Design and Development of Low-cost PositivePressure Portable Mechanical Ventilator

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Abstract— The COVID-19 pandemic has placed immense strain on global healthcare due to the sudden and excessive caseload burdens, compounded by insufficient access to the requisite supplies and equipment necessary to treat patients. This paper shows the development of a low-cost, open- source mechanical ventilator. Constructing a low-cost, open- source mechanical ventilator aims to mitigate the consequences of this shortage on those regions.

Keywords — COVID-19, low-cost Mechanical Ventilator, Portable ventilator.

1. INTRODUCTION

Ventilator or mechanical ventilator is a piece of equipment that assists the human who is undergoing an issue breathing by himself/herself, by replicating the action of breathing. The breathing action in humans is done by the downward movement of the diaphragm, this downward movement causes the negative pressure due to result of which the atmospheric air is sucked into the lungs. This action is roughly called negative pressure ventilation.

During old days to assist the human to breathe a system was made which consisted of a box and a powerful pump. The box used to cover the whole of human body except the head and was vacuum packed. A pump was attached to create a vacuum initially and then later on to create negative pressure and due to this negative pressure, any man/ woman using that system was able to breathe a little better. This procedure of ventilation is called negative pressure ventilation.

Positive pressure ventilation is quite the opposite of negative pressure ventilation. In positive pressure ventilation the process allows the patients to gain breaths and to reduce the work of breathing in acritically ill patient. The pressurized air or the breaths are delivered to the patients through the endotracheal tube or a tracheostomy tube. Positive pressureventilation has two semblances, one is non-invasive positive pressure ventilation (NIPPV) delivered through a mask which is air tight inside covering from nose to chin of the patient and the other is invasive positive pressure ventilation (IPPV) which is more or less bypassing the nose and mouth. IPPV system connects the pipe directly to the windpipe.

In this pandemic situation, due to the high transmissibility of the Coronavirus there was a sudden surge in the number of patients getting infected per day on the other hand this virus didn't had much mortality rate as more than 90 percent of the people were recovering from it rather than suffering life loss. As the Corona virus gets into a human body through nose or through mouth, firstly it replicates itself, then it attacks the lungs. Responding to such a fatal attack theimmune system tries to fight the virus but in turn causes damage to the alveoli of the lungs which causes ARDS (Acute respiratory distress syndrome). To curethe ARDS of the patients they need proper medication but along with it they also need assistance in breathing and for that purpose the mechanical ventilators are used.

Mechanical ventilation machines are widely used to help the patient assist in breathing. The major drawback these machines face is its robust mechanism

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and a very high cost. A situation where there is a need of more than thousands of mechanical ventilation machines it is very difficult to build and fabricate these machines under the given time. Even if we ignore the fact of its robust mechanism, we cannot ignore that it requires a very huge funding as an average ventilation machine costs around INR 500 thousand to INR 2 Million. To overcome such an issue, it was necessary to develop not only portable but low-cost ventilation mechanism.

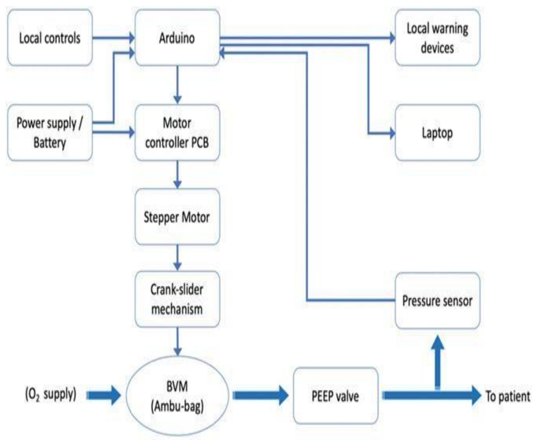


Fig. Block diagram of mechanical ventilator

2. WORKING

The working of the mechanism crucially depends upon two factors, namely, Software and Hardware. Here in we are using the Arduinouno microcontroller to actuate our hardware. Firstly, after the successful assembly of the necessary components, a power supply is connected to the unit as a source of electricity. In case we provide the AC power supply then we need to make sure that we connect a rectifier in series with it so that the system would not get damaged because of it.

A rigid structure is made which has enough strength and enough space so that it could hold all the required components of the system. The system's components include a silicon airbag which accumulates the air present freely in the environment, one end of the silicon bag is attached to the tube which is connected to the patients mouth also a one-way valve is present in between so as to make sure that the air goes in only one direction. The other end of the bag has a hole connected with again a one-way valve which makes sure that only air gets in through it.

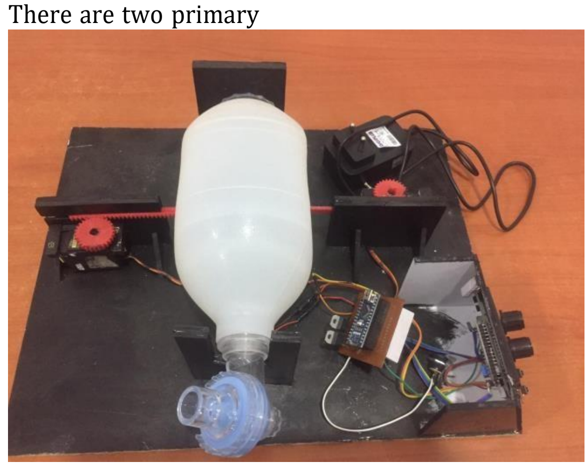
A stepper motor is fixed at the bottom of the structure which actuates the mechanism responsible for compressing and releasing of the silicon bag. This mechanism consists two couple of pinions connected to each other and extending a flat plate like structure used to hold the silicon bag from both the sides. The stepper motor is preprogrammed in such a way that it rotates in clockwise sense for some degree and then taking a minor halt of a second it will rotate counter clockwise with same degree to get back in original position.

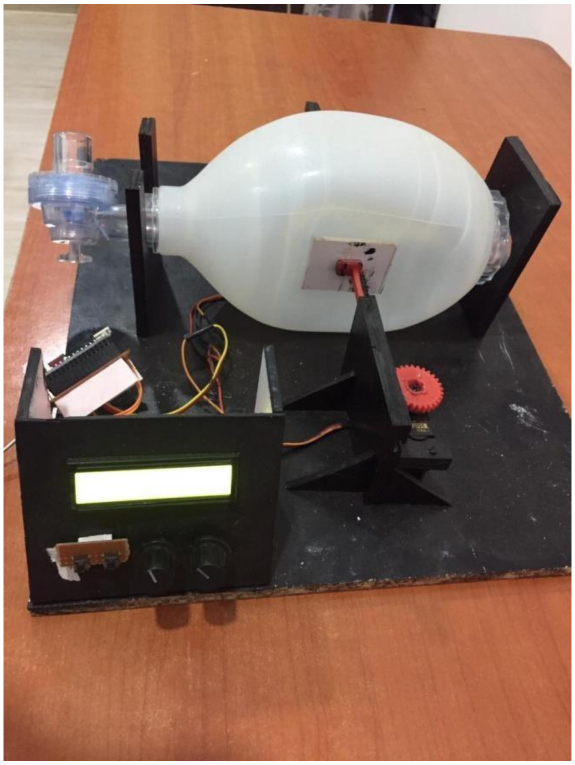
While the stepper motor makes a degree of rotation clockwise and counter clockwise, it actuates the mechanism responsible for compressing of the silicon air bag as a result of which the bag compresses pushing the air contained in it to the lungs of the patient and decompresses to fill itself back up.

As an extension to this, an LCD and a buzzer can also be used to indicate the breath per minute, oxygen level and sugar level of the patient and as the vitals go down the buzzer buzzes alarming the caretakers about the situation.

VENTILATOR REQUIREMENTS AND SPECIFICATIONS

Clinical ventilators are very complex systems with many sophisticated ventilation modes and closed-loop control abilities, much more than we sought to replicate in the VOV, and we consciously made the decision to prioritize a minimum viable ventilator with the necessary functionality to meet the immediate emergent potential needs during the pandemic. Through many conversations between clinicians and engineers, we arrived at the following understanding of what it is required to ventilate COVID-19 patients. Dynamics of Mechanical Ventilation Clinical mechanical ventilators operate by the principle of intermittent positive-pressure ventilation (IPPV), wherein the patient's lungs are inflated by applying positive pressure to the airways. There are two primary





modes of IPPV: Volume Controlled Ventilation (VCV) and Pressure-Controlled Ventilation (PCV). As the names imply, VCV operates by modulating the volume of air delivered tothe lungs, whereas PCV modulates the airway pressure. The VOV described in this article provides ventilation by compressing an Ambu bag by a programmable amount, implementingthe VCV paradigm.

Challenges of pulmonic Health observance the most objective of a pulmonic health observance system is tosee whether or not the processed knowledge comes from healthy or unhealthy lungs. Faults of any type within the equipment's operation ought to even be classified as unhealthy condition. Classifying whether or not the info comes from a healthy or unhealthy condition is significant for the patient's safety.

A. Hardware Contain Two Servo Motor One Ambulatory Bag Arduino Microcontroller Two Potentiometer Two Push Button Power Supply and LCD Display.

B. Here Are Two Push Button For Start And Stop Servo When Start Servo Motor Moves Linear Motion To Pump Ambu Bag Which Pump Oxygen We can Control Supply Through Arduino Microcontroller On LCD Display Can Monitor RPM Rate And Pump Can Adjust with Potentiometers.

3. CONCLUSIONS

Since the beginning of the COVID-19 pandemic, researchers are attempt to assist society face several issues caused by this pandemic. Among the recent initiatives, one has drawn the authors' attention: manufacturing low-priced, mechanical ventilators. The motivation comes from the worldwide shortage of mechanical ventilators within the treatment of COVID-19 patients—mechanical ventilators keep severely sick patients alive. This paper contributes to the present initiative.

This paper has detailed the construction of a functional, low-cost, and open-source mechanical ventilator. The authors' contribution to this topic aims to mitigate the effects of this worldwide ventilator's shortage shocking, unfortunate event that hits hard deprived areas.

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