CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)
Eleanor O. Frost

Project Number
S0311

Project Title
Increasing Power Output by Reducing the Windmill Blade Tip Vortex

Abstract

Objectives/Goals
As the blade of a horizontal axis windmill passes through the air, air pressure creates lift which improves blade performance. However, air pressure forms a vortex at the tip, reducing power output. A blade tip winglet can reduce the size of the vortex. (Xia 2013) My hypothesis is that the airfoils with winglets will produce greater electrical output than the airfoils without winglets.

Methods/Materials
To test my hypothesis, I used a windmill and wind tunnel design inspired by a 2009 US Department of Energy Report. The set up was similar to that used by Birch and Wilson in their 2013 study of the vortex. I tested 2 inch and 5 inch, Flat Bottomed and Symmetric blades with and without a winglet, at static angles from 5 to 15 degrees. The winglet was made of balsa wood and added to the blade tip; weight was added to the non-winglet blade so the blades were the same weight and had the same rotational inertia. The construction of the blades was inspired by a 2010 Sandia Labs paper, published in conjunction with the USDOE Office of Renewable Energy. I recorded 20 observations for each test. I averaged the results and calculated the standard deviation for each test. I calculated a t test statistic to see if the results were statistically significant to a 95% confidence level.

Results
My analysis of the experimental data shows that my hypothesis could not be supported to a 95% level of confidence. For the 2 inch blades, the tests without the winglet produced more power than those with the winglet but the results were not statistically significant. The 2 inch flat, 10 degree static angle test analysis showed that the blade without the winglet produced more power to a confidence level of just over 90%, suggesting that any benefit created by the winglet was overcome by additional drag. For the 5 inch flat blades, set to a static angles of 5 and 10 degrees, the blades with the winglet produced more power, however these results are not statistically significant.

Conclusions/Discussion
The test results generally suggest that any benefit from the winglet was overcome by drag added by the winglet. The 2013 winglet study by Xiu suggests there needs to be a match between the local flow and the design of the winglet. In future work, I would like to model the local flow and better match the design of the winglet to that local flow.

Summary Statement
Environmental Science

Help Received
Professor Farhat was very encouraging and supportive.