

The Wind Tunnel

Before we begin our study of aeronautics, we must first become more familiar with the wind tunnel and why they are used.

To test aircraft or airfoil designs a movement of air over a shape or "Airfoil" is required. This can be accomplished by two different means. By flying the aircraft (moving the aircraft through the air) and observing and taking data while the aircraft is in flight or by moving air over a static (at rest) airfoil and observing and taking data. Both methods are used in the design of aircraft and both have advantages and disadvantages.

The preliminary work is usually accomplished with the use of a wind tunnel for safety and cost reasons. An engineer by the use of a scale model of the airfoil or aircraft can perform tests without risking the life of the pilot if there is a failure. This allows the testing of radical new designs safely and efficiently. What this requires is a constant steady flow of air over the surface and this can be obtained by studying the wind blowing over the surface but this method is very limited. First the engineer must wait for a windy day to conduct his test, secondly a number of tests require a wind velocity (speed) which is greater than what mother nature can produce. Cost of design is reduced by allowing changes to be made to the model quickly and tested without flying the airplane.

Full scale wind tunnels that are large enough to test a full scale model of the aircraft do exist. They generally have test sections around 40 feet by 80 feet in size, they are limited to the maximum air velocity they can produce and the size of aircraft that can be tested. Such wind tunnels are expensive to operate. For our discussions we will deal with smaller wind tunnels that require scale models when testing.

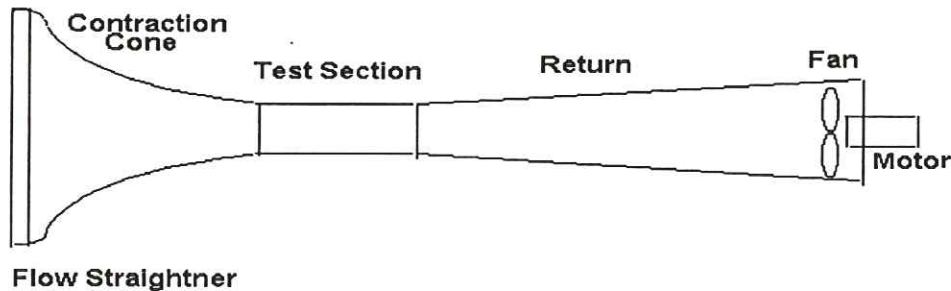
There are two basic designs of wind tunnels "Open Loop" and "Closed Loop."

The *open loop* design allows the air to enter the tunnel from the room and exhaust into the room after it passes through the tunnel. The *closed loop* design continually circulates the air within the wind tunnel. The closed loop design is generally used in larger wind tunnels. The FLOTEK wind tunnel that you will be using is an open loop wind tunnel.

Wind Tunnel Components

The main parts of the wind tunnel are:

- 1.) Contraction Cone - allows the air speed of the air taking from the room to be increased before it enters the test section.
- 2.) Flow Straightener - A honeycomb material which straightens the flow of air before it enters the contraction cone.
- 3.) Test Section - The area where the models are mounted. This part of the wind tunnel will have the highest air velocity. The walls of the test section are usually clear to allow flow observation studies of the model being tested.
- 4.) The Return - Allows the speed of the air from the test section to decrease before reentering the room.
- 5.) The Fan - Generates the air flow which passes through the wind tunnel. The fan is driven by an electric motor and placed at the end of the return section.



2. System Description.

2.1 Wind Tunnel Components

The Flotek 360 is illustrated in figure 1. It is an open-loop type wind tunnel that uses a ½ hp DC motor to drive a 12" aerodynamically shaped fan placed at the rear of the wind tunnel. In this implementation air is drawn through the wind tunnel then exhausted to the room after passing through the fan. A contraction cone of a 12-to-1 ratio is used to gradually increase the air velocity from the room to the test section. A honeycomb flow straightener is used at the entrance of the contraction cone to ensure that the air entering the contraction cone flows in a straight line, providing a laminar, low-turbulence airflow in the test section. A laminar flow is critical to ensuring that accurate data is measured on small models. Any flow separation from the model caused by turbulence will degrade the quality of the data. (To have the many formulas that are in the lesson plans compute properly, it is important that the data be both accurate and repeatable.)

After passing through the test section the air passes through the return (diffuser section). The air in the return is expanded at a very small angle to prevent airflow separation from the walls of the tunnel. If flow separation does occur, the air entering the fan near the fan tips would be in a stall turbulent condition, reducing the efficiency of the fan and increasing wind tunnel noise considerably.

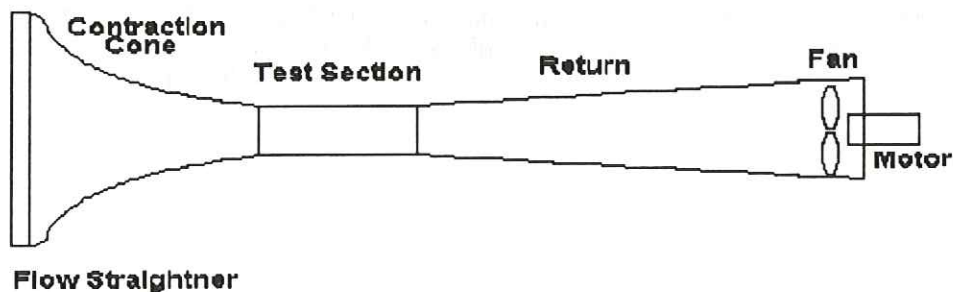


Figure 1. Wind Tunnel Basic Components

2.2 Instrumentation Components

Data Acquisition and computer control of the wind tunnel is accomplished by using an 8 channel Analog-to-Digital (A/D)/2 channel Digital-to-Analog (D/A) converter board. The acquisition system works by converting an analog voltage signal to digital data that can be read by the computer. Similarly, converting a digital signal from the computer to an analog voltage provides control for devices. The converter board is located in an ISA Slot inside the control computer, and a cable connects it to the Wind Tunnel's Data acquisition box located behind the contraction cone.

During operation, data sensing is accomplished by 8 0-10" water pressure sensors located in the data acquisition box. When a negative air pressure is applied to the active port of the pressure sensor, a voltage is produced that is read by the analog input (A/D) portion of the data acquisition board. The Data acquisition Board then outputs a digital signal to the computer software program. The software is programmed to allow the user to display the pressure signal from the wind tunnel test section model in a variety of different ways, and, in this implementation, one set of bar graphs displays Velocity (FPS), while the other set displays Pressure (Inches of Water).

3. System Operation.

3.1 Manual Control

Complete a Pre-Run Checklist Before Operation.

- 1) Turn the key on the lower left of the control box to the "Run" position. At this time the green "Control Power" light should illuminate to indicate the wind tunnel has power. Note: to increase operational safety, the key can only be removed in the "Lock" position.
- 2) Ensure the Manual Speed Control is set to Zero.
- 3) Press the "FAN ENABLE" button. If you do not hear the fan rotate, you should refer to troubleshooting chart in section 5.
- 4) Using the speed control knob, adjust the Fan RPM to achieve desired test section velocity for the test in progress. If the Fan RPM varies only slightly check the switch on the lower **Right Rear** of the control panel and ensure it is in the Proper position. This switch was provided to allow the operator to change between manual or computer control of the motor.
- 5) To Stop the Wind Tunnel, Press the "E-Stop" Button.
- 6) Turn the Key to the "LOCK" Position.

3.2 Computer Control

Complete a Pre-Run Checklist Before Operation.

- 1) To control the wind tunnel with the computer, the data gathering/control software must be running.
- 2) Double-click the Icon on the desktop for the correct test. (Example "Airfoil").
- 3) Once the Software is running, a screen will appear with a Dial in the upper Left hand Corner. This dial is provided to control the wind tunnel test section velocity.
- 4) Start the wind tunnel using steps 1-4 as described in the manual mode of operation.
- 5) The Key must be in the "Run" position and the "Fan Enable" button engaged.
- 6) Set the Fan RPM by placing the mouse pointer on the dial pointer. Click the Left Mouse Button and drag the pointer to change the test section velocity. If the Fan RPM varies only slightly check the switch on the lower **Right Rear** of the control panel and ensure it is in the proper position. This switch was provided to allow the operator to change between manual or computer control of the motor.
- 7) To change the airfoil "Angle of Attack," a slide bar on the Right Side of the screen is provided. Place the mouse pointer on the slide bar portion, click the left mouse button, and drag the slider to the desired "Angle of Attack". Note: if very small changes are being made, it may be necessary to move the pointer up and then back to desired point.
- 8) Once the test is completed stop the wind tunnel by pressing the "E-Stop" button. Turn the Key to the "Lock" position.

- 9) Exit the software and Shutdown the computer. (Shutting down the computer is recommended to stop voltage from being supplied to the angle of attack servo.)