CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

James D. Fagan

Project Number

J0111

Project Title

A Wind Tunnel to Examine Subsonic Aerodynamic Effects on Airfoils for Future Flight on Mars

Abstract

Objectives/Goals

My objective was to gain an understanding of aerodynamic principles that I could then apply to my design of an observation drone aircraft for Mars exploration.

Methods/Materials

I designed and built 2 closed circuit wind tunnels, 1 to measure lift force, and another to measure the drag force on several different airfoils that I also built. I used a vacuum cleaner for my air source. Forces were measured on a balance scale. I conducted over 500 individual tests to see how each airfoil would respond to different air speeds and different angles of attack. I made string probes to allow me to visualize the airflow around my airfoils while being tested.

Results

1. I found as airspeed increased, so did lift-and drag. Also, as angle of attack increased, so did lift and drag- But only to a point, when, depending on the airfoil, as angle of attack was increased above approximately 15-20 degrees lift would become unstable, or decrease, while drag would continue to increase. This was due to a condition known in aviation as a "stall", where airflow "detaches" from the upper surface of the airfoil.
2. I was able to demonstrate that the "equal transit time" theory of lift generation is incorrect.
3. I believe I was able to demonstrate that "Coanda Effect" increased lift on an airfoil, through an experiment of my own design.

Conclusions/Discussion

Based on my experiments so far, I think that an airfoil with a high camber wing and "built-in" angle of attack of 10-12 degrees would provide the best lift characteristics for a Mars observation drone, due to the Martian atmosphere being only 1/100 that of Earths.

Through my own experimentation, it is clear to me that the application of Bernoulli's principle to "Equal transit-time" theory of lift generation is untrue. Pressure above an airfoil is not reduced due to fast moving air, but fast moving air is produced because of the creation of a region of lower pressure. The "cause and effect" are reversed. This seems important to me because it does not seem possible to design the most efficient Martian airfoil without understanding the basic principles involved. I also learned and experimented with several other forces at work to create lift(and drag)such as "Entrainment", Newtons 3rd law, and Coanda effect.

Summary Statement

Research and wind tunnel experimentation to gain an understanding of aerodynamics that I can apply to the design of a Martian observation drone.

Help Received

Mr. Thomas Smid (M.S.C. Physics, Ph.d. Astronomy) His paper on areodynamics helped me to understand the effects of airflow on an airfoil at the molecular level. It also inspired me to build my triangular airfoils. My father supervised me at all times when I used power tools (jig saw and belt sander).