CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

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Project Number

J0124

Project Title

Analysis of Airfoil Performance in a Micro-Scale Wind Tunnel

Abstract

Objectives/Goals

The first objective of this study was to build a home-made wind tunnel and to perform meaningful quantitative analysis of the lift and drag performance of airfoils. Also, to evaluate the impacts of modifications to the airfoils including adding dimples and protrusions to the surface, and changing the length (#chord#) of the airfoils. The changes in lift and drag were measured at different air velocities.

Methods/Materials

A #Pendulum Technique# was applied to measure horizontal drag force. The airfoils were suspended from a 602 mm fishing line and the airfoil moved horizontally as it experienced drag. A Drag Calibration Device was built to calibrate the horizontal displacement measurements taken in the wind tunnel. A #Spring Technique# was used to measure lift force. As air flow was introduced to the front of airfoils, they lightened due to lift and the springs condensed. A Lift Calibration Device (LCD) was built to calibrate this vertical displacement. The vertical displacement in the LCD related to the spring constant and the amount of lift force.

Results

Results showed that the Base Airfoil mosly had the most lift. L/D#s were ~1.6-2.9. Airfoil A5 had longer chord which resulted in less lift but also less drag. L/D#s for A5 were ~2.0#3.4, better than A1. Airfoils A6#A8 included protrusions on top of the airfoil. Protrusions reduced lift and increased drag, resulting in L/D#s of 0.6-2.4. Airfoil A9 had dimples on top. Dimples reduced lift and increased drag. L/D#s for A9 were ~0.9#0.6.

Conclusions/Discussion

Dimples added to an airfoil (A9) mostly resulted in the most reduction to the L/D for all of the airfoils tested. Protrusions (A6-A8) resulted in lower lift and higher drag. This supported the hypothesis that modifications would inhibit performance of A1, though in some tests the results were less dramatic than the 4:1 change in L/D that was hypothesized. A5 had similar dimensions to A1, but a longer chord. A5 had substantially less drag than the other airfoils. A5 has the highest L/D of all airfoils tested. An extremely interesting observation occurred during lift testing. When air was allowed to leak through the side of the wind tunnel from under the airfoil but not from above it, the amount of lift displacement observed was substantially greater. This is a key finding for further study that the experimenter would like to pursue as it offers promise to improve wing performance of aircraft wings.

Summary Statement

A micro-scale wind tunnel was built economically in the garage to test and observe the lift and drag of six different airfoil designs at six different velocities inside of the wind tunnel.

Help Received

Mr. Kurtis Long helped with consultation on airfoil design, wind tunnel design, experimental apparatus, and ongoing discussion on results and conclusions.