Miniature Windmill Prototype 1 Test Report

Team 6

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Abstract: The issue of limited electricity is present in Burkina Faso today. With the problem of having to power a cell phone in a sub-saharan area, solutions to resolve this issue were made. These solutions included wind power, solar power, and hydropower. After weighing out the possible solutions, it was decided that the best option was to build a small windmill. A prototype was made and tested to determine what adjustments were needed for it to be a feasible solution to the problem at hand. With sturdier materials to withstand the harsh weather conditions, the second prototype will be able to produce wind energy for the family without the fear of the windmill breaking apart.

Introduction: Electricity is not very accessible in the sub-saharan country of Burkina Faso. Estimates show that almost fourteen million out of the eighteen million citizens in Burkina Faso do not have electricity. It was decided that the use of natural resources would be the best way to produce power for the family in Burkina Faso. Within the last couple of decades, Burkina Faso has tried to use natural energy to power citizens’ homes. They have used a variety of energy resources, including solar, wind, and hydropower. Due to the wind potential in the area, our group decided to use wind power. Wind speeds in Burkina Faso vary from month to month, but wind speeds can exceed forty miles an hour during the months between April and August. A prototype of a windmill was designed and tested to determine whether or not the windmill would be able to produce enough power to charge a phone. Expectations were that the windmill would be able to produce electricity without the need of an outside force apart from wind.
Methods/Physical/Computational Description:

<table>
<thead>
<tr>
<th>Order</th>
<th>Test</th>
<th>Requirements for passing</th>
<th>Did it Pass</th>
<th>What was Learned</th>
<th>Improvements that can be made</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fan Test (Does it Work)</td>
<td>The windmill spins at a minimum of one revolution per two seconds.</td>
<td>Yes</td>
<td>Light materials will have more revolutions per second.</td>
<td>Light-weight metal will be used.</td>
</tr>
<tr>
<td>2</td>
<td>Safety Test</td>
<td>There are no jagged edges on the prototype and the propeller does not fall off easily.</td>
<td>No</td>
<td>There needs to be a stronger fusion between the base and propeller.</td>
<td>More screws and stronger glue must be used.</td>
</tr>
<tr>
<td>3</td>
<td>Ease of Maintenance Test</td>
<td>Each part must be able to be put back onto the prototype in under ten minutes.</td>
<td>Yes</td>
<td>The parts are easily maintained.</td>
<td>None</td>
</tr>
<tr>
<td>4</td>
<td>Sturdiness Test (Outdoor Test)</td>
<td>The windmill still spun at a rate of at least two revolutions per second.</td>
<td>No</td>
<td>The prototype must be made of sturdier materials.</td>
<td>Sheet metal will be used for the propeller fins.</td>
</tr>
</tbody>
</table>

We go further into detail on what is in this chart in the paragraphs below. Also the pictures for the tests are placed right under each paragraph that explains that test.

The purpose of this project is to provide a way for a poor African family to charge their cell phones at a low price without leaving home. Early in the design process, many forms of energy production were investigated. Some of these include solar panels, thermoelectric generator, and dynamo generators. Based on price, ease of use, and efficiency, wind energy was selected. A prototype for a small wooden windmill was then designed and built. The prototype consisted of a base made of wooden boards and a propeller made from wooden dowels, cardboard fins, and a PVC pipe. The project was held together mostly by duct tape along with a
few nails as well as some hot glue. After the model was completely assembled, testing began immediately.

The first test was designed to determine whether or not the windmill would actually spin with only the force created by wind. The prototype was placed on a table across from a box fan. The fan was turned on and placed at varying distances to create different wind velocities. The windmill was observed to see if it would reach the desired rotation speed, which was a minimum of one rotation per two seconds. Even with the fan fifteen feet away and wind speeds of around six miles an hour, the prototype spun at an average of around three rotations per second. Therefore, the first prototype passed the test of spinning one rotation per two seconds. This test was created to make sure that the prototype could function without attention from the user, and that it would produce electricity even when there is not a vast amount of wind present.

The second test was used to determine if the prototype would be safe for everyone in Burkina Faso to use. The prototype could not be used if it caused potential danger for those using it in Burkina Faso. The entire surface of the prototype was searched for jagged edges, loose nails, or sharp corners. The structure must be sturdy enough to not fall off of the roof
during a storm. The base was made specifically made to withstand the strong winds that occur mainly during the months of April and May, where winds speeds can exceed forty miles per hour. The thickness, length and width of the base, which is one inch by fifteen inches by seven inches respectively, creates a sturdy structure so the chance of the windmill detaching from the roof is very limited. We encountered a problem when we left the prototype overnight. In the morning the propeller had come off and was detached from the base. This test failed because, though there were no jagged edges for the family to harm themselves on, the propeller did fall off and this could cause an injury.

The third test was designed to determine whether or not the prototype would easily be maintained. Spare parts must be easily accessible to those in Burkina Faso. Also, repairing these parts must not be too complicated so that the family is capable of doing it in case the windmill breaks during a storm. Passing this test meant that the individual would be able to take a broken piece of the prototype, repair it, and place it back onto the prototype within ten minutes. First, the prototype was taken apart and each piece was individually replaced. This test passed because each piece was able to be repaired within the ten minute time frame. Even when we encountered the problem of the propeller being taken off we were quickly able to fix that as well.

The fourth test examined the sturdiness of the structure. Each individual piece of the structure, including the PVC pipe, the propellers, and the base were pulled with considerable strength to determine whether or not the prototype could withstand strong winds and natural wear and tear. The prototype was then left outside on a roof for twenty-four hours. It faced wind speeds of thirty seven miles per hour as well as heavy rain to test its ability to function through severe weather conditions. The result of the test is considered to be passing if the windmill
remains structurally sound and continues to function throughout the entirety of the test. The results found that the cardboard fins were saturated from the rain and therefore could not spin as quickly as it did before the rain hit. In addition, the PVC pipe along with the propellor fell off of the base due to the strong winds. The first prototype did not pass this test because it could not produce any power after being hit with water.

Results: After finishing the prototype and the tests, some revisions must be done to ensure a sturdier yet lighter prototype. With the fan speed on the low setting, the air came out at around six miles an hour. The windmill spun three times per second while being fifteen feet from the fan on this low setting. With a lighter propeller, more rotations will occur in the same amount of time with the same wind speed. Also, either sturdier tape or heavier glue is required in order to increase the durability of the prototype. Solving this problem will in turn also solve the problem of safety because there will be no parts falling off of the windmill.

Interpretations of the Results: Changes in the structure of the prototype must be done to ensure that the windmill can properly function under any conditions and produce enough electricity for the family in Burkina Faso. The first prototype worked under ideal conditions. The propellers continued to spin for a while after being rained on but eventually broke. Before it broke, they spun at a much slower rate because the cardboard absorbed the water and made the propeller heavier. The propellers need to be made of a sturdier and material, such as sheet metal. In addition, more durable glue will be needed to fuse the base to the propellor, because it fell off. With the success of the first prototype, minor changes can easily be made to produce a windmill that will power the Burkina Faso family’s phone and survive harsh weather conditions.
Conclusions: Due to the lack of electricity in Burkina Faso, almost fourteen million people are without power. Without resources such as coal and petroleum, families in Burkina Faso find it hard to produce their own electricity. Therefore, natural resources such as wind power must be used as a replacement. A prototype of a windmill was made out of wood, a PVC pipe, cardboard, and wooden dowels. The prototype was tested based on durability, safety, revolutions per second, and ease of maintenance. After determining whether the first prototype passed or failed each test, documentation of changes that needed to be made to produce a better windmill was created. The revisions include sturdier material for the propeller fins and heavy-duty glue as well as screws to fuse each piece of the windmill together. With these changes, a sturdier, more efficient prototype will be created that can withstand harsh weather conditions and can produce and store energy for the family in Burkina Faso.
Works Cited


<https://weatherspark.com/#!/dashboard;ws=28539;t0=1/1;t1=12/31;graphs=windSpeed:1,windDirection:1>.


