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VENTILATOR FOR COVID PATIENTS

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Abstract:

The need and necessity for ventilator has been increasing due to the outbreak of covid. To overcome the shortage of these devices, there is no solution yet that can help in fulfilling this requirement. So in this work a ventilator is designed along with the measurement of health parameters like pulse rate and SPO_2 levels. Here in this work a prototype device is designed to give artificial breathing to the patient before he reaches the hospital during epidemic emergencies. The designed device uses a stepper motor that applies pressure on an air sack (BVM bag), there by pushing oxygen-concentrated air into the lungs. When the stepper motor comes back to its earlier position, it results in pressure being released from the air sack, making it to retain in its original shape. The procedure used is similar to breathing in and out manually which helps to give oxygen to the lungs. The entire ventilator mechanism of respiration should be in synchronous with a patient's normal respiratory rate. This is achieved by changing the speed of the stepper motor using the program. The sensor used here gives the values of pulse rate and oxygen levels of the patient which are displayed on the Liquid Crystal display (LCD).

Keywords: Ventilator, air sack, pulse rate, oxygen level, synchronous.

INTRODUCTION

Ventilator is a pneumatic and electronics system designed to monitor, assist or control pulmonary ventilation and respiration intermittently or continuously. It is used to control human body oxygen levels, during surgery where blood loss can result in hypoxia or lack of sufficient oxygen in the patient´s body which is best to have less human interaction. Mechanical ventilator is designed to maintain an adequate exchange of gases, even though diminished breathing rates and reduced myocardial use is found. However, it is also used to provide adequate lung expansion with the correct combination of anaesthetic sedation for muscle relaxing and to stabilize the thoracic wall. The respirator is made of a compressed air reservoir to fill air and oxygen supplies, a set of valves and tubes and a disposable or reusable tank. The air reservoir is pneumatically compressed several times a minute to deliver room-air or in most cases an air/oxygen mixture. The lungs elasticity allows releasing the overpressure which is called passive exhalation and the exhaled air is released usually through a one-way valve within the patient circuit. The oxygen content of the inspired gas is set from 21 percent (ambient air) to 100 percent (pure oxygen). This reference design simulates basic human lung behaviour. It is easy to test different pulmonary therapies without connecting a lung to the device. The objective of this development platform is to showcase free scale product capability while developing a ventilator. It represents a complex application where accurate measurement, correct instrumentation, power manager and signal integrity are a critical factor for correct operation of a machine which a human life may depend on.

Literature Survey

In this paper the designed mechanical ventilator will make the alarm ring when over pressure is detected. The arm movement maintains air flow with controlled volume of 500-600 ml with a continuous working with 12 RR/min that is sufficiently high for a Pneumonia Patient [1].

In this design the Solenoid values found in traditional ventilators with 2/2 (two –part) are replaced with values that operate in binary mode to allow or prevent flow of oxygen and air [2]. A research [3] produces a control and monitoring system for a mechanical ventilator. The mechanical ventilator consists of a gripper motion mechanism driven by a dc motor. The motion of the gripper creates pressure and releases pressure on an ambu bag. The depth of pressure exerted by the gripper is measured as the volume and pressure of air delivered to the lungs. The rate of pressure exerted is measured as the velocity of air flowing into the lungs. The control and monitoring system uses Arduino components as the main control. The Bluetooth based android application chosen is Virtuino, because it has a user-friendly interface and can work efficiently with Arduino to control and monitor variables on the ventilator via smart devices. Arduino is programmed to interact with the Virtuino application. The bluetooth module, alarm, air pressure sensor, blood oxygen level sensor (SpO2) and speed sensor will be connected directly to Arduino. In this work [4] a low cost ventilator with 8 sensors are used for data acquisition and is fetched over cloud to give a real time visualization over a mobile app.

In this work [5] a numerical approach was used to monitor the pulmonary condition where the pressure measurements from the limb was taken and a real time alert is sent to the clinician. In this paper [6] an interim guidance on contact tracing, testing in lab, prevention of infection and its control for the health of the public along with implementation of vaccination is studied. In this paper [7] the impact of covid pandemic on the services offered by the hospitals and the need for strategic plan is studied. In this study [8] the quality need of ventilators for children & adults in US hospitals was studied. In this paper [9] the surge for the next pandemic due to flu & influenza and how the hospitals must be prepared is discussed.

Proposed Methodology

The low cost ventilator uses a traditional bag-valve-mask (BVM) which operates with a motor belt connected to motor driver without the human intervention. The motor driver moves the arm clock wise and anti clock wise for automatic air flow with controlled pressure. The movement done by fingers manually is replaced by a automated mechanism in which a stepper motor is operated using a program written in Arduino.

The automatic arm gives the BVM compression required for movement. The BVM automatically moves and presses the BVM to pump oxygen for patients suffering from pneumonia. BVM mask has artificial breathing oxygen reservoir bag and has an option for oxygen cylinder. As there is no cylinder, natural oxygen from air is taken by BVM mask. The compressions in BVM mask take place due to lead screw mechanism which gives pressure by moving front and back. A part from BVM, a oxymeter sensor is used which measures pulse rate and SPO_2.

The pulse oxymeter has red and infrared light which measures Spo_2 levels when the finger is placed inside. The light having two wave lengths are sent through the finger to measure these parameters in the body, which are displayed on LCD. Low levels of blood oxygen results in abnormal circulation, which results in shortness of breath, chest pain, high BP, headache etc.

The normal value of Spo_2 is 95% and for patients with chronic lung problems it will be 90%. An ideal Spo_2 level is 96% and 99% and ideal heart rate is 50 and 90 beats per minute (BPM).

When accident occurs the first important thing is, air is given for lungs to have proper breathing.

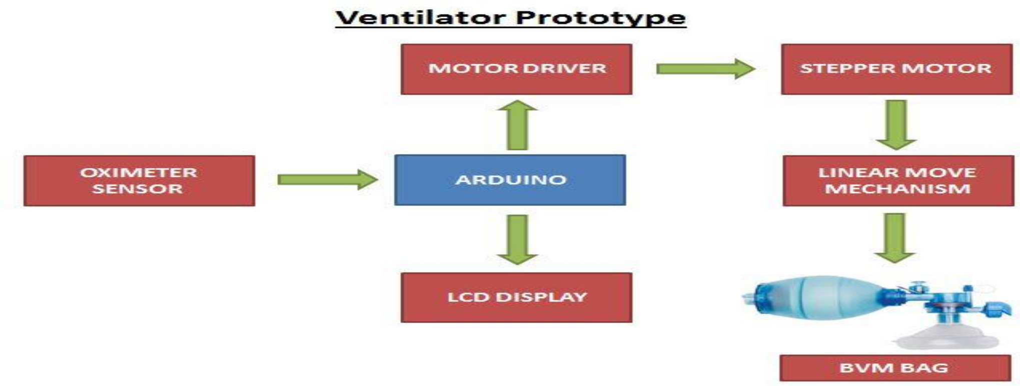

Fig 1. Block diagram

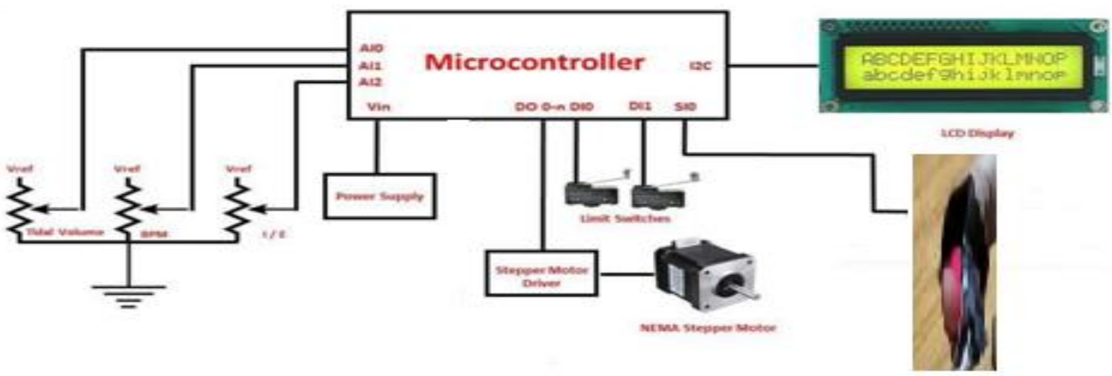

Fig 2.Circuit diagram

The designed ventilator has several parts consisting of: mechanical hardware consisting of a gripper mechanism which is driven by a DC motor. The gripper functions to apply pressure to the resuscitator bag to provide inspiratory and expiratory pressure. The mechanical design uses a Gripper model that can apply pressure to an resuscitator bag.

BAG VALVE MASK

In BVM ventilation, a self-inflating bag (resuscitator bag) is attached to a nonrebreathing valve and then to a face mask that conforms to the soft tissues of the face. The opposite end of the bag is attached to an oxygen source (100% oxygen) and usually a reservoir bag. The mask is manually held tightly against the face, and squeezing the bag ventilates the patient through the nose and mouth. Unless contraindicated, airway adjuncts such as nasopharyngeal and/or oropharyngeal airways are used during BVM ventilation to assist in creating a patent airway. Positive end expiratory pressure (PEEP) valves should be used if further assistance is needed for oxygenation without contraindications to its use. If bag-valve-mask ventilation is used for a prolonged period of time or if improperly performed, air may be introduced into the stomach. If this occurs and gastric distention is noted, a nasogastric tube should be inserted to evacuate the accumulated air in the stomach.

Manual resuscitator cause the gas inside the inflatable bag portion to be force-fed to the patient via a one-way valve when compressed by the rescuer; the gas is then ideally delivered through a mask and into the patient's trachea, bronchus and into the lungs. so as to be effective, a bag valve mask must deliver between 500 and 800 milliliters of air to a traditional male adult patient's lungs, but if supplemental oxygen is provided 400 ml should be adequate. Squeezing the bag once every 5 to six seconds for an adult or once every 3 seconds for an infant or child provides an adequate vital sign (10–12 respirations per minute in an exceedinglyn adult and 20 per minute in a child or infant). Professional rescuers are taught to make sure that the mask portion of the BVM is correctly sealed round the patient's face (that is, to confirm proper "mask seal"); otherwise, pressure needed to force-inflate the lungs is released to the environment. this can be difficult when one rescuer attempts to take care of a mask seal with one hand while squeezing the bag with other. Therefore, common protocol uses two rescuers: one rescuer to carry the mask to the patient's face with both hands and focus entirely on maintaining a leak-proof mask seal, while the opposite rescuer squeezes the bag and focuses on breath (or tidal volume) and timing. An catheter (ET) may be inserted by a sophisticated practitioner and might substitute for the mask portion of the manual resuscitator. This provides safer airway between the resuscitator and also the patient, since the ET tube is sealed with an inflatable cuff within the trachea (or windpipe), so any regurgitation is a smaller amount likely to enter the lungs, then that forced inflation pressure can only move into the lungs and not inadvertently move to the stomach (see "complications", below). The ET tube also maintains an open and secure airway in the least times, even during CPR compressions; as hostile when a manual resuscitator is employed with a mask when a mask seal will be difficult to take care of during compressions.

Fig 3: Position of BVM mask

RESULTS AND DISCUSSION

This section presents experimental data and discusses their implications for patients' treatment.

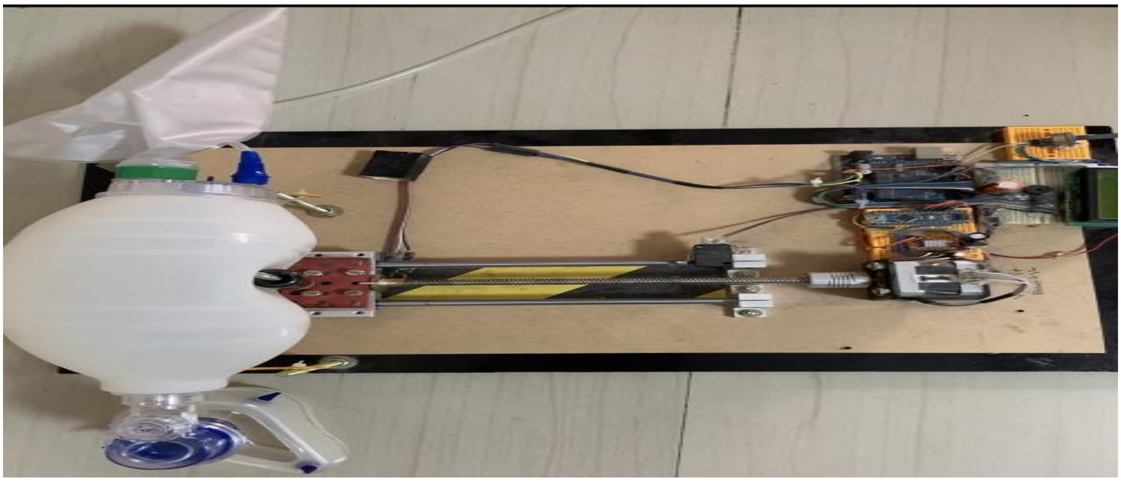

Fig 4: Prototype development board

The low cost ventilator uses a traditional bag-valve-mask (BVM) which operates with a motor belt connected to motor driver without the human intervention.

The motor driver moves the arm clock wise and anti clock wise for automatic air flow with controlled pressure. The movement done by fingers manually is replaced by a automated mechanism in which a stepper motor is operated using a program written in Arduino.

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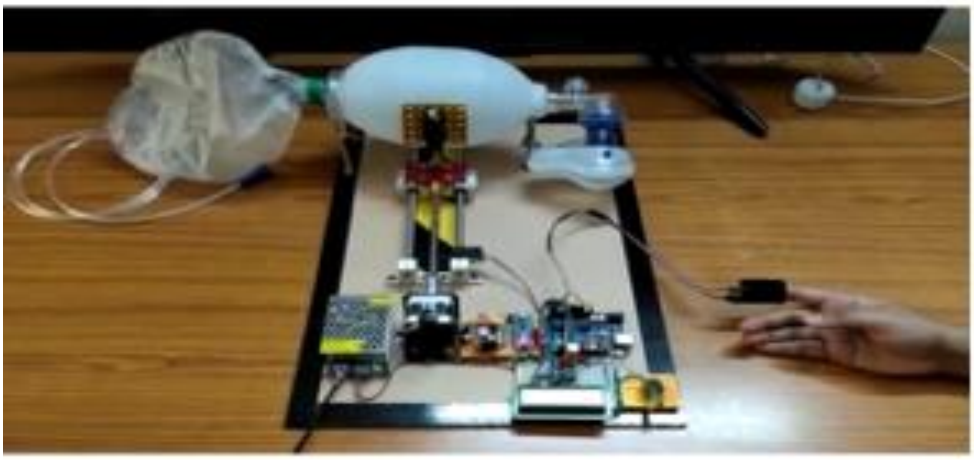

Fig 5: Pulse oximeter placed on finger

The pulse oxymeter has red and infrared light which measures Spo_2levels when the finger is placed inside. The light having two wave lengths are sent through the finger to measure these parameters in the body, which are displayed on LCD. Low levels of blood oxygen results in abnormal circulation, which results in shortness of breath, chest pain, high BP, headache etc.

The normal value of Spo_2 is 95% and for patients with chronic lung problems it will be 90%. An ideal Spo_2 level is 96% and 99% and ideal heart rate is 50 and 90 beats per minute (BPM).

Fig 6: Readings of Pulse rate and spo2 displayed on LCD

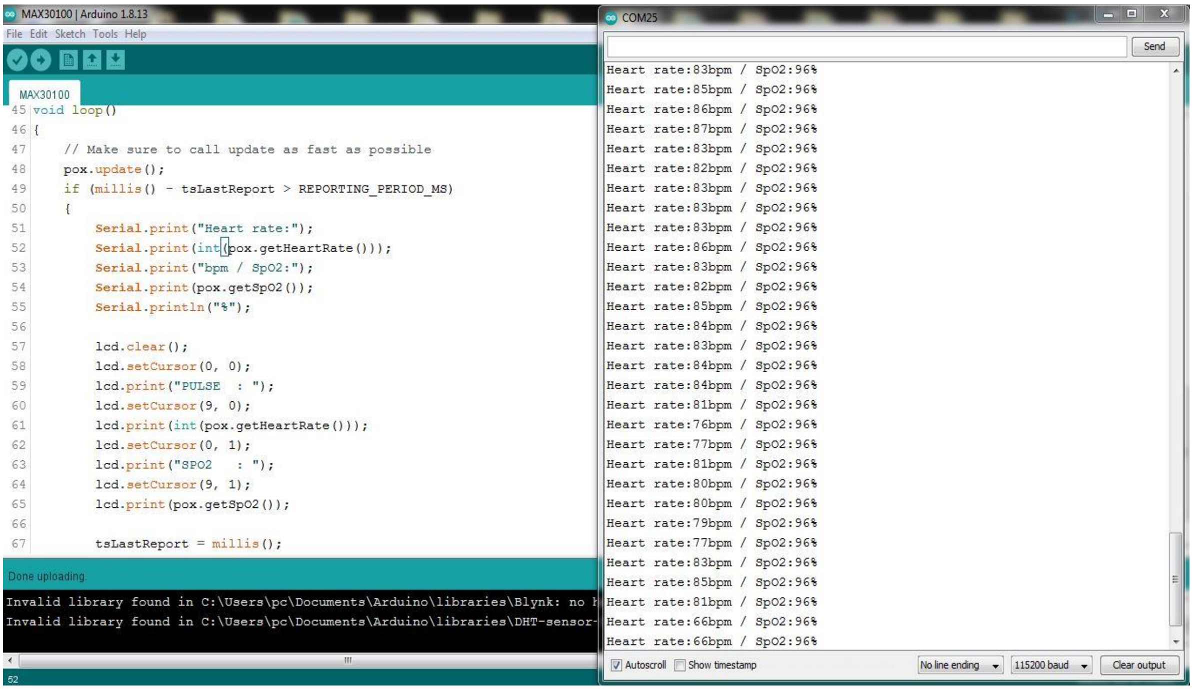

Fig 7: Results on Serial Monitor

The calculations show that 12 RR/min is needed for required amount of tidal volume.

Future scope:

To minimise adverse interactions between lung pathology and ventilatory settings that promote VILI requires two distinct strategies, according to the authors. "On one side, decreasing the inspiratory (and possibly the expiratory) mechanical power and damaging strain should decrease VILI; and on the other, steps to increase lung homogeneity should decrease the likelihood of injury." The best available manoeuvre to encourage mechanical homogeneity, supported by solid pathophysiological background and proven clinical results, is prone positioning for those patients in whom inhomogeneity is prevalent (moderate-severe and severe ARDS), the authors add.

In this project adding more parameters like vital sign, ECG etc. Making the system integrate with internet and the system in order that doctors can access from remote location. Making the system cheaper in order that the scarcity of ventilators in India will be removed.

Conclusion:

Ventilators are devices that support a person's breathing if they are experiencing respiratory failure. There are different types of ventilators, including non-invasive and invasive, that provide varying degrees of support. Demand for ventilators has increased due to COVID-19. It can take time to recover from being on a ventilator. So, in this work a novel approach of ventilator is designed along with the measurement of health parameters like heartbeat and SPO2 levels.

This research produces a control and monitoring system for a mechanical ventilator. The mechanical ventilator consists of a gripper motion mechanism driven by a dc motor. The motion of the gripper creates pressure and releases pressure on an resuscitator bag. The depth of pressure exerted by the gripper is measured as the volume and pressure of air delivered to the lungs. The rate of pressure exerted is measured as the velocity of air flowing into the lungs. The control and monitoring system uses Arduino components as the main control.

In conclusion, the paper says a possible pathway towards "improved" mechanical ventilation for a future patient would consist of the following steps:

- Define excessive strain and mechanical power, normalised for lung volume.
- Measure/estimate lung inhomogeneity to assess the prevalence of stress raisers and the distribution of mechanical power/stress–strain.
- Determine whether a given ventilatory set applied to the lung parenchyma of which the mechanical characteristics are known is associated with risk of VILI and how much.
- If a mechanical ventilation set cannot be found to avoid an excessive risk of VILI, alternative methods (as the artificial lung) should be considered.

REFERENCES

1. Abhishek Pandey,Aradhya Juhi et-al .2021. An introduction to low cost portable ventilator design-International conference on advance computing and Innovative technologies in Engineering, IEE Xplore - 20 -04-2021.
2. Anovel ventilator design for covid-19 and Resource –limited setting –Michael made Kurozwal et-al.

3. IoT Enabled Ventilator Monitoring System for Covid-19 Patients -Mashoedah et al 2021 J. Phys.: Conf. Ser. 2111 012035
4. Design and Development of an IoT based Smart Ventilator Siemens Centre of Excellence in Manufacturing National Institute of Technology, Tiruchirappalli
5. Low-Cost, Open-Source Mechanical Ventilator with Pulmonary Monitoring for COVID-19 Patients- Leonardo Acho , Alessandro N. Vargas, and Gisela Pujol-Vázquez Actuators 2020, 9, 84; doi:10.3390/act9030084
6. World Health Organization: Critical preparedness, readiness and response actions for COVID-19: interim guidance, 7 March 2020. (No. WHO/COVID-19/Community Actions/2020.1). World Health Organization. 2020.
7. Zhang X, Meltzer MI, Wortley PM: FluSurge--a tool to estimate demand for hospital services during the next pandemic influenza. Med Decis *Making.* 2006; **26**(6): 617–623.
8. Rubinson L, Vaughn F, Nelson S, *et al.*: Mechanical ventilators in US acute care hospitals. Disaster Med Public Health Prep. 2010; **4**(3): 199–206
9. Huang HC, Araz OM, Morton DP, *et al.*: Stockpiling ventilators for influenza pandemics. Emerg Infect Dis. 2017; **23**(6): 914–921.