Robert Fox
24 April 2007
Physics HL

To Investigate the Optimum Windmill Design

Planning A:

Problem statement:

Windmills convert the wind into either mechanical or electrical energy. If the efficiency of the windmill can be increased, then the need for expensive, polluting, power generators will be reduced. As a result, we would be helping the environment and economy at the same time

Research Question:

The study that power is directly affected by the angles and/or the number of blades on a windmill and to determine the optimum efficiency for a windmill design

Hypothesis:

The blade angles: I have predicted that as the angle lowers the obvious reaction to the wind would be more surface areas and thus the more power the wind mill as more wind is striking more of the blades. The countersuit being that the larger the angles become the less surface areas and thus the windmill produces less power. .

Number of blades: According to my own knowledge I predict that the more blades added to the wind mill will produce more power as there is more surface area for the wind to contact.

Variables:

Independent Variable: number of the blades + angles
Dependent Variable: Time to lift weight
Controlled Variable: wind speed, the mass of weight, the size of the blade

Planning B:

Materials:

- Windmill tower
- 4 detachable wind blades
- 0.5m long string
- 3 x 10g weights
- Hairdryer
- Stop watch

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Method:

1. Collect and prepare all materials and apparatus needed for experiment
2. place built windmill tower on a desk facing the hairdryer
3. hairdryer to desired power
4. hang the weight (0.03kg) from the 0.50m string at the end of the turbine
5. begin with 4 blades at a 30° angle and turn the hairdryer on keeping it at a constant distance from blades, hold blades to prevent them from revolving
6. Let go of the blades and simultaneously start timing the time it takes for the weight to be lifted to the top.
7. repeat this process 5 times
8. after that change the number of blades to 2 with the 30 degree angle and repeat the last 2 steps
9. follow through to complete the process with 4 blades at 45° and 70° angles and after repeating it with 2 blades
10. Record data and observe

Results:

- The number of blades being used (2 and 4 blades) will provide sufficient a amount of data to get a good idea of the what happens.
- 3 angles were chosen to complete experiment, them being 30°, 45°, and 70° respectively giving a good overall all rounded result for good analysis.
- I decided to take 5 trials for each variable and average it getting a more valid result to insert into my calculations.

Data Collection

Mass : 0.03kg
The displacement: 0.5m +/- 0.05cm

Time vs. blades

Numer Of blades	Trial #	4	2
Time s +- 0.15	1	7.62	12.93
	2	7.50	12.45
	3	7.84	12.12
	4	7.32	13.32
	5	7.25	12.76

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Time vs. blade angles

The blade angle (°) +- 0.5	Trial #	30	45	70
Time s +- 0.15	1	7.54	12.02	17.45
	2	7.86	11.56	17.89
	3	7.33	12.57	18.67
	4	7.30	12.25	17.25
	5	7.49	12.36	18.04

Data Processing:

Deriving the equation:

$$W = Fs$$

$$P = \frac{W}{t}$$

We can determine an equation for power:

$$P = \frac{Fs}{t}$$

Time vs. blade angles

The blade angle (°) +- 0.5	30°	Uncertainty	45°	Uncertainty	70°	Uncertainty
Average time s	7.504	0.15	12.152	0.15	17.86	0.15
Power W	0.020	4.1	0.012	3.7	0.08	2.2

Time vs. blades

Number of Blades	4	Uncertainty	2	Uncertainty
Average/ s	3.13	0.15	5.02	0.15
Power/ W	0.04	2.3	0.02	3.4

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Conclusion:

My hypothesis was that the blade angles and also the number of blades would affect the power of a windmill as either variable is increased. This experiment proves my hypothesis correct in saying that more blades and the lower the angle is the more efficient the windmill will be. As suspected the 4 blades turned out to produce almost double the power (0.04 W) than the 2 blades did (0.02 W). This observation has annotations that power is directly proportional to the number of blades but however the results can not only be dependant upon this as too few variations of trials were tested for a rounded, fair result. For the blade angles there was quite a obvious result that the 30° produced the highest power (0.020 W) and quite a substantial difference of 0.012 W, at (0.08 W) for the 70° angle.

Limitations of the experiment would be that there was not a variation of shape of the blade and change of material. The wind speed and direction was another factor as this was not held constant during the trails. These factors if tweaked slightly could affect the results vastly.

The measuring devices used could have been more precise. The wind speed and direction could have been kept constant by fixing the hairdryer in place at a certain angle and distance always from blades for fair results. Varying the blades shapes and material would give a better understanding and a more supporting experiment to prove the hypothesis with.