Novel Oxygen Concentrator using ARM Processor

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***Abstract*— an Oxygen concentrator has got immense importance in Covid pandemic. Lack of oxygen supply increased demand of oxygen concentrator world widely. an oxygen concentrator is a device that concentrates the oxygen from typically ambient air by selectively removing nitrogen to supply an oxygen-enriched product gas stream. An oxygen concentrator takes in air and removes nitrogen from it, leaving an oxygen-enriched gas for use by people requiring medical oxygen due to low oxygen levels in their blood. Oxygen concentrators provide an economical source of oxygen in industrial processes where they are also known as oxygen gas generators or oxygen generation plants. Studies so far conducted show that need of oxygen concentrators in India are used devices by patients, technical services are inadequate, no periodical maintenance is being done for devices requiring regular maintenance and control, and some devices do not yield the expected oxygen purity in long-term use. These problems in the oxygen concentrators are the most important factors causing delays in the treatment process because the patients are unable to receive oxygen at sufficient purity levels during the scheduled period. Therefore, it has become a necessity that oxygen concentrators are rearranged as devices fulfilling medical requirements and minimizing patient/device-based problems. This requirement leads us to do research on oxygen concentrator. Here ARM processor is used as main controller. ARM controller controls and monitor all activities of sensors to have good application at the end. The proposed system will be cost effective and efficient machine for respiratory patients. It may help to lower down the medical treatment.**

Keywords*—*ARM processor, COPD, LTOT, Pressure Sensor, MFC.

I. INTRODUCTION

Union Carbide Corporation and Bendix Corporation were both early manufacturers of Oxygen concentrators. Home medical oxygen concentrators were invented in the early 1970s, with the manufacturing output of these devices increasing in the late 1970s. Before that era, home medical oxygen therapy required the use of heavy high-pressure oxygen cylinders or small cryogenic liquid oxygen systems. Both of these delivery systems required frequent home visits by suppliers to replenish oxygen supplies. In the United States, Medicare switched from fee-for-service payment to a flat monthly rate for home oxygen therapy in the mid-1980s, causing the durable medical equipment (DME) industry to rapidly embrace concentrators as a way to control costs. This reimbursement change dramatically decreased the number of primary high pressure and liquid oxygen delivery systems in use in homes in the United States at that time. Oxygen concentrators became the preferred and most common means of delivering home oxygen. The number of manufacturers entering the oxygen concentrator market increased drastically due to this change. Union Carbide Corporation invented the molecular sieve in the 1950s which made these devices possible. It also invented the first cryogenic liquid home medical oxygen systems in the 1960s.

This instrument provide supplementary oxygen for patients with chronic obstructive pulmonary disease (COPD) and, in higher concentrations, for severe chronic hypoxemia and pulmonary edema. They may be used as an ADJACENT treatment for severe sleep apnea (in conjunction with a continuous positive airway pressure unit). Oxygen concentrators are typically used as stationary sources to provide long-term oxygen therapy (LTOT) to patients at home. Oxygen concentrators consist of a cabinet that houses the compressor and filters; tubing; a nasal cannula and/or face mask. Portable units will additionally include an AC and/or DC charger, and a battery. The concentrator draws in room air and passes it through a series of filters that remove dust, bacteria, and other particulates. In the first step of the concentration process, a compressor forces air into one of the two cylinders containing sieve material, where nitrogen is adsorbed, leaving concentrated oxygen and a small percentage of other gases found in room air. Simultaneously, in the other cylinder, nitrogen is desorbed and exhausted into the atmosphere. In the second step, the function of the cylinders is reversed in a timed cycle, providing a continuous flow of oxygen to the patient. Oxygen concentrators may fail to produce therapeutic levels of oxygen because of common problems involving the air-intake system, malfunctioning sieve-control valves, and contaminated sieve materials. Water vapor in room air can compromise the adsorption of nitrogen in the sieve beds by entering through small leaks in the internal tubing; if sufficient water vapor contaminates the sieve beds once again, the gas delivered will be room air. Patients may suffer irritation from nasal CANNULA. Because excess oxygen enhances and accelerates combustion, extreme care must be taken to avoid using the concentrator near combustible materials and sources of ignition. A reserve compressed-oxygen tank and regulator should always be available in case of a power failure.

In both clinical and emergency-care situations, oxygen concentrators have the advantage of not being as dangerous as oxygen cylinders, which can, if ruptured or leaking, greatly increase the combustion rate of fire. As such, oxygen concentrators are particularly advantageous in military or disaster situations, where oxygen tanks may be dangerous or unfeasible. Oxygen concentrators are considered sufficiently foolproof to be supplied to individual patients as a prescription item for use in their homes. Typically they are used as an adjunct to CPAP treatment of severe sleep apnea.

There also are other medical uses for oxygen concentrators, including COPD and other respiratory diseases.

People who depend upon oxygen concentrators for home care may have life-threatening emergencies if the electricity fails during a natural disaster.

The proposed system implements innovative and cost effective method. This system will be efficient and capable to address problems in existing system. The ARM processor as a main controller provides flexibility to adapt modification while upgrading and improving the proposed system.

II. Paper Survey

The paper named as 'Design and Implementation of an Oxygen Concentrator with GPRS-based Fault Transfer System' states that "Long-term oxygen therapy (LTOT) is one of the several methods increasing the duration of survival in chronic obstructive pulmonary disease (COPD), with the oxygen concentrators being the most appropriate and economical choice for this treatment. Studies so far conducted show that a significant amount of oxygen concentrators in Turkey are used wrongly by patients, technical services are inadequate, no periodical maintenance is being done for devices requiring regular maintenance and control, and some devices do not yield the expected oxygen purity in long-term use. These problems in the oxygen concentrators are the most important factors causing delays in the treatment process because the patients are unable to receive oxygen at sufficient purity levels during the scheduled period. Therefore, it has become a necessity that oxygen concentrators are rearranged as devices fulfilling medical requirements and minimizing patient/device-based problems in parallel with the developments in the field of medical electronics. In this study, a low-cost oxygen concentrator with a GPRS-based fault transfer system is designed for patients receiving LTOT and the practical application of this device is realized on a prototype. The most important feature of the designed oxygen concentrator is the ability to detect the fault cases occurred in itself, and then to send them to the related technical service and hospital authority through the GPRS-based fault transfer system without reliance on the patient's statement. This ensures the prevention of delays during the treatment period caused by the functional problems of the device" [1].

The paper named as 'Oxygen Separation from Air Using Zeolite Type 5A.' states that "An adsorption (PSA) unit consist of two – tubes columns pressure swing, (6cm diameter and 70cm bed length) and a dryer part (12cm diameter and 27cm) filling with activated alumina have been constructed to study the separation of oxygen from air using commercial 5A zeolite under the effect of adsorption pressure (1 to 6 bar), adsorption time (20s), product flow rate (1 liter/min) on the product oxygen purity. For the case of 2-column, 4-step operation, the results show that an optimum concentration product of oxygen was 76.9%purity, at the adsorption pressure 4bar, Temp 17.4°C."[2]

The paper named as 'Development and integration of oxygen generator for home air conditioner' states that "An Oxygen Generator is developed to interface with Home Air Conditioner that serves for Home Oxygen Therapy & it is controlled by a Microcontroller which is connected to an IoT app through which users can monitor and control the whole system. Oxygen levels are to be maintained as per OSHA cited acceptable levels. For generating oxygen we are using Pressure Swing Adsorption Technique with two bed molecular sieve columns with Zeolite filled inside in it which acts as a Filtering component of Nitrogen. When a Pressurized air is passed through the Zeolite it filters out Nitrogen (due to its chemical nature Nitrogen molecules gets trapped inside its pores) and allows rest of the Air components pass through it so that we can get oxygen enriched air at the outlet and it is given to home." [3]

The paper named as 'Contemporary portable oxygen Concentrators and diverse breathing behaviours -a bench comparison' states that "Decades of clinical research into pulsed oxygen delivery has shown variable efficacy between users, and across a user's behaviors (sleep, rest, activity). Modern portable oxygen concentrators (POCs) have been shown as effective as other oxygen delivery devices in many circumstances. However, there are concerns that they are not effective during sleep when the breathing is shallow, and at very high respiratory rates as during physical exertion. It can be challenging to examine the determinants of POC efficacy clinically due to the heterogeneity of lung function within oxygen users, the diversity of user behavior, and measurement issues. Representative bench testing may help identify key determinants of pulsed-oxygen device efficacy." [4]

The paper named as 'Comparing supplementary oxygen benefits from a portable oxygen concentrator and a liquid oxygen portable device during a walk test in COPD patients on long-term oxygen therapy' states that "Background: Differences in oxygen delivery between portable oxygen concentrators (POC) and liquid oxygen (LO) portable units, pose a question if POCs are equally effective as LOs in reducing exercise-induced hypoxaemia. Design: Randomized, single-blind clinical trial. Patients: Thirteen COPD patients (means: age 66711 year, FEV1 35.2713.7% predicted) and respiratory failure (means: PaO2 5275 mmHg, PaCO2 51.377.5 mmHg). Methods: All patients underwent a series of 6-min walk tests (6 MWT) carried out in random order among one of the three devices: POC, LO cylinder and cylinder with compressed air (CA). Oxygen supplementation was 3 lpm for LO and an equivalent to 3 lpm in a pulse flow system for POC. Results: The mean SpO2 was equally improved at rest: 92.972.8% with POC and 91.772.0% with LO compared to CA—87.872.7% (POC and LO vs. CA po0.05). POC and LO significantly improved oxygenation during 6 MWT (mean SpO2 was 84.375% and 83.874.2%, respectively) compared to breathing CA—77.677.4%, po0.05. Mean 6 MWT distance increased with LO (350783 m) and POC (342796 m) when compared to CA (317784 m), however, these differences were not statistically significant. Dyspnoea score assessed at the end of the exercise (Borg scale) was significantly lower when breathing oxygen (4.271.2 with POC and 4.171.7 with LO vs. 5.471.9 with CA, po0.05)."[5]

The paper named as 'Long-Term Oxygen Therapy in COPD: Factors Affecting and Ways of Improving Patient Compliance' states that "Long-term oxygen therapy (LTOT) is the cornerstone mode of treatment in patients with severe chronic obstructive pulmonary disease (COPD) associated with resting hypoxaemia. When appropriately prescribed and correctly used, LTOT has clearly been shown to improve survival in hypoxemic COPD patients. Adherence to LTOT ranges from 45% to 70% and utilization for more than 15 hours per day is widely accepted as efficacious. Although several studies have addressed the level of patients' adherence to LTOT, few have suggested or evaluated interventions that conduce to compliance enhancement. The lack of sufficient data regarding COPD patients following oxygen prescription is an enormous void that must be duly confronted to augment clinical effectiveness and cost containment for the long term use. The present review article highlights factors influencing the compliance of patients using LTOT and emphasizes novel strategies and interventions that may prove to be of significant benefit given the remarkably little current research appraising this issue. Therefore, additional research should be promptly performed to verify the efficacy of newly designed approaches in improving the outcomes of patients receiving LTOT."[6]

III. SYSTEM DEVELOPMENT

The proposed system is illustrated in figure.1 .It gives us idea about oxygen concentrator working.

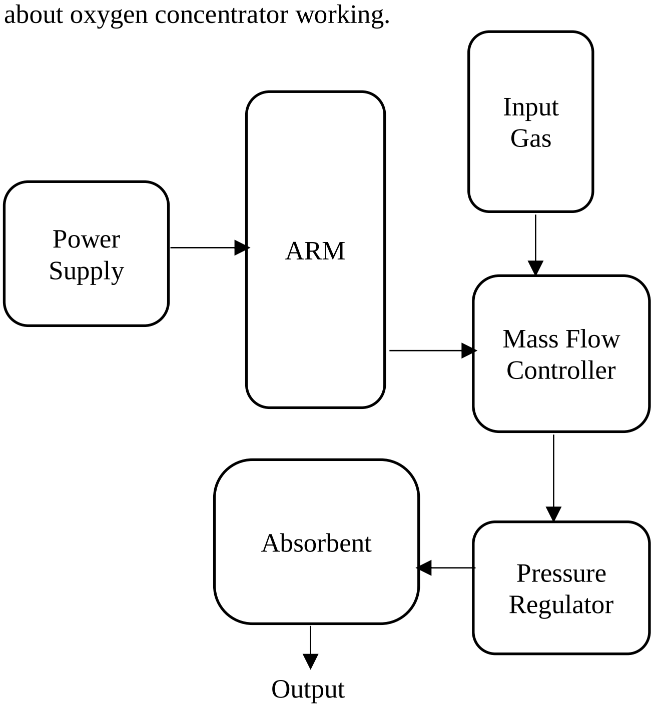

Figure.1 Proposed System

As shown in Proposed System mass flow controller and pressure regulator are based on pressure sensor and valves. ARM controller is used to control and monitor all the embedded components for proper functioning of oxygen concentrator. Absorbent is used to separate Oxygen and nitrogen from ambient air. Input gas may be gas cylinder or ambient air.

IV. RESULTS

Table. 1 illustrates the outcomes of implemented system. Outcomes of target device are compared with respect to Airflow, pressure, power, oxygen concentration etc. The mentioned parameter indicates that target device is working satisfactorily, but still there is a large scope for improvement.

Parameter	Expected	Actual
Air flow	15 LPM	6.5 LPM
Oxygen concentration	80% above	Variation 52% to 60 %
Pressure	12 PSI	7 PSI
Power	450 w	650 w

V. CONCLUSION

The proposed system is cost effective and highly accurate. It is successful attempt to overcome drawbacks of existing system. ARM controller makes system easier for adaptation and upgradation. It avoids manual errors during handling. System is designed as such that controller takes its own decision of varying oxygen supply to the patient. The special care is taken to avoid generation of impure oxygen. Filters added to the proposed system ensures purity of an oxygen.

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