Turbine Report

Team: The Whirly Polar Bears

Abstract

This research involved brainstorming, creating, and testing different designs for an effective and efficient design for a wind turbine. The design goal of this project was to produce an innovative turbine, which would also be able to produce power efficiently. The method of reaching this goal was by first exploring additional resources and brainstorming ideas, then creating the wind turbines, testing them, and revising. Throughout this process, several designs were created, with two of them being turbines spinning perpendicular to the fan, the third one spinning flat on an axis parallel to the table, and the fourth a traditional wind turbine for use as a "failsafe". After conducting tests and revising, our results showed that the traditional fan blade produced the most power, however, the flat one was the most efficient. While it did not produce much power, we believe that given more time, it could be revised to be even more efficient. Our research also shows that vertical-axis wind turbines (VAWTs) are just as effective and efficient as their traditional horizontal-axis counterparts.

Design Goal

Our design goal in the beginning was to produce a turbine that creates the most power, however throughout the design process, we changed our focus onto creating the most innovative design.

Brainstorm Session/Explore

We started our design process with brainstorming, where several designs were proposed, ranging from the traditional leaf-shaped blades to curved blades. However, an idea was proposed in which the face of the turbine would be positioned perpendicular to the fan, and after looking on the internet, a design similar to that of an anemometer, a wind measuring device, was found. Also found was another VAWT (Vertical-Axis Wind Turbine), which was the basis for another one of our design. We collectively agreed on these two ideas as the basis for what all of our designs would look like.

An anemometer

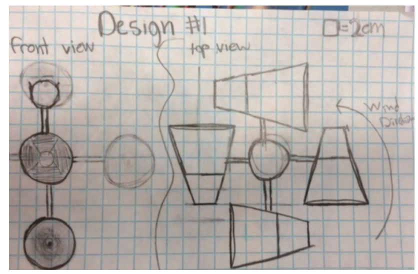
An example of a vertical -axis wind turbine

Design 1: Efficiency 0%

We tried to model the original vertical-axis anemometers as close as we could, using Styrofoam cups as blades with small "mini" cups attached to the ends (as to make it more aerodynamic) spinning perpendicular to the fan, catching the air in the cups and pushing the turbine around. However, we were leery about what kind of support the blades, which were glued to wooden stakes, needed so we put a plastic hub for extra support. The four blade decision was simply because 1) that is what the majority of anemometers had and 2) the size of our blades allowed four blades maximum and we wanted the most we could without blocking the airflow for the next blade. When tested, as seen in our data below, it moved very slowly. The extra weight from our hub and blades affected our design negatively by making it harder to move. We took that into consideration for our next design.

Top view of Design #1

Side View of Design #1



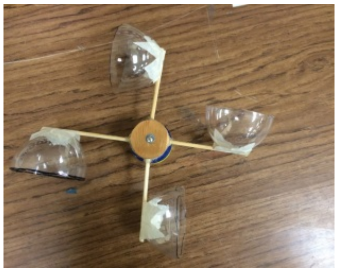
Scale Drawings of Design #1

Design #1 Averages

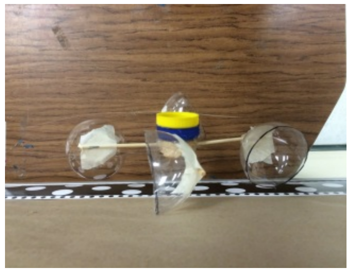
Airspeed (m/s)	Voltage (V)	Milliamps (mA)	Amperes (A)	Power (W)
5.4	0.03	0	0	0

Design 2: Efficiency 0%

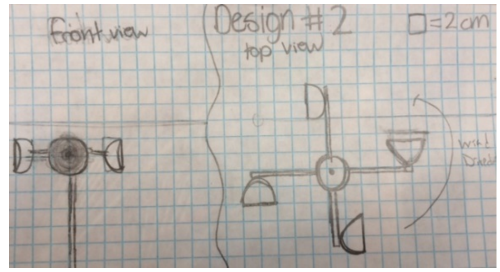
We noticed that all of the anemometer designs had spherical blades, so instead of the Styrofoam cups we attached the top parts of plastic water bottles to create spherical blades. These were attached, much like the first design, on small wooden stakes that were hot glued into a hub. This time, the group decided that the bigger plastic hub was unnecessary and just added extra weight so we did not included it in the design. When tested, though it did move faster than Design 1, the fan blades were too far out to catch the focused air, directed by the small fan. We decided that instead of creating a whole new design, we would revise the design by shortening the stakes so that the blades can catch the directed wind. We ended up shorting the blades from 9 cm to 5 cm. This time the blade produced 0.53 average volts instead of the design 2 initial 0.39 average volts. Though this did make the turbine turn faster it did not produce power.



Top view of Design #2



Side View of Design #2



Scale Drawing of Design #2

Design #2 Averages

Airspeed (m/s)	Voltage (V)	Milliamps (mA)	Amperes (A)	Power (W)
5.5	0.4	0	0	0

Revised Design #2 Averages

Airspeed (m/s)	Voltage (V)	Milliamps (mA)	Amperes (A)	Power (W)
5.5	0.53	0	0	0

Design 3: Efficiency: 0.01%

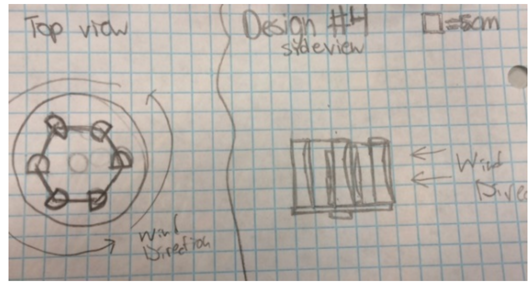
Seeing as having the first two designs (which were perpendicular to the fan) were not working, the decision was made to flip the design such that the blades rotated on an *axis* perpendicular to the fan, which meant having the blades spin on a base parallel to the table. We also decided to make longer blades, as to catch more airflow by having a greater amount of surface area.

Originally, the design consisted of having the blades mounted on wooden skewers, but this idea was not very favorable, as it required mounting the flimsy end of the (half water bottle) blade onto it, which would take some difficulty to accomplish. Thus, it was decided to use a circular-cut piece of heavy board as the base. The blades were fitted in via notches cut into the board and hot-glued as to make it sturdier.

For this design to power a house for 24 hours 13,333,333 turbines would be needed. While this design was not very efficient, we believe that, given more time, it could be made to be so. Some improvements suggested by Mr. Frank White were to have fewer blades, and move the existing ones closer together, as to catch the air better. With these improvements, and others, this turbine can be made to be very successful.

Top View of Design #3

Side View of Design #3



Scale Drawing of Design #3

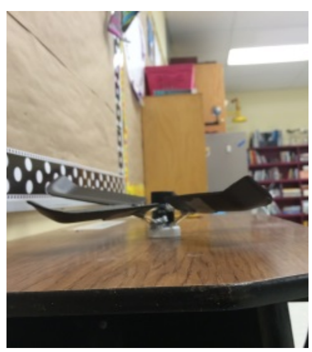
Design #3 Averages (Out of 12 Tests)

Airspeed (m/s)	Voltage (V)	Milliamps (mA)	Amperes (A)	Power (W)
5.9	0.9675	0.1	0.000103	.0001

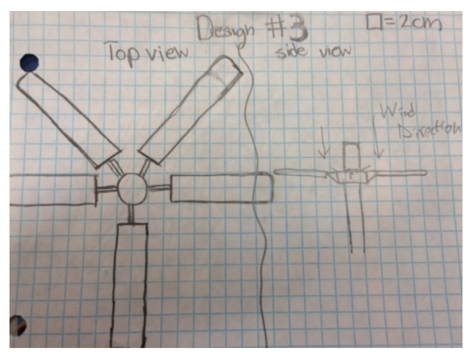
Design 4: Efficiency: 0.00605%

Our fourth design was a traditional fan blade. Originally we were sticking to the anemometer idea, but since we weren't having much luck we decided to create a failsafe if all of the anemometer ideas failed. We used the long edge of a Styrofoam tray. The tray edges had a slight curve, which was great for catching wind. The blades were 15 cm long, but then with an additional 3 cm when you attach them the stakes that in turn attach to the hub, a black film canister.

Side View of Design #4



Top View of Design #4



Scale Drawing of Design #4

Design #4 Averages

Airspeed (m/s)	Voltage (V)	Milliamps (mA)	Amperes (A)	Power (W)
6.1	0.94	0.03	0.00003	0.000025

Variables During the Design Process

1. Surface Area of the Blades

In the wind turbine lab one variable that could be changed in the design is the surface area of the blades. The final wind turbine used five blades with the surface area for each blade measuring 96cm. Changing the dimensions of the blades could work to either make the blades turn slower or faster. If the blade is made shorter in length the spin of the blade will turn faster. However by having a shorter blade, less air flow would be utilized, it would be "wasted" wind if the blades were constructed with more length there would be more mass and therefore more force would be necessary to spin the blades around.

2. Wind speed

Wind speed is another variable that could be changed in this lab. If a more powerful fan were used to generate more wind, the turbine blades would have a greater force on them and turn faster. The average airspeed would have to be greater than 6.1 m/s, which would increase voltage (V), milliamps (mA) and the amperes (A), which would then have a greater effect by increasing the total power of the turbine and making it more efficient.

Energy Transfers and Conversions

The source of wind energy all starts from the sun. The sun creates nuclear energy by the fusion of hydrogen. That energy is given off of the sun into space by way of radiant energy. When it hits earth it heats up the ground with thermal energy. That in turn heats up the air, again thermal, and the air moves. This creates wind, which is mechanical energy. Wind energy is only mechanical, though it is in its last stage it goes through many different conversion

Conclusion

Based on the results of our testing, we can see that the traditional fan blade succeeded in providing the most power. However, it was not the most efficient. The VAWT had an efficiency of 0.0027%, which, while not a lot, is more than the traditional turbine's efficiency of 0.00605%. Based on these findings, we can conclude that the VAWT was more efficient than the HAWT. Given more time, it is believed that the VAWT could be made to be much more efficient in terms of creating power and blade design.

Resources

Mogielnicki, J., D. Harmon, J. Kramer, D. Lyons, D. Lentine, D. Taylor, and MC Baker. Power in the Wind. Create It Lab. N.p., n.d. Web. Mar.-Apr. 2016.

"What Is the Most Efficient Design for a Wind Turbine?" - Quora. N.p., n.d. Web. 12 Apr. 2016. "Anemometer." Wikipedia. Wikimedia Foundation, n.d. Web. 12 Apr. 2016.