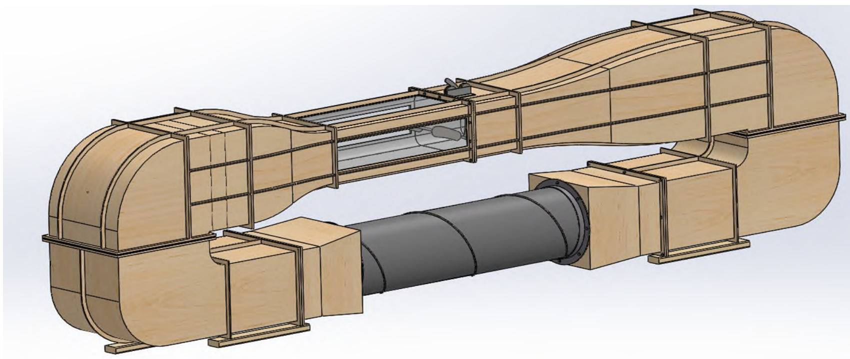
Portable Research Wind Tunnel

This design summary outlines a conceptual wind tunnel that could be transported to various facilities and provide a useful platform for aerodynamic research. The concept would consist of lightweight modular sections that could be individually transported to a location and quickly assembled. The size of the sections would be such that they could be brought to the location with a standard truck or van.



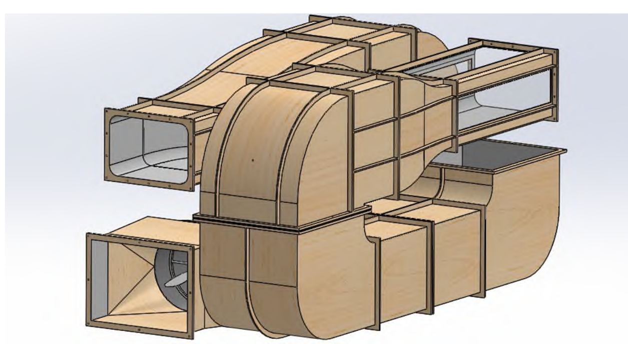
Basis of Design

The design is based on the ability to provide fundamental aerodynamic research in a portable package. To meet this objective, the wind tunnel consists of five sections that form a small closed loop subsonic research wind tunnel with a test section cross-section of approximately 12 inches by 18 inches.

The concept was initially developed as a potential training tool for use in classroom instruction where a permanent wind tunnel was not necessary or desired. It is designed be easily transported and assembled by students, require minimal access to power, be compatible with a classroom environment, and provide to ability to consistently gather data for standard aerodynamic experiments.

Unique Aspects of Design

The key design aspect is the ability to transport and easily reassemble the wind tunnel. This is accomplished by designing in sections that are can be man carried for short distances and can fit into a standard truck or van. The packed form (shown below) fits in a volume of 4ftx4ftx8ft.



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Other aspects of the design include flexibility in flow control, ability to operate with only wall outlet power, and applicability to a wide range of experiments.

Design Details

Construction

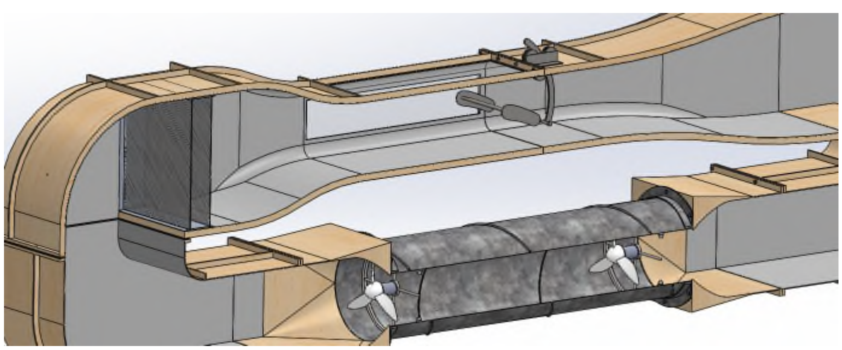
The initial concept is shown constructed out of thin plywood with external ribs. These materials were chosen due to their ready accessibility and workability. The structural design results in a stiff and lightweight structure. The interior is finished with sanded microsphere filled epoxy covered with a high durability paint. The test section includes three removable windows for model access and viewing of test specimens.

The motor section consists of an inlet and outlet transition piece bolted to a standard thin-wall spiral duct section. The use of spiral duct simplifies construction, provides an ideal housing for propellers, and allows for addition of external sound deadening insulation as necessary.

When assembled, the bottom sections (two turning sections and the motor section) are all bolted together at flanges as a single rigid assembly and are supported by the floor. The two upper sections (diffuser section and test section) are bolted together at flanges. A thick, vibration absorbing gasket is installed on the top flange of the bottom sections. The top section is placed on top of this vibration absorbing gasket and locating pins are used to maintain alignment. This style of construction allows for simple assembly and use of a gasket that provides a high flexibility seal that isolates motor vibrations from the test section.

Aerodynamics

The principle aim of a research wind tunnel is to provide high quality and repeatable flow conditions. For this particular design, the compatibility with a classroom environment is also a driver of the design. Several unique features are discussed below that are driven by these objectives.



- The size of the inlet and outlet plenums is maximized to create high static pressure/low flow boxes to minimize flow variability in the test section.
- A significant area contraction before the test section and a long test section help condition the flow.

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- Screens are used at the inlet to the test section for flow straightening. Additional turning vanes could be incorporated if necessary.
- The length of the diffuser section is maximized to prevent downstream flow separation that would negatively impact the usable cross-section of the wind tunnel.
- Filleted inside corners minimizes turbulence at the wall.
- Sound insulation can be easily incorporated around the motor tube to minimize sound.
- The closed loop concept minimizes airflow disturbances and volume in a classroom.

Operation

The wind tunnel would be operated by adjusting flow using motor controllers powering propellers in the motor section. Nominally large RC aircraft motors and propellers have been determined to provide the appropriate amount of power at the targeted conditions. Manual control with input from instrumentation installed in the test section could be used to control test section velocity, or an automatic system could be easily integrated where a target velocity is maintained.

During operation, model viewing is provided by windows on three walls of the test section. The windows are removable for insertion of models, adjustment of instrumentation, etc. These window panels could also be replaced with panels holding custom experiment equipment.

Power Requirements

Preliminary calculations show that a maximum velocity of 60 mph in the test section could be achieved with an input power of 2400W. At 30 mph, only around 300W would be needed. The assembly shown has two motors in parallel. Each motor shown is a 2500W motor but would likely be operated where each only provides half of the needed power which improves propeller efficiency and extends motor life. Initially only one motor may be installed with the other added as needed. Changes in the motor/propellers could be easily performed to target different conditions.

A separate power system would be required to power the DC motor controllers. A power system consisting of a portable battery and integrated charger is envisioned. For the initially selected motors, a 40V battery would be required to meet design conditions. As a reference for size, a single large capacity battery used for power tools (40V and 5Ah) would provide power for around 4 minutes at the highest velocity and 40 minutes at low speed with no external power. This indicates that the power system could be relatively compact. Low speed testing could be reasonably performed where no AC power connection is available, and for high power runs, concurrent charging and/or additional batteries can be used to extend the run time as needed. In either case, standard AC wall power would be sufficient to perform most aerodynamic experiments.

Future Work

A white paper is being prepared to show the preliminary calculations performed to show feasibility of the concept. The white paper will also consider enhancements such as integrated force balances and active boundary control in the test section.

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