Low-Cost Pulmonary Ventilator for Patient Monitoring for Covid-19 Disease

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Abstract — Positive pressure ventilation has been an important component of respiratory disease management for the last 50 years. External instruments called ventilators are intended to help a patient accomplish a certain operation. It is to maintain or enhance a person's breathing capacity if he has a problem with his own breathing. It is a piece of equipment, software application, or product scheme that is used to increase, sustain, or boost the functional capacities of people with pulmonary difficulties. The developed system of a lab model ventilator is the subject of this article. The ventilator's robustness and functionalities, which are not only easily adaptable but also exact lower cost and cost-effective. The proposed design for a ventilation system was constructed with wooden parts weighing 6 kg and measuring 14×7×9 inches in dimension. It works without essential to the human hand since it breathes by the compression of a traditional bag-valve mask. In addition, it has a low-battery warning system as well as an assist control. This method implemented is novel, low - cost, less dependent on external power and easy to manage.

Key words — air pressure, AMBU bag, bag valve mask, Restoration mask, ventilator.

I. INTRODUCTION

Ventilators are important in human life. It gets its energy from a battery-powered electric motor that runs at 24 volts DC. The main goal of this article is to teach you about medical ventilation systems, microcontroller programming, how to build a ventilation system, how to control pressure with a setting key, how to control a gear motor, and how to control motor speed. Different functions are needed for breathing, such as pressure and the required amount of breaths per minute, which are regulated by a simple input board with buttons. In addition, it has a low-battery warning system as well as an assist control. This proposed ventilator concept costs \$150, but once commercial production is scaled up, cost savings will be realized, and it will be available for \$100 [1].

In terms of current ventilator technology, this piece of prototype is both cost and energy efficient. Based on the characteristics mentioned above, it can be considered a viable

alternative. To design the medical ventilation system, the project's criteria were first closely studied. This project's approach may be detached into two sections that are software and hardware applications. To determine future improvements, data was gathered from reference books and websites. The required components were obtained from the local market [2].

In the event that the lungs collapse, automated ventilation is desired for the diseases mentioned above. This prototype would assist a patient in inhaling and exhaling so that carbon dioxide and oxygen will be exchanged, and the patient will live with artificial respiration. The cost of ventilators, which are still in operation in most pre-village hospitals, is prohibitive. Poor nations seem to be reluctant to provide such facilities, and the reason for this is obvious: the high costs of accessing and using them. As a result, their upkeep is also an expensive company expense. Another issue in those developed countries is the attention of vital facilities in urban areas only [3].

Eight babies died of pneumonia due to a lack of ventilators in the hospital as a result of such a shortage in a Lahore region. This obviously demonstrates that there is a ventilator deficit in hospitals. As previously said, the high cost of commercially available ventilators is a significant cause of this shortage. As a result, such prototypes will alleviate cost-related issues in developing countries [4].

II. PROTOTYPE DESIGN

Although the ventilators used in today's emergency rooms are extremely practical and revolutionary, their acquisition costs are correspondingly high. Due to exorbitant costs, such innovatively sophisticated mechanical systems are prohibitively expensive for use in asset-poor countries. Furthermore, these ventilators are often brittle and powerless when used repeatedly, necessitating costly administration contracts from the manufacturer [6]. This has led to activities such as exchanging ventilators among emergency clinics and purchasing less reliable upgraded units in developing countries.

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As almost the first model was incorporated with the core concept of collecting documents of needed amounts of energy and forces, the single arm idea was the corner technique for BVM compression. It was done in order to predict the machine's functioning requirements. The devices are put constructed using four wooden components that are joined together with nails and wooden glue. The foundering wooden piece is used to secure them. The factual is modest to cut and attach [5].

Fig. 1. Block diagram of this work.

Fig. 2. Circuit diagram of this work.

On the vertical sheet, one hole was drilled, and on the opposite sheet, a larger hole was drilled. These two holes were drilled into it. The BVM's two ends were inserted into these two holes. There under BVM, wooden pieces were put to show assistance from the bottom. The top of the design was left exposed for element testing and inspection [7].

Even the first test was carried out in order to unlock the machine's performance criteria. The prototype's single arm system yielded useful information. The outgoing pressure difference from the BVM was measured using an analog airflow sensor. The motor's motion was altered in response to the pressure sensor's needed values. Based on these tests, it was determined that the highest amount of electricity necessary for the machine to work was 24 watts, as well as the highest torque was 0.75 newton meter. The greatest amount of fluid supplied each stroke was around 700mL. As a result, for huge mainstream for clinical circumstances, this

is sufficient [8].

As moveable elements were included into the enclosures, enhancements were made based on the fundamental correcting features and insights gained from the original solution of the device. The enclosure's proportions were enlarged to accommodate the iron arm's mobility in a more manageable manner. In addition, specific preparations were created for the microcontroller, battery, and motor. The upper half of the enclosure was constructed of clear acrylic, with holes drilled from the unit's side to house the LCD and buttons. Blocks erected for the purpose of support were also moved further beneath the Ambu. A potentiometer was also linked to the LCD, which could be used to raise the intensity of the display depending on the surroundings (shadow or sunlight) [9].

In the control layout, the ventilator was operated in three different modes. There were different modes: child, infant, and adult. Because various age groups had distinct breathing needs, the pressure and speed of each of those were variable. These specifications are listed in the table under [10].

TABLE I: AGE AND BREATHING

Age Group	Breaths per Minute (BPM)
6 month	30-40
10 year	17-23
Adult	12-18

By just pushing the appropriate mode button, the desired mode may be activated. If someone wishes to utilize the baby mode, they will need to modify the Ambo Bag as well. Because the backpacks for adults and newborns are varied [11].

To start the work, let's acquire a general overview of all of the elements we'll be using. It is critical to have complete knowledge of both hardware and software requirements. The following are the parts we're using Breadboard, Arduino Nano (ATmega328), 103 temperature sensor, LCD Display with header (16×2), adapter (AC to DC 12V), DC gear motor, button, beeper, and ventilation Set.

Fig.3. Gearing motor presentation curves.

It is a 16 MHz microcontroller board with a serial hardware port, 6 ADC inputs, 14 digital I/O pins and a power rating of 5 volts, based on the ATmega 328 microcontroller [12]. The main benefit of Arduino is that programmes, without having any hardware programming to graze the program, can be put straight into the device. Five steps to schedule an Arduino are known. A precise integrated circuit temperature measurement device has been utilized with the LM35 sensor. The LCD screen has been utilized to provide a large range of applications and is an electronic display module [13].

From the above curve we can get this equation (1).

$$Y=0.0096x+0.0057 \quad (1)$$

As the name indicates, the self-expanding bag spontaneously inflates without a gas supply. It is constantly inflatable, ready for use and portable as this is not reliant on on a compressed foundation for rise. The self-expanding bag has four parts: Oxygen supply, air supply, valve assembly and patient supply [14].

Fig.4. LM35 characteristic curve.

Fig. 5. AMBU bag.

When the bag is restored to compression, air is sucked into the bag via a one-way valve at either end of the bag. Small extension or protrusion to the oxygen intake situated adjacent to the air inlet can be connected to the oxygen tubes [15]. An oxygen line is not required for the bag to work in the self-inflating bag. It should only be attached if the child is raised with a combination of oxygen-enriched air instead of room air. Air passes via a mask or an endotracheal tube in the patient's departure from bag to baby. Self-inflated bags are placed between the bag and patient exit using a valve assembly [16].

In the case of newborns with backup for supplementary oxygen, the NRP recommended that room air recovery be started in the term if the baby doesn't improve, despite 90 seconds' efficient ventilation. As oxygen is regarded as a medication it must be carefully monitored in its usage in newborns. The usage of an oxygen reservoir can obtain high levels of oxygen with a self-expanding bag. A reservoir of

oxygen is an instrument that is fitted via the air intake of the bag. It has a high concentration of oxygen in a chamber [17].

A. Restoration Masks

Restoration masks occur in numerous formulas, dimensions and tools. The choice of a special mask for a certain child depends on how well it is appropriate for the face of the child. Reanimation masks feature either coiled or uncoiled rims. Non-cushioned masks are not soft and hence stiff, abrupt, and have either a soft, flexible substance, like foam or an air-inflated ring. Cushioned masks are constructed of a soft, flexible material like foam. Masks can be rectangular or circular.

Round: A round mask can achieve a ventilation screen. It may not fit above the nose and mouth properly when the mask is too small. The impact on the eye might be applied if the cover is excessively wide. Anatomically: Some masks are designed to match the facial contours. Such covers are known as masks in anatomical form. They are put on the face to the most points of the masks on the nose. A seal with an architectural mask is easy to achieve [18]-[25].

B. Security Features

There are some security topographies. In order to avoid excessive pressure from unintentionally coming into the lungs, two safety measures are included in resuscitation bags. Every neonatal resuscitation bag should include at least one of these two qualities. The first is a pressure release valve, often called a pop-off valve or a security valve. These valves are configured to discharge 30-40 cm of water. Thus, if pressures over that limit are created, the valve opens and avoids the transmission of the extra pressure to the child. The emergency valve can be covered momentarily to permit water pressure of above 40 cm [26]-[28].

This can be essential to ventilate the rigid, unrated lungs of a newborn, particularly during the first few respirations. A pressure gauge should be connected to any self-inflated bag that allows the pop-off valve to be circumvented. The second security function is a pressure gauge or manometer that measures the high pressure of inspiration.

TABLE II: COST BALANCE

Name	Quantity	Price in TK
Arduino Nano	1	300
Gear Motor	1	2500
2x16 LCD	1	200
24v step-down transformer	1	1000
Ventilation set	1	2000
Bridge diode	1	100
2200uf capacitor	1	50
7805 voltage regulator	1	30
AC Cord	1	50
470uf capacitor	2	50
Tip122 power transistor	1	50
Push switch and cap	3	20
Power switch	1	10
12v relay	2	20
Bd547 transistor	2	10
Project structure board	1	500
Temperature sensor		10
Total Cost		6900 TK (BD)

Some bag uses are here. For intermittent, positive pressure ventilation, maximum expiratory pressure in preterm newborns, judging necessary pressure before the baby is connected to the follower. There's a slight of a carrier misuse. Do not use the bag for the free flow of oxygen, high pressure can lead to pneumothorax, Long breathing with 100percentage oxygenation can cause adverse health effects for oxygen and bags must be avoided before esophageal evacuation and diaphragm herniation in meconium colored liquid [29]-[35].

III. RESULTS

The results and discussion of the calibration of needle valve is represented here. The position of the needle valve was adjusted, and the corresponding digital voltage and flow were recorded. In this work, the curve fitting is performed, and the equation relativity flow and digital voltage is obtained.

Fig. 6. Hardware part of the prototype.

The advantages of this work are simple-to-control, easy to use, nobody needs a medical specialist to run it, we can use it at home, cheap installation costs, dependable in an emergency.

IV. CONCLUSION

A prototype device is created in this study to help patients who can respire partly by themselves. This gadget has a basic and dependable design, which the sufferer may readily accept. This study focuses on reducing the components and enhancing device efficiencies, so that they feel as comfortable as the ordinary air conditioner when using this gadget for the patient. In this article needle valve, together with the potential meter, the flow analyzer is replaced to make the whole set-up economical. Because programming is easy, Arduino Uno panel has been utilized. The study led to the invention of the laboratory model fan. The device's operational model has been built. An imitation lung has been appeared. The model mechanism was operated by the breath and tidal volume medical representation, including the regulated arm and

batteries alarm. BVMs are widely accessible on the market, which is why their induction also has a favorable burden on subsequent proceedings. Work is also being proposed on several areas with the resultant results, including strategies to limit mortality to their lowest rate, reduction weight and prolonged battery life. A more productive use of alarms will be tested. During the last phase, testing was pushed to meet the requirements set for the ventilator to make the product competitive with the marketplace, for the reason of evaluating the ventilation on a lung model. In future, we will perfectly and safely build our task mode. To check everything with our smart phone, we also add GSM and pulse sensor.

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