A Review on Emergency Low Cost Ventilator

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Abstract— Coronavirus Disease 2019 (COVID-19) threatens to our medical infrastructure causing spikes in mortality rates because of shortage of critical equipment like ventilators. A key weapon in the fight against the rampaging novel coronavirus is the ventilator. Many ventilators are available but those are very costly so peoples are not capable to buy an expensive ventilator. Hence, we need to design a ventilator having less cost and must perform better operation as compare to other ventilators. This paper introduces an Emergency low cost ventilator, which for use in mass casualty cases and resource-poor environments. As it delivers breaths by compressing a conventional bag-valve mask (BVM) with a pivoting cam arm, eliminating the need for a human operator for the BVM. Its weight is about 1kg. It has user friendly input adjustment knobs. Helps to control air pressure. Its manufacturing cost is less than Rs.10,000. Through this prototype we achieve low cost, User friendly, Portable and Power saving ventilator technology.

Keywords: Ventilator, Low cost, BVM, Portable, COVID-19

I. INTRODUCTION

"The Emergency Low Cost Ventilator "is designed for the patients who require artificial air breath. some has respiratory diseases, improper functioning of lungs require this device. The worldwide medical community currently faces a critical shortage of medical equipment to address the COVID-19 pandemic. In particular this is the case for ventilators, which are needed during COVID-19 related treatment at onset, during the intensive care phase and during the very extended recovery times.

There is a wide spectrum of devices, ranging from highly classy through to simpler units useful in the milder phases of illness. Amid pandemic crisis in India we were motivated to furnish the local shortage of this medical equipment and develop some semi-automatic mechanical ventilator that could be used in emergency medical units in hospital as well as mobile medical units such as ambulances to provide emergency ventilation using an Ambu bag-based setup to patients affected with COVID-19.

The ventilator we here design and develop using Arduino, includes all these requirements to develop a reliable yet reasonable DIY ventilator to help in times of pandemic. We here use a silicon ventilator bag coupled driven by DC motors with 2 side push mechanism to push the ventilator bag. We use toggle switch for switching and a variable pot to adjust the breath length and the BPM value for the patient.

Our system makes use of blood oxygen sensor along with sensitive pressure sensor to monitor the necessary vitals of the patient and display on a mini screen. Also an emergency buzzer alert is fitted in the system to sound an alert as soon as any anomaly is detected. The entire system is driven by Arduino controller to achieve desired results and to assist patients in COVID pandemic and other emergency situations. A stepper motor is a type of DC motor that works in discrete steps. It consists of Arduino Uno, (NEMA17) Stepper motor, Stepper motor driver module (A4988), Potentiometer, LCD Display, Oximeter (Max30100), Pressure sensor (BPM180) Silicon Ambu bag. The output of pressure sensor and Oximeter sensor is analog. The Arduino digitizes this input voltage, converts it into milivolt and display it on LCD display. Then by controlling the potentiometer analog input given to Arduino which converts into digital form and given to motor driver module to control the movement of DC motor which supports the pumping of Ambu bag.

II. NEED OF PROJECT

Current projections estimate that up to 1 million ventilators are needed in the United States to manage the COVID-19 pandemic. Also the ventilators available in market are very costly and complicated in design. The common persons cannot afford those ventilators. For given circumstances, requirements that could be essential for the functioning of the movable ventilator are proposed as following points.

- Main focus of developing ventilator is providing ventilators to people at low cost.
- This uses less power supply for operation
- Easily relocate from one place to another place due to light weight
- Proximity of infection should be controlled.
- Spare parts should be easily available and have capability of easily repairable.
- No Professional operator requires.

III. RELATED WORK

Till now there are many ventilators developed for the patients which cannot be able to take normal breath. We design the ventilator for patients which works on pumping action of DC motor controlled by Arduino, and get sensed by the Pressure sensor and Oximeter. The following paper describes different types of Ventilator which are available in market.

While many ventilators are on the market, an adequate low-cost ventilator is lacking. A cost-performance distribution is depicted in Figure 1 with manually operated BVMs on the low end of cost and performance, and full-featured hospital ventilators on the other extreme. Research paper [3] explain it. The middle section of the chart includes the existing portable ventilators which can be broadly categorized as pneumatic and electric. Pneumatic ventilators are actuated using the energy of compressed gas, often a standard 50 psi (345 kPa) pressure source normally available in hospitals. These ventilators have prices ranging from Rs. 50,000-2,50,000. This category includes products

such as the VORTRAN Automatic Resuscitator (VAR™), a single patient, disposable resuscitator. However, these systems cost an order of magnitude more than our target price and depend on external pressurized air, a resource to which our target market may not have access.

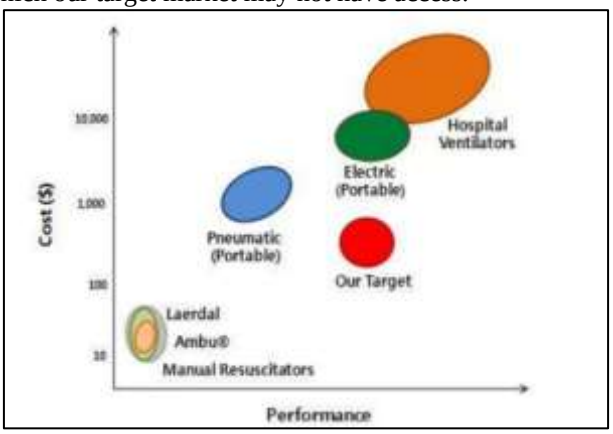

Fig. 1: Cost-performance distribution of ventilators

A unique design currently under development is the ARMEE Ventilator based off of carefully reconstructed Army design Without any moving parts the system controls air flow so that its output alternates between two pressure levels. Research paper [4] explains it with careful design the pressures, flow rates and cycle times can copy the output of a mechanical ventilator. This design available on GitHub being licensed a CERN Open Hardware License appears to be particularly amenable to digital fabrication. which is difficult to handle.

The United States Department of defense has also developed several rugged "portable electric ventilators". one such ventilator is the Johns Hopkins University applied physics laboratory mini ventilation unit which waits 6.6 lbs. (3 kg)measures 220 cubic inches (3600 cubic centimeter) and can operate up to 30 minutes on a battery which has featured with single knob operation but due to this tidal volume and breath rate cannot be controlled by user. Explained by research paper [7].

Researchers at Durgapur-based Central Mechanical Engineering Research Institute (CMERI) has indigenously developed a ventilator amid rising cases of COVID-19.The design, controllers. And embedded electronics of this ventilator have all been customized to ensure price efficacy as well as meeting the requirements of the relevant industries.

IV. PROPOSED WORK

In related work we see there is different technology used for designing a ventilator.

Human lungs use the reverse pressure generated by contraction motion of the diaphragm to suck in air for breathing. A contradictory motion is used by a ventilator to inflate the lungs by pumping type motion. A ventilator mechanism must be able to deliver in the range of 10-30 breaths per minute, with the ability to adjust rising increments in sets of 2. Along with this the ventilator must have the ability to adjust the air volume pushed into lungs in each breath. The last but now the least is the setting to adjust the time duration for inhalation to exhalation ratio. Apart from this the ventilator must be able to monitor the patient's blood oxygen level and Exhaled lung pressure to avoid over or under air pressure simultaneously to control breath rate.

The ventilator we here design and develop using Arduino encompasses all these requirements to develop a reliable yet affordable DIY ventilator to help in times of pandemic. We here use a silicon ventilator bag coupled driven by DC motors with 2 side push mechanism to push the ventilator bag. We use toggle switch for switching and a variable pot to adjust the breath length and the BPM value for the patient.

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AC Power supply is giving to device it is input of ventilator. Again this AC power supply is given to rectifier, which converts AC power supply into DC power supply. Then regulator is used to regulate the DC voltage. Regulator keeps the power level stabilized regulator is controls the voltage. The user interface consists of an LCD screen that allows the user to set the operating parameters of the device and start compression in less than one minute. During operation, this display also informs the user of the current Air pressure and blood oxygen level. The user can adjust the settings during usage of the device without shutoff. An emergency shut off button allows for immediate cessation of compression. Regulated voltage is given to the microcontroller again the microcontroller controls the movement of motor for pumping the Ambu Bag. Fig. 2 refers the block diagram of proposed ventilator.

The pressure sensor is used to major pressure on the Ambu bag. According to this pressure there is controlling action on motor taken by microcontroller. We can control the moment of Ambu bag by controlling the voltage supply by regulator. Blood oxygen sensor used to major blood oxygen level of patient input is given from blood oxygen sensor is displayed on LCD.

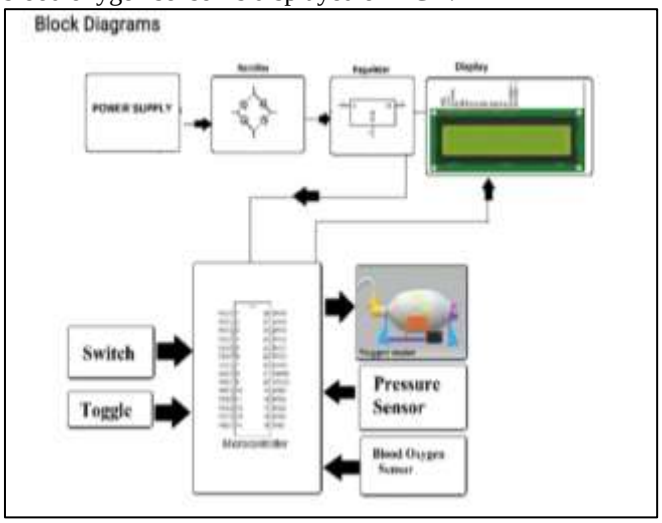

Fig. 2: Block diagram of Ventilator

The amount of oxygen, the patient receives can be controlled through a monitor connected to the ventilator. If the patient's condition is particularly fragile, the monitor will be set up to send and alarm to the caregiver, indicating an increase in air pressure. Also the Spo2 sensor connects to give info about oxygen level of patient, and also heart rate. No professional person is required to operate proposed ventilator. This ventilator has simple design which makes it easy to handle.

V. Device Design

A. Air Delivery Technique:

The main strategy was identified for the ventilator's air delivery system. Strategy delivers breaths by compressing an air reservoir that is Ambu bag. This approach was adopted as it eliminates the need for the continuous operation of a positive pressure source. This reduces power requirements and the need for expensive and difficult to repair pneumatic components. Where most emergency and portable ventilators are designed with all custom mechanical components, we chose to take an orthogonal approach by building on the inexpensive BVM, an existing technology which is the simplest embodiment of a volume-displacement ventilator. The main drawback with BVMs is their manual operation requiring continuous operator engagement to hold the mask on the patient and squeeze the bag. To eliminate this drawback, we design this ventilator.

B. Compression Machinery:

The most obvious means to actuate a BVM is to copy the hand motion for which the bag was designed. This requires the use of linear actuation instruments. Here we make a Cam arm (flipper like structure) to compress the Ambu Bag. This flipper like structure is connected with the shaft of DC motor. The Ambu bag is placed between two wooden blocks for support. This single flipper reduces the power consumption and was therefore the method of choice. This mechanism is shown in fig. 3.

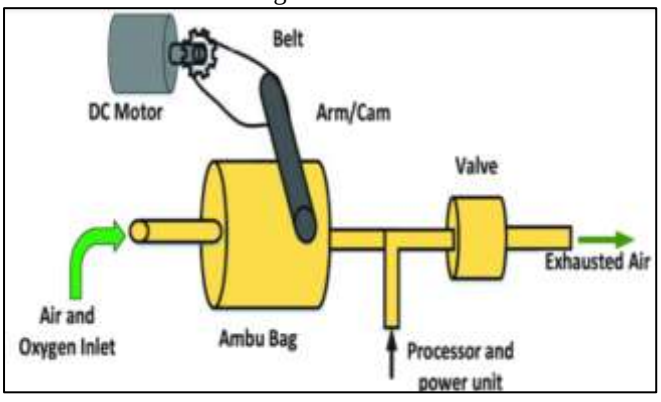

Fig. 3: Compression Machinery

C. Algorithm

This flowchart is given in fig. 4. Which shows the actual mechanism of working of ventilator? Which starts with start button? Then it receives the signal from microcontroller. Servo motor operates according to controlling signal of microcontroller. The cam arm is connected with servo shaft also starts to move. This all makes to compress the Ambu bag and deliver oxygen to patient.

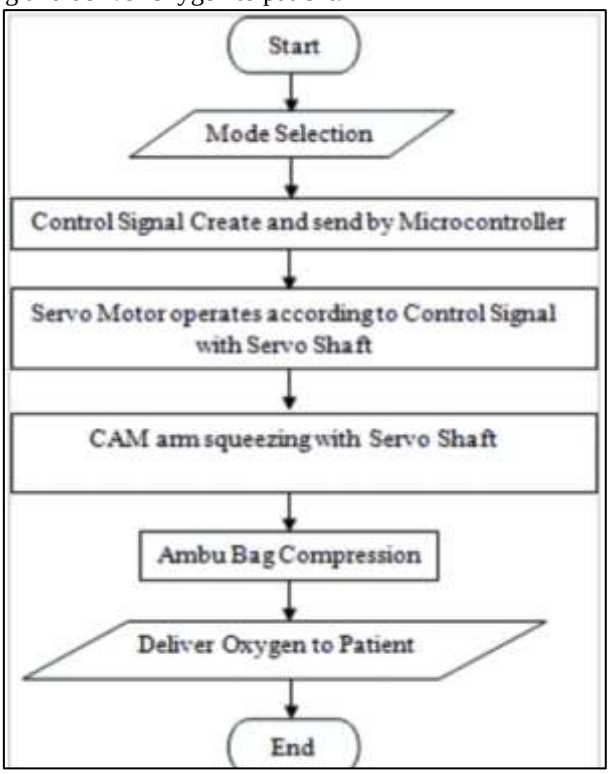

Fig. 4: Flowchart of mechanism

VI. Result

From above project we have successfully developed a Emergency ventilator for economic growth .Testing in volunteers with resistive and restrictive loads provided positive results on the feasibility of the ventilator prototype for application in humans. We successfully run this ventilator system.

VII. Conclusion

Based on the finding the study the following conclusion drawn. In this paper Emergency low cost ventilator has been developed this controlled by user. This ventilator is useful for covid-19 patients. Since the start of COVID19 pandemic, researchers have been striving to help society. Ventilators keep severely ill patients alive Future work is needed to achieve the potential of this approach not only on the technical side, but also by developing policies, updating regulations and securing funding mechanisms for the development and testing of open source ventilators for both the current COVID19 pandemic, as well as for future pandemics and for everyday use in low-resource settings.

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