Wearable Oxygen Concentrator Generator In Healthcare

Prakash P[1], Parinitha T[2], Krishnaveni A[3], Rajasaran M[4]
[1]Assistant Professor, Dept of Medical Electronics
[2, 3, 4]Dept of Medical Electronics
[1, 2, 3, 4] Velalar College of Engineering and Technology, Erode, Tamil Nadu.

Abstract- *A wearable oxygen concentrator generator is an innovative medical device specifically intended for round-the-clock oxygen therapy and full mobility. In contrast to conventional portable oxygen concentrators (POCs), which are heavy and must be transported in carts or bags, wearable oxygen concentrators are very light, collapsible, and easy to wear on the body, e.g., on the belt or in vest type. The devices recycle and deliver oxygen from the air that surrounds us, enhancing patient mobility, convenience, and autonomy. Hands-free, they prevent the fatigue of wearing heavy units, making them suitable for active patients suffering from respiratory conditions such as COPD, asthma, or pulmonary fibrosis. Wearables also minimize hospital visits and improve home care. Compared to portable concentrators, wearables are more ergonomic, lighter, and more convenient, enabling more effortless oxygen therapy in daily life. Future innovation will include AI-managed oxygen flow control and real-time monitoring of a person's health, further transforming respiratory health.*

Keywords- Wearable oxygen concentrator generator, oxygen therapy, respiratory conditions, real time monitoring, AI-managed oxygen flow control.

I. INTRODUCTION

For patients with chronic respiratory diseases like COPD, asthma, and pulmonary fibrosis, the ideal levels of oxygen are essential in maintaining daily lifestyles and overall quality of life. Oxygen therapy is a common form of treatment to help such patients, but available delivery systems in the form of portable oxygen concentrators (POCs) and oxygen tanks may not always be optimal. POCs are often bulky and have to be pulled on trolleys or carried in bags, limiting mobility and independence. This mobility restriction can make day-to-day activities cumbersome, with discomfort and lowered quality of life.

To overcome such limitations, wearable oxygen concentrator generators (WOCs) have been introduced as a revolution in respiratory therapy. They are very light, portable, and body-worn, like on a belt or integrated into a vest. Unlike conventional POCs, WOCs provide hands-free oxygen therapy, allowing patients to move around without the need to carry bulky equipment. They draw oxygen from the ambient air and provide a steady and reliable oxygen flow, thus making oxygen therapy more convenient and effective.

Along with portability, WOCs have advanced features like AI-driven oxygen flow management and real-time health monitoring with individualized therapy, enhanced oxygen saturation monitoring, and enhanced safety. These functions result in reduced hospital stays, enhanced home care, and enhanced patient independence. With healthcare gravitating toward more individualized, portable, and technology-driven solutions, WOCs are the future of oxygen therapy, enabling patients to enjoy healthier, more independent lives.

II. LITERATURE REVIEW

Oxygen therapy is imperative for trauma patients, especially in military and emergency settings where hypoxemia increases mortality. The traditional oxygen cylinder is bulky and difficult to wear, and thus wearable oxygen concentrators (WOCs) are a portable option. Research proved that a modular system using a portable concentrator, rebreather circuit, and ventilator can achieve a high FiO2 of 0.8. The battery-driven system offers continuous oxygen supply without an external power supply, increasing mobility and convenience. WOCs enhance patient management, reduce hospital visits, and support medical personnel in various operating environments. [1Prehospital oxygen (O2) therapy to trauma casualties is a recognized clinical practice for hypoxemia management. In the military setting, there is debate about the use of O2 for all medical and trauma patients in the forward operating environment and the keeping of peripheral capillary blood saturation (SpO2) at a specific level. [2]. The cost of commercial CPAP machines limits their utilization in resource-constrained settings, with makeshift oxygen installations risking hyperoxia in neonates. PoliteO2blend is a low-cost device, blending oxygen with room air, filtering, and humidifying the gas. A pilot study in the University Teaching Hospital treated 45 neonates with

target SpO2 (90–95%) under FiO2 0.21–0.6. Use duration was from 5 hours to 7 days, allowing safer oxygen therapy. The machine reduces risks of oxygen toxicity with makeshift installations. PoliteO2blend is proposed as a safer, low-cost option for neonatal respiratory therapy. [3][4];5]

The COVID-19 pandemic had led to a global shortage of medical equipment, including oxygen, which was in short supply in India during the second wave. The demand-supply mismatch led to innovative solutions like PSA-based oxygen generators. The technology, based on OBOGS developed by DRDO and DEBEL for military aircraft, was a reliable source of oxygen. PSA technology allows for effective on- site generation of oxygen for medical purposes. The present review addresses the scientific rationale, applications, and benefits of PSA-based oxygen plants. The plants have been crucial in meeting oxygen shortages during the pandemic. [6]. Safe delivery of oxygen to children and infants is a global problem. A new oxygen blender system was developed to deliver controlled oxygen-enriched air without the requirement of compressed medical air. The system was tested using oxygen concentrators and oxygen tanks in this research. Outcomes showed accurate delivery of oxygen at ±5% of the set point even with nasal occlusion. The system was also supply tolerant and performed well. The new technology offers a low-cost approach for the improvement of pediatric oxygen therapy worldwide. [7][8]

A Pressure Swing Adsorption (PSA) technology-based oxygen concentrator efficiently separates oxygen from ambient air through the removal of nitrogen. The device supplies high-purity oxygen (94.7%) at low flow rates (0.5-3 L/min), which is ideal for COPD patients. It is economical, lightweight, and quieter than existing market products. Experimental results confirm its long-term efficacy and greater oxygen purity. The technology provides an affordable and effective alternative for individuals unable to purchase commercial oxygen concentrators. [9]. Snap-on medical oxygen concentrator is a stand-alone, new machine employing quick pressure swing adsorption for continuous oxygen supply. It is simple to connect to an available compressed air source, so it is portable and most suitable for extensive oxygen therapy needs. It employs LiLSX zeolite to generate 90% purity of oxygen with higher rate of production when connected to house air. The device is lightweight, durable, and more efficient than traditional stand-alone concentrators. It is most suitable for hospitals, military camps, and cruise ships with continuous compressed air supply. [10][11][12].

Oxygen therapy has been promoted from inpatient to outpatient therapy for the management of chronic pulmonary disease and hypoxemia. This article discusses oxygen devices (concentrators, compressed gas cylinders, liquid oxygen) and delivery systems (high- and low-flow), and their indications, benefits, and drawbacks. It offers up-to-date information for therapists to deliver optimal patient care. Proper selection of oxygen devices and delivery systems is required for effective respiratory therapy. [13]. Oxygen concentrators are needed by oxygen therapy patients. Lithium zeolite, a material that enhances oxygen purity by nitrogen adsorption, is investigated in this research work. Arduino microcontroller and HX710B air pressure sensor are employed and utilized to measure oxygen flow rates with high accuracy. Results show that efficiency is increased by using lithium zeolite with high oxygen purity at low energy expenditure. The findings are utilized in the production of more efficient and environmentally friendly portable oxygen concentrators (POCs) for oxygen therapy. [14][15]. Self-fill home oxygen systems provide an economical solution for long-term oxygen therapy (LTOT) patients, allowing them to refill ambulatory cylinders independently. The systems reduce cylinder delivery dependency, which is beneficial for rural communities and reduce the environmental impact by minimizing the use of fossil fuels. They have been shown to improve patient mobility, quality of life, and healthcare cost savings effectively. Their use can enhance independent living and reduce the workload for healthcare professionals. [16][17].

A Portable Automated Oxygen Delivery System was developed to optimize oxygen administration for hypoxaemic patients. It features an Oxygen Reader Subsystem and an Automated Adjustment Oxygen Delivery Subsystem, communicating wirelessly. This system extends oxygen therapy beyond ICUs, reduces healthcare costs, and improves patient care by optimizing oxygen delivery. [18].

III. EXISTING SYSTEM

Oxygen concentrators are medical equipment to concentrate oxygen from surrounding air for supply of supplemental oxygen to patients suffering from respiratory illnesses. The currently used systems primarily involve Pressure Swing Adsorption (PSA) technology wherein air is drawn through zeolite molecular sieves that selectively absorb nitrogen and release the oxygen to the patient. Oxygen supplied by these concentrators is of the quality of 90-96% and delivers a stable quantity to patients suffering from chronic obstructive pulmonary disease (COPD), hypoxemia, or other respiratory illnesses. The majority of oxygen concentrators are fixed equipment requiring continuous electrical power, making them suitable for home and hospital use. They can deliver continuous-flow or pulse-dose oxygen at flow rates of 0.5 to 10 liters per minute (L/min), depending on the device. Traditional concentrators are typically heavy,

bulky, and noisy, restricting mobility and requiring backup oxygen supplies in case of power failure.

More recent developments have included portable oxygen concentrators (POCs), powered by battery power and using lightweight materials to promote increased mobility. They do come with oxygen output restrictions and will not be useful for patients who require high-flow oxygen therapy. Oxygen concentrators are part of and cost-effective component of long-term oxygen therapy in spite of these limitations..

IV. PROPOSED SYSTEM AND METHODOLOGY

Oxygen concentrators are medical equipment that draw oxygen from the surrounding air to deliver supplemental oxygen to patients with respiratory disorders. The current systems mostly employ Pressure Swing Adsorption (PSA) technology, where air is drawn through zeolite molecular sieves that preferentially adsorb nitrogen, resulting in concentrated oxygen for the patient. These concentrators generally deliver oxygen at 90-96% purity, providing a consistent supply to patients with chronic obstructive pulmonary disease (COPD), hypoxemia, or other respiratory diseases. The designed wearable oxygen concentrator generator is a small and smart medical device that can offer continuous oxygen therapy with full mobility and real-time health monitoring. In contrast to conventional portable oxygen concentrators (POCs), this device is light, wearable, and hands-free, enabling users to move around without the need to carry heavy devices.

The wearable oxygen concentrator generator is a smart, lightweight, and compact medical device that offers continuous oxygen therapy while tracking the SpO_2 level and heart rate of the wearer. The device combines PSA-based oxygen concentration technology, real-time health monitoring sensors, and a microcontroller-based control system to provide maximum performance and convenience.

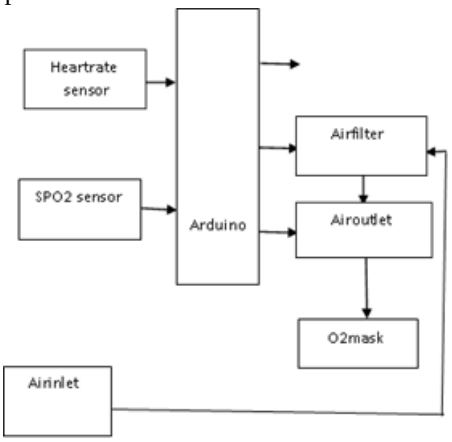

Fig 1. Block diagram

This portable oxygen concentrator generator is a lifeline for patients who require oxygen therapy. It's not just a machine that delivers much-needed oxygen but also one that constantly tracks your vital signs so you get the ideal amount of oxygen at the precise moment you need it.

The machine sucks in ambient air, cleanses it, and then separates the oxygen from the nitrogen through Pressure Swing Adsorption (PSA) technology. The concentrated oxygen that results is directly provided to you in an oxygen mask.

A built-in sensor, MAX30102, based on optical sensing technology, monitors your real-time oxygen saturation (SpO_2) and heart rate. The data is passed to the brain of the device, Arduino Node(MCU), which then modifies the flow of oxygen depending on your situation. The 16×2 LCD screen displaying your oxygen level, SpO_2 values, and heart rate. And with Wi-Fi connectivity, your caregiver or doctor can keep track of your progress from a distance, making sure you're getting the very best care.

The device uses a rechargeable battery, allowing you to roam free without concern about running out of power. And with wearable design, you can clip it to a vest or belt and easily take it with you wherever you go.

A. HEART RATE SENSOR AND SPO2 SENSOR

MAX30102 is an optical biosensor that can measure heart rate and SpO_2 non-invasively through red and infrared

LEDs. It can also measure blood oxygen content based on light absorption by deoxygenated and oxygenated

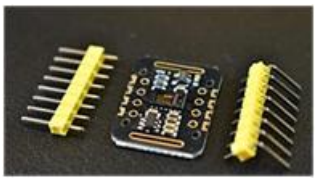

Fig 2. MAX30102 Heart rate sensor

haemoglobin. It is based on blood volume changes per beat to get the heart rate. It communicates with an Arduino Node(MCU) via I2C to display real-time data on an LCD (16×2 with I2C module). Adding this sensor to a wearable oxygen concentrator gives continuous vital sign monitoring, enhancing patient mobility, safety, and the efficiency of oxygen therapy.

B. AIR INLET, AIR OUTLET AND AIR FILTER

Air inlet, air outlet, and air filter are all vital components of a wearable oxygen concentrator for efficient oxygen inhalation, cleaning, and distribution. Ambient air is sucked through the air inlet and purified through a high-efficiency air filter, removing impurities and dust to deliver clean oxygen supply. The cleaned air is then put through Pressure Swing Adsorption (PSA) such that nitrogen is removed by zeolite molecular sieves, leading to concentrated oxygen. This oxygen is directed to the air outlet, which is connected to an oxygen mask or nasal cannula for patient consumption. The filters must be cleaned regularly to prevent dust buildup, which can impair oxygen flow rate and concentration. The constant oxygen supply is given by a battery-powered compressor, and the unit is portable and lightweight. Real-time monitoring sensors also can regulate oxygen flow based on SpO_2 levels, making them more efficient and saving energy. All these components are important in delivering clean, concentrated oxygen, improving patient mobility, independence, and overall respiratory therapy.

C. ARDUINO(NODEMCU)

Arduino Node(MCU) is a compact Wi-Fi microcontroller that is ideal for IoT-based medical devices like wearable oxygen concentrators. Designed on the ESP8266 chipset, it processes real-time sensor data such as the MAX30102 SpO_2 and heart rate sensor as well as oxygen delivery system control. It interacts in an effective way using the I2C protocol, reducing wiring complexity and improving performance. Low power usage enables it to offer long battery life, and hence it is suitable for continuous operation. LCD 16×2 with I2C module offers essential readings like oxygen saturation, SpO_2, and heart rate. Its Wi-Fi capability supports remote monitoring of health, which allows healthcare providers to track patient information in real time.

Fig 3.Arduino (node MCU)

D. OUTPUT DESIGN

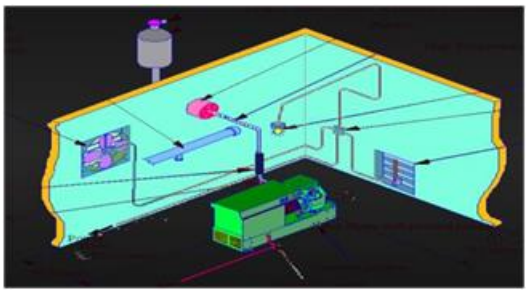

Fig 4. Design of Wearable oxygen concentrator generator

V. FUTURE ENHANCEMENT

Imagine in the future when wearable oxygen concentrators are compact, lighter, and more efficient. Patients breathe freely and easily, unencumbered by cumbersome gear. Sensors track oxygen levels around the clock, automatically making the optimal adjustments for the best flow. Artificial intelligence takes over, learning the patient's individual needs and optimizing oxygen therapy accordingly. Battery life is longer, minimizing the inconvenience of repeated recharging. And with improved longevity, patients are free to live life without the worry of their device. The future of oxygen therapy isn't all about technology - it's about enabling patients to live life to its fullest.

VI. RESULT AND CONCLUSION

The portable oxygen concentrator generator has proved to be an efficient and effective oxygen delivery device, delivering 90–95% pure oxygen at flow rates of 0.5–3 L/min, which is medical standard for COPD, asthma, and respiratory patients. The machine effectively combines Pressure Swing Adsorption (PSA) technology to filter oxygen from atmospheric air, delivering a steady stream of purified oxygen.

MAX30102 sensor was able to read SpO_2 levels and heart rate in real time and provide the same information to the Arduino Node(MCU) microcontroller. The latter will dynamically modify oxygen flow rate accordingly based on patients' needs. The I2C 16×2 LCD is simple for monitoring oxygen level, heart rate, and SpO_2 levels. It was made in such a way to be wearable, portable, and lightweight to achieve full mobility by patients. A rechargeable battery drives the system, offering long operating hours without being frequently charged. The provision of Wi-Fi connectivity provides for remote patient monitoring, which allows healthcare professionals to monitor oxygen levels and vital signs in real-time. The provision of an air filter provides for clean oxygen intake, extending device lifespan.

In conclusion, the wearable oxygen concentrator generator is an affordable, energy-saving, and patient-friendly

technology that improves independence, decreases hospitalization, and enhances overall respiratory treatment for patients using long-term oxygen therapy.

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