Valle-inspiron - A Low-cost Frugal Ventilator for Emergency COVID19 Patients

Designed and Developed by team of engineers with support from Innovation, Incubation & Entrepreneurship Development Centre (IIED Centre), National Institute of Technology Srinagar and GVEI Tinkering Lab

Committed to serving society through innovations, an emerging response system was generated by the Innovation, Incubation and Entrepreneurship Development Centre (IIEDC) of NIT Srinagar due the current pandemic which has affected millions of people globally and caused thousands of deaths. The centre assisted three enthusiastic engineers of the valley to undertake the design and development of low-cost frugal ventilator prototype, to meet the increasing demand for low-cost effective ventilators. Two alumni and one PhD student of NIT Srinagar had joined hands to meet the challenge for developing a ventilator using locally available materials and parts and have successfully designed and developed a prototype of a ventilator, *named as Valley-inspiron*. The two engineers are presently working as Assistant professors in the Department of Electronics and communication, Institute of Technology (IOT), the University of Kashmir.

Prior to this project, the centre had also successfully organized COVID-19 open idea challenge, designed, fabricated and distributed 100 PPEs to local hospitals at a cost of Rs.47,500 and assisted a team in design & development of Ruhdaar frugal ventilator at IUST.

The Valley-inspiron ventilator project is financed by the IIED centre and is also assisted by a few others. The project was undertaken despite strict lock-down conditions and non-availability of materials and components, which were subsequently arranged from different sources and disassembling obsolete pieces of equipment. Since NIT Srinagar was converted into a quarantine centre and the centre was unable to obtain curfew passes for the team, the trio decided to undertake this project at tinkering lab of Green valley school situated at Ellahi Bagh, and used many of the lab facilities such as 3d printer etc. The ventilator presently is in the testing phase and only after obtaining the final approvals from the medical fraternity, it would be taken to the next stage of manufacturing. Local industry has offered support to produce it in large volumes and supply it to local hospitals.

The worldwide medical community currently faces a critical shortage of medical equipment to address the COVID-19 pandemic. In particular, that is the case for ventilators too, which are needed during COVID-19 related treatment at the onset, during the intensive care phase and during the much-extended recovery times. Companies are scaling up production, but this will not be sufficient to meet the demand according to the current forecast. Amid the pandemic crisis in India, there was a need in the erstwhile state of Jammu & Kashmir to cater to the local shortage of this medical equipment and develop a somewhat semi-automatic mechanical ventilator that could be used in emergency medical units in hospital as well as mobile medical units such as ambulances, in order to provide emergency ventilation requirements to patients going to a milder phase of COVID illness. The unit is designed to support standard ventilator modes of operation, most importantly PRVC (Pressure Regulated Volume Control) mode, SIMV-PC (Synchronised Intermittent Mandatory Ventilation); and in addition, a basic mode of operation: CPAP (Continuous Positive Airway Pressure). The unit is not yet approved medical device and is in the concept and prototyping stage. There is a war-footing plan to test the unit by simulation models initially followed by human testing before delivering it to the hospital for patient use.

Conceptual Design and working

The targeted modes of operation, as explained above, are principally SIMV and CPAP along with PEEP. The design has the patient safety built-in as a priority so that all failure modes revert to a situation which prioritises patient safety. In particular, if the patient stops breathing in pressure support mode, the ventilator switches automatically onto mandatory ventilation. The conceptual schematic is shown in figure 1. The unit takes as input the standard compressed or mixed air supply available in hospitals, in such a way that one supply could be connected to several units. It is expected that typically the pressure supplied with button feature will help the patient to catch the attention of the doctor in case of emergency.

The connections presented by the unit to external input/outputs will follow hospital standards. The supply pressure is reduced by a pressure regulator to approximately 200 mbar. The system concept is based around a buffer volume (ambulator bag) of approximately 2 litres. The filling of this buffer is controlled by the input valve (valve in). By controlling the opening time, one can achieve the desired target pressure in the buffer after which the valve (valve in) is shut. This buffer filling occurs during the expiratory part of the breath cycle. If the buffer pressure is within tolerance of the required pressure, the output valve (valve out) is then opened, initiating the respiratory cycle. The respiratory rate, inspiratory time (corresponding to the open time of valve out) and pause time are all controllable. If a PEEP pressure is set, then the pressure in the lungs will have the minimum of the PEEP pressure. In the case where the tidal volume is not achieved at a particular pressure setting, due to changes in the patient's airway resistance this can then be gradually adjusted.

Figure 1: Propose Ventilator Conceptual design

SIMV mode will allow the patient to take spontaneous breaths, and will assist the breathing when the spontaneous breath is taken. This mode uses an additional sensor for the detection of the negative pressure initiated by the patient breath. If the patient respiratory rate does not achieve the target value, additional mechanical ventilation is provided by the unit. During the operation all the parameters are measured and displayed using a suitable indicator panel (operator pannel) which comprises an OLED display panel. The operator panel besides having necessary on off switches has emergency call

Specifications:

- The proposed ventilator is designed with following specifications:
- Working Pressure: Up to 50 cm H2O.
- Operation modes: PRVC, SIMV-PC, CPAP, as defined above.
- Exhaust mode: PEEP available with a set range between 0 and 5 cm H2O.
- Minute volume flow capability: Up to 20 litres/min.
- Inspiratory flow capability: Up to 120 litres/min.
- Respiratory rate: 10–30 breaths/min.
- Inbuild UPS functioning feature.
- Low battery feature for Inbuild UPS
- Minimum calibrated air supplying capacity per stroke : 100 ml
- Maximum calibrated air supplying capacity per stroke : 600 ml
- Lung Pressure, Air moisture/humidity, Temperature measurement.
- Ability to be connected to monitor to display various vital waveforms of patient.
- Ability for monitoring of various vitals graphically using android platform(phone).

The Technical Team.

Rouf ul alam Bhat received B.Eng. Degree in CE from University of Kashmir in 2007, M .Tech Degree in Communications & information tech. **From Dept. Of ECE NIT Srinagar,** India in year, 2010. He is currently a Research Scholar in the Department of Electronics &IT at University of Kashmir,pursuing PhD in Flying robotics and IOT.He is working as assistant professor in the Dept. Of Electronics engineering, Institute of Technology,University of Kashmir, Srinagar, India.His main research interests lie in low cost automation,robotics,image processing.He has published his work through various research papers and patents.He has got various innovation awards and accolades at various platforms.He is a serial innovator with a long list of innovations in social and agriculture categories.

Liyaqat Nazir is working as Lecturer in the departmentof Electronics and Communication Engineering at UoK, Hazratbal. He has obtained his **PhD from National Institute of Technology Srinagar.** His work focuses specifically on the designing reconfigurable hardware-based architectures. His main research interests include Network on-chip, Digital VLSI design, Mixed-signal design, RF IC Design, Reconfigurable architectures, Architectural and technology-dependent optimizations targeted for FPGA platforms, etc. He is a member of IEEE. He is also a lifetime member of IETE.

Afshan Amin Khan received B.Eng. Degree in ECE from Islamic University of Science and Technology, India in year, 2011 and M .Tech Degree in ECE from Lovely Professional University, India in year, 2014. He is currently a **Research Scholar in the Department of CSE at National Institute of Technology, Srinagar, India.**

The Coordination & Supportive Team

The project was supported and financed by the Innovation, Incubation and Entrepreneurship development centre (IIEDC) of National Institute of Technology Srinagar, headed by Dr. Saad Parvez, who coordinated the project and continuous provided logistic and moral support to the team.

The Chairman Mr.M.Y.Wani and other school officials of the Green Valley Education Institute , Ellahi Bagh Srinagar, offered all their support for allowing the team to work in the school's tinkering lab for long hours and use its facilities, despite lockdown conditions.

Dr Talib Khan, Associate Professor, Perioperative Medicine Anaesthesiology, SKIMS medical Institute provided many useful inputs to the team from medical perspective which were incorporated in the ventilator. He has promised to perform tests and trial runs at SKIMS hospital before the design is selected for mass manufacturing.

Mr. Abdul Hamid, CEO Rahim Greens coordinated and provided logistic support as and when required and is committed to mass produce the ventilator

at his own expenses, after successful testing and approvals of the ventilator from the SKIMS ethical board is obtained. He also would supply 20 ventilators to different hospitals of Kashmir free of cost.

The team is also thankful to many other persons who directly or indirectly supported the project.

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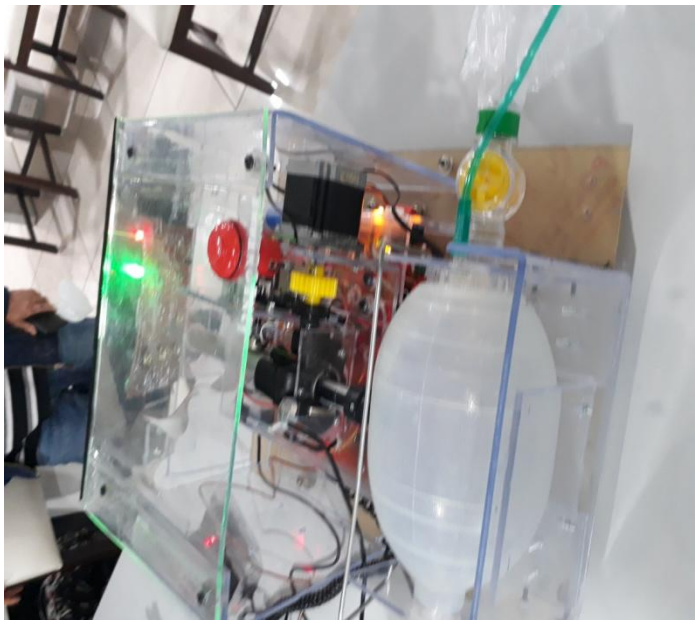
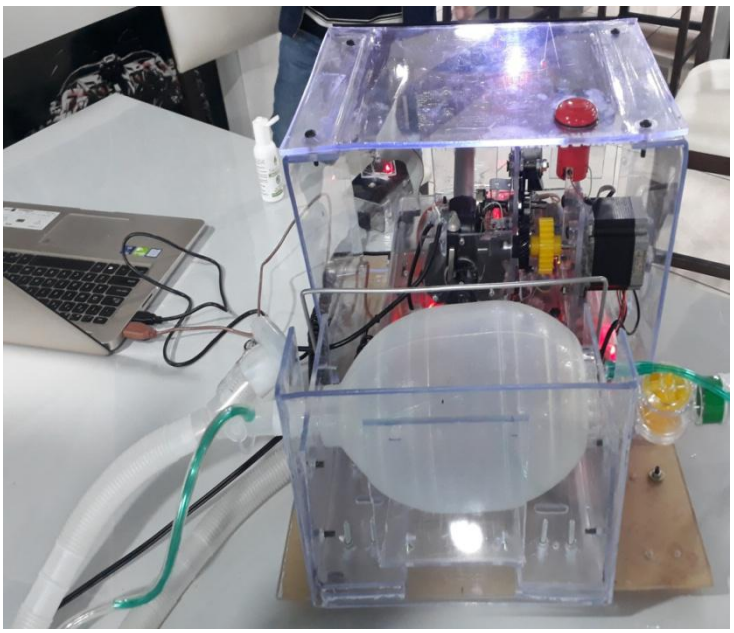
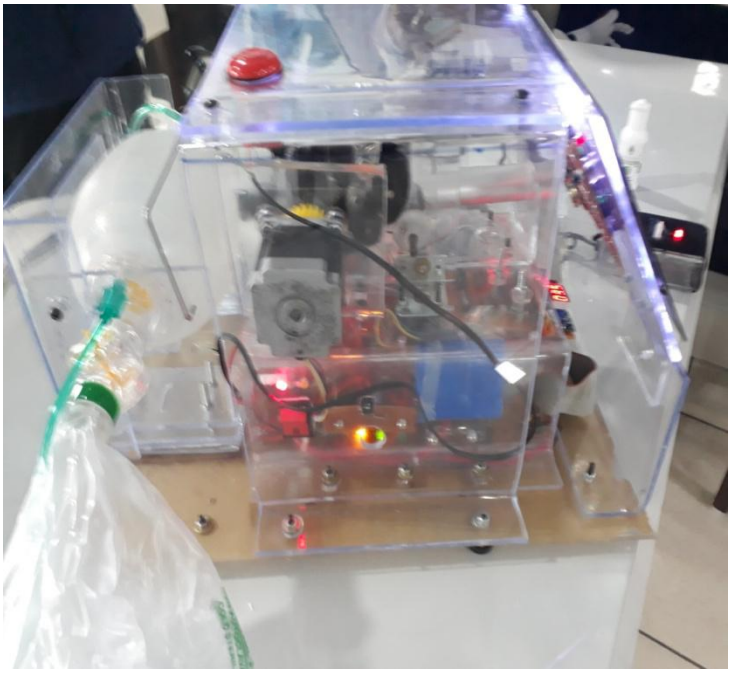
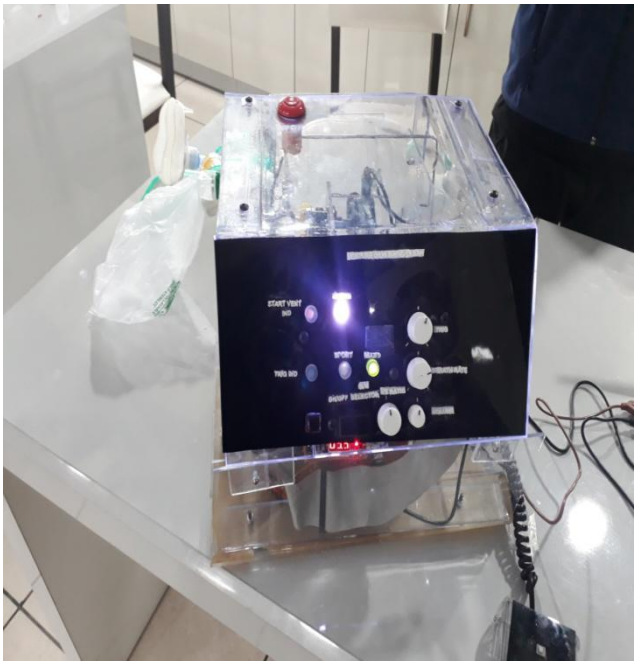
Photos of Valley-vent ventilator










I AM AN INNOVATOR