as low as 85% can also use oxygen concentrators in emergency situations or till they get hospital admission. However, it is recommended that such patients switch to a cylinder with higher oxygen flow and get admitted to a hospital as soon as possible. The device is not advisable for ICU patients.

Doctors recommended their patients to undergo oxygen therapy with an oxygen concentrator for several medical conditions. Our lungs absorb oxygen from the air and transfer it into your bloodstream. In a blood test, if it indicates low blood oxygen levels, the doctors recommend short or long-term oxygen therapy.

In the context of Covid-19 and the estimated spread, there may be a shortfall of oxygen cylinders. In this context, an oxygen concentrator could play an essential role in treating mild to moderate cases of Acute Respiratory Infection associated with Covid-19, while saving oxygen cylinders to treat more severe cases.

So, our society needs more of oxygen and as we are providing oxygen through this project we are contributing to the society.

- Concern For Safety and Environment-

Breathing supplemental oxygen with an oxygen concentrator is designed to be a safe and life-sustaining activity. But, as with all types of devices, it is important that a few tips for proper usage are learned.

One misconception is comparing a portable oxygen concentrator to compressed oxygen or oxygen tanks, equipment also used for providing supplemental oxygen. Though using an oxygen compression unit, it does not carry the same hazards.

It's still important to consider the following guidance when it comes to portable oxygen concentrator safety.

1. Maintain safe distances from open flames or fires.

2. Use precaution when showering or bathing. For safety, it's crucial that portable oxygen concentrator does not get wet or be exposed to moist air.

3. Maintain safe distances from pools and other bodies of water. As with the previous portable oxygen concentrator safety tip, it's important that you prevent your unit from getting wet. If portable oxygen concentrator gets wet, it must turn off the unit and unplug it immediately.

4. Avoid smoking while on or near a portable oxygen concentrator. Smoking in the same room with the portable oxygen concentrator or where any oxygen carrying accessories are located is to be avoided.

5. Avoid aerosol products. It is important that to avoid aerosol products while using portable oxygen concentrator. This includes hairsprays, many body sprays, and even some air fresheners. Aerosol products are highly flammable.

6. Properly store portable oxygen concentrator when moving or travelling and Do not block intake vents.

7. Noise is one of the common disadvantages of Oxygen Concentrators. There are various components combined in an Oxygen Concentrator that collect, filter, and compress the air. The Emanating noise from a portable oxygen concentrator can be more disturbing for patients.

3.3 Compliance to Standards:

Comparison of Oxygen Concentrators

- MAX O2 Output - 5 LPM

Manufacture	AirSep		Medical	Vilbiss	Labs Inc	Invacare	Krober		Medical	Respironics	Medical,Inc.
Model	Newlife Elite	VisionAire	Companion	525	Activox DUO2	PerfectO2	Aeroplus	Krober	Nuvo Lite	EverFlo	EasyFlow5
Power (W)	350	290	250-350	310	372	280-325	280-325	280-350	300-330	350	350
Power Efficiency (W/LPM)	70	58	53-117	67	75	65	65	56-58	60-660	70	70
Min O2 output (LPM)	0.125	0.125	0.5	0.5	-	0.5	0.5	1	0.125	0.5	0.5
Max O2 output (LPM)	5	2-5	5	5	5	5	5	5-6	5	5	5
Outlet pressure (kPa)	45-60	30	30	60	60	35	35	70	50	40	55
Power Input options (VAC/Hz)	120/60, 220-240/50, 220/60	115/60, 220-240/50, 230/60	120/60, 230/50	115/60 230/50 230/60	110/60, 230/50	120/60	230/50, 115/60	230/50, 115/60	115/60, 230/50, 230/60	115/60, 230/50, 230/60	115/60
Temperature	10-40◦C	5-40◦C	5-40◦C	5-40◦C	10-40◦C	10-35◦C	10-40◦C	10-35◦C	10-38◦C	13-32◦C	10-35◦C
Relative Humidity	95%	95%	95%	95%	95%	20-60%		95%	95%	95%	95%

Table No.1. Comparison of OC with Output of 5LPM

➢ MAX O2 Output - Greater than 5 LPM

Manufacture	AirSep		Tech.co.Ltd	Invacare	Medical
Model	Newlife Intensity	Newlife Intensity	HG Series	Platinum™XL	Nuvo 8
Power (W)	410	590	350-530	585	490
Power Efficiency (W/LPM)	52	59	60-117	59	61
Min O2 output (LPM)	0.125	-	1	0.5	2
Max O2 output (LPM)	8	10	3-10	5	8
Outlet pressure (kPa)	135	135	40-80	35-60	115
Power Input options (VAC/Hz)	120/60, 220-240/50, 220-240/60	120/60, 220-240/50	220/50	120/60	115/60, 230/50-60
Temperature	5-40◦C	5-40◦C	10-40◦C	10-35◦C	10-38◦C
Relative Humidity	10-95%	10-95%	30-85%	60%	95%

Table No.2. Comparison of OC with Output >5LPM

<u>Conclusions of comparisons</u>:

These types of POC models have markedly different performance, which emphasizes the need to adjust the POC setting to meet the specific patient's needs at rest and with activity with reference to the Physician.

3.4 Identification of essential concepts:

As various studies mention a COVID-19 infected patient may need between 5 - 15 litres of oxygen per minute.

It's not easy to achieve oxygen production in such quantities through electrolysis in a domestic setting.

Chemical oxidation reactions on the other hand are unstable (explosive) and just not advisable in a domestic setting.

Oxygen concentrators are an attractive solution since they use atmospheric air freely available in unlimited quantities in our surroundings as their input and they are relatively safe. They do not involve cryogenic liquefaction of oxygen as is done with cylinders, so this cuts out huge engineering hassle and makes their design quite simple and tractable.

The method involves passing air through a bed of grains called artificial zeolites. The nitrogen is adsorbed

(With a "d", not a "b", meaning it sticks) onto zeolite molecules and most (but not all) oxygen is allowed to pass through.

Assuming all nitrogen in the air passing through the zeolite is adsorbed, for every 100 litres of air pumped

through the bed, we remove 78.1 litres of nitrogen and are left with almost (not all) 21 litres of oxygen and less than a litre of other rare gases. Therefore, the 21.9 litres of gas exiting the zeolite bed contains (21/21.9) x100 = 95.6% of oxygen, which meets medical grade specifications.

The crucial point is the assumption that all of the nitrogen in the air is being removed by the zeolite bed, and most of the effort goes into ensuring that.

3.5 Components list:

- Arduino Uno
- Oxygen Sensor
- Pressure gauge
- Pneumatic Pipes
- Pneumatic Valves & Joints
- Zeolite Vessel
- Silica gel crystals
- Supporting Frame
- Resistors
- Cables and Connectors
- PCB and Breadboards
- Adapter
- Relays
- Solenoid valves
- Cannula
- Oxygen mask
- Compressor

- Arduino Uno

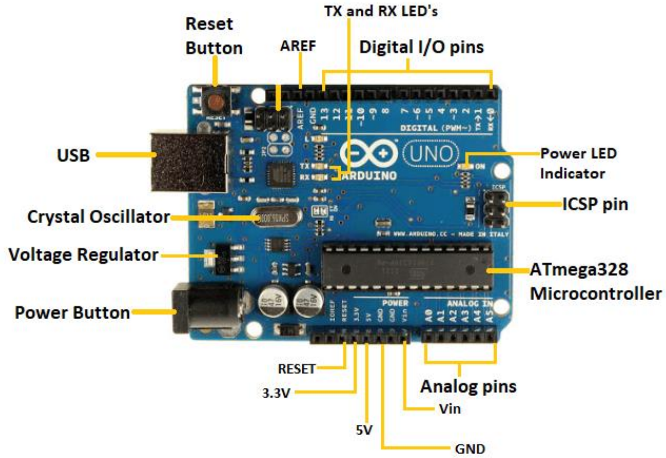

Fig. No.3 (a)

- Oxygen sensor

Fig. No.3 (c)

- Pressure Guage

Fig. No.3 (e)

- Pneumatic valves

Fig. No. 3(b)

- Zeolite vessel

Fig. No.3 (d)

- Silica gel crystals

Fig. No.3 (f)

- Pneumatic Pipes

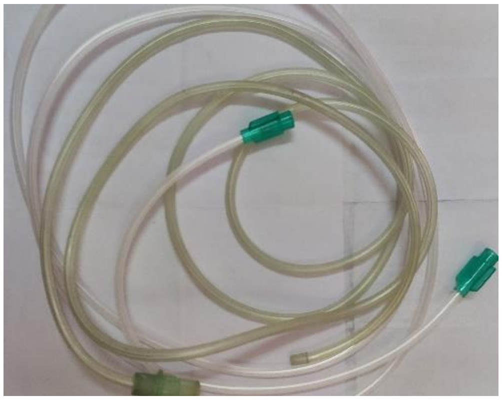

Fig. No.3 (g)

- Resistors

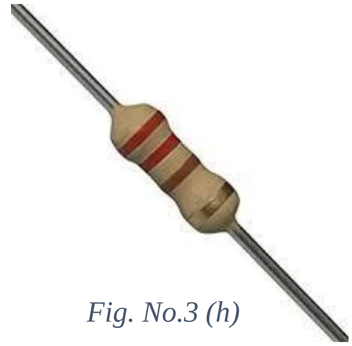

Fig. No.3 (h)

- Zeolite crystals

Fig. No.3 (j)

- Breadboards

Fig. No.3 (i)

- Relay

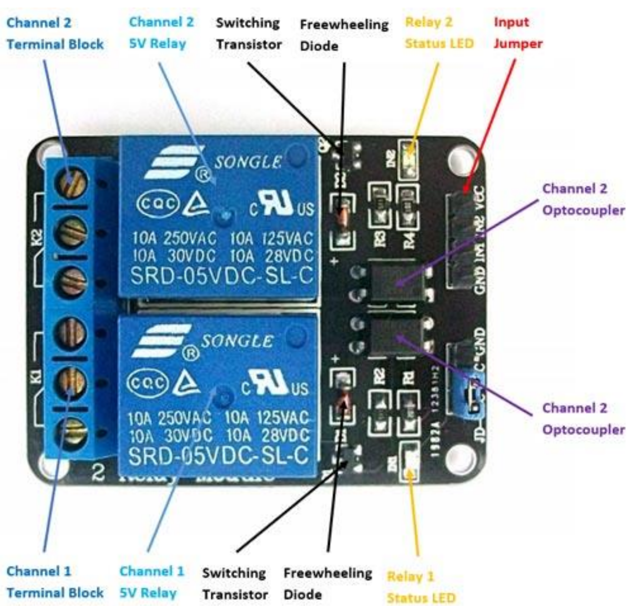

Fig. No.3 (k)

- Battery

Fig. No.3 (l)

- Oxygen Mask

Fig. No.3 (m)

- Air Compressor

Fig. No.3 (n)

Figure No.3. Components

3.6 Cost Estimation:

Components Name	**Specifications**	**Quantity**	**Costing in Rupees**
Air Compressor	340 Watt	1 Unit	1200 ₹
Canister Filter	2 Lt, 5 Bar Pressure	2 Unit	400 ₹
Zeolite Crystals	Zeolite 13x	2 Kg	500 ₹
Silica Crystals	27- 40% Absorption	2 Kg	300 ₹
Solenoid Valves	24 Volt	2 Units	400 ₹
Relays	5 Volt DC, 2 Channel	1 Unit	190 ₹
Oxygen Sensor	OOM202, Electrogalvanic	1 Unit	500 ₹
Breadboard	5 Amps, 6.5 X 4.4 X 0.3 Inch	1 Unit	120 ₹
Jumper Wires	4-20 mA	12 Units	40 ₹
Pressure Gauge	-30 To 250 PSI	1 Unit	370 ₹
LCD Display	16/2, 5 Volt	1 Unit	250 ₹
Arduino	Atmega328P, 5 Volt	1 Unit	360 ₹
Connectors and Pipes	6mm Pipes and Connectors	6 Units	240 ₹
Battery	12 Volt DC	1 Unit	300 ₹
Resistor	5 KΩ	2 Unit	20 ₹
Oxygen mask	Adult Sized	1 Unit	125 ₹
Wooden Case	35 X 25 X 35 cm	1 Unit	450 ₹
		Total Budget =	**5765 ₹**

Table No.3. Cost estimation table

3.7 Flow Chart:

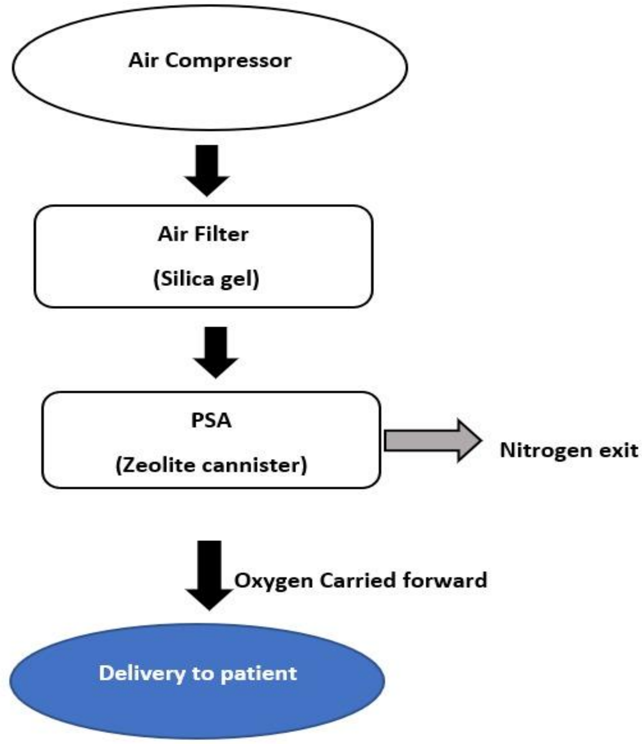

Figure 4. Flow chart of Oxygen Concentrator

The design below is scalable from portable units for individual use that are commercially sold to larger installations that some hospitals use to produce their own medical grade oxygen. What changes from the portable to institution-scale systems is the compressor size and the quantity of zeolite needed for concentrated oxygen production. Otherwise, the process, which is shown in the flowchart below (Figure 1) is identical between the two scales. The basic process requires an air compressor that pumps air at a pressure above the standard atmospheric pressure through an air filter. The air then passes through a chamber containing the zeolite crystals that remove nitrogen, and out comes medical grade oxygen that is stored in a tank before being supplied to patients. Now we get into the specifics of each step in the above process. We start by shooting down our earlier assumption -- that all nitrogen in the pumped air is removed by the zeolite crystals: it is not. I will not get into an involved discussion of the thermodynamics of sorption kinetics and adsorption equilibrium; the interested reader is referred to this study. Simply put, the amount of nitrogen removed by zeolite depends on both temperature and pressure of air.

3.8 Time frame:

Task no.	Task	Start	End	Days	% Done	Work Days
1	**Project Planning**					
1.1	Need statement	1/11/2021	1/11/2021	1	100 %	1
1.2	Problem definition Process	1/11/2021	1/11/2021	1	100 %	1
1.3	Initial Research and Market Survey	2/11/2021	2/11/20211	1	100 %	1
1.4	Literature Survey	3/11/2021	3/11/2021	1	100 %	1
1.5	Papers, Magazines, Books, Journals / Internet	4/11/2021	5/11/2021	2	100 %	2
1.6	Designing Draft Report	6/11/2021	9/11/2021	3	100 %	3
2	**Design**					
2.1	Component requirement	8/11/2021	9/11/2021	2	100%	2
2.2	Diagram Planning	10/11/2021	10/11/2021	1	100%	1
2.3	Designing	10/11/2021	10/11/2021	1	100%	1
3	Development	11/12/2021	20/12/2021	9	100%	7
3.1	Hardware Assembly	21/12/2021	28/12/2021	7	100%	6
3.2	Checking Accuracy	15/01/2022	26/01/2022	11	100%	11
3.3	Connection of pipes	6/02/2022	8/02/2022	2	100%	2
4	Testing and Demo	03/03/2022	05/03/2022	2	100%	2
4.1	Diagnosis	01/04/2022	05/04/2022	4	100%	4
4.2	Checking System	10/05/2022	15/02/2022	5	100%	5
4.3	Final Testing	16/05/2022	17/05/2022	1	100%	1

Table No. 4. Time Frame for Planning of Project

Gantt Chart:

A Gantt chart, commonly used in project management, is one of the most popular and useful ways of showing activities (tasks or events) displayed against time. On the left of the chart is a list of the activities and along the top is a suitable time scale. Each activity is represented by a bar; the position and length of the bar reflects the start date, duration and end date of the activity.

7th SEMESTER (Project Phase-I)				
Month/Year	Sep-21	Oct-21	Nov-21	Dec-21
Project Activities				
Project Group Formation				
Deciding Area of project				
Synopsis Submission				
Finalization of Topic				
Literature Review				
Methodology				
External Exam(Phase-I)				

8th SEMESTER(Project-Phase-II)				
Month/Year	Feb-22	Mar-22	April-22	May-22
Project Activities				
Experimentation				
Testing				
Result and Discussion				
Preparation of Project and Project submission				
External Exam (Phase-II)				

Table No. 5. Plan of Project

Chapter 4

Methodology

The 5 Step Concentrator Process:

1. Takes air from the room.
2. Compresses the oxygen.
3. Takes out nitrogen from the air.
4. Adjusts the way the air is delivered.
5. Delivers the purified oxygen O2.

There are many parts that make up a portable oxygen concentrator. A compressor and sieve bed filter are a couple of the main parts. The compressor compresses air that is filtered into the concentrator, then delivers the air in a continuous stream.

The compressed air moves to the sieve bed filters. The sieve bed filter plays an important role, as it is the device that removes the nitrogen from the air. A material called Zeolite, which is a six-sided microscopic cube with holes on each side, is in the sieve bed and this is what removes the nitrogen from the air.

Two sieve beds are located in the concentrator. After air is first compressed in the concentrator, it is forced into the first sieve bed. Oxygen is sent into the product tank. The first sieve bed then gets filled up with nitrogen. Next, the gas flow is switched, and the compressed air is moved to the second sieve bed. The first sieve bed’s compressor is sent to the outside room, and the air from the product tank goes back into the first sieve bed.

The drop in pressure from the first sieve bed and the weakening of oxygen makes the Zeolite release nitrogen. The Oxygen and Nitrogen come back together and are released in the room as regular air. The air is then compressed and sent to the second sieve where Oxygen is moved through it to the Product Tank. The whole cycle starts over again with the first sieve after a few seconds. Other important parts are the cooling system that keeps the portable oxygen concentrator from overheating, and the nasal cannula that delivers the purified oxygen after the oxygen has been passed through all the sieve bed filters. The cannula helps improve oxygen absorption.

4.1 WORKING OF OXYGEN CONCENTRATOR:

Oxygen concentrators are devices which separates oxygen from the intake air to the purity rate of 90-95%. The easiest way to separate oxygen from atmosphere containing 21% oxygen, 78% nitrogen and 1% other gases is to use PSA (Pressure Swing Adsorption) technology.

In this method, zeolite plays a vital role to eliminate nitrogen gas because of its nitrogen adsorption property. The air passes over zeolite molecules which placed in a container known as sieve bed. The block diagram of oxygen concentrator using PSA technology is shown fig. (2).

The device consists of air filter, compressor, a molecular sieve, a 2-way solenoid valve, a product tank, pressure regulator and water container. In this system, air from atmosphere first passes through air filter and the compressed to high pressure using compressor.

The pressurized air first passes through molecular sieve-1 where nitrogen adsorption takes place and leaves enriched oxygen mixture. When desired pressure inside sieve bed-1 reaches to set limit that means sieve bed-1 completely saturated with nitrogen and indicates no further passage of oxygen. This time period is known as switching time which obtained by 2-way solenoid valve operated on external time circuit.

Then solenoid valve switches the flow to molecular sieve bed-2 and adsorption takes place in sieve bed-2. Meanwhile the first sieve bed is depressurized and regenerated by removal adsorbed nitrogen using exhaust system.

When second sieve is saturated with nitrogen the pressurized air is given back to sieve bed-1 and sieve bed-2 is depressurized and regenerated. Thus, pressurization and depressurization cycle continue alternatively during entire operation. This entire process is known as “Excavation Process”. The oxygen obtained in the product tank is of 90-95% of purity and brought to suitable pressure using pressure regulator. Then it is given to the patient through oxygen mask. The molecular sieves which contain chemical called “5A or 13A Molecular Sieve” are very important component of the system which affects performance of the system. Hence two molecular sieves are used to obtain uninterrupted supply of oxygen. The design of each molecular sieve depends upon bed length, bed diameter, and air pressure. To determine the quantity of zeolite, nitrogen removal design equations are used given as;

QfCftx = qfMLx/Lb

Where,

Qf: Volumetric flow rate,

Cf: Concentration of solute,

tx: Time front has travelled at LX,

qf: loading per mass of adsorbent in equilibrium with the feed concentration

M: total mass of adsorbent in the bed

Lx: position in the bed less than or equal to total bed length

Lb: length of bed

The use of large volume product tank decreases purity of oxygen. Hence volume of the tank is determined by the size of sieve beds and compressor power. An air filter filters all harmful particles such as dust, humidity caused by environmental conditions up to 0.3microns. The compressor used to compress ambient air is a dry air compressor of single electric motor. Pressure regulator reduces the pressure from the product tank to oxygen mask in the range 5- 10 psi.

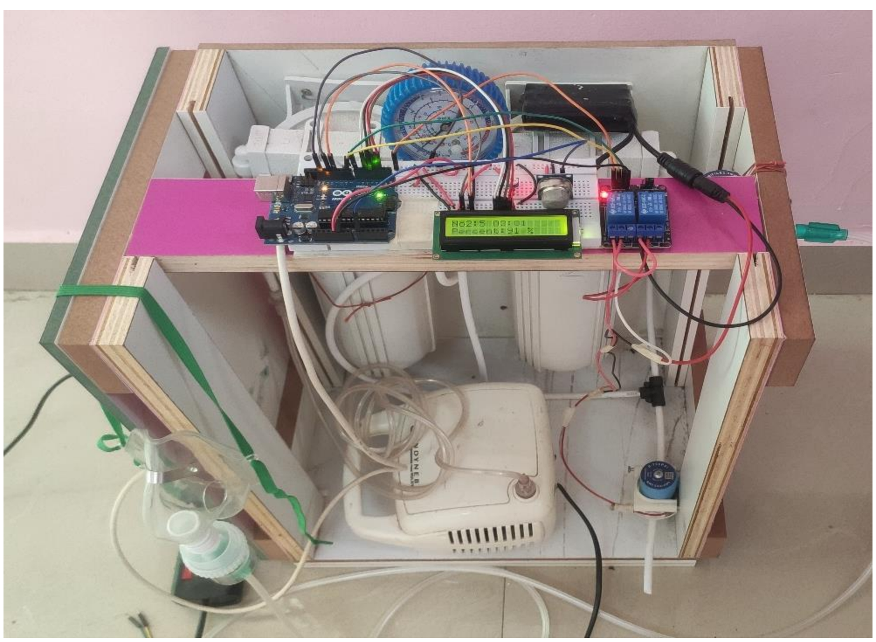

Figure 5(a). Working Model of Oxygen Concentrator

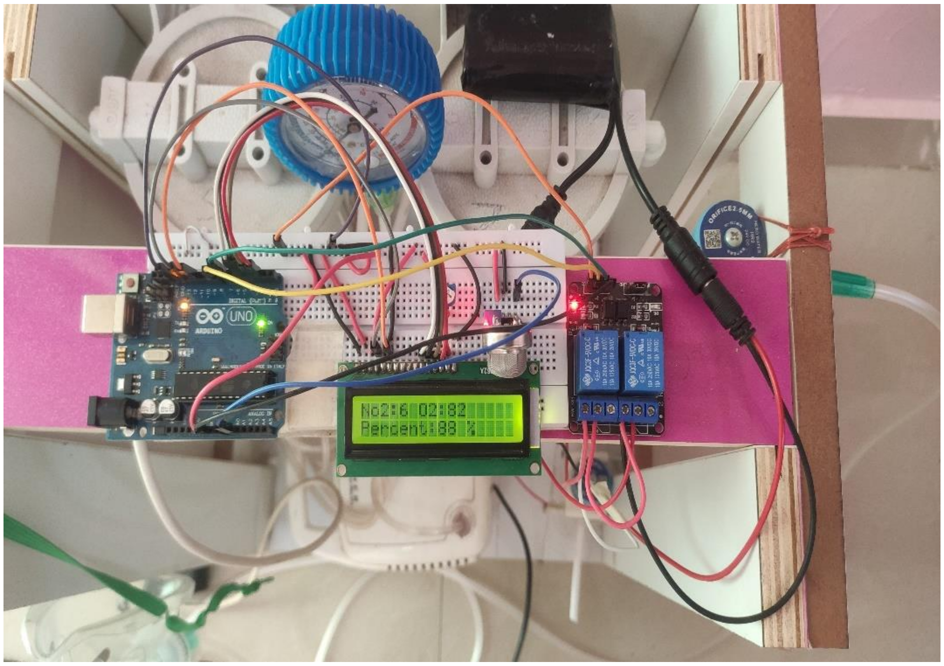

Figure 5(b). Display and Breadboard circuit

4.2 <u>CONTROL OF PROPOSED SYSTEM:</u>

The control system of an oxygen concentrator consists of motor driving circuit, solenoid valve driving circuit, sensing circuits and microcontroller which controls all the system. The motor driving circuit connects the electric motor to AC line or cut- off depending upon data received from sensing circuits. The sensing circuits include pressure sensors, temperature sensor and oxygen purity sensor. The solenoid valve driving circuit uses IC555 as a timer circuit to operate solenoid valves at specified time interval. These all-control circuits are centrally connected to a microcontroller which controls the performance of proposed oxygen concentrator.

4.3 Comparison of Systems:

Project Oxygen concentrator	Product available in market
❖ Cost effective 8K	❖ Available from 20k to 80k
❖ Most of components are made in India	❖ Most of the components are imported
❖ We are using adsorption swing technology	❖ Most of using adsorption swing technology
❖ Use of reusable components	❖ 1 time use components
❖ Components are easily available	❖ Most are imported and expensive
❖ Simple design	❖ Delicate design
❖ Easy to maintain and understand	❖ Easy to understand but hard to maintain
❖ Parts are cheep	❖ Parts are expensive
❖ Highly durable and rugged	❖ Highly durable and rugged
❖ Needs to change canister every day	❖ Depends on product

Table No. 6. Comparison of Project systems

Chapter 5

Result and Discussion

Result:

Oxygen concentrators are devices which separates oxygen from the intake air to the purity rate of 90-95%. The easiest way to separate oxygen from atmosphere containing 21% oxygen, 78% nitrogen and 1% other gases is to use PSA (Pressure Swing Adsorption) technology. In this method, zeolite plays a vital role to eliminate nitrogen gas because of its nitrogen adsorption property. The air passes over zeolite molecules which placed in a container known as sieve bed. Another important factor which affects oxygen purity is the volume of a product tank. The use of large volume product tank decreases purity of oxygen. Hence volume of the tank is determined by the size of sieve beds and compressor power. An air filter filters all harmful particles such as dust, humidity caused by environmental conditions up to 0.3microns. The compressor used to compress ambient air is a dry air compressor of single electric motor. Pressure regulator reduces the pressure from the product tank to oxygen mask in the range 5- 10 psi

Discussion:

Oxygen is essential for anaesthesia and resuscitation. The gas is normally supplied in cylinders, which are bulky to transport, and occupy a lot of space. In a developing country like Nepal, transportation of O_2 cylinders is difficult, erratic and unreliable. During landslides, floods and other disasters, hospitals may not be approachable by road. The supply of O_2 cylinders has failed many times, even in the operating rooms of the central hospitals, leaving the anaesthesiologist to provide anaesthesia for emergency surgery without access to O_2 . This puts the patient at considerable risk of hypoxia and even death. Smaller hospitals have more acute problems since the supply of O_2 cylinders is limited and, once the stock is exhausted, it can take months to be re-supplied. A portable oxygen concentrator that extracts O_2 from the atmosphere seems to be the answer.

5.1 Applications:

1. This condition is where your airways become inflamed and begin producing a lot of mucus, which makes it harder to breathe. While there are a number of pharmaceuticals that can treat and control asthma, an oxygen concentrator can pump high levels of oxygen into the bloodstream of the patient while they're having or have already had an asthma attack

2. Pneumonia is an infection where you develop inflammation in either one or both of your lungs' air sacs and in many cases, fill them up with fluid. Many pneumonia patients have been prescribed oxygen therapy and have seen good clinical outcomes.

3. Sleep apnea is a sleeping disorder that can be serious and cause the individual's breathing to sporadically stop and start during their sleep. Usually, treatment for this condition is continuous positive airway pressure (CPAP), weight loss, and physical exercise, though some people with sleep apnea may require oxygen therapy

4. In a developing country like ours, one may anticipate problems associated with the effects of high relative humidity during the rainy season, high dust content in the air during the dry season, and high altitude.

5. Concentrators are designed for continuous operation and can produce oxygen 24 hours per day, 7 days per week, for up to 5 years or more. These devices can be used at any level of health facility. But not used in highly specialised care units such as ICUs, where centralised oxygen supply is preferred. They are highly applicable in situations which require home based supplementation is indicated such as COPD, Sleep Apnea etc. For these there is a need for continuous source of reliable power and a system for regular cleaning and maintenance by users and technical personnel alike

Chapter 6

Conclusion

We have used the oxygen concentrator regularly in our anaesthesia practice. From time to time we have used it for resuscitation of patients on the ward or in the postoperative rooms. Many surgical camps in Nepal use the concentrator in field situations. Th concentrator has been very reliable and cost effective. We have calculated that it can generate enough O2 to pay for its cost within a year.

The overall use of the oxygen concentrator in anaesthesia has been reliable and satisfactory. Thus, we recommend the oxygen concentrator as a safe, simple and reliable method to provide oxygen in locations where cylinders may not always be available.

In pandemic situations like war, covid-19, the clinical specialists will always be challenged to provide advanced healthcare support to preserve human life. The modern medical system can provide highest standards of healthcare in such pandemics by giving mobility and modularity. The portable oxygen concentrator is one of the best examples of a modern medical system which is evidence based, highly recommended and time tested. It provides very economical and easily applicable solution to oxygen shortage

Several factors, including the extreme climatic conditions, the lack of experience of the nurses in providing oxygen therapy and the presence of hypoxic children, make the supervised set up of an oxygen concentrator in a rural Senegalese hospital realistic.

The clinical and financial benefits of this project were evident. This study has highlighted the urgent need for the introduction of a new technology by specific training of the medical team and a rigorous maintenance programme (as recommended by the WHO).

Since this study, several other concentrators have been set up at Ndioum Hospital: A European maintenance technician has worked for 4 months with the hospital’s local team, and the clinical and technical training of the nurses has improved. The introduction of concentrators in hospitals in developing countries should be encouraged. Only by increasing the amount of oxygen available for therapy can the high mortality rates among children suffering from ARI be reduced.

Chapter 7

Future Scope

1. A fault transfer system is to be designed for monitoring performance of oxygen concentrator at anywhere using GPRS technology. Any fault occur in the system will be notified to user and take respective action. It mostly divided into two parts hardware and software. The hardware includes sensors, GPRS modem and software includes microcontroller software, graphical user interface software.
2. Increase availability of affordable and cost-saving accessories and devices:
3. Flowmeter stands allow multiple paediatric patients to be treated with one machine. Current flowmeter stands are difficult to find and cost nearly the same as the concentrator.
4. Devices with dual outlets, higher oxygen outlet pressure and nebulizing functions are valuable in neonatal and paediatric wards, and some devices currently have this feature (but publications regarding their performance in LRS have not yet been found).
5. Some device features that may be useful to end users and purchasers may not be readily specified in manufacturer specification sheets. This includes stating whether the device has flow limiters to prevent the user from overdrawing oxygen and damaging the devices.
6. Improve research and knowledge-sharing on life-saving essential health technologies:
7. There is limited knowledge of the power quality among the different health systems in developing countries. Quantitative information on voltage fluctuations could help inform procurement needs and specification development for manufacturers and standards organizations to produce oxygen concentrators and other electrical medical devices better suited for these countries.
8. There is limited evidence-based research on the widespread clinical and economic impact of oxygen concentrators and oxygen therapy in LRS. More studies are necessary to improve awareness, increase procurement efficiency and motivate stakeholders to prioritize oxygen availability in LRS. Available Modalities for Home-Based Oxygen Therapy Home-based oxygen therapy devices must be adequate to replace the needs of patient outside hospital and be adaptable to suit their daily needs and requirement.

Chapter 8

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Appendix

Arduino code

```
#include <ADS1X15.h>
#include <wire.h>
#include <MQ2.h>
#include <ADS1115_WE.h>
#include <Adafruit_CircuitPlayground.h>
#include <LiquidCrystal.h>

//display  pins declaration
const int rs = 12, en= 11, d4 = 5, d5 = 4, d6 = 3, d7 =2;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);
Adafruit_ADS1115 ads(0x48);

void setup(){
  Serial.begin(9600);
  lcd.begin(16,2);//Defining 16 columns and 2 rows of lcd display
  lcd.print("Oxygen");

  ADS1115 ads(0x48);
  Adafruit_ADS1115 ads(0x48);
  Serial.println("Single reading from AIN0...3. ADC Range:+/- 5.144V (1 bit = 3mV/ADS1115, 
0.1875mV/ADS1115)");
  ads.begin();

  pinMode(7,OUTPUT);
  pinMode(8,OUTPUT);
}
```

```
void loop(){


 // code for solenoid valves:
  digitalWrite(7,HIGH);
  digitalWrite(8,LOW);
  delay(5000);
  digitalWrite(7,LOW);
  digitalWrite(8,HIGH);
  delay(5000);

  // code for oxygen sensor
  int16_t adc0, adc1, adc2, adc3;
  adc0 = ads.readADC_SingleEnded(0);
  adc1 = ads.readADC_SingleEnded(1);
  adc2 = ads.readADC_SingleEnded(2);
  adc3 = ads.readADC_SingleEnded(3);
  Serial.print("AIN0: ");
  Serial.print(adc0);
  Serial.println(" ");
  delay(1000);
}
```