Testing & Prototyping of a High-Flow Nebulizer

Dr. Robert Bittle's TCU Engineering Senior Design 2026, Lead by Andrea De Leon

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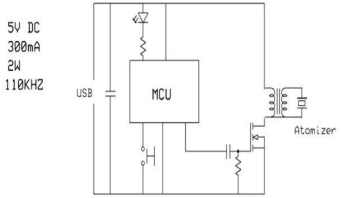
Abstract

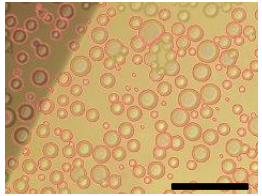
This project's objective is to prototype a high-flow nebulizer that is capable of vaporizing 5 mL of medication in a 60 second treatment. After extensive research & testing of numerous existing nebulizers, we have chosen to develop two nebulizers. The first nebulizer uses vibration to push the medication through a tiny perforated mesh plate. The second nebulizer vibrates the medication directly as produces mist. These two systems are affectionately called the "mesh" & "ultrasonic" nebulizers; we are developing 2 independent prototypes for each of these methods.

PCB Design for Mesh Prototype



The PCB board in the prototype is responsible for efficiently powering 12 meshes with 80V AC at 109.5khz. The plan is to use a rechargeable 5V DC battery to power a "pulse-width modulator", which will provide a clean AC signal. Then a mini-transformer is used to ramp up the voltage from 5V to 80V.

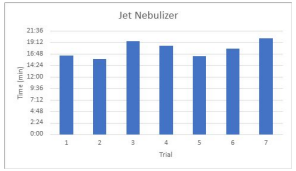
Droplet Size Testing



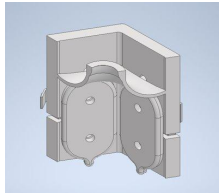
The commercial jet nebulizer is sprayed onto a glass slide, a microscope is used to capture a high-contrast image of the droplets, then MATLAB code is used to analysis the photograph and provide a droplet size distribution. The commercial nebulizer spec sheet mentioned a droplet size distribution between 3-6μm, and our results we're in the 5-10μm range. We made sure to take the photograph quickly as to not allow time for the droplets to shrink via evaporation, it is unclear how large of an impact this had on the readings.

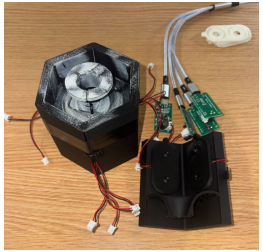
Runtime Testing

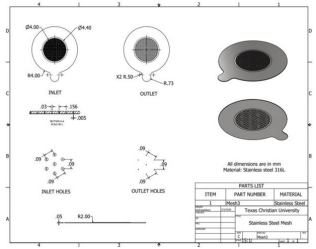
After conducting 7 trials of this commercial jet nebulizer, the runtime was 17.5 min (+/- 2 minutes).

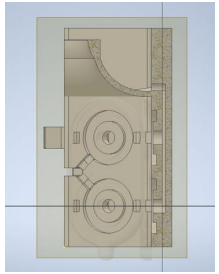


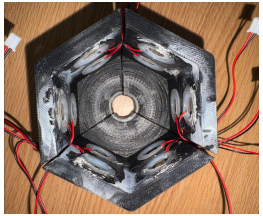
Mesh Prototype

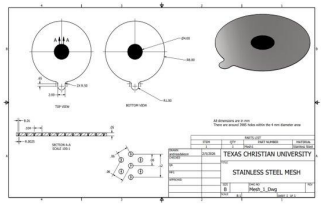












Discussion

The mesh prototype, seen to the left, is our most promising prototype. The desired 5 mL/min flow rate can be achieved with just 10 of the 12 meshes on. A small fan will be attached to the top of the enclosure to drive the aerosolized medication down & out through our custom mouth pieces. An attached, 3-D printed enclosure will house all of the circuitry & the 5V battery.

$$\text{Measured Flow Rate} = \frac{7.5\ mL}{5\ min} * \frac{1}{3\ meshes} = 0.5\ \frac{mL}{min * mesh}$$

$$\text{Required Flow Rate (with this prototype)} = 0.5\ \frac{mL}{min * mesh} * 10\ meshes = 5\ \frac{mL}{min}$$

Jet

Mesh

Ultrasonic

Nebulizers	Droplet Size	Runtime
Ideal Values	>5 microns	>1 minute
Commercial Jet Neb	5 - 10 microns	15 - 20 mins
Our Ultrasonic Neb	pending	47 seconds
Our Mesh Neb	7 microns	pending