



FLOW VISUALIZATION TUNNEL

V1

AEROLAB LLC

8291 Patuxent Range Road

Suite 1200

Jessup, MD 20794

Phone: 301.776.6585

Fax: 301.776.2892

contact@aerolab.com

www.aerolab.com

TABLE OF CONTENTS

Introduction	3
Description	3
Tunnel Overview	5
Main Control Panel	6
Model Operation and Experiment Suggestions	7
Airfoil with Blown Flap	7
Airfoil with Vacuum Holes	7
Airfoil for Student Experimentation	7
Airfoil with Tangential Blowing Slots	8
Venturi	8
Circular Cylinder (Spin Model)	8
Delta Wing	8
Example Images	9

INTRODUCTION

The shape of an object moving through a fluid has a major influence on the way the fluid reacts. Using the AEROLAB Flow Visualization Tunnel (FVT), students can see firsthand the flow of air over objects such as airfoils, wings, cylinders and other aerodynamic shapes.

While the AEROLAB Flow Visualization Tunnel is great for group demonstrations, it's also intended for hands-on student experimentation. Students can change pitch angles, deflect flaps, rotate circular cylinders and apply vacuum or blowing to improve aerodynamic performance. Hands-on activities motivate learners because the effects of their adjustments are immediate and obvious.

DESCRIPTION

Wind Tunnel

- Length: 53 inches (1.35m)
- Height: 28.5 inches (72cm)
- Width: 17 inches (43cm)

Cabinet:

- Height: 37 inches (94cm)
- Width: 45.5 inches (1.16m)
- Depth: 24 inches (61cm)

Power requirements:

115 VAC 60 Hz ONLY, minimum 15 Amp circuit, international use requires a transformer.

Flow visualization tunnels, in particular, require exceptionally smooth, steady airflow. This quality of airflow is aerodynamically termed laminar flow. Laminar flow contains no eddies or other types of turbulence. Turbulence is undesirable because it diffuses the injected water vapor lines causing them to lose definition and appear fuzzy.

In general, laminar flow is not easy to generate and difficult to maintain. Two factors promote laminar flow: a carefully designed inlet bell mouth (known as the contraction) and an effective honeycomb flow straightener. The AEROLAB Flow Visualization Tunnel design includes a large-area-ratio (inlet to outlet) contraction and engineered aluminum honeycomb. The honeycomb provides approximately 7700 hexagonal channels, 7 inches in length and 1/8 inch across flats (Aspect Ratio 56). Honeycomb is also employed at the exit of the model area to ensure laminar flow.

Vaporized water (created by an ultrasonic atomizer) is introduced in streaklines spaced 0.25 inches (6.35mm) apart through a special rake. The rake is located near the exit of the contraction. The ultrasonic atomizer is housed in an enclosure directly below the smoke rake. During prolonged use, water vapor condenses in the vapor line. To remove the water droplets and restore vapor flow, the control panel has a purge button.

Airflow is generated by a centrifugal blower downstream of the test section. Airspeed is infinitely controllable through a knob on the main control panel. The knob is attached to a flap which throttles the flow out of the blower.

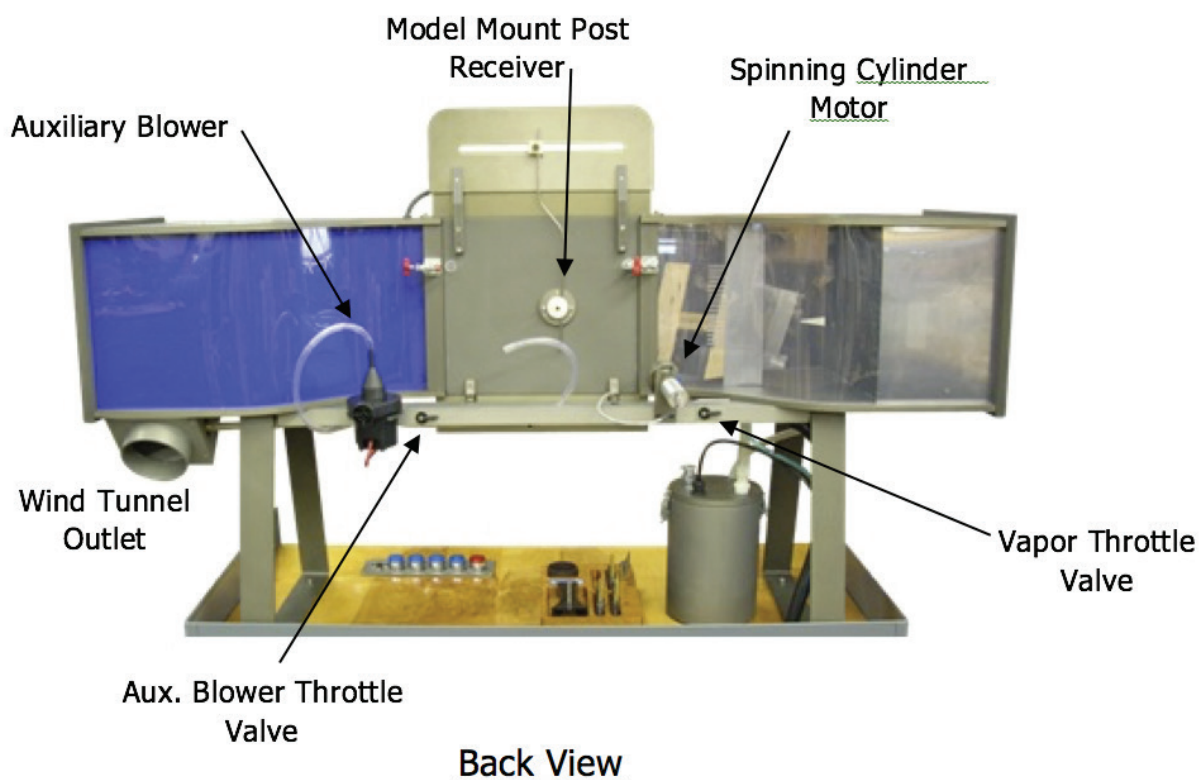
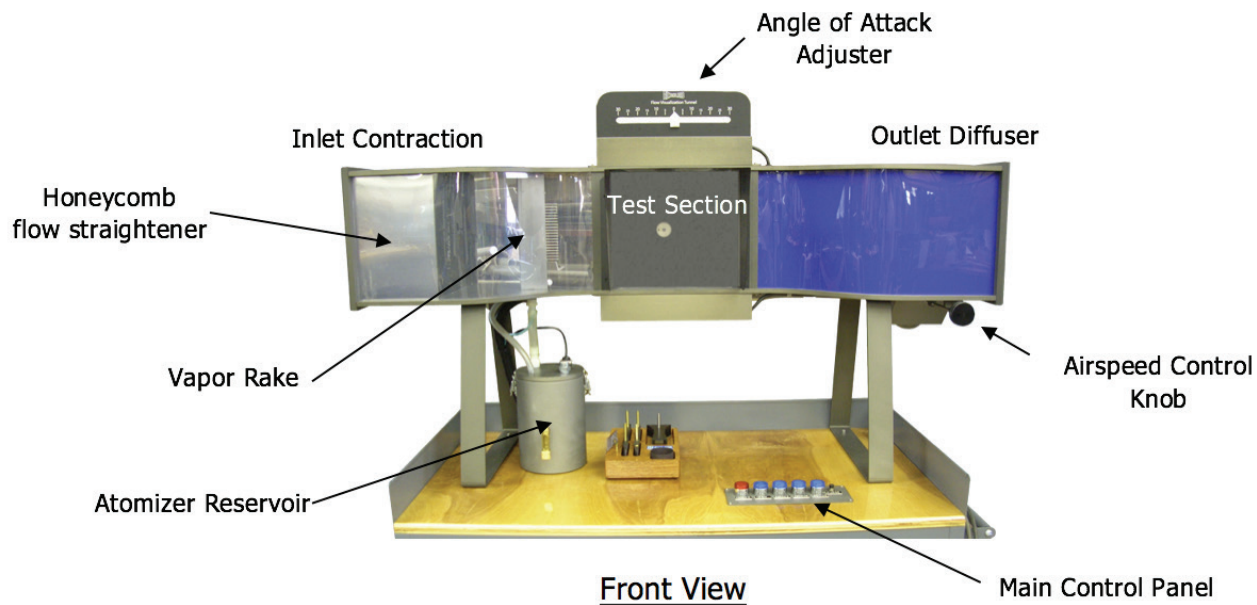
The flow visualization tunnel is fabricated with an aluminum frame consisting of top and bottom plates. Suitably cross-braced, it stands on aluminum legs. The top and bottom plates have machine-milled grooves which retain the acrylic sides. One side of the converging section, the contraction, and the test section are enclosed with a single piece of clear acrylic. This construction enhances the appearance and makes visible the entire vapor rake and streamline flow pattern. The side walls downstream of the test section are formed of opaque blue acrylic to harmonize with the anodized aluminum. The rear wall of the test section is finished in non-reflective black to enhance viewing and photography. A removable visor is added to diminish the effect of exterior light.

The atomizer begins to function virtually immediately, so warm-up time is not required.

Models are mounted by opening the hinged back panel and inserting the model stem through the angle-of-attack mechanism.

Air under positive or negative pressure can be piped from the auxiliary blower to models. The rotating cylinder model can be rotated at a fixed speed. Fluorescent lights are mounted both above and below the test section to illuminate the model and the streaklines.

Tunnel Overview



Main Control Panel



The POWER button is the main switch for the tunnel. Nothing can operate unless this switch is engaged. The air compressor (located inside the cabinet) will run for a short period of time and the test section lights (top and bottom) will turn on when this button is activated.



The FAN button activates the wind tunnel fan.



The SMOKE button activates the atomizer.



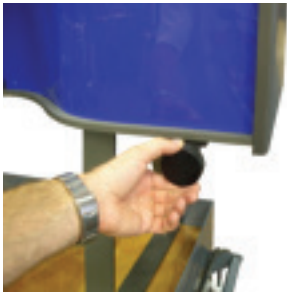
The MOTOR button activates the cylinder electric motor.



The VACUUM button activates the auxiliary blower. The blower provides pressurized air and/or vacuum to the vacuum/blowing models.



The PURGE button provides a short blast of air to the vapor rake. This blast of air clears the rake of collected water droplets.



The AIR SPEED knob (located on the right side of the FVT) changes the wind tunnel airspeed. Turn the knob clockwise to slow the flow or counterclockwise to speed it up.

Model Operation and Experiment Suggestions

Note - Because the airfoil models span the test area (they go from wall to wall), air is forced to move in only two dimensions (it cannot flow sideways to go around the ends of the models). This type of flow is termed *two-dimensional*.



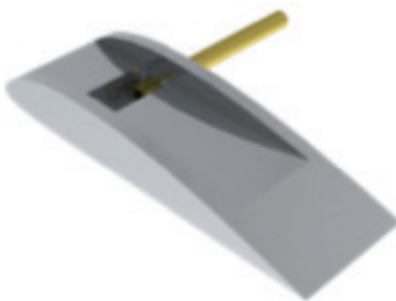
Airfoil with Blown Flap

The Flap Model is intended to be used with and without blowing – note the slot just in front of the flap hinge on the top of the airfoil. The flap can be adjusted down or up. The model demonstrates the Coanda Effect when used with blowing. The Coanda Effect is used to increase high angle-of-attack performance. The intensity of the blowing should be adjusted to the lowest possible setting to achieve the desired result. The Boeing C-17 Globemaster III employs blown flaps to increase performance.



Airfoil with Vacuum Holes

Vacuum applied to the top surface of a wing can increase high angle-of-attack performance. The Airfoil with Vacuum Holes serves to demonstrate this phenomenon. The intensity of the vacuum should be adjusted to the lowest possible setting to achieve the desired result. As an added experiment, use cellophane tape to partially or fully close holes and observe the result.



Airfoil for Student Experimentation

A large chamber has been cut into the top surface of the student experimentation airfoil. The chamber can be covered with tape or paper and holes or slots can be opened to experiment with the application of blowing or vacuum.



Airfoil with Tangential Blowing Slots

The Flap Model is intended to be used with and without blowing – note the slot just in front of the flap hinge on the top of the airfoil. The flap can be adjusted down or up. The model demonstrates the Coanda Effect when used with blowing. The Coanda Effect is used to increase high angle-of-attack performance. The intensity of the blowing should be adjusted to the lowest possible setting to achieve the desired result. The Boeing C-17 Globemaster III employs blown flaps to increase performance.



Venturi

The Venturi model serves to demonstrate the effect of a converging duct on moving air. Observe the streaklines as they pass through the model. Change the pitch angle of the model and observe the streaklines.



Circular Cylinder (Spin Model)

The Circular Cylinder serves to demonstrate the Magnus Effect. Operate the tunnel with and without the cylinder spinning. Note the direction of the spin and the effect on the streak lines. By observing the vapor lines, what is happening and why.

Note - The delta and rectangular wing models allow air to flow around them just as it would on an actual aircraft. This is termed three-dimensional flow because the air is allowed to move in all three dimensions.



Delta Wing

The delta wing model serves to demonstrate the vortices generated by such a wing design. The wing's angle of attack can be adjusted by gently twisting the wing on the mounting post. Also, change the yaw, or side-slip, angle of the model by means of the model mount and observe the result. Discuss the advantages of a delta-wing aircraft. What is the benefit of the obvious vortices generated on the top of the wing?

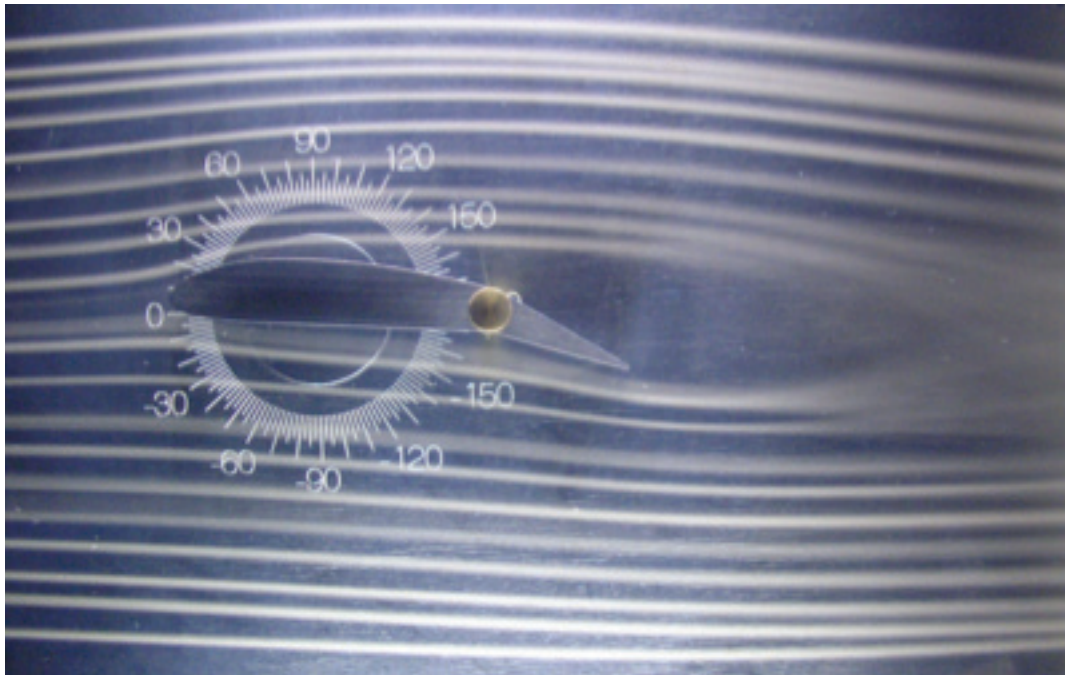


Rectangular Wing

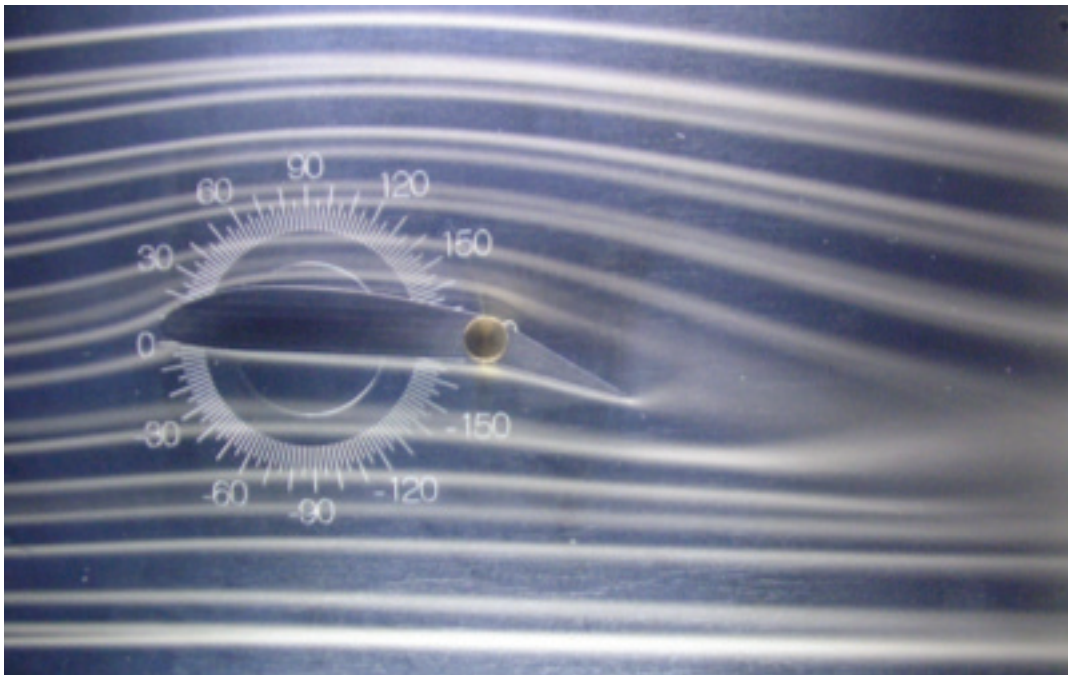
The rectangular wing model serves to demonstrate the vortices generated by such a wing design. The wing's angle of attack can be adjusted by gently twisting the wing on the mounting post. Discuss the vortices – How do they affect the performance of the wing?

EXAMPLE IMAGES

Airfoil with Blown Flap

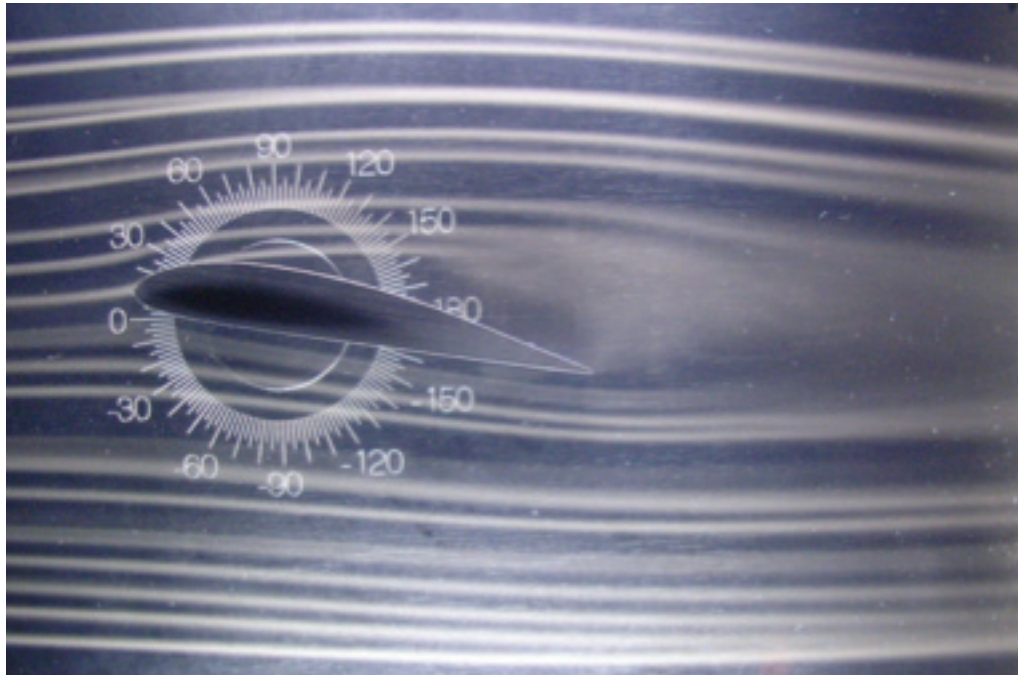


Without Blowing

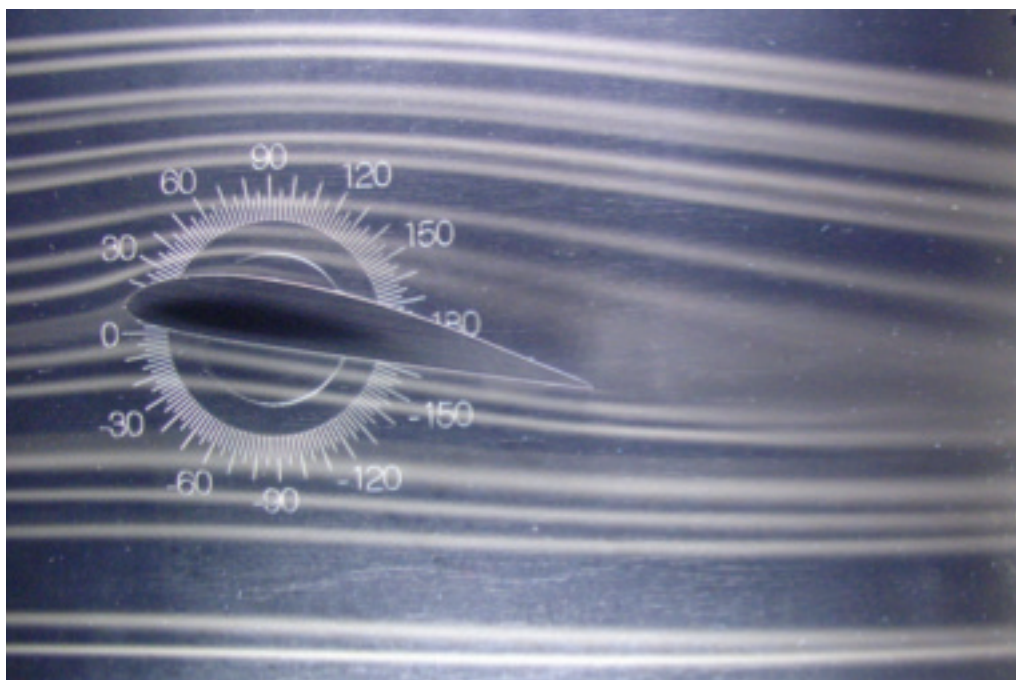


With Blowing (No Change in Pitch Angle or Flap Deflection)

Airfoil with Vacuum Holes

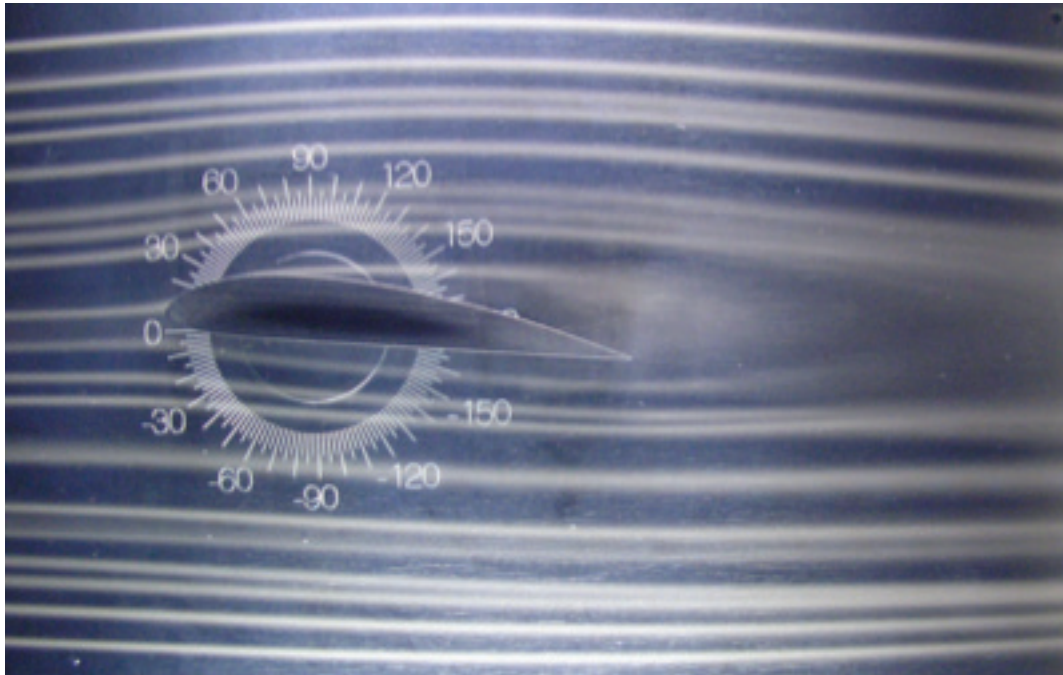


Without Vacuum

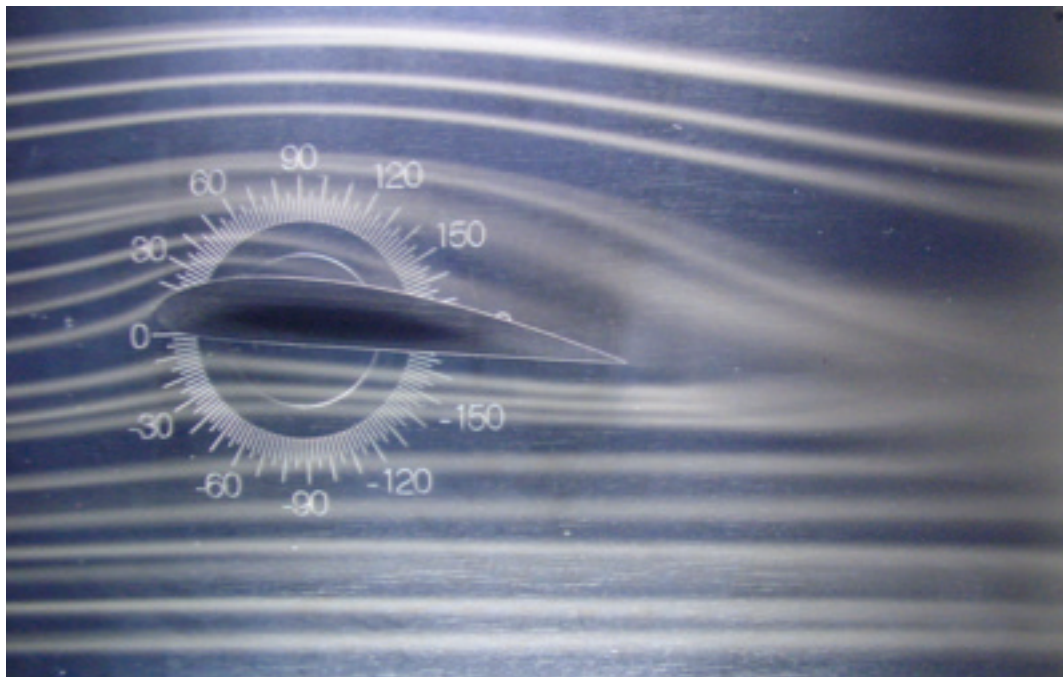


With Vacuum (No Change in Pitch Angle)

Airfoil with Tangential Blowing Slots

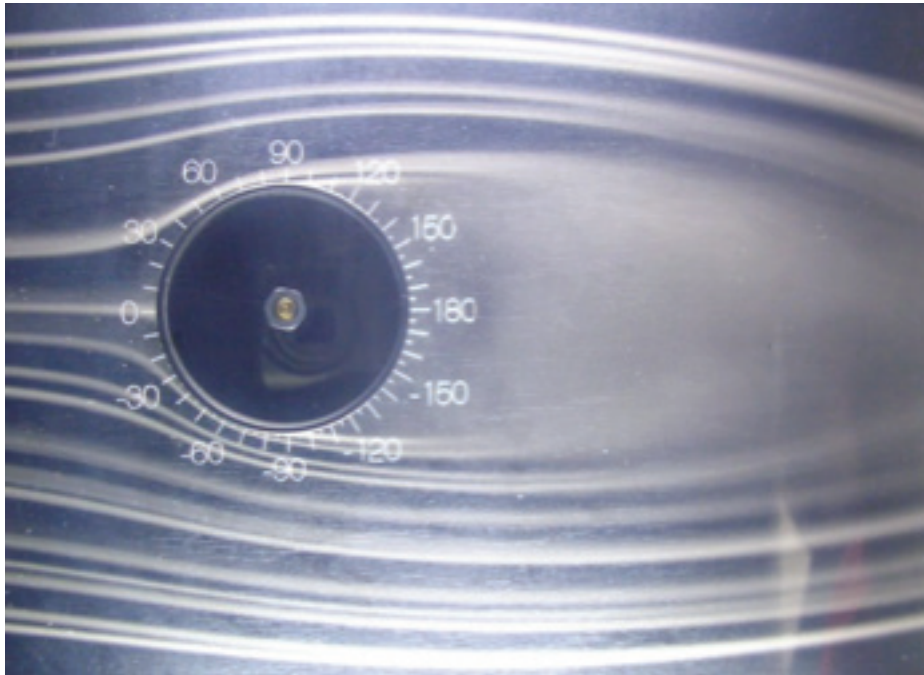


Without Blowing

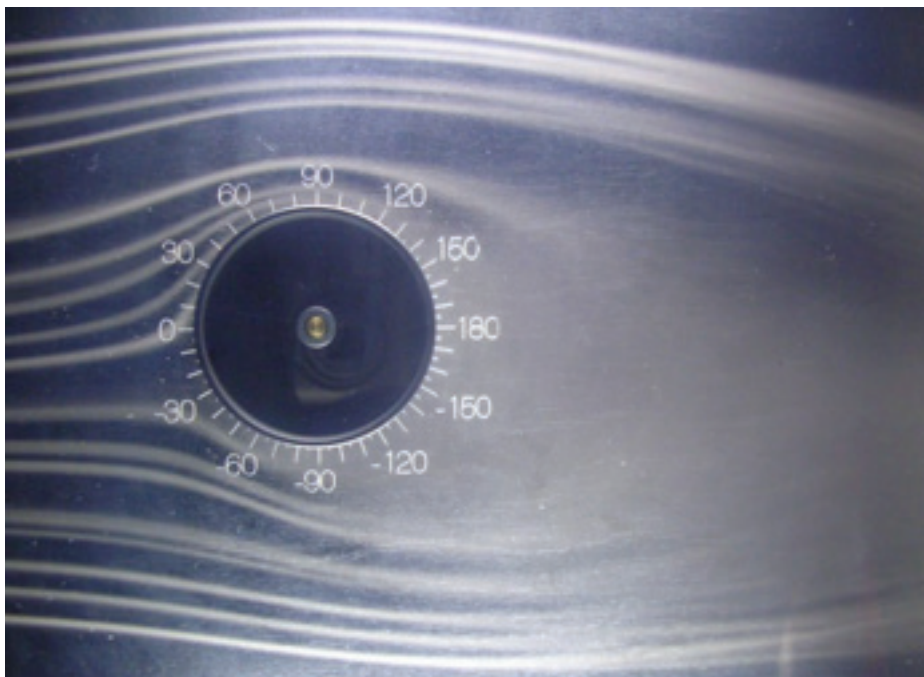


With Blowing (No Change in Pitch Angle)

Circular Cylinder (Spin Model)

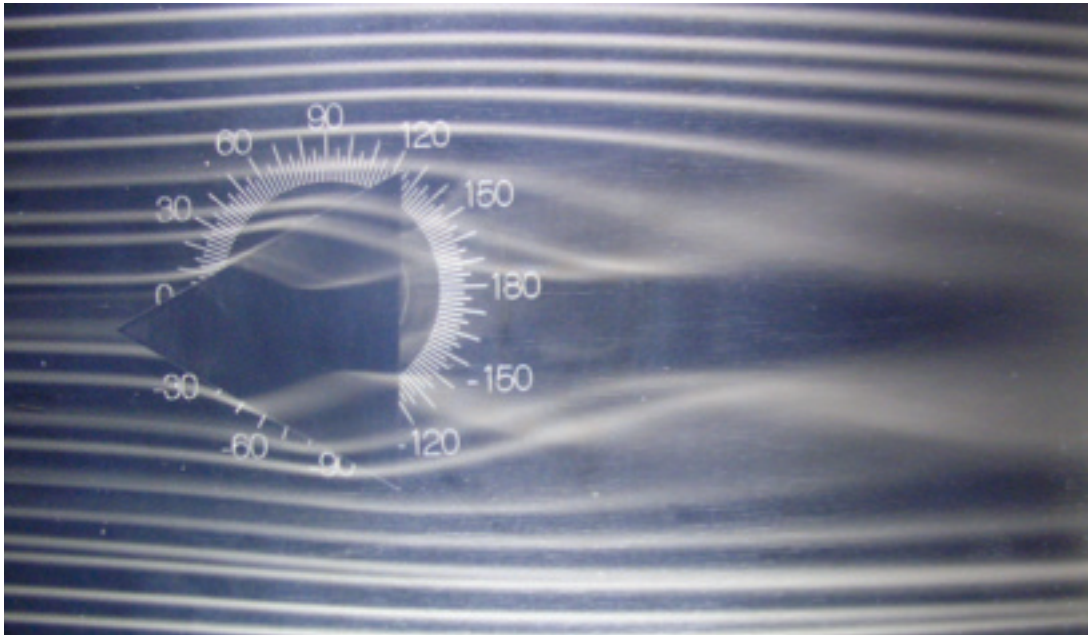


Without Spinning (Motor Off)

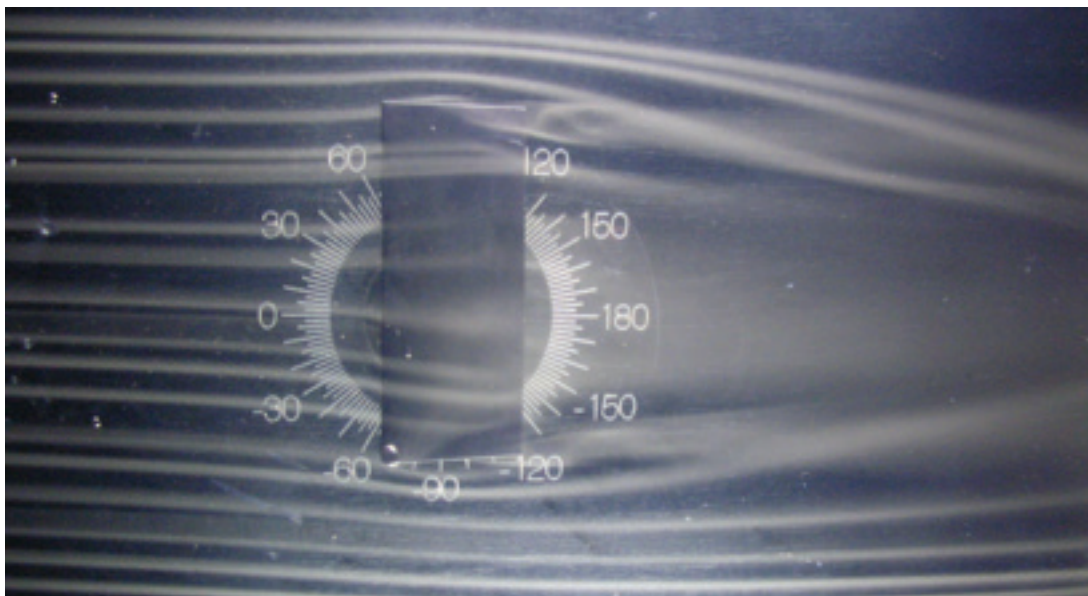


With Spinning (Motor On)

Delta Wing



Rectangular Wing



Venturi

