Design of Oxygen Generator Based on Oxymetry: Prototypes for Vergenios Baby

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Abstract. Oxygen therapy saves lives in several respiratory and non-respiratory diseases in neonates and children. The most common indication for oxygen therapy in newborns was pneumonia, one of the leading causes of death in children under five years old in most developing countries. The Oxygen Concentrator (OC) comes as a welcome change to this cylinder place. Oxygen concentrators save up to 25-50% in cost over cylinders in poor resource settings. This oxygen therapy is even more effective if a control system is given to regulate the oxygen needs of the client in the form of oxymetry control. Designed an oxygen concentrator with Pressure Swing Adsorption and Oxymetry Pulse Control for newborns and neonates. This study uses a research and development design. The variables tested in this study were the Oxygen Generator's function based on oxymetry and the volume of oxygen produced. At this stage, the Oxygen Concentrator assembly and coding are carried out, consisting of a series of hardware and software for oxygen concentrator software with a Pressure Swing Adsorption (PSA) work system equipped with Arduino-based pulse oximetry control. The results of the research at this stage are that the hardware of the Oxygen Concentrator Based on Oxymetry has been assembled and the completion of the Arduino IDE coding. Testing the Oxygen Concentrator Based on Oxymetry function works properly which is marked when the power button is in the ON position; the Pressure Swing Adsorption (PSA) unit shows the LCD screen display entering the main menu. The words "Ready to use" appear, and the oxygen indicator on oxymetry shows the concentration of oxygen produced. At this stage the oxygen concentration produced is an average of 36%. At this stage the Oxygen Generator Based on Oxymetry is functioning but with a low oxygen concentration, so it is necessary to make improvements in the assembly design of the next prototype.

Keywords: Mechanism, Oxygen Generator, Oxymetry.

1 Introduction

Hypoxic respiratory failure (HRF) in newborns is characterized by hypoxemia secondary to increased "right-to-left" pulmonary vascular resistance. Common causes of HRF are meconium aspiration syndrome, respiratory distress syndrome (RDS), pneumonia/sepsis and primary pulmonary hypertension. One of the therapies is oxygenation

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[1]. Oxygen therapy remains an expensive alternative inaccessible to the majority of severely ill children hospitalized in developing countries. This is especially true for patients in small district hospitals, where, even if some oxygen delivery facilities are available, supplies are often unreliable and the benefit of treatment may be reduced due to poor maintenance, inappropriate equipment, poorly trained staff or guidelines which is inadequate [2].

Raising awareness of this issue is likely to have clinical and public health benefits. Health care workers must be aware of the clinical signs indicating hypoxaemia. More reliable detection of hypoxaemia can be achieved through more widespread use of pulse oximetry, which is a non-invasive measure of arterial oxygen saturation. Oxygen therapy should be more widely available; in many remote settings, this can be achieved by using oxygen concentrators, which can run on regular or alternative sources of power [3][4].

Oxygen therapy saves lives in several respiratory and non-respiratory diseases in both neonates and children. The most common indication for oxygen therapy in newborns is pneumonia, which is one of the leading causes of death in children under five years old in most developing countries. Most of these deaths are related to hypoxaemia, and oxygen therapy is thus an important component of therapy. Within developing countries, at the district level, the source of oxygen is often cylinder oxygen, and in some places liquid oxygen, but this is heavy, transport is complicated and requires a reliable distribution system for refilling each time. The Oxygen Concentrator (OC) comes as a welcome change to this cylinder place. Oxygen concentrators save up to 25-50% in cost over cylinders in poor resource settings. Although the initial outlay of oxygen concentrators is higher, it is cost-effective in the long run and despite the low initial cost of oxygen cylinders the cumulative cost of filling and maintaining is higher depending on the cost of transportation and service in a particular area [5].

This oxygen therapy is even more effective if a control system is given to regulate the oxygen needs of the client in the form of oxymetry control. Therefore, in this study, researchers will look at trying to design an oxygen concentrator with Pressure Swing Adsorption and Oxymetry Pulse Control.

2 Method

This study used a research and development design. The variables tested for the validity of this study were the function of the oxygen concentrator and the oxymetry pulse control automation system. The functioning of the oxygen generator is shown by the work of the oxygen concentrator, which shows the resulting oxygen saturation. Oxygen demand fulfillment automation system based on the results of oxygen saturation measurements in a conditioned environment

The need in designing this product is adjusted to the efficiency and effectiveness of the tool so that it can be effective and efficient. The product of this research will create an oxygen concentrator with a Pressure Swing Adsorption (PSA) working system equipped with an Arduino-based pulse oximetry control [6]. The stages carried out in this study included assembling the tool, coding the tool, testing the functioning of the

oxygen generator, determining the resulting concentration and evaluating the operation of the pulse oximetry system. Product validation is an activation process to assess whether the product design, in this case, the new work system, will rationally be more effective than the old one or not.

3 Result and Discussion

This research has produced a tool with the working mechanism and effectiveness as follows in Fig. 1.

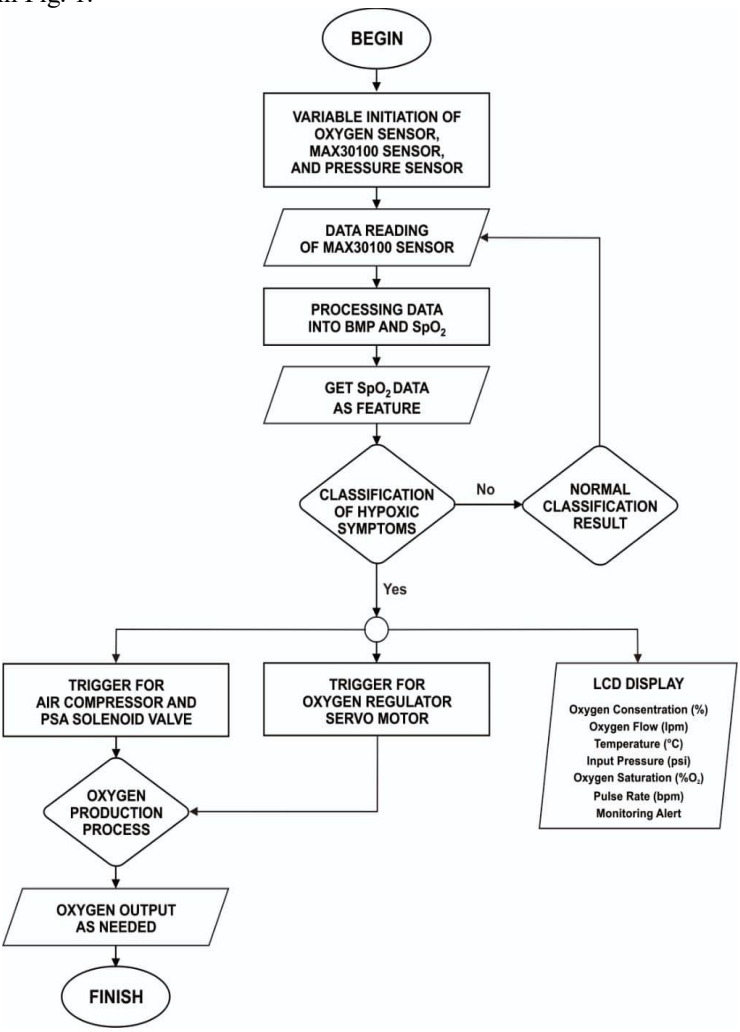

Fig. 1. The Diagram on working mechanism of Oxygen Concentrator

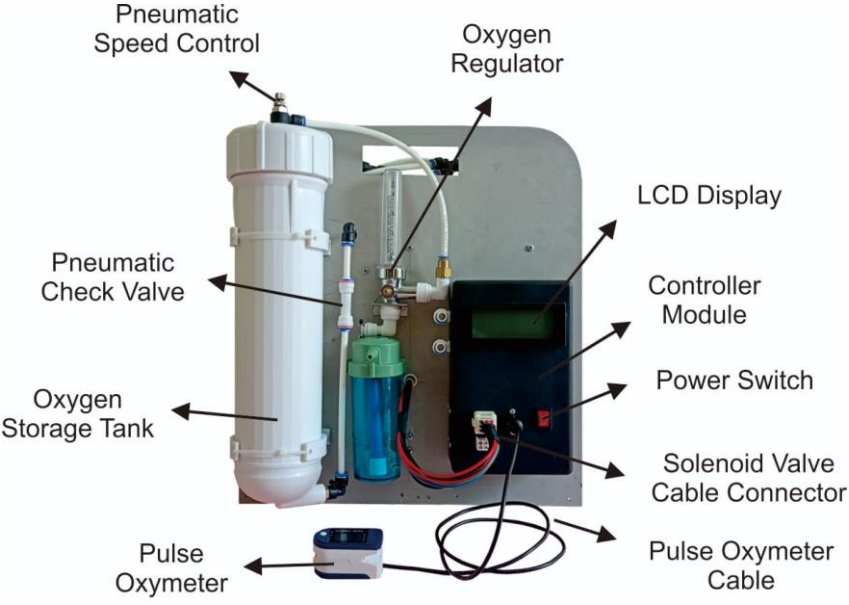

Fig. 2. Front view of the Pressure Swing Adsorption (PSA) Oxygen Concentrator

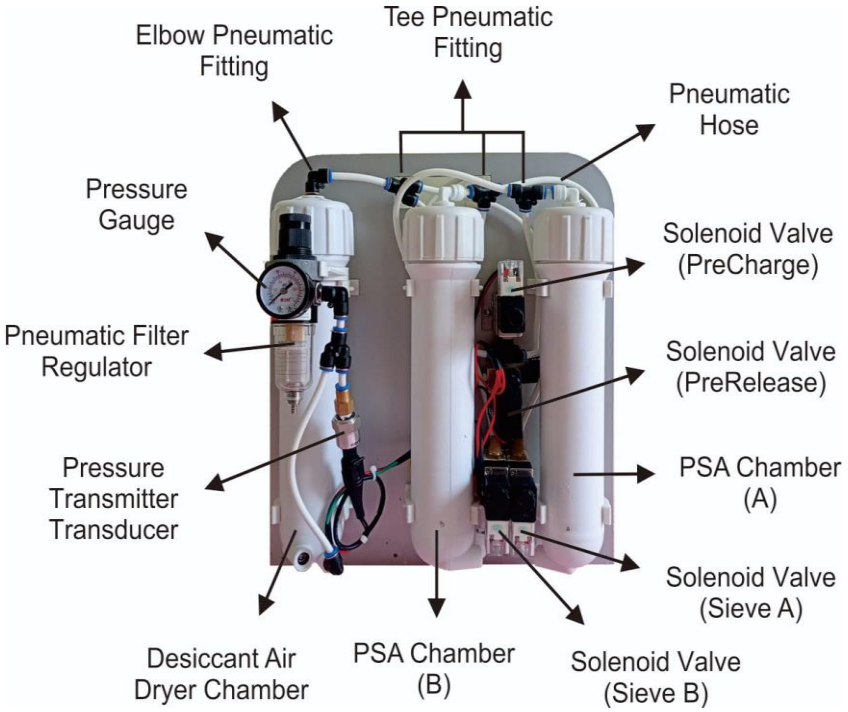

Fig. 3. Back view of the Pressure Swing Adsorption (PSA) Oxygen Concentrator

The use of oxygen concentrator in Fig. 3 and Fig. 4, begins with:

1. Position the oxygen concentrator (oilless compressor and pressure swing adsorption) in a room with good air circulation, as it will become very hot when the machine operates.
2. Operate an oilless compressor as a unit for producing compressed air by supplying 220VAC voltage, the machine will draw a lot of electric power (550 Watts).
3. Operate Pressure Swing Adsorption (PSA) as a unit for producing high concentrations of Oxygen (O2) gas by supplying 220VAC electric voltage. Then press the power button in the ON position, the unit will perform a running test for a few moments until the LCD screen displays on the main menu and the words "Machine Ready to Use" appear.
   The high-pressure air coming from the oiless compressor will be filtered and readjusted by the pneumatic filter regulator to then enter the desiccant air dyer tube which contains Silica Dioxide (SiO2) as an absorbing medium for the moisture content in the air.
   Dry air coming from the air dyer desiccant tube flows alternately into the PSA tube (housing membrane) which contains zeolite molecular sieve 13X as an adsorbent for nitrogen (N2), argon (Ar) and carbon dioxide (CO2) gases. The mechanism for separating the flow of dry air into the PSA tube (housing membrane) alternately involves a solenoid valve controlled by an Atmega 328 microcontroller which regulates the relay module switching program[7][8].
   If the PSA tube A (housing membrane) is compressing dry air (solenoid valve sieve A is ON, solenoid valve precharge is OFF), then the zeolite molecular sieve 13X will absorb nitrogen gas (N2) and separate oxygen gas (O2) into next stage. On the other hand, the zeolite molecular sieve 13X in the PSA B tube (housing membrane) which contains nitrogen gas (N2) is saturated due to the process of absorption of dry air in the previous compression cycle (solenoid valve sieve B is in OFF condition, solenoid valve precharge is in ON condition) so that Nitrogen gas (N2) will be wasted out of the Pressure Swing Adsorption (PSA) system due to the pressure of oxygen gas (O2) from the PSA tube A (housing membrane) through the prerelease solenoid valve which works in the opposite direction to the precharge solenoid valve condition [9]. Air with a high oxygen concentration coming from a PSA tube (housing membrane) which works alternately will be flowed into the oxygen storage cylinder, the air flow is regulated using a check valve fitting to avoid backflow of air [6]. Oxygen storage cylinders are equipped with speed control fittings to regulate the pressure and flow rate of oxygen gas (O2) to the oxygen regulator.
4. Connect the humidifier bottle to the oxygen flowmeter outlet and use distilled water in the humidifier bottle. Make flowmeter settings according to the required Oxygen (O2) gas flow (Liters Per Minute).
5. Connect the cannula hose to the humidifier outlet hole, check the hose for bends or leaks. Place the nasal cannula under the nostrils to get high levels of oxygen, interference with the tube can cause oxygen (O2) gas supply to not be optimal.
6. Connect the oximeter cable connector to the oxygen concentrator main module and clamp the oximeter unit on your finger, then the control program will automatically

operate the oxygen concentrator according to the predetermined oxygen saturation requirements. The oximeter serves to measure oxygen saturation in the blood in a non-invasive way without having to take a blood sample.

7. Oxygen concentrator (oiless compressor and pressure swing adsorption) will go to shutdown when oxygen saturation meets predetermined criteria with stable oxygen saturation interval values for 1 (one) hour. If the oximeter detects that the oxygen saturation value falls below the set criteria, the oxygen concentrator will start operating again until the conditions are met again.
8. Program coding is divided into 2 parts, including the Pressure Swing Adsorption (PSA) controller and the oximeter controller, the program is still in the development process.

The Pressure Swing Adsorption (PSA) controller coding regulates the duty cycle of solenoid valve sieve A, solenoid valve sieve B, solenoid valve precharge, and solenoid valve prerelease which involves a pressure transmitter transducer sensor as a safety system when working in high pressure air.

Oximeter control coding by comparing how much red light (red light) absorbs deoxyhemoglobin and infrared light (infrared) absorbs oxyhemoglobin in the arteries. The light is processed by the sensor into data that functions as a trigger for the oxygen concentrator work system (oiless compressor and pressure swing adsorption) with predetermined parameters [10].

The results of the assessment of the functioning and concentration of oxygen produced are shown in Table 1.

Table 1. The Percentage of Oxygen Concentration Produced at A Pressure of 4 BAR

Oxygen concentration (%)	Result on LCD				
	Testing 1	Testing 2	Testing 3	Testing 4	Testing 5
4 BAR	26%	42%	33%	38%	42%

The results of the research at this stage are that the hardware of the Oxygen Concentrator Based on Oxymetry has been assembled and the completion of the Arduino IDE coding. Testing the Oxygen Concentrator Based On Oxymetry function works properly which is marked when the power button is in the ON position, the Pressure Swing Adsorption (PSA) unit shows the LCD screen display entering the main menu and the words "Ready to use" appear, and the oxygen indicator on oxymetry shows the concentration of oxygen produced. At this stage the oxygen concentration produced is an average of 36.2%. This was re-evaluated by evaluating the assembly of the device which found the ineffectiveness of the valves that had been set and the measure of absorption in the form of a molecular sieve with an inaccurate diameter. It is possible to choose a smaller diameter so that the cross-sectional absorption area is larger and produces a more optimal oxygen concentration.

At this stage the Oxygen Generator Based on Oxymetry is functioning but with a low oxygen concentration, so it is necessary to make improvements in the assembly design of the next prototype.

4 Conclusion

The Oxygen Concentrator with a Pressure Swing Adsorption (PSA) unit is already functioning, but it is still improving the program coding so that it can function according to the achievement targets.

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