Portable Calibration Wind Tunnel

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Project Introduction

The goal of the Office of Naval Research (ONR) Fatima design team is to create a **small, portable wind tunnel that will be used to calibrate a liquid water content probe during a 2022 field experiment**. The wind tunnel will need to achieve the following criteria: have variable wind speeds, variable temperatures, a high humidity range, and be light-weight.

Figure 1. CAD model for closed-loop wind tunnel with heating and humidifier elements.

What will this be used for?

Complex sensors, like a liquid water content **(LWC)** probe, **must be calibrated in areas like the environment it will be tested in to ensure accurate data collection.** The LWC probe will be used in remote testing sites, therefore a small wind tunnel is needed to be able to travel safely along with other field-testing equipment.

Project Goals:

1) Design and manufacture a wind tunnel that is 0.30m x 0.30m x 0.91m roughly and weighs less than 20.4 kg
2) Speed range of 2 - 10 m/s within the test section
3) Humidity reached between 80-90% inside of the test section
4) Temperature reaches 20°C above the outside ambient temperature inside the test section of the wind tunnel

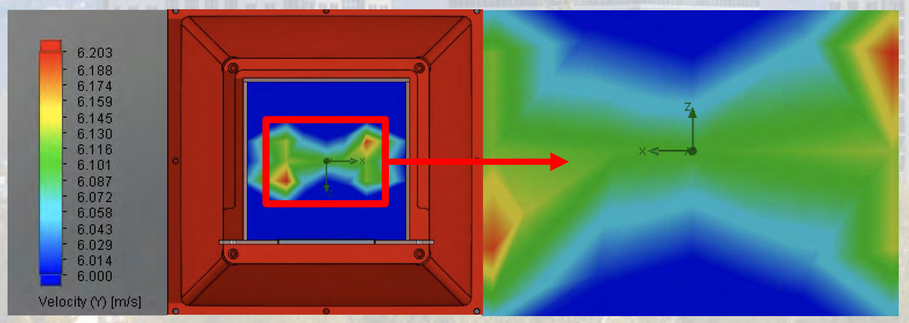
Project Methods

- ➔ Used **SOLIDWORKS Flow Simulation** for computational fluid dynamics **(CFD)** simulations for an open-loop wind tunnel design
- ➔ Completed CAD model & prototype assembly with 3D-printed and aluminum parts
- ➔ Found voltages that correspond with desired wind speeds using pressure transducer and pitot tube
- ➔ Collected wind speed data for 2-10 m/s, then added in humidity & temperature variables for a closed-loop design.
- ➔ Incorporated a low-cost environmental measurement station **(LEMS)** for simple data collection interface
- ➔ Designed electronics interface box to clean up wiring and create permanent circuitry
- ➔ Performed statistical analysis of humidity values for further assessment of data collection procedures

Experimental Spatial Wind Speed Plot

Figure 2. Measurements of air velocities in the plane normal to the flow at the center of the test section for a nominal target speed of 6 m/s.

CFD Spatial Wind Speed Plot



Figures 3 & 4. CFD top cut plot of spatial contour within the test section at 6 m/s.

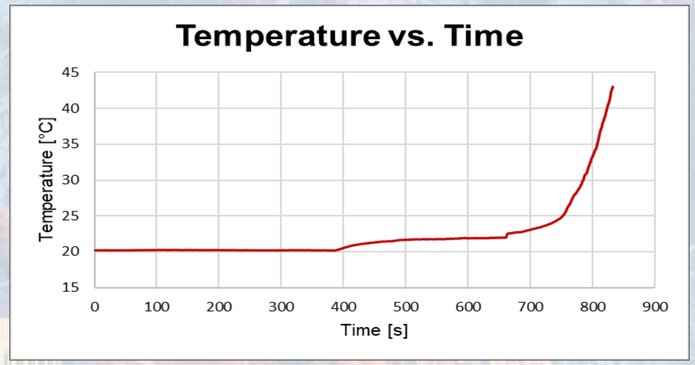
Discussion

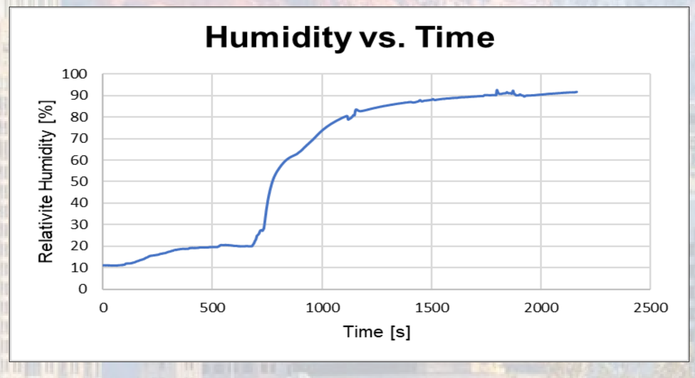
The team was able to achieve the following milestones:

1) Velocity range of 2.74 - 12 m/s
2) Temperature range of 22 - 43 °C
3) Humidity range of 15 - 90%

Target vs. Experimental Wind Speed

Expected Speed	Experimental Speed	Speed % Error
2	2.74	37
4	4.08	2
6	5.99	0.17
8	8.02	0.25
10	10.05	0.5
12	12.05	0.42





Figures 5 & 6. Humidity data points taken at half capacity of humidifier for ~800s and then full for the remaining time. For temperature data points, heater was on 0 V for ~400s, up to 30 V for ~300s and 60 V for the remaining time.

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