Alternative Power Source for Dental Hygiene Device

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Problem Statement

Last year, the NAU department of Dental Hygiene needed a power supply for the Wig-L-Bug dental device. Team 15 delivered the completed project on time and met all design objectives. That project is finished, and the sponsor has no further need of team 15.

This semester, the team will be working on a hypothetical project. The team will analyze solutions that can work with the current power source (by charging the battery) or replace the current power source altogether.

Summary of Designs

The team will be looking at five alternative power sources for the Wig-L-Bug. At this point, the team does not have specific numbers for the designs. In this phase of design, the team is trying to assess the practicality of the following five options:

a. Mechanical Wig-L-Bug
b. Solar Panel
c. Manual Generator
d. Gas Generator
e. Wind Power

Mechanical Wig-L-Bug

The current Wig-L-Bug uses a 50W electric motor spinning at 5000RPM to turn a cam, which provides eccentric motion to mix up filling material. The simplest solution to eliminating the need for electric power is to replace the electric motor with a manual crank handle and a gearbox. This solution could likely be implemented for less than 100 dollars. The team currently has a broken Wig-L-Bug device to test on.

Compared to other designs, the all mechanical Wig-L-Bug has several major advantages. It is relatively compact, lightweight, cheap, and simple. It requires very little setup time, making it portable. It does not rely on the weather. As long as a person can crank it, it will work.

The downside is that it will only work while somebody is cranking it. 50W for ten seconds is a reasonable amount of effort. Mixing filling material for 200 cavities will require some effort.

Solar Panel Design

For this design, a solar panel will be used to collect solar energy and transform solar energy to electricity. And a lithium battery is connected to solar panels to receive and store the electricity produced. Then the battery transmits electricity to Wig-L-Bug and drives Wig-L-Bug to work normally. The power of solar panel is unstable and it changes with the intensity of sunlight, so

we need a stable output power supply for Wig-L-bug. Therefore, a lithium battery is indispensable in this design, because it can provide a constant output power.

Some information is collected from Indian websites: the average solar resource in Mampa is 4.37 kWh per day, and the efficiency of solar panels is between 0.1 and 0.21. Based on these data, our team calculated that the area of the solar panels will be between 0.327m^2 and 0.686m^2 at least. In practical use, the area will be larger than the calculated because the solar panel will not change when directions of sunlight are varying. Our estimation for the area of solar panel is between 0.6 $m^2$and 1.0 m^2. The actual area will depend on the efficiency.

Solar energy is a practical optional resource for us to replace electricity resource. It is environment-friendly and renewable. No pollution and noise will be created in the process of charging the battery. However, the disadvantages of solar panel design limit its practical application. Firstly, the cost of the solar panel is much higher than other designs'. For example, even though we use the cheapest solar panel, the cost will still be $ 600 at least. Secondly, this design relies on the weather in excess. If it is cloudy, the efficiency of solar panel will be reduced to a large extent. Lastly, this design is not portable enough because it will occupy a large area. In conclusion, the usability of solar panel design is lower than other four designs'.

Manual Generator Design

Another design is to use a manual generator to power up the dental device. The team came up with two ways to realize the manual generator concept. The expected output from a manual generator is 50W at 12V. The first one is to use a military crank generator as shown in Figure 1. The cost of a portable manual generator with a hand crank is about $ 200. The other way is a bicycle. Figure 2 presents our bicycle design. The team plans to attach a bicycle to a car alternator. A car alternator is used to convert mechanical energy to electrical energy and a car battery is used to store that energy. All parts used in this design are available in India. A detailed instruction will be given to our client in order to show them how to assemble all the parts. The estimated cost is $ 300 but it might vary according to local prices in India.

Figure 1. Manual Generator with a Hand Crank

Figure 2. Bicycle Generator

Gas Generator Design

A gas generator is another idea to supply electricity for the dental hygiene device. For such a design, our team plans to use a chainsaw motor, an alternator and a car battery. A chainsaw

motor is almost always a two-stroke gasoline internal combustion engine, usually with a cylinder volume of 30-120cm^3. A chainsaw motor is shown in Figure 3.

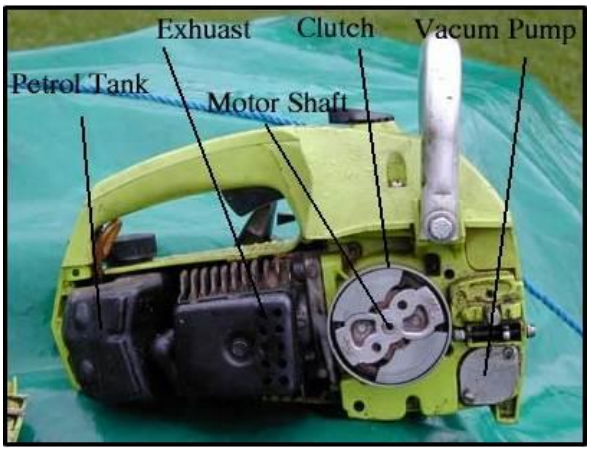

Figure 3. Chainsaw Motor

An alternator is an electromechanical device that converts mechanical energy to electrical energy in the form of alternating current. Most alternators use a rotating magnetic field with a stationary armature but occasionally, a rotating armature is used with a stationary magnetic field. An image of an alternator is shown in Figure 4.

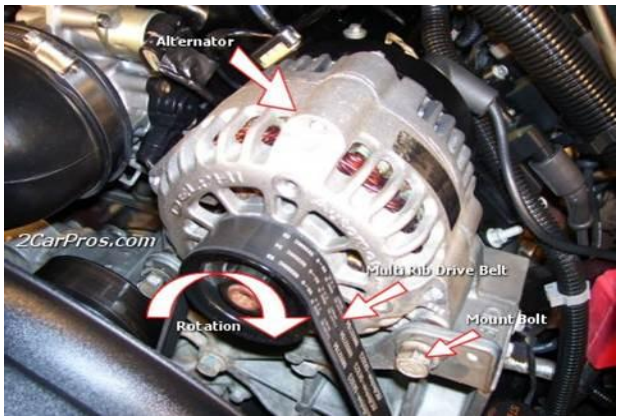

Figure 4. Alternator

For this design, motor shaft (Figure 3) should be connected to the rotation (Figure 4) of the alternator with a rubber belt. When the chainsaw motor is working, motor shaft can drive the rotation. Then the alternator can convert mechanical energy to electrical energy.

The main advantage of a gas generator is that it can supply the most power compared to other designs. Besides there is no limit for location and time, since a gas generator could generate electricity without wind and sunlight. However, it may make noise and emit much exhaust in the process of generating electricity.

Wind Turbine Design

Wind turbine is considered as a good alternative power source for the dental device. A small scale wind turbine with a desired output of 50W is available. Table 1 shows the specifications from the manufacturer. According to the specification, a wind turbine is powerful enough to provide sufficient energy for the Wig-L-Bug. A further research on local wind resource is required to determine whether the design is practical since the output power from a wind turbine depends on the wind speed. The size of the rotor seems a little large but it can be taken apart during transportation.

A major advantage of a wind turbine design is that no manual work is required to power up the dental device. Depending on local wind speed at ground level makes the output power not reliable. Thus, the major drawback of the system is that it may not work consistently comparing to other concepts.

Table 1. Specifications of a 50W Wind Turbine

Rated power	50W
Rated DC voltage	DC 12V/24V
Rated current	4.4A/2.2A
Cut-in wind speed	3.5m/s
Cut-out wind speed	15m/s
Rated wind speed	12m/s
Rotor diameter	0.83m
Weight	2.6kg

Conclusion

In this report, the team generates five alternatives power sources for the Wig-L-Bug without using a lithium battery, which is used in our previous design. Those designs have both advantages and disadvantages. In this report, the team only includes a preliminary design analysis to see which design is likely to fail. In order to make a decision on which design is more appropriate to solve the problem, further design analysis and selection are expected.

Appendix

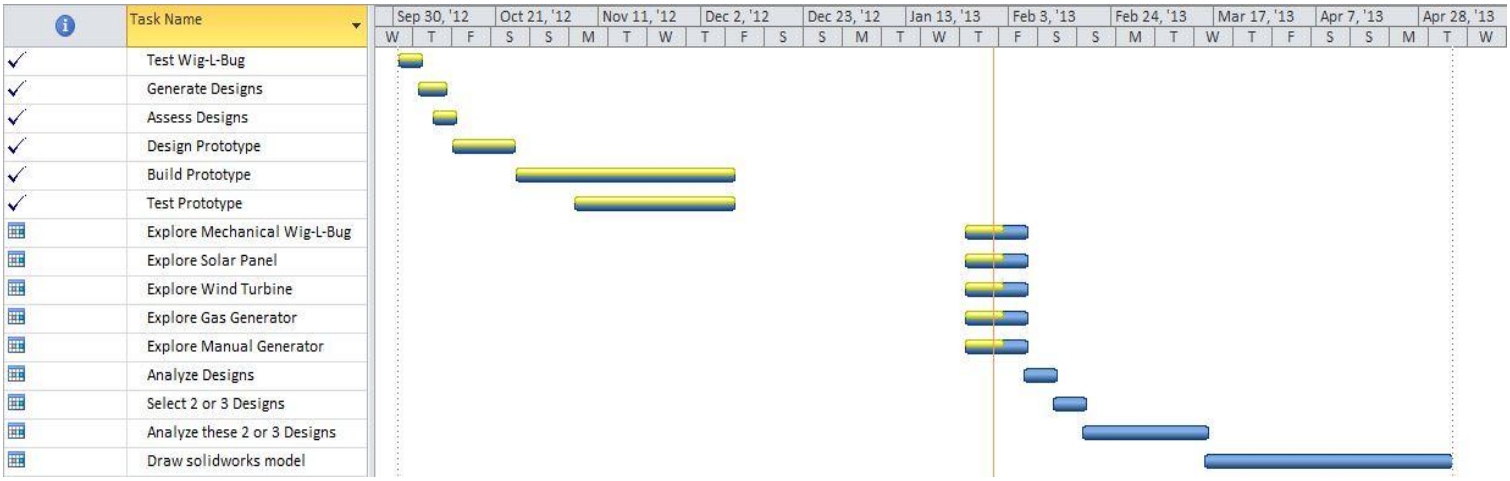

Figure 5. Gantt Chart

Reference

Stecasolar.com. General Recommendations for Alternating Current and Hybrid System. Web. 26 January 2013.

Bomara.com. No Harmony In Harmonics. Web.26 January 2013.

En. Wikipedia.org. Chainsaw Motor. Web. 26 January 2013.