CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)
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Project Number
J0105

Project Title
Prop It Up! Static Thrust and Efficiency of Small Aircraft Propellers

Abstract

Objectives/Goals

1. To construct a simple yet accurate force balance which can measure the static thrust of different types of small model aircraft propellers as a function of RPM and power.

2. To find the properties of small aircraft propellers which give the most static thrust for the least power, i.e. are most efficient under given conditions.

Methods/Materials

The force balance uses meter stick and fulcrum to balance the thrust of a spinning prop with a moveable weight. I used a variable voltage DC supply and motor to vary the propeller RPM, which I measured with a strobe lamp source to "freeze" the image of the spinning prop.

I investigated the effects of variables RPM, pitch, and number of blades (2 or 3) on thrust/power ratio (=efficiency). I also tested a 5-blade refrigerator fan as a demonstration, and a compact disc as a "zero thrust, minimum drag" control. I took measurements at ~16 voltage steps from 0 up to 5 Volts, and back down again to 0 Volts for validity.

Results

The force balance can measure steady thrust accurate to ~0.3 grams. I found that the lowest pitch propellers needed to spin at higher RPM to produce the same static thrust, but used less power to do so, i.e. they were more efficient.

Comparing 2- vs. 3-bladed propellers, at higher thrust the 2-bladed props proved more efficient (even though they operated at higher RPM). However, at low thrust, the efficiencies were similar, a result which I did not find in the literature, but makes sense since slow blades act more "independently".

Conclusions/Discussion

Applications of static thrust include helicopter rotors (main and tail), hovercraft, micro-UAVs and blimps. Designers of these are always looking for the most "bang for the buck", i.e. the most thrust for the least power expended. My project demonstrated that the most efficient propeller choice has 2-blades, large diameter, low pitch and operates at low RPM. However, for very low thrust applications (such as a blimp) I found that a 3-bladed prop could provide similar performance, with the advantage of lower RPM (and noise) and more compact size. More tests including 1-bladed and 4-bladed propellers, are needed to confirm and extend this conclusion.

Summary Statement

I constructed a force balance and strobe to measure and compare the static thrust of small propeller designs as a function of RPM, pitch, and power required.

Help Received

Father helped me with MS Excel formatting and chart setup; local hobby stores provided advice on propeller mounting and motor choice; Force balance parts on loan from Grossmont College; DC power supply on loan from school.