Designing, Prototyping, and Testing a Novel, Portable, Energy Efficient, 3D Printed Ventilator With a Diaphragm Mimicking Membrane and an Intuitive User Interface

Brar, Harjaisal (School: Stockdale High School)

During Phase 1 (2020-2021), a 3D printed ventilator was created with a modular design that could use multiple power sources to mitigate the shortage of ventilators during the COVID-19 pandemic. Phase 2 (2021-2022) focused on modifying the 3D printed ventilator to improve the portability, power efficiency and user interface. To achieve these goals, a new, improved design with the incorporation of membranes was created using Fusion 360. It was then printed and assembled. Since it did not have bellows and did not require compression, it was likely more energy efficient. The ventilator was controlled through an intuitive user interface built using React, Node.js, Python, and C++ which allowed wireless control through an easier-to-use GUI. Testing was done with a commercial test lung and a spirometer on four simulated model patients. Tidal volume (TV) and respiratory rate (RR) were inputted and the variance of TV and RR from their setpoints was recorded for the Phase 1 ventilator (P1V), Phase 2 ventilator (P2V), and hospital grade ventilator (HGV). The results showed that the variance of TV and RR of P2V was comparable to the HGV and less than the P1V, indicating that P2V was more precise than P1V and similar to the HGV. Also, P2V consumed under 2% of the power consumption of HGV and 60% of P1V. Further testing of the ventilator can be done in a hospital following IRB approval. In the future, the design can be further modified to incorporate humidifiers and other features to improve its functionality.

Awards Won:
Fourth Award of $500
King Abdulaziz &amp
his Companions Foundation for Giftedness and Creativity: NOT TO BE READ -- $200 cash prize for each Enrichment award recipient
King Abdulaziz &amp
his Companions Foundation for Giftedness and Creativity: Mawhiba Universal Enrichment Program awards (and a $200 cash prize)
International Council on Systems Engineering - INCOSE: Certificate of Honorable Mention, a 1-year free student membership to the INCOSE, and free virtual admission to the 2022 International Symposium of the INCOSE