Dallin Romney

Airfoil Aerodynamics

Figures and Tables

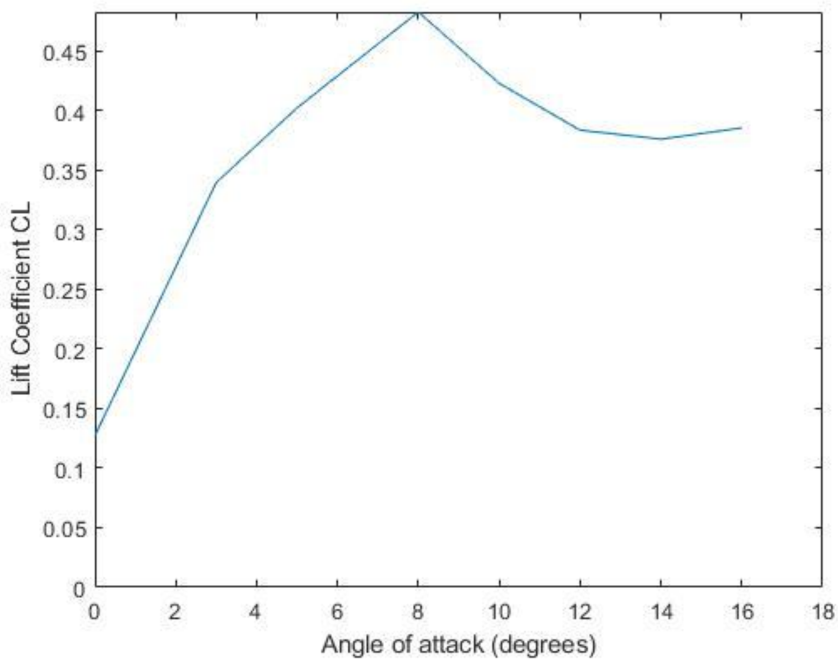

Figure 1. Lift coefficient C_L versus angle of attack α

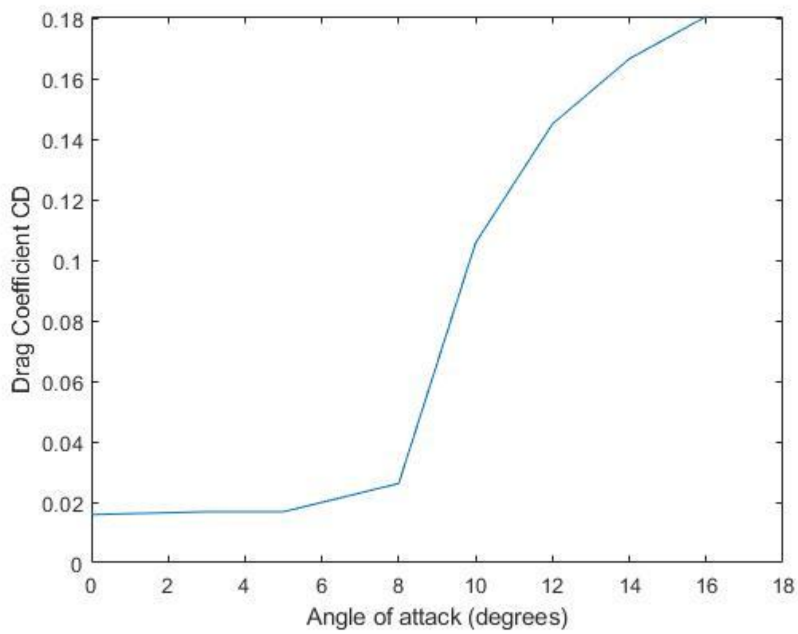

Figure 2. Drag coefficient C_D versus angle of attack α

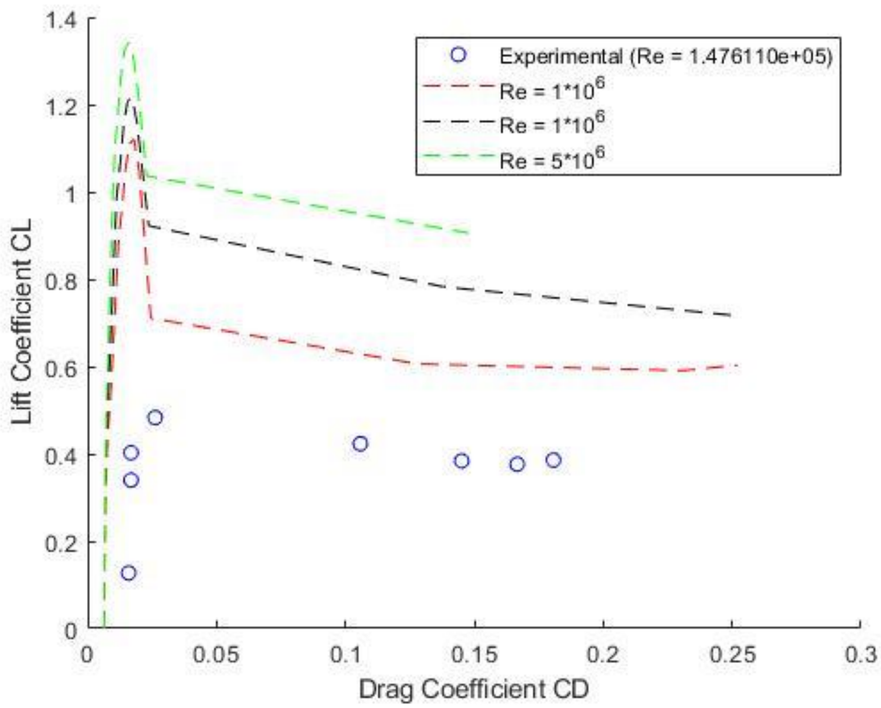

Figure 3. Drag coefficient C_D versus angle of attack α

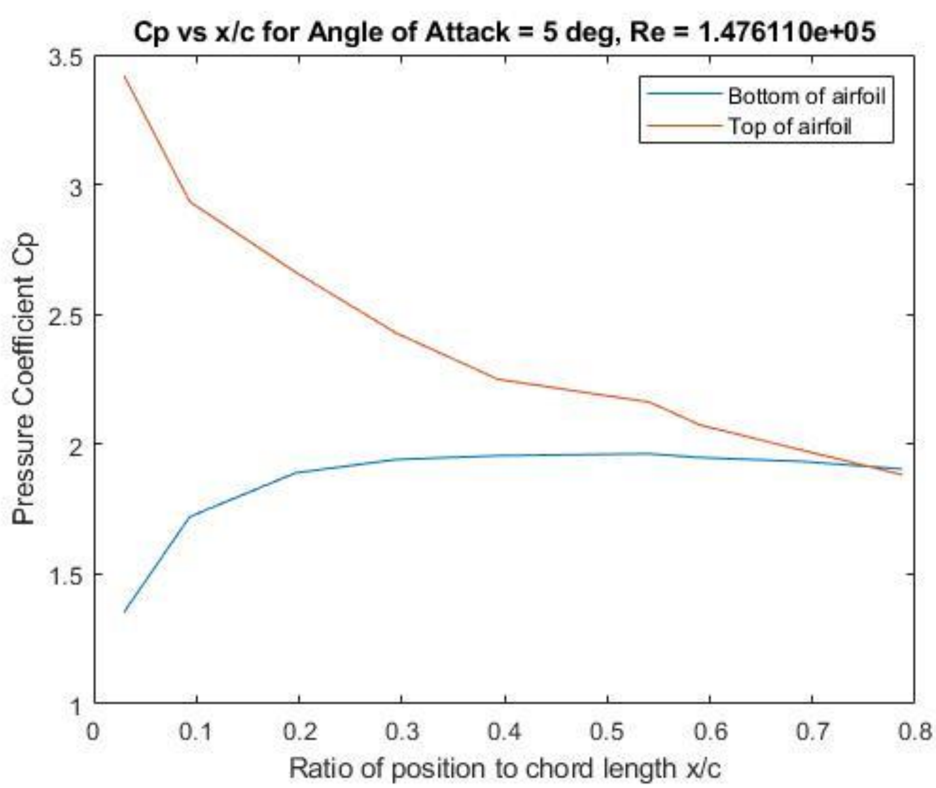

Figure 4. C_p versus x/c for an angle of attack below stall (5°)

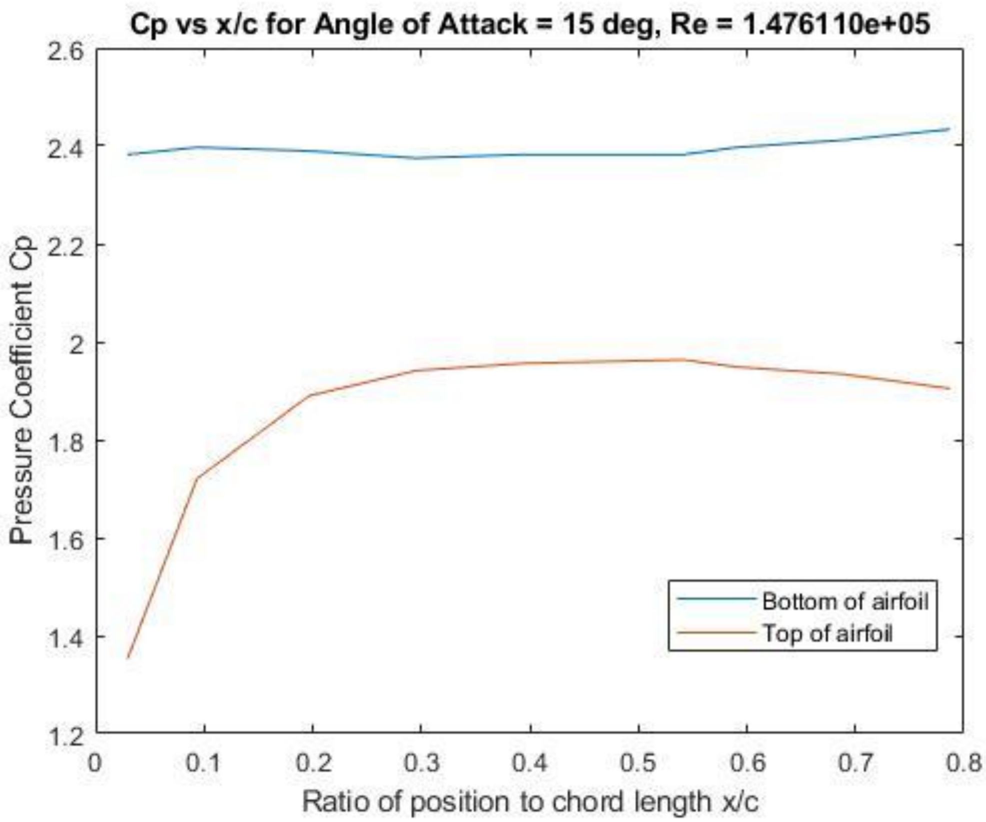

Figure 5. C_p versus x/c for an angle of attack above stall (15°)

Short-Answer Questions:

1. Describe what happens to the lift coefficient before and after stall.

Before stall, the lift coefficient increases in a concave-down manner. After stall, the lift coefficient decreases in a concave-up fashion.

2. Using appropriate fluids terminology, describe why the lift and drag increase with angle of attack up to the stall angle.

As the angle of attack increases, the boundary layer enlarges and the frontal area increases significantly, causing drag to increase. Also, as the angle of attack increases, the pressure gradient becomes greater and lift increases as the flow below the airfoil is compressed and the flow above is depressed. At stall, the air begins to separate from the airfoil before a desirable pressure gradient can form, the lift decreases, and the relationship to drag becomes complex. Vortices that form in the flow above the airfoil can contribute to more drag.

3. Identify sources of uncertainty in the measurements and speculate how it could lead to discrepancies between the experimental results and published/accepted data.

One source of uncertainty is the precision of the measurement instruments. Another is discrepancies between fluid properties at high and low elevations; In Salt Lake City, the air pressure is lower, and our experiment temperature was higher than 15 °C. These would both cause the density to be lower and the kinematic viscosity to be higher, affecting the Reynolds number of the flow significantly ($\nu \approx$ 1.85e-5 vs. $\nu \approx$ 1.45e-5). Our readings of the angle of attack from the protractor could have been off – that was probably the least precise measurement instrument. Also, we used dynamic pressure to calculate air velocity, while in the previous lab we used an equation to relate the wind tunnel frequency to airspeed. The results of those two equations differ significantly; from dynamic pressure, V = 25.6 m/s; from the speed/frequency correlation, V = 31.8 m/s. This raises doubt in the velocity measurements. Finally, perhaps the largest source of error was in the lift and drag measurements, as their precision was low, they were constantly shifting, and we just eyed it and took a rough approximation.