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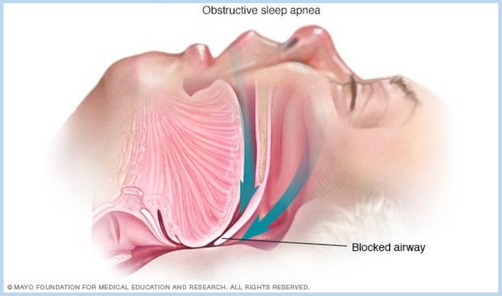
NovaResp Technologies
breathe easier

Department of:
Mechanical Engineering

Prototyping a Tubeless CPAP Machine

Background: What is CPAP and Sleep Apnea

Sleep apnea is the obstruction of the air way during sleep. Can lead to sever health concerns with risk of death.



To combat sleep apnea **Continuous Positive Airway Pressure** (CPAP) is supplied. This condition effects millions around the world. (Mayo Clinic, 2019)

Project Description

Design a self-contained portable CPAP Machine that integrates with NovaResp's proprietary algorithm to modify supplied air.

Requirements

- Design must be able to achieve a mixed air flow pressure of up to 16 cmH2O and combined flow rate of at least 6 L/min
- Design must support at least one full night of use (8h)
- Design must be tubeless and wireless
- Design must have enough space for a battery and other required electronics
- Design must be small enough to incorporate into a standard CPAP face mask

Testing and Validation

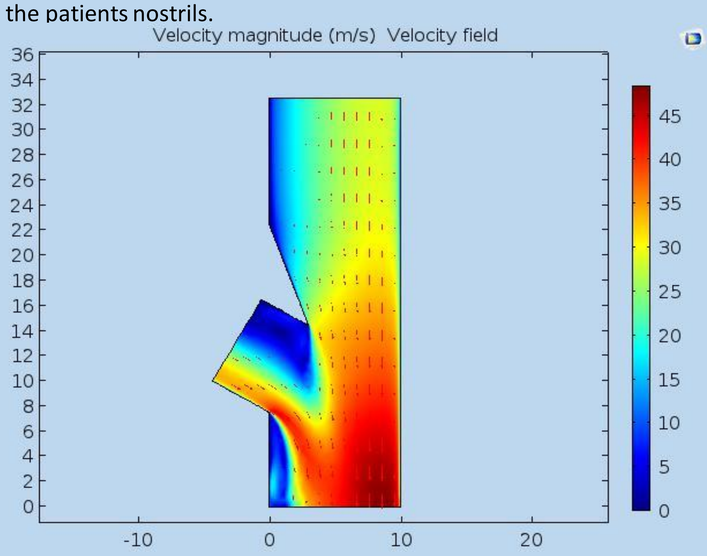
Test Set Up:
The pump was attached to the appropriate end of the tube, while a pressure sensor and tube were attached to the other.
One team member would breath through the apparatus, the other would record the pressure.

Test Results:
Through 75 tests, a pressure increase was noted between no pump flow and pump flow. This is the first step of validating the simulations. Notable losses come from the increased length of the tubing required for testing.

High Pressure – Low Flow Designs

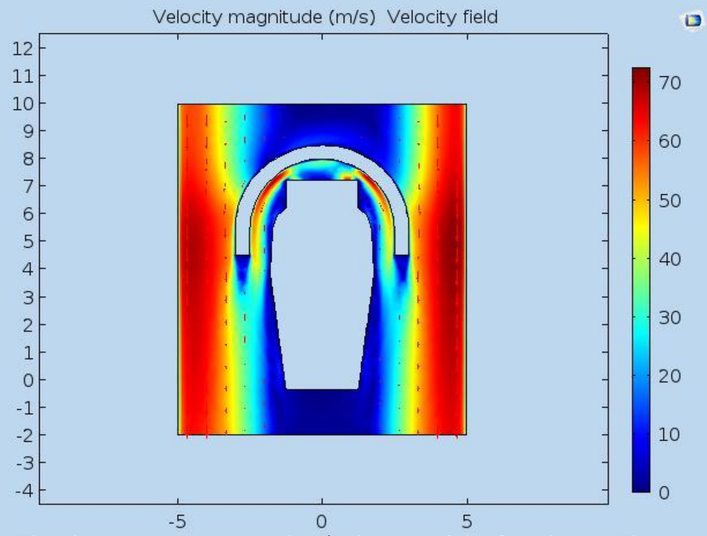
These designs rely on the use of high-pressure mini-pumps, and access to atmospheric air to meet requirements.

Design 1: Lipped tube
The mini-pump supplies air at the top opening of the tube. This flow is augmented by access to atmospheric air from the opening on the left. Lastly, air flows out the bottom, where the tube interfaces with the patients nostrils.



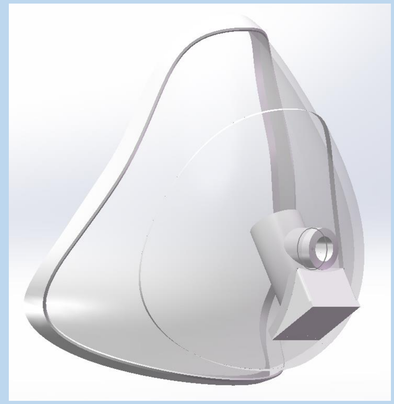
Testing of this design was completed using 3D printed models attached to NovaResp's artificial lung machine.

Design 2: Airfoil
This design uses an airfoil to increase flow speed from the pump, and entrain atmospheric air to meet required flow and pressure. This design was only modeled and not tested.



This design is approximately 1/3 the size of the first design. This design takes advantage of the "Coanda Effect". This effect is defined by the entrapment of air as it goes around an airfoil. (Cong, 2019)

Proposed Design



This design integrates the lipped tube design (Design 1) into a full face mask. The tubes are positioned such that the patient's nostrils rest comfortable around the outlet.
This design hosts room for the required electronics and lithium-ion batteries for power.
The mask will be held on by adjustable straps, much like current CPAP machines. This allows for a tight face fit to minimize leakage and maintain pressure and flow.

Conclusion and Recommendations

Through physical testing and simulated results, this project has validated the potential for low-flow, high-pressure pumps in CPAP applications. While a perfect and final solution has not been found, the door has been opened to various possibilities as is shown by 2 separate simulated designs.

Going forward there are two key areas that require further work. The first is humidification. While not required, this drastically improves patient comfort. Given the size of this design, a removable and passive, humidification method is recommended. Secondly, a one-way valve must be designed to operate within the tube at the required pressures. This valve is used to protect the pump from being back driven.

References

1. Mayo Clinic. (2019, March 23). *Sleep Apnea*. Retrieved from Mayo Clinic Website: https://www.mayoclinic.org/diseases-conditions/sleep-apnea/symptoms-causes/syc-20377631
2. Cong, R. (2019, March 26). *How Does the Dyson Air Multiplier Work*. Retrieved from Jameco: https://www.jameco.com/jameco/workshop/howitworks/dysonairmultiplier.html

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