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The Coanda Conundrum

Background

My experiment was constructed to test the Coanda effect which occurs when a fluid that is traveling parallel to a nearby surface adheres to that surface. If the surface curves the fluid will follow the surface around the curve. The fluid is attracted to the surface because of a difference in air pressure. It is that difference in pressure that also creates the lift overtop of an airfoil. There are some limitations to this effect such as the surface that the fluid is travelling on must be smooth. Any major roughness in the surface will cause the fluid to lose its attraction to the surface. Also there is a point where the curve is too sharp for the fluid to follow. The Coanda Effect was discovered by Henri Coanda in 1938. I first heard of this effect when I was watching Daily Planet on the Discovery Channel, and I wondered how different circumstances affect the amount of lift that was produced.

Purpose

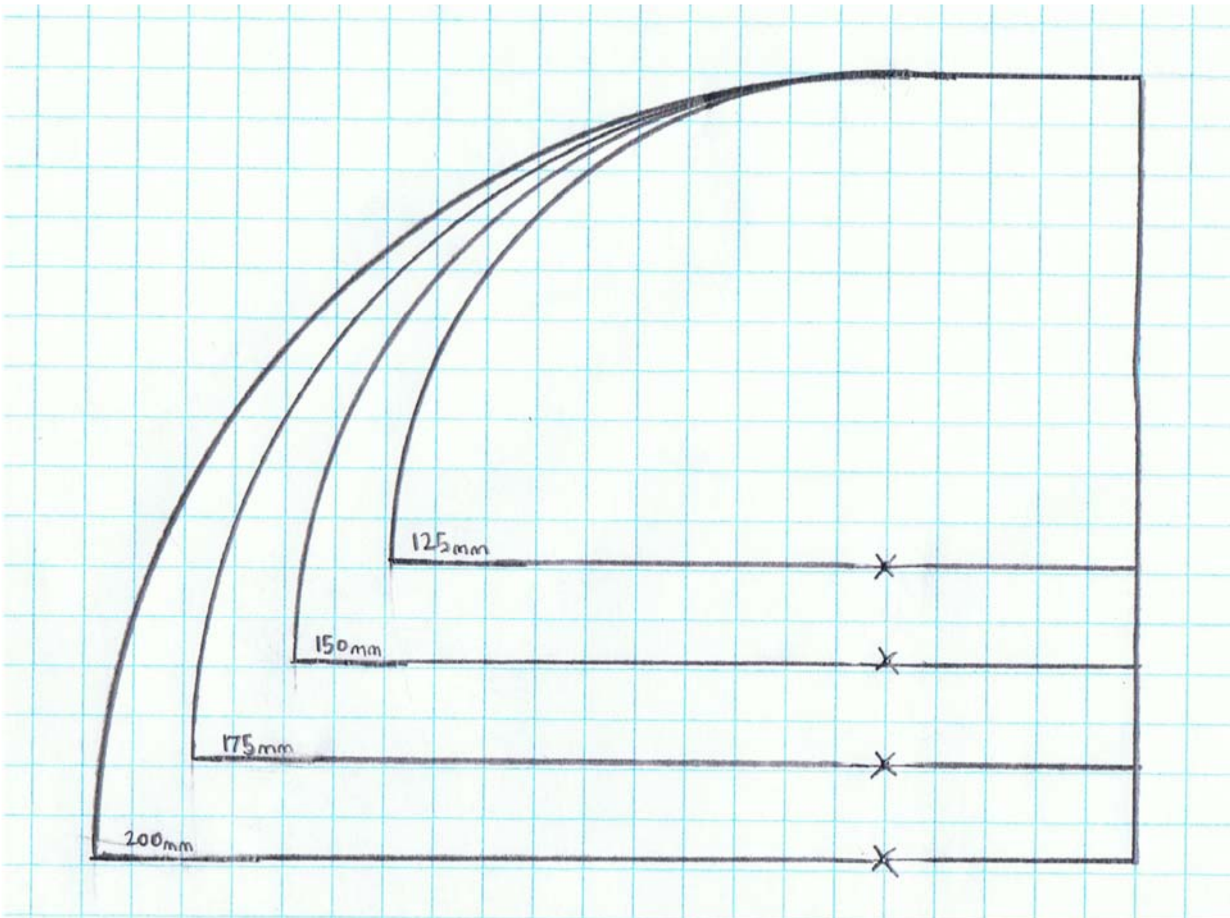
The purpose of this experiment is to discover what radius of curvature will produce the most lift using the Coanda Effect. I hoped there would be a clear distinction between the different curves in the foils to show a good representation of how the Coanda Effect works.

Hypothesis

I think that a smaller radius of curvature will produce more lift using the Coanda Effect.

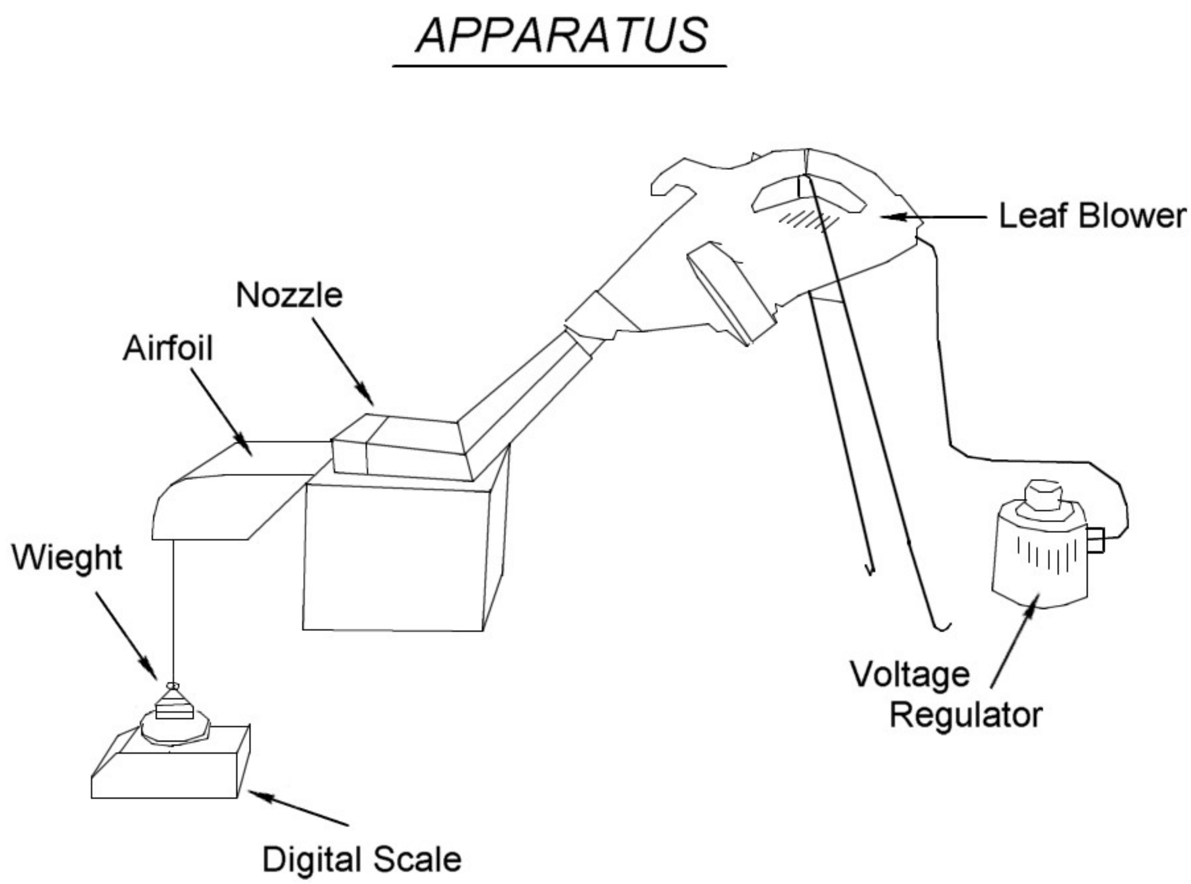
Procedure

The basis of my experiment is to blow air overtop of different airfoils. The airfoils are constructed out of extremely lightweight cell foam. To create the foils, start off by cutting out 4 identical top sheets with a 150mm width at the top that fan out to a 235mm width at the bottom. These sheets must be identical so that every airfoil will have the same surface area and therefore will all have the same area that can produce lift. To create the curve of the airfoil, draw a straight line 64mm long on a piece of graph paper. Then draw a line 125mm long perpendicular to that line. Using a compass with the centre of the circle at the end of the 125mm line, draw a quarter of a circle with radius 125mm that attaches to the end of the 64mm line. Then trace the shape onto two pieces of foam in order to produce the two sides of one 125mm airfoil. In order to create a three-dimensional airfoil from the two cutouts, attach one of the top sheets to the two side panels with ZAP-O cyanoacryate glue. To prevent the top sheet from cracking, which would hinder the potential lift, a heat gun is used to encourage the top sheet to bend over a cardboard tube. The top sheet with the general curve is then attached to the side panels using the glue. This process is repeated to create a 150 mm, 175mm and 200mm radius airfoil.



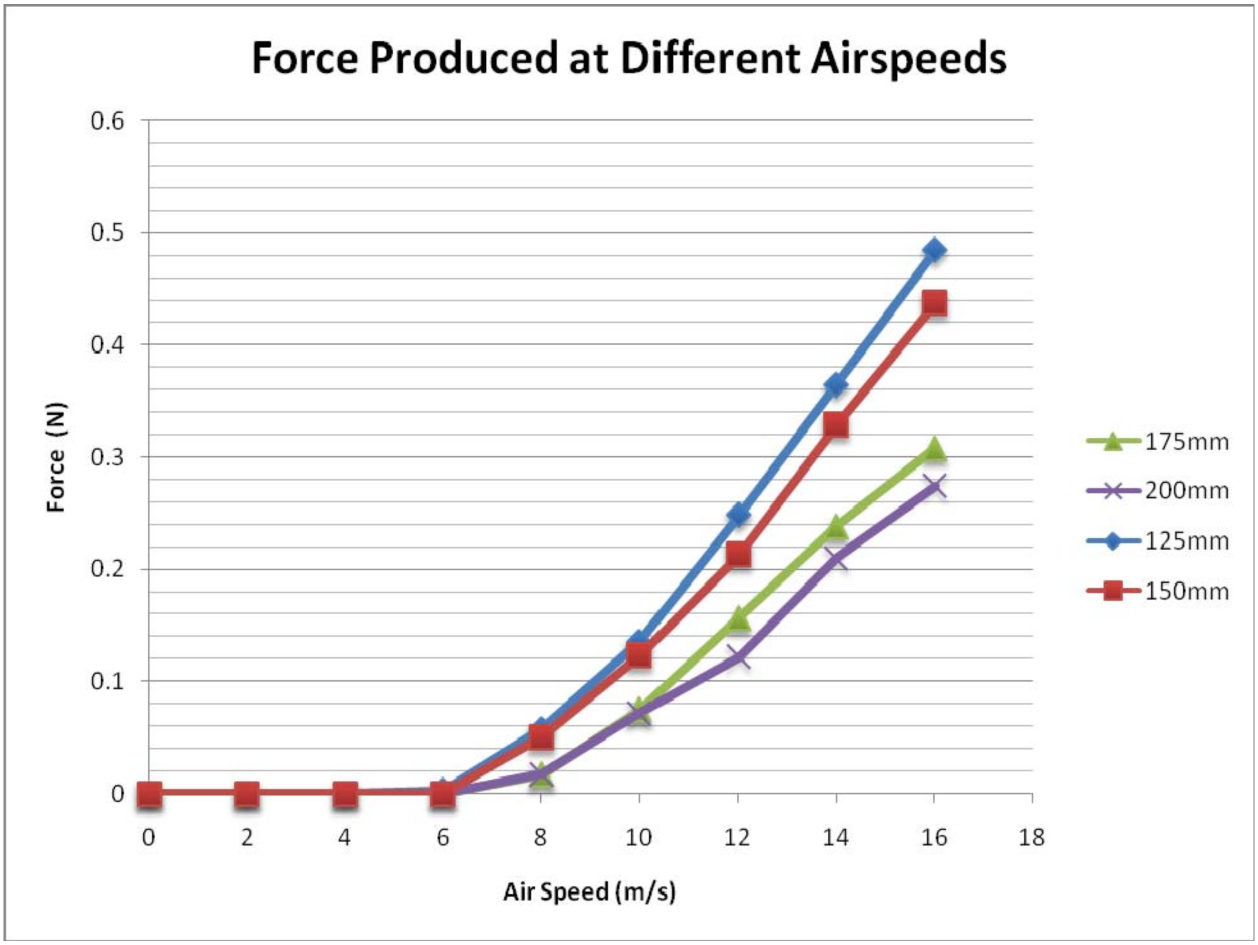
The experimental apparatus used to test the four different airfoils consists of a leaf blower with the airfoil taped under the nozzle. The electric leaf blower is connected to a regulator to adjust the airspeed. Attached to the bottom of the foil is a string with a weight on the other end. The weight rests on top of a digital scale. Moving air from the leaf blower passing over top of the airfoil will produce lift using the Coanda effect and will relieve weight from the scale. The difference between the starting weight and the weight when the wind blows is the amount of lift produced. Cut away at the side panels until the foils are all the same weight.

Attach the 125mm radius airfoil below the leaf blower and the string underneath the airfoil. Tare the weight on the scale. Using an anemometer to measure the wind speed, adjust the regulator so that the wind speed is 2m/s. Record the weight on the scale and then adjust the regulator until the wind speed is at 4m/s and record the weight. Repeat this process increasing the wind speed by increments of 2m/s. Upon completing the testing of the 125mm radius airfoil change the airfoil to the 150mm radius airfoil and repeat the process followed by the 175mm and the 200mm radius airfoils. Convert the weight in grams to kilograms and then multiply by 9.8 which is the gravitational constant to record the lift as a force.



Results and Observations

All of the airfoils do not produce any thrust below an air speed of 6m/s. After the airspeed exceeded 6m/s the amount of thrust produced increased as the air speed increased. The difference in thrust produced between the airfoils at each air speed was small at the beginning and then the difference increased at each air speed. The 125mm radius airfoil constantly produced more thrust than the other airfoils after 6m/s of air speed while the 200mm radius airfoil produced the least amount of thrust. As the radius of curvature decreased the amount of lift produced increased. All of the airfoils produced the most amount of thrust at 16m/s.



Conclusions

There was no thrust recorded from 0m/s to 6m/s of airspeed because the amount of thrust produced at the low airspeeds was not enough to lift the weight of the airfoil and overcome the force of gravity so the airfoil does not lift nor does it relieve any weight from the scale. The airfoils produced more thrust with a greater air speed because air traveling at a higher velocity will have a lower pressure. Therefore at faster air speeds there is a greater pressure difference which results in a stronger force from the higher pressure air to the lower pressure air. The higher pressure air particles below the airfoil will push towards the lower pressure fluid above causing the foil to lift. More lift will be produced the greater the differential in air pressure. When the fluid is attracted around the curve the fluid will increase in velocity. The smaller the radius of curvature in the airfoil results in more lift being produced. The sharper the angle the greater the fluid will increase in velocity due to Bernoulli's Equation of Continuity. A fluid will increase its velocity to try and stay together and eliminate any gaps in the air. Therefore the fluid traveling over the sharper curve will have the largest increase in velocity and then produce more lift due to a greater increase in the differential of air pressure. Overall the smaller the radius of curvature the greater the amount of thrust produced. This is important to know so that you can manipulate a fluid and control how it flows over certain surfaces. In a lot of airplanes the wings will be specially shaped so that certain curves and slants in them will affect how the air travels overtop of the wings to maximize lift. Also car manufacturers can use this information when designing their cars. When the air travels overtop of the car the Coanda Effect will cause the car to lift at high speeds. That is why manufacturers have installed spoilers on the backs of cars which interrupt the airflow to keep the car firmly on the ground.

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