Generating Power from Wasted Human Energy

Karl Cook

Abstract
Humans exert forces on objects every day. The goal of this project was to attempt to use some of that energy to make electricity that everybody needs. The swinging motion of the door was chosen as the wasted energy to be used. The harnessing of this energy was achieved by placing a homemade electric generator on the opposite side of the pivot side of the door and attaching a string to the edge of the door. An efficiency of 23% was found for the generator and maximum Watt output of about 8.25 W was calculated.

1 Theory

1.1 Basics of a Generator

The goal of a generator is to create a potential voltage difference between the two ends of the wires. The voltage difference invariably becomes the output voltage of the generator. The faster the magnet spins within the coils the faster the electrons move and the greater is the potential difference achieved.

1.2 Electromagnetic Induction

Electromagnetic induction is the production of a voltage across a conductor by means of a changing magnetic flux acting on the conductor. The magnetic flux can be changed either in strength or alignment. Furthermore, the faster the change in magnetic flux, the greater the voltage created across the conductor. When you put a coil of copper wire close to a magnet, the electrons in the wire will align with the magnetic field of the magnet. This alignment is the source of electromagnetic induction because it is the changing of magnetic flux that forces the electrons to align differently in turn, moving them along the wire and

This paper was written for Dr. James Dann's Applied Science Research class in the spring of 2009.

creating voltage. This is explained in Faraday's law of induction: the induced electromotive force or EMF in any closed circuit is equal to the time rate of change of the magnetic flux through the circuit.

1.3 Increasing the Power

In a twenty-inch piece of thirty-AWG copper wire there are a given number of electrons, so invariably there is a maximum amount of current and voltage that can be produced from the twenty-inch piece of wire. If you had more thirty-AWG there would be more electrons available and if you used twelve-AWG wire even more. The maximum number of electrons available is important, but equally important is the size of the magnet that is supposed to align the electrons and induce them into motion. If you have a hundred feet of thirty-AWG wire wrapped in a circle with a radius of two feet and a little half-inch cube supermagnet rotating in the center, you won't get very much voltage. This is because the magnetic field drops off the further away you get from it. Also, having a larger magnet would align more of the electrons, producing a greater voltage. In conclusion, the most wire and the largest magnet with the greatest magnetic field rotating as close as possible to the wire will create the largest output of electrical power.

2 Generator design

2.1 Which to Spin

In an electric generator there is always the choice of having the coils rotate or the magnet. In some applications the difference in weight of the magnet and the coils is so great that you have to use one or the other. For the application of the design in this project the use of either was very possible. However the choice was made to have the magnet rotate on the axle instead of the coils. This is because having the coils rotate means a brush system also has to be used to get the electricity out of the spinning coils. The brush system is difficult to build well and can fail easily; furthermore, there is a large chance of loss of voltage because of poorly made brushes. There are a few drawbacks to having the magnet rotate, such as the added force needed to rotate the axle because of the added weight of the magnet and the difficulty of centering the magnet on the spinning axle to reduce vibration at high RPM.

2.2 How to Attach to the Door

It is very important to get as much rotation of the generator per opening of the door because more rotation means more power. So the challenge was to figure out how to attach the generator to the door in order to get the maximum amount of rotation while at the same time keeping it out of the way of the person opening the door. It was concluded that putting the generator at the top of the door frame opposite the hinge would allow for maximum rotation while being out of the way. Attaching the axle of the generator to the end of the door that moves the greatest distance ensures maximum rotation of the generator.

2.3 Resetting

The generator needs to reel itself back in after each opening of the door so that it can be ready for the next time the door is opened. This needs to be done within certain parameters. First, the reel-in system needs to be fast enough so the string does not get caught in the door when it swings shut; and second, it cannot be so strong that it makes the door too hard for a person to open. It was concluded that a system similar to those used in tape measures would work best because it could handle the many rotations of the axle and could be easily tweaked to make it more or less resistant.

2.4 Latch

The design of the generator called for it to rotate only when the door was being opened but not when the reel-in system was working. If the generator was rotating while the reel-in system was working it would just cause more resistance for the reel-in system and the generator would not create that much power. To remedy this problem the string is wrapped on its own reel that can rotate freely from the axle, but it is connected to a one-way latch that forces the generator to rotate when the door is opening and not when it is closing (see Figure 1).

2.5 Aligning the coils

Initially there were several coils going many directions, but after initial testing it was found that some of the coils were counteracting each other, hindering the overall output of the generator. This is because one coil was producing a positive voltage while another coil was producing a negative voltage at the same time. The two voltages were canceling each other out. Looking deeper into how to fix this, I concluded that the two coils were wrapped in opposite directions. It was easily fixed by simply switching the leads.

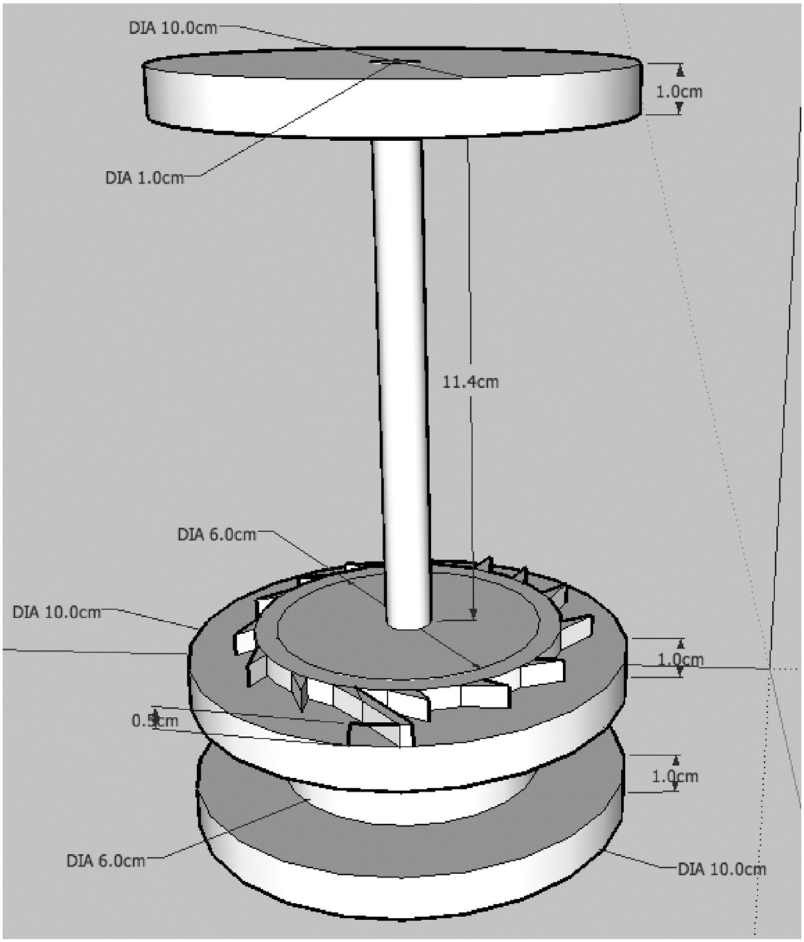

Figure 1: *The wire reel at the bottom connects to the latch system right above, which spins the axle above.*

3 Tests

3.1 Drill Test

The first tests of the generator were done using an electric drill to rotate the magnet. The generator was attached in parallel to a 50 Ω resistor and then to a Labquest machine. The resister is used to measure Watts using the equation $P=V^2/R$ (P being the power in Watts, V being the volts, and R being the resistance). By rotating the drill at different speeds and observing how the different speeds affected the power output, it was possible to load the data into a graph with RPM [revolutions per minute] on the x axis and Watts generated on the y axis. Once there were enough data points, the application of a few different curve fits was used to find the maximum output of the generator. Figure 2 shows two different curve fits, the top being a cubic curve fit and the bottom a Gaussian fit.

3.2 Efficiency

Another important number to calculate was the efficiency of the generator. Getting the number was done by having a known weight, in this case is a 1 kg piece of metal, pull on the generator with a known acceleration, in this case gravity. The weight was allowed to fall toward a motion detector that sensed how fast it was falling. As the weight was falling it was rotating the generator, creating power. Taking the AC current output graph and calculating the RPM and the output from the generator, power in versus power out could be compared. After that the calculation for power in was done by taking the speed of the falling kilogram weight in meters/second, multiplying it by the weight of the falling object (1 kg), and then multiplying that by the acceleration of gravity (9.8 m/s^2).

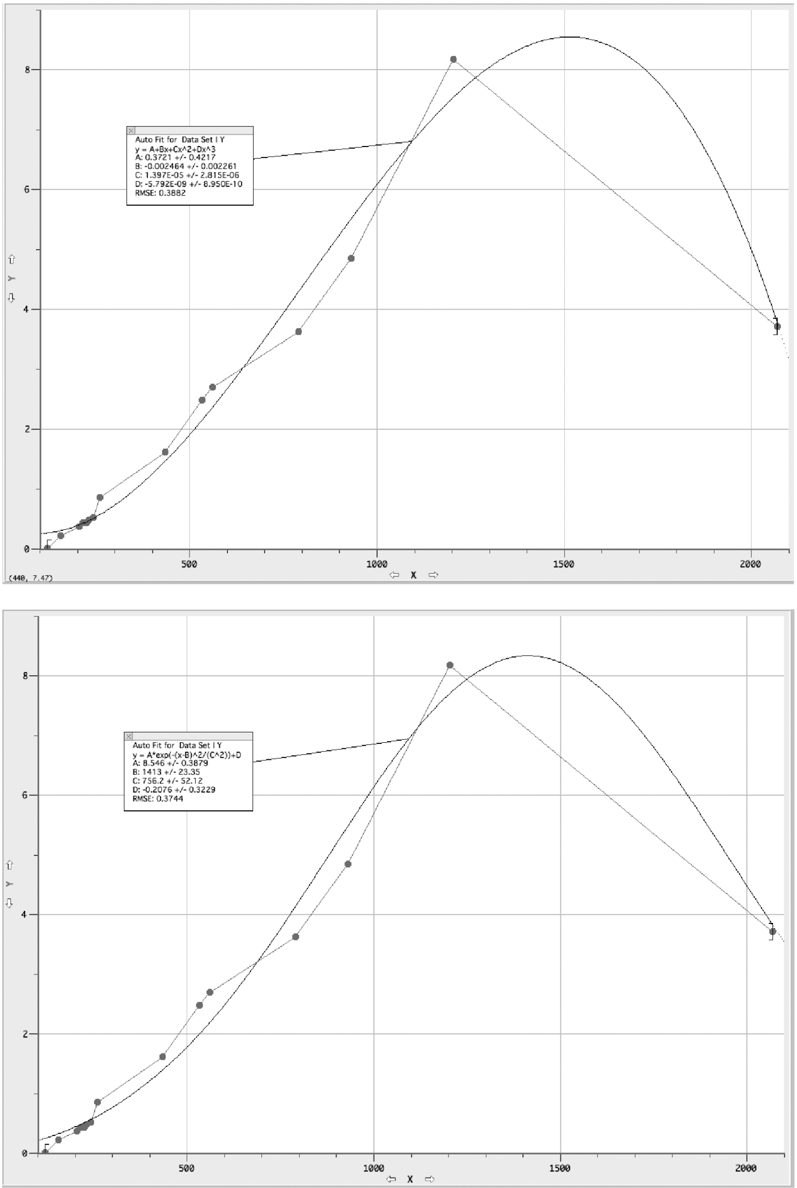

Figure 2: *Cubic (top) and Gaussian (bottom) curve fits to show maximum output of the generator.*

4 Results and Discussion

4.1 Summary

Table 1 shows the RPM and power output of the generator for all tests: from the drill tests to the efficiency tests to the door tests. This is also the table that the graphs in Figure 2 derive from.

4.2 Maximum Output

As shown in Table 1, the highest power output was recorded at 8.18 Watts at 1204 RPM, but looking at the graphs in Figure 2 it can be seen that according to the curve fits the maximum output is slightly higher than 8.18 W. If the person opening the door could open it at around 1200 RPM every time, the output of the generator would be around its maximum. The test that produced 8.18W lasted for about three quarters of a second, which for this project was a big success.

RPM	Watt	RPM	Watt	RPM	Watt
119	0.009	231	0.48	561	2.7
156	0.22	243	0.52	790	3.62
205	0.378	260	0.852	930	4.85
215	0.44	435	1.62	1204	8.18
225	0.437	534	2.48	2069	3.72

Table 1: *RPM to output in Watts*

4.3 Equations Used in Evaluation of Data

$W=F*\Delta x$, where W is work in Joules, F is the force pulling, and Δx is the change in distance of pulling the string.

$P_{out}=V*I$, where P_{out} is the output of generator in Watts, V is voltage, and I is current in Amperes.

Since $V/R=I$, $P_{out}=V^2/R$

$P_{in}=W/t$, where P is energy input in Joules/time, or Watts

$Efficiency=P_{out}/P_{in}$

4.4 Efficiency

In this project efficiency is a measure of how much of the energy put into rotating the magnet comes out as power from the generator. To calculate it you take the power out and put it over the input power as calculated in 3.2. The average efficiency of the generator resulting to 22% is surprising considering that the goal was to reach double digits (see Table 2).

RPM	Calculated Efficiency
231	22%
225	21.90%
205	21.20%
205	20.50%
243	23%

Table 2: *Tests for the efficiency of the generator.*

4.5 Error

The calculation of error was difficult for this project because there were a few things that could have caused error. For example, the resistor might not have been exactly 50 Ω, but the exact number is not known. The Labquest measures 500 samples a second, but what if I did not take a measurement exactly when the peak voltage occurred? The accuracy of the motion detector is also unknown. In some of the tests the RPMs were the same but the peak-to-peak voltage was different for each rotation. There were many different sources of error that were difficult to measure and minimize, which makes it difficult to assign error bars to the graphs in Figure 2. ●

5 Acknowledgements

To Dr. James Dann, my Applied Science Research teacher, who gave me the idea of using wasted energy to generate electricity. To my parents, for paying for all the supplies and allowing me to use the workshop to make all the parts of the generator.

6 References

[1] Hyperphysics,
http://hyperphysics.phy-astr.gsu.edu/Hbase/electric/farlaw.html

[2] *Vernier probes and sensors*,
http://www.vernier.com/probes/index.html

[3] Vernier Software and Technology, Vernier LabQuest Reference Guide, Version 1.1 (April 2008),
http://www2.vernier.com/manuals/labquest_reference_guide.pdf

[4] Applications of electromagnetic induction (July 1999),
http://physics.bu.edu/~duffy/PY106/Electricgenerators.html