BYU Flow Lab Assignment 1

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Abstract

200 words, and then we're done with the abstract.

1 Introduction

Many airfoil shapes exist in the world. The purpose of this research is to understand the effect of camber, airfoil thickness, and Reynolds number on the aerodynamics of an airfoil.

2 Methods

2.1 Angle Of Attack Experiment

To further understanding of airfoils. The effect of angle of attack on airfoil performance was measured. The experiment was done by creating a code in Julia that utilized Xfoil to predict the following coefficients: lift, drag, and moment. It is important to note that the particular Xfoil solver utilized accounted for viscous effects.

To accomplish this, I wrote up a function with the following inputs: airfoil data, angle of attack range, incremental angle of attack, the desired number of panels, and the number of iterations (how many times the software will iterate to match the boundary flow). The particular airfoil shape used for this experiment was a symmetric NACA16-006 airfoil. The respective coefficients were then plotted against the specific range of angle of attack values utilized. The specific range of angle of attack values was from -9 degrees to 14 degrees incrementing by 0.5 degrees. The Reynolds number was assumed to be 10000. Once the data was gathered, it was compared with plots found from Airfoiltools.com to test the accuracy of the results. It is important to note that AirfoilTools.com used a Reynolds number of 50000.

2.2 Reynolds Number Experiment

The Reynolds number experiment is very similar to the angle of attack experiment. A similar function was built in Julia with an additional input for the range of Reynolds numbers desired. Two new functions were added in which wrote the data to a CSV file and then plotted the subsequent functions and saved the files under a common folder.

For this experiment, the NACA16-006 symmetric airfoil was utilized. The range of angle of attack was from -9 to 14 degrees. It incremented by 1 degree for each data point. The range of Reynolds numbers where: 1e3, 1e4, 1e5, 1e6, and 1e7. The data points were gathered in a folder and compared with Airfoiltools.com data.

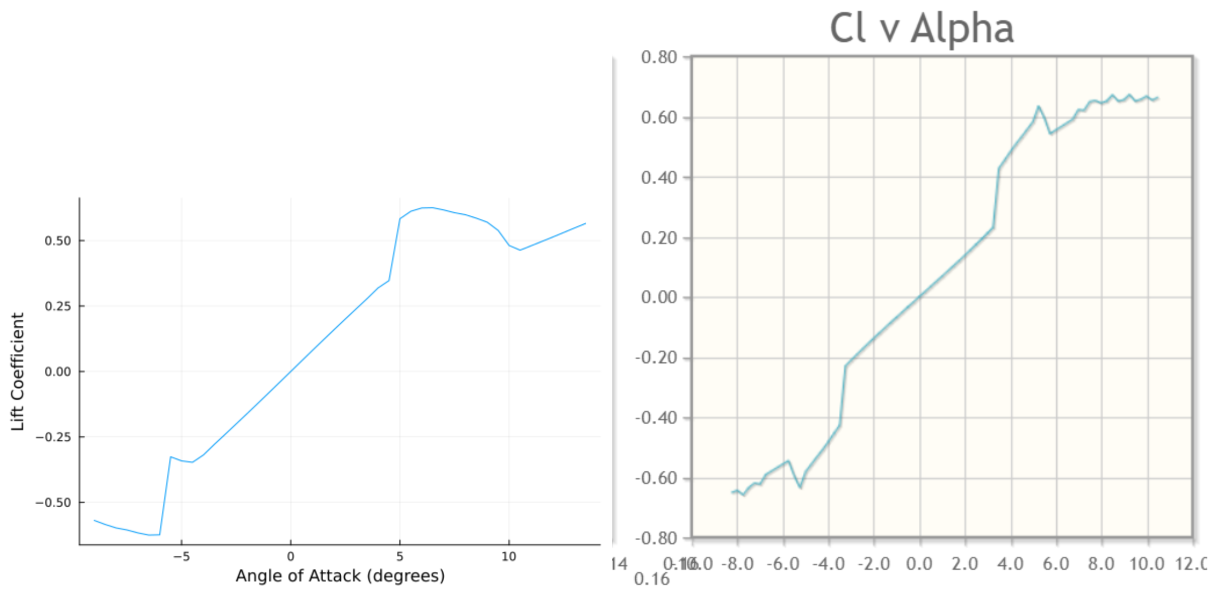
2.3 Airfoil Thickness and Camber Experiment

Similar to the last experiment, a function was called in Julia with the same inputs except for instead of a Reynolds number range it called for airfoil thickness or camber. Two programs in Julia were created with the only difference being whether airfoil thickness or camber was the input.

The results were plotted in their own respective folders. The airfoil used for this experiment was a NACA 2412. For the airfoil thickness experiment the camber was held constant at 2% (all percentages are percentages of the airfoil chord) whilst the airfoil thickness was measured at the following values: 12%, 15%, 20%, 25%, and 30%. For the camber experiment the airfoil thickness was held constant at 12%. The following camber values were tested: 2%, 4%, 5%, and 9.5%.

3 Results

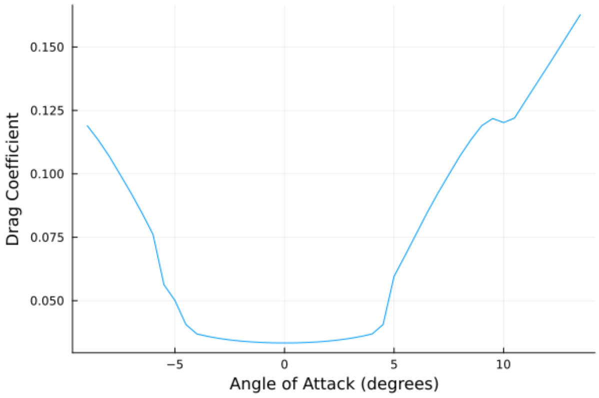
3.1 Angle of Attack Experiment



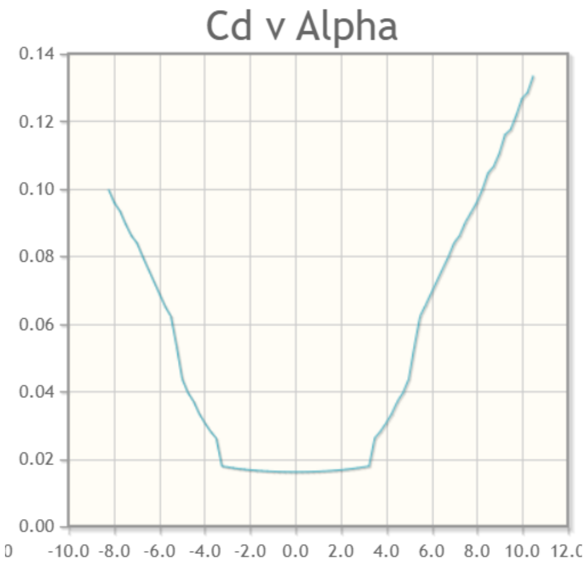
(a) Experimental Lift Coefficient

(b) Airfoiltools.com Lift Coefficient

Figure 1: Lift coefficients for a NACA16-006 airfoil

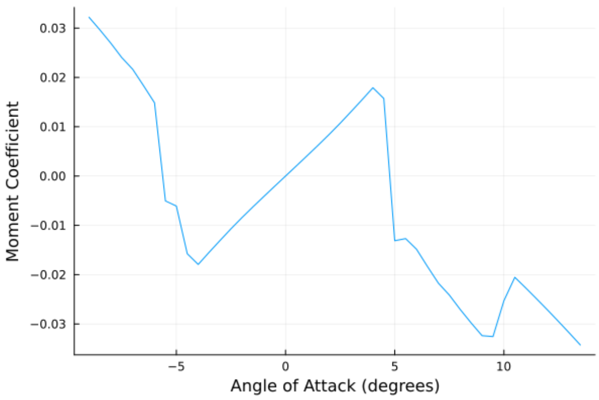


(a) Experimental Drag Coefficient

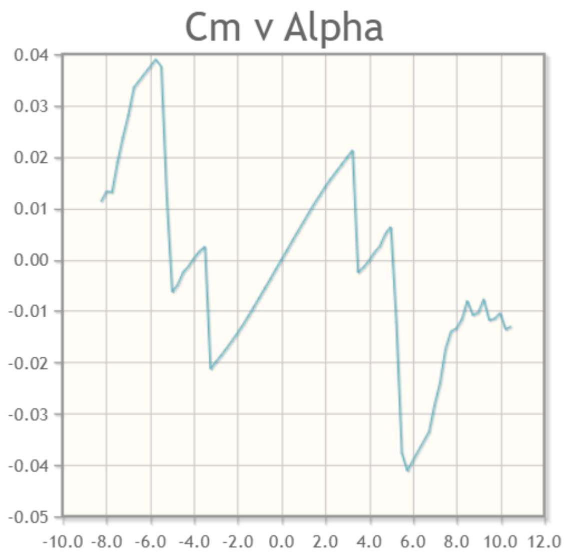


(b) Airfoiltools.com Drag Coefficient

Figure 2: Drag coefficients for a NACA16-006 airfoil



(a) Experimental Moment Coefficient



(b) Airfoiltools.com Moment Coefficient

Figure 3: Moment coefficients for a NACA16-006 airfoil

3.2 Reynolds Number Experiment

Due to the abundance of data, the results are described which show some of the key differences of airfoil performance based off of a change in the Reynolds number. Another reason why the graphs are not included is because most solutions had 1 or more angle of attack solutions not converge. This led to a spike in the graph that diminished all the other data as to make any pattern not visible from the graph alone.

After looking through the CSV files, there were some notable trends in the data. As the

Reynolds number increased the lift coefficients were increased, drag coefficients decreased, and moment coefficients decreased. To illustrate this, increasing the Reynolds number from 1e3 to 1e7 led to a 32% increase in the lift coefficient for an angle of attack of 2.5 degrees. The drag coefficient received a drastic reduction. It was 16.5x smaller for a Reynolds number of 1e7 than for a Reynolds number of 1e3. The moment coefficient was roughly 60% smaller by increasing the Reynolds number from 1e3 to 1e7.

This was the trend up until about 10 degrees of angle of attack. At this point things became a little unclear. Some experiments showed both the lift and moment coefficients decreased as the Reynolds number increased past 10 degrees. Whilst others would do the opposite. The drag coefficient generally followed the same trend of decreasing as Reynolds number increased. However, at these large Reynolds number there were some increases in the Reynolds number. The issue is that much of the data did not converge so it is hard to tell the overall trend.

3.3 Airfoil Thickness and Camber Experiment

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4 Discussion

References