CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)
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Project Number
S0308

Project Title
Producing Electric Power from the Wind

Abstract

Objectives/Goals
My objective is to evaluate the output and flow mechanics of three different windmill rotor blades to optimize performance. I want to calculate the dynamic angle of attack for each experiment. My hypothesis is that the symmetric airfoil will outperform the flat bottom and control blades.

Methods/Materials
I tested two sizes (blade widths of 2"& 5") of three blade cross sections in two wind conditions (11.2 and 5.8 ft/sec) and set at 6 "Static Angles," (5 to 30 degrees) The blades were made by Flying Foam so that each 2" blade was the same thickness and weight and so too for each 5" blade. The blades were reinforced and pre-stressed (Sandia Labs 2010) during assembly. The windmill and wind tunnel were inspired by a 2009 Dept of Energy report. Before recording output, and rotational velocity data, the windmill rotor had reached steady-state. I used pink markings on one blade and a strobe light to measure rotational velocity. I averaged 6 observations for rotational velocity and 10 for output. I graphed output vs Static Angle. I graphed Dynamic Angle vs distance from rotor center and Static Angle (Petrov 2005) I graphed the Ratio of the Coefficients (Lift/Drag) for each point along the leading edge.

Results
Symmetric blades out performed the flat bottom and control at both 11.2 ft/sec and 5.8 ft/sec wind speeds. All output was at a maximum at 5 degree static angle except for four tests which showed the influence of the vector resulting from the starting vortex. Combining this vector with the dynamic angle of attack, results in the "net geometric angle of attack." The graphs of the dynamic angles along the rotors all start at a maximum value close to the center of the rotor and decrease in a sloping line as you go out the rotor blade. Just a small portion of the rotor producing near the maximum of the ratio of the coefficients is enough for the whole system to produce some level of power.

Conclusions/Discussion
The output graphs show the benefit of the airfoil and also show that that benefit decreases dramatically with increasing static angle. The Ratio of the Coefficients graphs showed that for all static angles there is some section of the blade that is producing at the maximum Ratio of the Coefficients (Lift/Drag), and area under the curve is related to output. The flow mechanics for the five and ten degree static angle setting are more productive than for the static angles greater than 15 degrees.

Summary Statement
My project is about evauating the flow mechanics and output of windmill blades to optimize performance.

Help Received
Prof. Farhat and Duraisamy were my project mentors; SC Academy meetings offered guidance on papers and boards;