Wind Tunnel Enhancements

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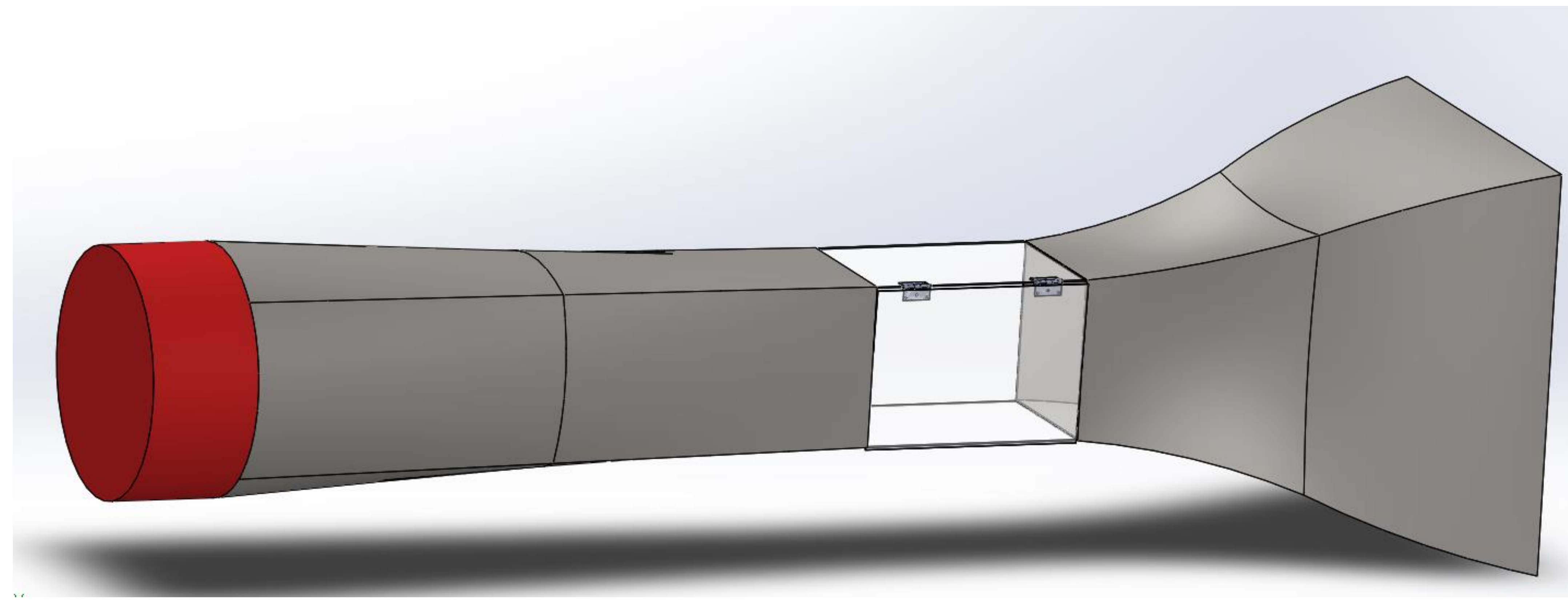
Project Description

The designated project for capstone is "wind tunnel enhancements" which involves improving the accuracy and flow of the current model. Wind tunnels are typically large tunnels with air blowing through them. The tunnels are used to replicate the actions of an object flying through the air or moving along the ground. The current model has low efficiency and is not ideal for accurate testing. For this project revising the existing model did not deem to be an appropriate method due to the amount of incorrect dimensioning and curve ratios it has. A full rebuild was needed in order to get the tunnel running appropriately and producing laminar flow. The wind tunnel will be optimized internally to increase airflow efficiency and lower the amount of turbulent flow inside the tunnel which causes errors in the data collection.



Fundamental Requirements

Functional Requirements	Yes	No
Shorten the length of the wind tunnel	X	
Access door to the test chamber	X	
Fits through engineering building doors and hallways		X
Increase efficiency by 25%	X	
Produce laminar flow	X	

- **Segmented design allows for quick assembly/disassembly**
- **Fitting the components through the engineering building doors allows for ease of relocation**
- **Increasing usability for the operator, with easy access to testing section, clear visibility for easy observation, and simple controls**
- **Increasing testing efficiency within tunnel by 25% by improving the laminar flow produced by using proper contraction ratios**

Engineering Standards

American Society of Engineers (ASCE) ASCE/SEI 49-12	**Documentation of tested simulation of project in order to predict and understand the nature of experiment/project before execution.**	**Simulations were carried out in SolidWorks to help see a virtual representation of wind behavior, the tunnel's structural components and how to approach them with respect of the wind flow.**
American National Standard Institute (ANSI)	**Ensures that all provisional services and purchases pertaining to a project within the country stays within the country's borders.**	**All service and purchases related to the wind tunnel were carried out within the country with receipts to show**
Standard ASCE/SEI 7	The loads produced by these tests are suitable for use in building codes and standards	The requirements outlined in this Standard satisfy requirements for wind tunnel testing set out in Minimum Design Loads for Buildings and Other Structures
Standard ANSI/NECA 1-2015	States that all electrical equipment be installed in a neat and workmanlike manner.	This standard is used in Arizona and includes elaboration on proper electrical connections.

Updated Design Components

Project Overview

A complete overhaul was needed due to:

Gaps/Cracks

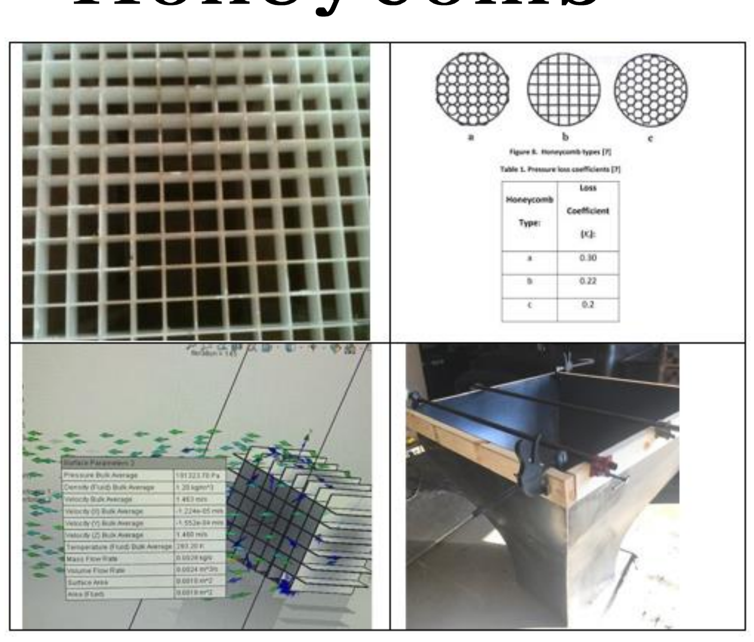
Turbulent pockets

Improper area ratio, contraction ratio, and length ratio

No access to the test chamber

> 35% error as seen in 2019 Statics Class

Honeycomb

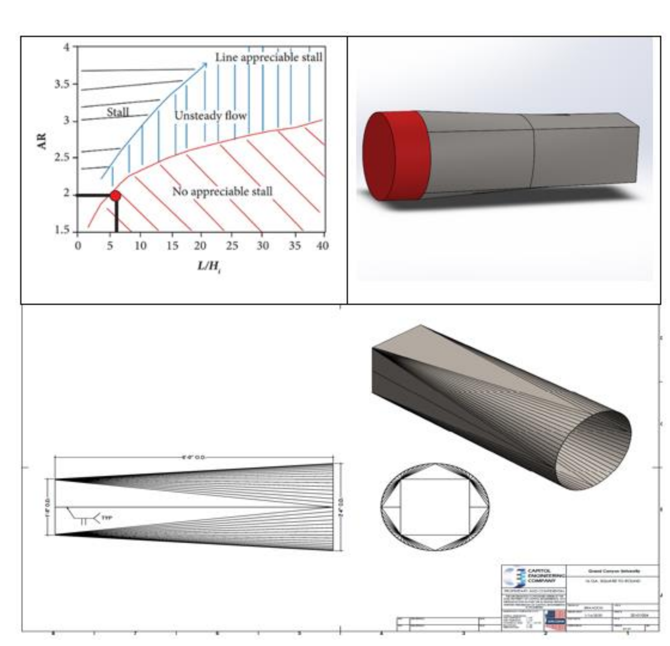


½" Honeycomb pattern x 3" depth

Two mesh screens (1/8" and ¼")

Wooden assembly to space and mount screens in front of intake

Diffuser



Equation 3 (AR): $A_i = 18'' = .4572m = .209m^2 = \frac{A_e}{A_i} = \frac{.3973m^2}{.209m^2} = 1.9$

Equation 4 (L/Hi): $\frac{l_d}{H_i} = \frac{2.44m}{.4572m} = 5.34$

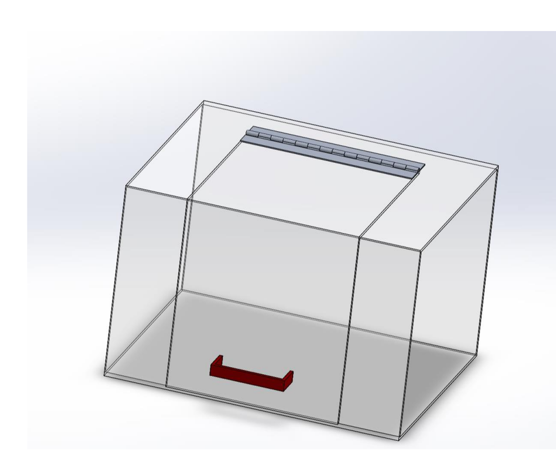
Implemented length to height ratio

New conical shape to prevent turbulent pockets

Area ratio taken into consideration

Seamless design to prevent air leaks

Test



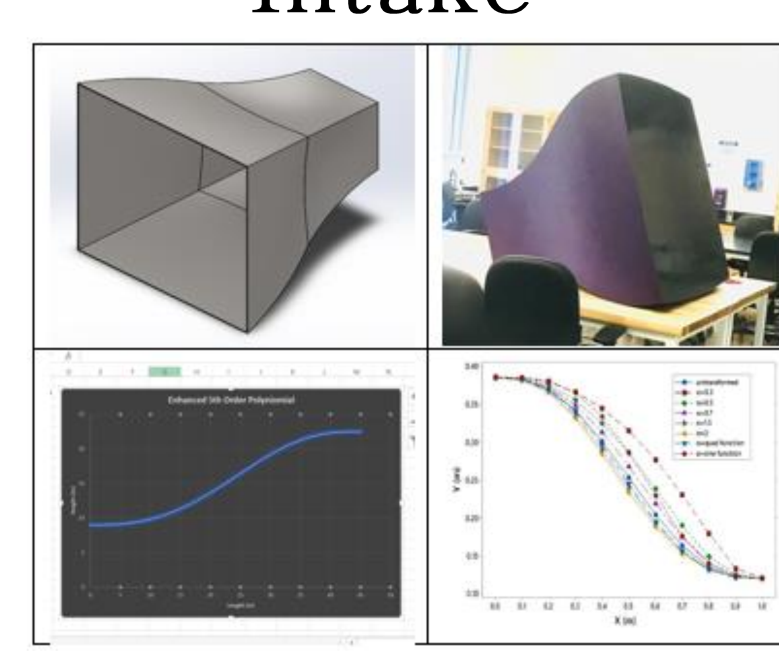
The test section will now have updated dimensions and a hinged access door.

Dimensions:
18" x 18" (entrance)
18" x 18" (exit)
Length: 2 feet

The test section will be made out of (1/4") acrylic.

Slip fit design to ensure tight seal

Intake



Equation (1) 5th order Polynomial $h = [-10\varsigma^3 + 15\varsigma^4 - 6\varsigma^5](H_i - H_0) + H_i$

Where: $\varsigma = \frac{x}{L}$ and Hi and Ho is the height of contraction inlet and outlet from the center axis and L is the length of contraction.

Equation (2) Improved polynomial $y = (\eta(H_i^{\frac{1}{\alpha}} - H_e^{\frac{1}{\alpha}}) + H_e^{\frac{1}{\alpha}})\alpha$

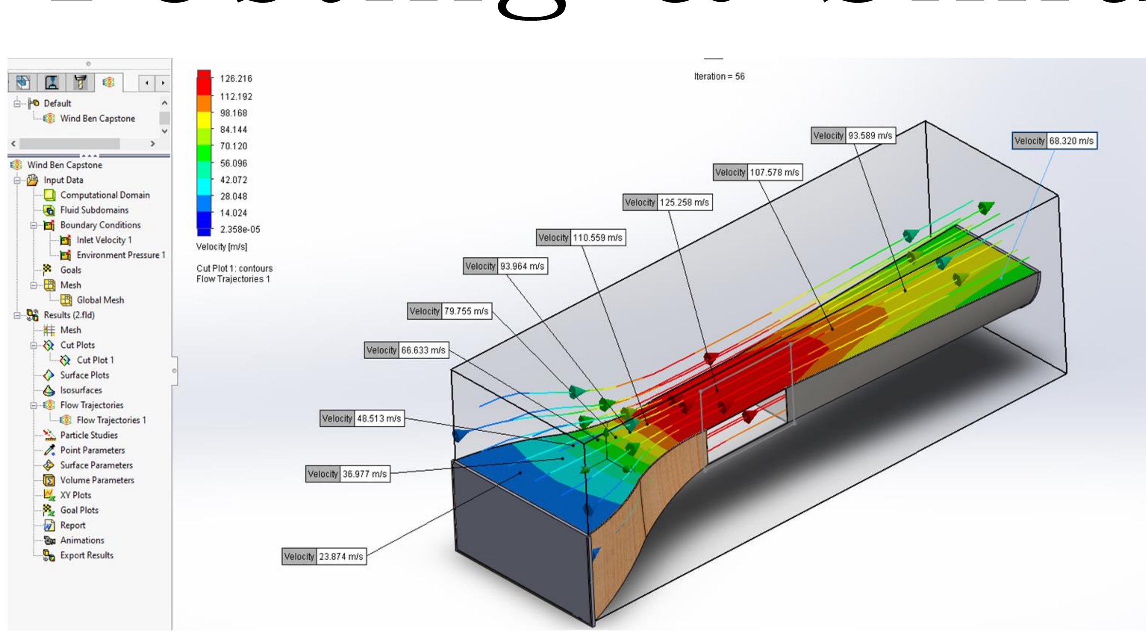
Where: $\eta = 10\zeta^3 - 15\zeta^4 + 6\zeta^5$ and ζ is the dimensionless axial distance from the inlet.

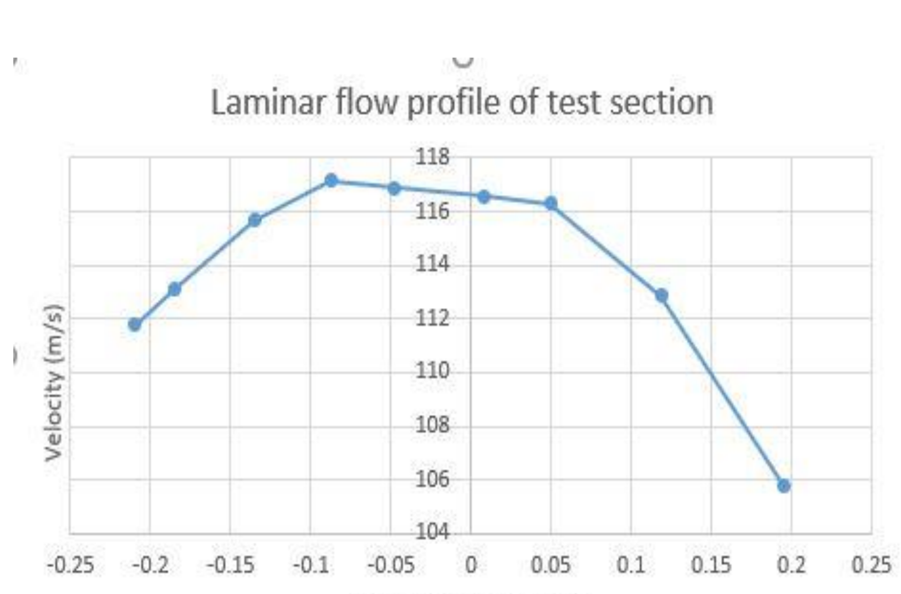
Contraction Ratio:

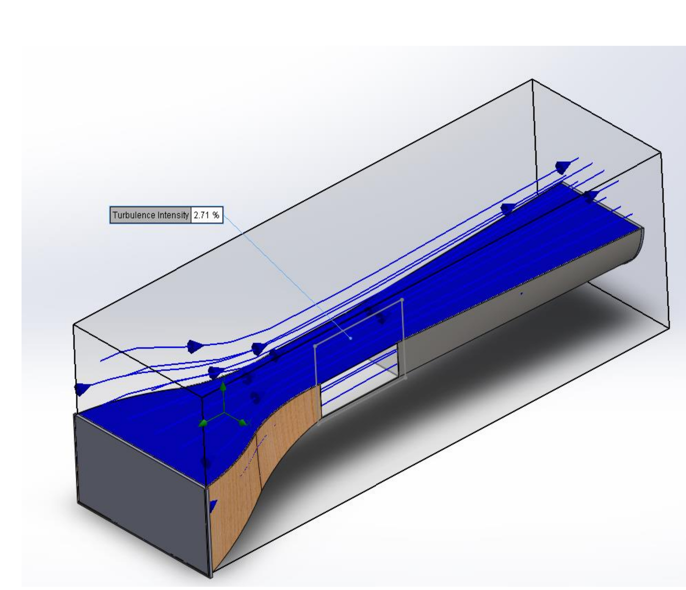
$\frac{45^2}{18^2} = 6.25, \textit{Ideal condition } 6:9$

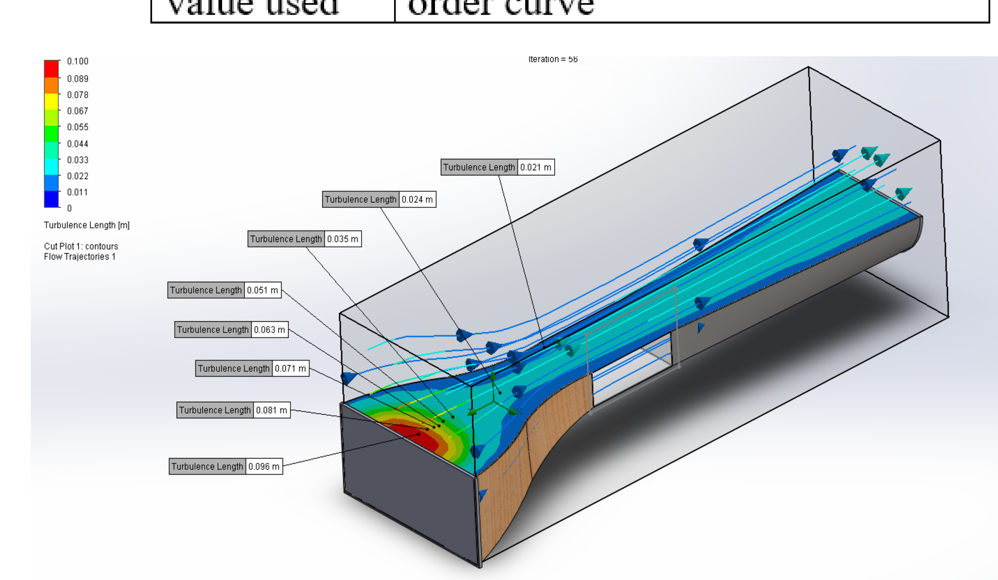
5th order polynomial curve	Proper Contraction Ratio of 6.25 instead of 3
Higher alpha value used	Higher alpha value used for the 5th order curve

Testing & Simulation









The flow simulations are based off of the dimensions from the updated wind tunnel design. The simulations provide a demonstration of the functioning design in which meets the required specifications. This includes the production of laminar flow and a uniform velocity profile within the test chamber. The development of this uniform profile is the key element in justifying laminar flow. Without uniformity, the wind tunnel would prove to house turbulent areas.