CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
James D. Fagan

Project Number
J0107

Project Title
Design of a Low Density Subsonic Wind Tunnel for Martian Research

Abstract

Objectives/Goals
My objective was to build a wind tunnel that could simulate the low density environment of Mars.

Methods/Materials
I constructed a closed circuit, double return wind tunnel using schedule 80 PVC pipe, which has a vacuum capacity of 30 Hg. I used an electric model airplane fan for my tunnel wind source. This was powered by a 12 volt power supply. A thrust tester was used to control the fan RPM. Air velocity was measured by a anemometer that I modified to work inside the enclosed tunnel. I built my tunnel's settling chamber using 3 flanges, which allowed me to remove or exchange various screen mesh assemblies. A removable honeycomb section was built, also using flanges to install it into the settling chamber. String probes were built into the tunnel viewing ports for flow visualization. 12 airfoils were built with magnets attached for attaching to the viewing ports. A strain gauge was built into my test section for measuring drag and thrust forces. Several different tunnel configurations were tested before final assembly: single return, double return, single nacelle, dual nacelle, 90 degree corners, 2x 45 degree corners. Each was also tested with and w/o turning vanes. Each configuration was evaluated for flow quality and air speed.

Results
After conducting over 220 tests, I have determined that a double return tunnel is more efficient than a single return tunnel, given equal return passage diameters, that wind tunnel corners comprised of 8 x 45 degrees are more efficient than corners comprised of 4 x 90 degrees. The less abrupt 45 degree corners decreasing energy loss by 7.2% on average, 10.19% in my final chosen double return design. I tested individual settling chamber screens as well as combinations for best tunnel flow quality, and also determined screen losses to be cumulative. I found turning vanes not only improved flow quality as I had expected, but surprisingly they actually increased air speed as opposed to no turning vanes by approx. 5%.

Conclusions/Discussion
My low density tunnel will allow testing of aerodynamic forces to see if they occur in the same proportion as expected, or if entrainment or Coanda effect were greater or lesser due to increased molecular spacing of the Martian atmosphere, ultimately affecting lift generation associated with Bernoulli's principle. This is vital to know for the proper design of an efficient Mars aircraft.

Summary Statement
I have designed and constructed a wind tunnel to simulate the Martian atmosphere to test aerodynamic forces in its lower density environment.

Help Received
I designed and built the tunnel on my own. Mrs Duncan, my woodshop teacher allowed me access to the shop after school to build my tunnel components. Ms Mcallister, my science teacher was always helpful in suggesting where to get supplies, websites helpful in graph production, and critiquing my raw data.