Explore the Influence of Wind Turbine's Blades on Its Output and Efficiency

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Abstract

Wind turbines convert wind energy into electricity. The efficiency of this conversion is measured by comparing the incoming winds speed and the output power. This paper focuses on how the properties of blades affect the output and power of wind turbines. The attributes of turbine blades that affect output and efficiency, such as blade size and angle of entry are considerable. Although results generally match with theory models, we find a size limit with blade length.

Theory

- Wind energy calculation formula

$$P = \frac{1}{2}\rho A v \cdot v^2 = \frac{1}{2}\rho \mathrm{A} v^3 (1)$$

- Betz theory .

The maximum power that can be produced by the wind wheel is,

$$P_{\max} = \frac{8}{27}\rho \mathrm{A} v^3 (2)$$

By dividing the equation (4) and equation (3) , we can derive the maximum efficiency of the wind turbine theory.

$$\eta = \frac{P_{MAX}}{\frac{1}{2} A \rho v^3} = \frac{\frac{8}{27} A \rho v^3}{\frac{1}{2} A \rho v^3} = \frac{16}{27} = 0.593$$

method

Wind

Wind turbine Fan

Figure 1: Using the fan provide wind power, and measure the output and efficiency of wind turbine.

The basic method of this experiment is to provide wind energy with a fan, measure the output voltage of a wind turbine with a multimeter, and calculate the power efficiency..

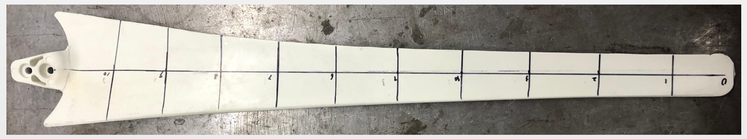


Figure 2: The sample of blades.

In the experiment, we used wood to make different size scales to the smaple, such as 1/2 size, 7/10 size, 9/10 size, the same size and 1.5 times size to the sample's size. Then we measure how the different sizes of blades can affect the output and efficiency with different wind speed. Also, we measure the output and efficiency change when we alter the wind angle.

Results

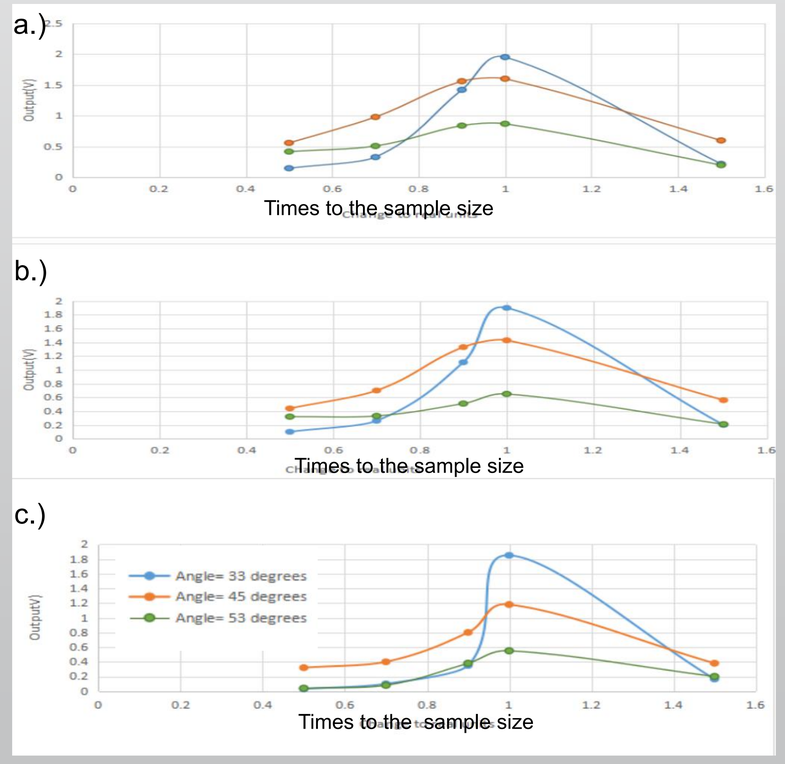
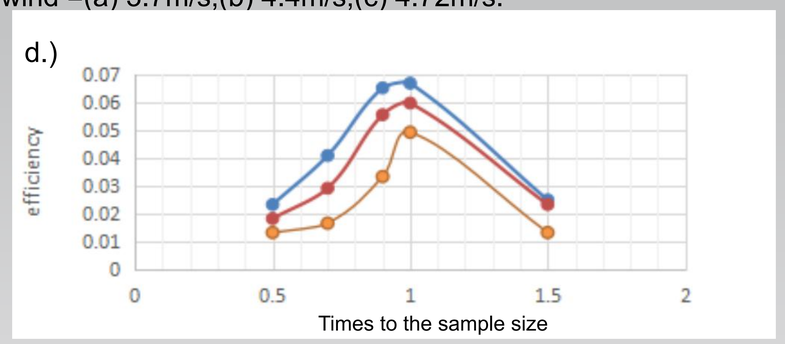


Figure 3：The relationship between the output voltage and the sizes of blades in different wind angles when average speed of wind =(a) 3.7m/s,(b) 4.4m/s,(c) 4.72m/s.



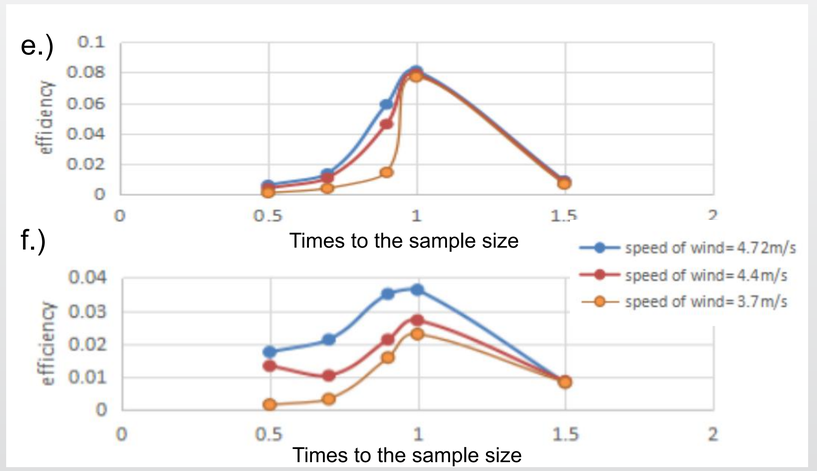


Figure 4：The relationship between the efficiency and the sizes of blades in different speed of wind when wind angle =(d) 33, (e)45,(f)53 degrees.

Summary

The best size in my measurement is 1:1 size.
The best angle in my measurement is 33 degrees.

Future Work

- How to improve the work:
  Use PVC material to make blades
  The blades can be made directly by 3D printing technology
  Trying to streamline the blades
- The following research direction:
  Weight each blade to estimate moments of Inertira
  Explore how the output attenuates with weight under different winds.

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