Harnessing Wind Energy with Recyclable Materials

By
Katherine Carroll, Margo Dufek,
Leanne Willey, and Andrew McCarthy
Team 03

Midpoint Review

Document

Submitted towards partial fulfillment of the requirements for
Mechanical Engineering Design – Spring 2013

Department of Mechanical Engineering
Northern Arizona University
Flagstaff, AZ 86011

TABLE OF CONTENTS

Problem Statement

Introduction

The "Harnessing Wind Energy with Recyclable Materials" (H-WERM) design project is a project initiated, and sponsored by Srinivas Kosaraju, a Mechanical Engineering professor at Northern Arizona University, located in Flagstaff, Arizona.

The customer of the design project cannot be specifically identified as an organization or a corporation: the final project design is intended for citizens of third world countries who are in need of relatively small quantities of electrical energy. The energy is intended to be used to provide basic living "luxuries" such as lighting and the use of fan(s)

Needs Identification

Inhabitants of third world countries, whom do not have access to electrical grid network(s) of power production facilities, are in need of electricity.

Project Goal and Scope of Project

Goal Statement: To provide inexpensive electricity to third world country citizens who have limited access to electricity.

Scope: To provide an inexpensive, portable wind turbine system to harness wind energy. The wind turbine system will include both a wind turbine to generate electricity, and a means of storing the electricity generated.

Updated Design

A few changes were made to the wind turbine design described in the previous report. From the previous design with a motorcycle stator and flywheel mounted on the same shaft as the turbine, multiple changes were made to increase performance. The updated design is shown in Figure 1. The following sections describe the specific changes to each of the turbine components.

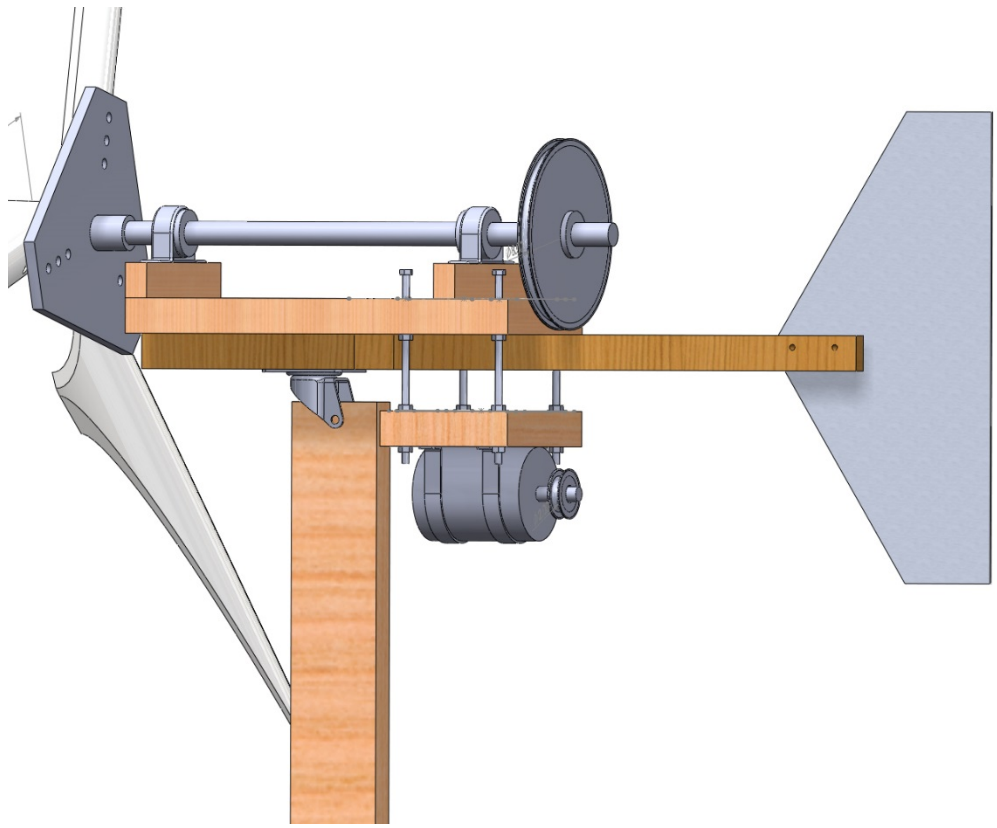

Figure 1: Updated Wind Turbine Design

Generator

The revolving flywheel and stationary stator were replaced with a small Ametek DC generator. This generator was chosen for its availability and power output. Running at 400 RPM, it should produce 100 Watts at 14 Volts, which is sufficient to supply power to the appliances and charge the car battery in the circuit.

Pulley System

A pulley system, shown in Figure 1, was implemented to increase the gear ratio of the overall system to 4:1. A 2" pulley is mounted on the generator shaft, and an 8" pulley is mounted on the main turbine shaft. With this pulley system, more torque is required to turn the turbine blades, but the DC generator rotates four times faster than the turbine shaft, increasing the RPM input to the generator. The turbine shaft is mounted on top of the base of the wind turbine with two pillow top bearings for overall balance and rigidity.

Within the pulley system, a V shape belt will be used to transfer the rotational load to the DC generator. This type of belt will operate with a no slip condition, sustaining grip with the least amount of friction. To achieve this, a tensioning system will be implemented. This tensioning system contains four 8" bolts that will go through the wooden base and connect to the DC generator plate, as shown in Figure 2. These bolts will have nuts and washers placed throughout its overall length, allowing the tension of the V belt to be adjusted.

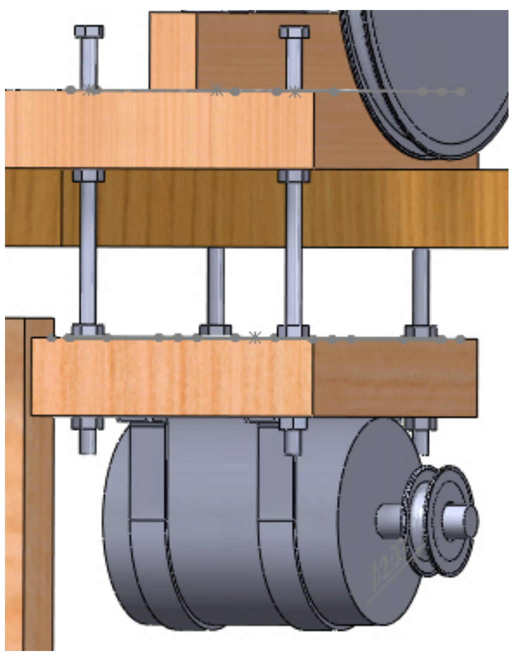

Figure 2: 8" Adjustable Bolts

Turbine Blades

The construction of the blades has slightly changed in this design. The previous plan was to heat the PVC pipe, flatten it into a sheet, and then lay it over a wooden airfoil template. This would, theoretically, allow the blades to be crafted to an exact aerodynamic shape, and would ensure the greatest amount of power supplied by the turbine. However, the team decided this process would be impractical, as the slight increase in efficiency was not worth the amount of construction time required. Instead, the team decided to cut one PVC pipe into three sectional blades, lengthwise. This allows the blade to capture the natural twist of the pipe's circumference, and it is easy to cut the blades to be tapered down at the end. The blades will be cut from either 4" or 6" Schedule 40 PVC, depending on availability.

Turbine Hub

The wind turbine blades will be mounted using a hub system that directly attaches to the center shaft. The hub will be made from thick sheet metal, about 1/8 of an inch, and will have a six hole pattern to mount the blades. The overall shape of the hub will be circular, and the turbine blades may slightly overlap each other when attached. A 1" metal collar with a setscrew hole will be welded to the back of the hub and then attached to the shaft using a setscrew.

Parts Checklist

Table 1 shows a list of the parts and raw materials required for construction of a prototype, and whether they have been collected.

Table 1 – Parts Checklist

Material / Part	Acquired
2" Pulley	√
2x4 Wood	√
2x8 Wood	√
8" Bolts	√
8" Pulley	-
Car battery	-
Caster wheel	√
Generator	√
Nuts & washers	√
Pillow top bearings	-
PVC blades	-
PVC pipe	√
Sheet metal	√
Turbine hub	-
Turbine shaft	-
V-belt	-
Weather vane	-
Wood screws	√

Building Progress

Unfortunately, the building progress of the prototype was postponed because the team was unable to finalize the design until the generator was acquired. This left the team with three weeks to construct the prototype before the first hardware review. To date, the team has collected the majority of the parts for the project, and has started fashioning the turbine blades.

Because the team purchased a used generator, it is necessary to test the power output to ensure it will operate as anticipated. Although the motor specifications indicate an ideal operating speed of 400 RPM will produce the voltage required for the design, the team will test the motor to verify this claim. The generator will be tested using a voltmeter, and a general-use power drill. The generator shaft will be turned at increasing RPMs until the voltmeter outputs the required voltage. The RPMs determined from this experiment may affect the gear ratio needed for the H-WERM prototype. If this is the case, the team will purchase alternate pulleys to meet the generator RPM requirements.

The team has started to fashion blades for the prototype, however, the team is currently using 4” PVC pipe for the blade material. The reason for using a different size of material than anticipated is availability. The team is looking into other companies to find a larger diameter pipe. If the team cannot find the ideal pipe size for the blades, the team will use the 4” blades that are currently being made.

The team also anticipates cutting the wooden base pieces and creating the turbine hub by the end of the week. If the team is able to finish the blades, cut the wood base, and create the turbine hub, then the prototype will be assembled this weekend. The assembly process of the prototype just involves fastening the major components together.

To complete the above tasks, the team has assigned individual roles. For example, one team member is to create the turbine hub by the end of the week, and another is required to test the generator, et cetera. By allocating specific roles, multiple tasks can be completed in parallel.

Current Timeline

Table 2 shows an updated timeline for the H-WERM project. To ensure a successful prototype of the H-WERM design, the team generated a list of tasks to be completed before the first hardware review. These tasks include testing the generator, fashioning the blades, cutting the base out of wood, obtaining the remainder of the parts, creating the wind turbine hub, and assembling the prototype. These added tasks are shown in red in Table 2.

Table 2 – Current Timeline

Phase 1: Material Collection	Week 1			Week 2			Week 3		
	1/14	1/16	1/18	1/21	1/23	1/25	1/28	1/30	2/1
Reasses Design									
Gather Hardware Materials									
Gather Electrical Components									

Phase 2: Part Construction	Week 4			Week 5			Week 6		
	2/4	2/6	2/8	2/11	2/13	2/15	2/18	2/20	2/22
Build Hardware Components									
Build Electrical Circuit									

Phase 3: Assembly Construction	Week 7			Week 8			Week 9		
	2/25	2/27	3/1	3/4	3/6	3/8	3/11	3/13	3/15
Test Generator									
Cut Turbine Base									
Build Turbine Hub									
Fashion Blades									
GatherRemaining Parts									
Assemble Turbine System									

Phase 3: Testing / Finalize Design	Week 10			Week 11			Week 12			Week 13		
	3/18	3/21	3/23	3/25	3/27	3/29	4/1	4/3	4/5	4/8	4/10	4/12
Test Prototype												
Redesign & Retest Prototype												
Prepare Deliverables												

Phase 4: Prepare for UGRADS	Week 14			Week 15		
	4/15	4/17	4/19	4/22	4/25	4/27
Prepare Deliverables						
Practice Presentation						

Conclusion

The wind turbine design has undergone the following changes:

- Motorcycle stator and flywheel replaced with an Ametek DC generator.
- Pulley system implemented to add a 4:1 gear ratio.
- Blades will be simply cut out of PVC, instead of molded into an airfoil shape.

Most of the raw materials have been gathered for the prototype, and the team is currently working on obtaining the remaining parts and constructing the different turbine components. The team anticipates having a prototype finished by the first hardware review.

References

"PVC Pipe Size Dimensions, Identification & Pressure Ratings." FlexPVC.com. Web.

Twidell, John, and Anthony D. Weir. Renewable Energy Resources. London: E & FN Spon, 1986. Print.

Professor David Willey, Northern Arizona University.

Professor Srinivas Kosaraju, Northern Arizona University.

http://ecorenovator.org/wind-power-tutorial/

http://greenterrafirma.com/

http://researchgroups.msu.edu/system/files/content/DevelopmentofSmallWindTurbineBlades.pdf