CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)
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Project Number
S0304

Project Title
Design and Construction of a Miniature Helium Airship

Abstract

Objectives/Goals
This project aimed at developing a design concept for a miniature helium airship that had a minimal size and sufficient lift to carry necessary payloads for outdoor applications. The concept was validated by successful fabrication and flight demonstration of a mini-airship.

Methods/Materials
The mini-airship had a gas bag and a non-rigid hull expanded by a carbon skeleton frame. This unconventional combination eliminated the permeability requirement of the hull and reduced the strength requirement of the gas bag. Lightweight materials thus could be used for construction. The skeleton frame, though flexible, allowed streamline hull shaping and provided mounting support for the propellers and payloads. To select the most efficient propeller, the thrust, rotation speed, and power consumption of various propellers were measured with a homemade test set which used a solar cell to detect the propeller rotation. A new parameter, the ratio of propeller thrust to total power consumption, was defined and used for propeller selection. Calculations based on more than 30 equations were performed repeatedly to reach a design that had sufficient thrust and lift.

Results
The mini-airship had a volume of only 1.1 cubic meters and a weight of 0.895kg. A payload lift capacity of 0.25kg was achieved at a buoyancy ratio close to 1. Outdoor flight test demonstrated a speed of >3.3 m/s. This was the smallest airship that ever achieved such combined performance. Its hull shape was scaled from Model 111 in the NACA report TN-614 for low drag at low Reynolds numbers. The hull length to maximum diameter ratio was scaled from the original value of 5 to 2.5 for easy handling of the airship. Unexpectedly, a dependence of the propeller thrust on the third power of the propeller diameter was observed. To explain the observation, an integral equation was derived from the blade element theory which states that if the product of the chord and the lift coefficient of the blade element is a constant along the radius of the blade, the propeller thrust is proportional to the third power of the diameter.

Conclusions/Discussion
For the first time, a non-rigid hull and a gas bag was combined to form a mini-airship. The mini-airship had the smallest hull volume for the lift capacity and outdoor flight ability it demonstrated. These results represented a significant breakthrough in the development of mini-airship for practical applications.

Summary Statement
Based on a new design concept, a mini-airship was fabricated which had the smallest hull volume for the 0.25kg lift capacity and >3.3 m/s outdoor flight speed it demonstrated.

Help Received
Dr. Bob Boyd and Mr. Peter Starodub provided mentorship and guidance. Parents provided transportation and financial supports.