Airfoil Performance Analysis and Wind Tunnel Engineering

Interim Report

Linn-Benton Community College Chapter
Of the Society of Physics Students

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Abstract:

Our chapter proposed to design and build a small-scale wind tunnel of high aerodynamic precision. We want to use the wind tunnel to independently verify the lift and drag coefficients of several standardized NACA airfoils. The wind tunnel will become a fixture of our physics department for future use in undergraduate research, education, and outreach.

Project Overview and Progress:

Our wind tunnel design incorporates three major parts: contraction cone, test section, and diffuser. Our major design criteria were desired wind speed through the test section, minimal turbulence, portability, and safety. Our constraints included physical size, cost of components, and electrical limitations for the motor.

Because we plan to operate this wind tunnel in a variety of settings, our design allows the wind tunnel to be separated for transportation in and out of doors and elevators. The contraction cone and test section will be mounted on a portable steel frame, while the diffuser, fan and motor will be mounted on a separate frame.

Portability also limits our access to electricity, requiring us to use standard 110V one-phase outlets. We have used this constraint to determine our maximum possible power consumption. Using optimization software from the fan manufacturer (MultiWing) we selected a fan and motor system which matches flow rate and pressure to our physical system, while simultaneously maximizing wind speed through the test section. Using Bernoulli’s equations and elementary pressure principles, we calculated results of several configurations before finalizing the geometry of our test section and diffuser.

Our test section is 16” high, 20” wide, and 36” long. Two sides are constructed from wood, while the other two sides are tempered glass, all within a metal framework. The glass allows us to observe the interior during trials and to use the wind tunnel during demonstrations.

Our diffuser has been created from sheet metal using a standard ‘square-to-round’ technique. In order to minimize turbulence, we have put a small angle (~3°) on the diffuser. It is 5 feet long, and surrounds a 24” diameter fan at the outlet. The diffuser and test section will be bolted together using a framework we have designed using SolidWorks.
In addition to designing and beginning the construction phase of our project, we have worked to secure lab space on our campus and make the space suitable for our needs. We are also collaborating with faculty and students from our school’s Welding Department to construct the cart for transportation as well as portions of the wind tunnel structure. For the stages of the project that involve electronics we are communicating with our school’s Mechatronics Department.

We have started planning for our data collection system, in which we will use force and pressure sensors connected to an Arduino micro-controller. We plan on using Vpython to process the data collected and display the results in a way that can be visually interpreted. Our goal is to have our Arduino micro-controller and Vpython program work together to allow live plotting and interpretation of the data to allow easy use in our school’s Physics Department.

For the remainder of the year, we will be designing and constructing the contraction cone in addition to completing the fabrication of the other portions of our apparatus. We feel we are on track to have the wind tunnel completely assembled by the end of 2012.

Budget:

Our proposed budget of $1,533 was intended purchase materials to construct the wind tunnel. The budget has been fairly accurate for the items we have purchased so far. The actual cost for our fan and motor, our most expensive components, was only $34 more than what we estimated. We saved money in our budget through the donation of sheet metal, and have acquired an adjustable frequency motor controller through another funding source.

<table>
<thead>
<tr>
<th>Expenditure</th>
<th>Amount</th>
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<tbody>
<tr>
<td>Fan, 24 inch, airfoil design</td>
<td>$97.50</td>
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<tr>
<td>Electric Motor, WEG 1HP</td>
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<td>Glass</td>
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<td>Wood, steel, aluminum, adhesive</td>
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<td>Book, Wind Tunnel Testing</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>$734.79</strong></td>
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