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Design and Construction of a 20 000 Mah Wind Power Bank

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ABSTRACT

The study aimed to design and construct a portable wind power bank, using quantitative research method to explain the concept and define the problems needing improvement. One type of wind-powered battery charging will be explored in this paper. Wind-powered battery is an instrument which combine mechanical and electronic devices to charge small devices like mobile phones. With the rapid development of global economy, people continued to carry more portable electronic products, which are drained or discharged as a result of longtime uses. This can be used in times of power interruptions, outdoor activities where charging are necessity. It is designed to install fixedly in home rooftops but can be detachable and carried whenever necessary. It is an energy saving and eco-friendly device and function by wind velocity. The device consists of wind turbine driving a generator and operates at variable speed. It consists of three modules which are power supply, power storage, and phone charging module, all performing different functions. The power supply module consists of physics, principles, and design. The power storage module includes the components' parameters responsible for the restoration of energy to the battery after it has been used to charge mobile phones. This paper analyzes the property of the system components. The effect of parameter variation and the system configuration on the system performance are also investigated. Recommendations to improve the system performance are suggested. The researchers highly recommend to design weightless and most efficient as well as the high efficient mechanical design of rotor.

Keywords: *portable wind power bank, battery charging, turbine, generator*

INTRODUCTION

Background of the Study

A battery charger or power bank is a device used to transfer energy by imposing electrical current flows through a rechargeable battery (Zeng, 2015). Wind power bank is a device that will allow anyone to take advantage of the abundance of renewable resources. This is a light weight and movable device that uses the power of the wind to store electrical power.

Additionally, a power bank is a portable device comprised of a special circuit that control power flow. They allow the storage of electrical energy (i.e. deposit it into the battery bank) and then later use it to charge any mobile device (i.e. withdrawn it from the battery bank).

Thus, power banks have become increasingly popular as the battery life of phones, tablets and portable media player is outstripped by the amount of time spent using them each day. By keeping a battery backup close by, you top up your device(s) while far from a wall outlet. Power banks are good for almost any USB-charged devices. Cameras, MP3 players, mobile phones, tablets etc. as long the power bank is charged. Most commonly power bank will have a dedicated input sockets for receiving power. This power can come from a USB sockets on your computer, but may charge faster when using a wall socket adapter. In most rare occasions, power bank can use the same socket for input and output, but this is rare and should not be assumed of any power bank, as trying to force power into an output can damage the battery (Cable Chick Blog, January 29, 2014). Common type of power bank needs a cord and an adapter to charge from outside AC source. This power bank was developed by using both AC source and a mechanical way of producing electricity. The device will not work by itself, it requires wind energy. The device must be supplied with sufficient amount of wind enough to produce and store power.

With the rapid development of global economy, people continued to carry more portable electronic products, as mentioned earlier, which are drained or discharged as a result of longtime uses.

As civilization grows, the need for more energy does as well. The only problem with this is that, main sources of energy, non-renewable resources, are depleting at a faster rate. Research has shown that in the next 70 years the world's entire oil reserves will run out, and if the current consumption of oil continues it will be much less than that. The simple solution is to use renewable resources such as solar and wind power instead, but even with the obvious answer renewable resources only make up around 15% of all the sources of energy used on Earth (National Renewable Energy Laboratory, 2005).

Moving towards energy sustainability will require changes not only in the way energy is supplied, but in the way it is used, and reducing the amount of energy required to deliver various goods or services is essential (Tan, 2016).

Some of the reasons of not converting over to renewable resources is because most of the machines used to harness the energy are large apparatuses that most people don't have access to.

This study contributes something beneficial to the universe and this small step in cleaning our energy is only the beginning.

Objectives of the Study

Generally, this study aims to design and construct a power bank with rechargeable battery that will be able to charge mobile devices and is capable of supplying 20 000 mAh current rating.

Specifically, the study sought to answer the following:

1. Identify the characteristics of the wind power bank components in terms of:
   - 1.1 design;
   - 1.2 principle;
   - 1.3 functions; and
   - 1.4 mechanism
2. Determine the system parameters of the components in terms of:
   - 2.1 wind speed;
   - 2.2 rotor rotational speed;
   - 2.3 rotors to generator speed;
   - 2.4 generator output; and
   - 2.5 battery output
3. Determine the working principle of the power bank in terms of:
   - 3.1 capacities;
   - 3.2 output specifications; and
   - 3.3 charging time

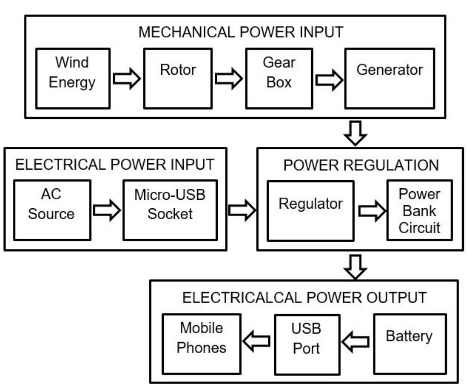
RESEARCH METHODOLOGY

This chapter presents the methods used by the researchers. It includes the power supply module, the power storage module, and the phone charging module with their working principles and technical feasibilities.

Power Supply Module

This section specifically answers the first objective, which discusses the components' design, the science and principle behind it, as well as the functions and its mechanisms.

Figure below presents the energy conversion diagram or the basic clustering diagram of a portable wind power bank design.



Basic Clustering Diagram of the Portable Wind Power Bank Design

Wind power physics. This section specifically discusses how a wind turbine turns its energy of motion into power that can be used to do work and gives technical specifications of a wind turbine to figure out how much power to generate from it. How does a wind turbine work? Wind turbines kinetic energy from wind and transform it to electricity. Wind moves perpendicular through what is called a "swept area" – the circular plane created by the turbine blades. The blades are at a tilt so they are able to capture the force of the wind and spin the axis which turns the gears in a gear box, which then turns the generator to produce electricity.

The section explains where the wind power equation comes from, how the power from a turbine is calculated, what factors to consider, what features of the turbine can be altered to generate more or less power. Essentially, the wind power equation is a more general equation for kinetic energy (KE), which is the energy of an object in motion measured in Joule that has to do with its mass and how fast it is moving.

$KE = \frac{1}{2}mv^2$; Where KE = kinetic energy in Joules, m = mass in kg, and v = velocity in m/s. But for air, m = ρAv. The wind power equation (P) then is:

$$P = \frac{1}{2}(\rho)(A)(v^3) = \frac{1}{2}(\rho)(\pi r^2)(v^3)$$

Considering the efficiency measurements and factors, since no process, like in a wind turbine, is 100% efficient due to losses in the different components, the wind power, the wind power equation would be:

$$P = \frac{1}{2}(\rho)(\pi r^2)(v^3)(c_p)(CF)(\eta_G)(\eta_B);$$

Where P = power generated in Watts, ρ = density of wind in kg/m³, v = velocity of wind in m/s, πr^2 = swept area (where r = blade length in m), c_p = performance coefficient, CF = capacity factor, η_G = generator efficiency, and η_B = gearbox efficiency.

Performance coefficient (c_p) is theoretically 59.26 percent. This is referred to as the Betz Criterion or the Betz Limit. It was the value that Albert Betz, a German engineer, formulated in 1919, and still accepted as the maximum or optimal efficiency of a wind turbine in the conversion of kinetic to mechanical energy and applies to all wind turbine designs. It is the theoretical power fraction that can be extracted from an ideal or undisturbed wind stream. Modern wind turbines operate at a slightly lower practical non-ideal performance coefficient. Considering the frictional losses, blade surface roughness, and mechanical imperfections, between 35 to 40 percent of the power available in the wind are extractable under practical conditions.

The Betz Equation is analogous to the Carnot cycle efficiency in thermodynamics suggesting that a heat engine cannot extract all the energy from a given source of energy and must reject part of its heat input back to the environment. Whereas the Carnot cycle efficiency can be expressed in terms of the Kelvin isothermal heat input temperature and the Kelvin isothermal heat rejection temperature, the Betz Equation deals with the wind speed upstream of the turbine and the downstream wind speed.

The limited efficiency of a heat engine is caused by heat rejection to the environment. The limited efficiency of a wind turbine is caused by braking of the wind from its upstream speed to its downstream speed, while allowing a continuation of the flow regime. The additional losses in efficiency for a practical wind turbine are caused by the viscous and pressure drag on the rotor blades, the swirl imparted to the air flow by the rotor, and the power losses in the transmission and electrical system.

Betz developed the global theory of wind machines at the Göttingen Institute in Germany (Le Gouriérès Désiré, 1982). The wind rotor is assumed to be an ideal energy converter, meaning that:

1. It does not possess a hub; and
2. It possesses an infinite number of rotor blades which do not result in any drag resistance to the wind flowing through them.

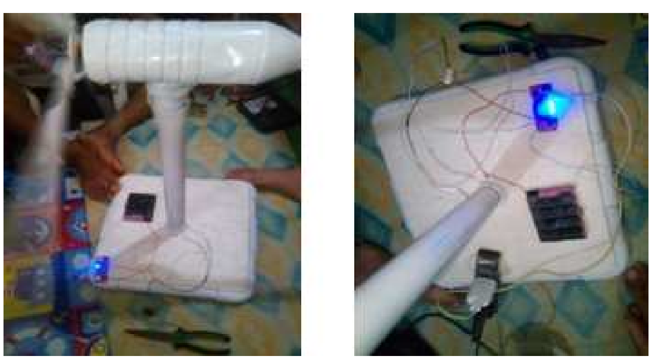
In addition, uniformity is assumed over the whole area swept by the rotor, and the speed of the air beyond the rotor is considered to be axial. The ideal wind rotor is taken at rest and is placed in a moving fluid atmosphere. Considering the ideal model shown in Figure 3, which shows the pressure and speed variation in an ideal model of a wind turbine, the cross sectional area swept by the turbine blade is designated as S, with the air cross-section upwind from the rotor designated as S_1, and downwind as S_2.

The wind speed passing through the turbine rotor is considered uniform as V, with its value as V_1 upwind, and as V_2 downwind at a distance from the rotor. Extraction of mechanical energy by the rotor occurs by reducing the kinetic energy of the air stream from upwind to downwind, or simply applying a braking action on the wind.

Testing and Evaluation

After the different modules (battery charging module, power storage and phone charging module) had been constructed, they were partially assembled and installed for testing.

The first test was to determine if the partially assembled prototype is able to store power by two sources. First is from wind energy which was done by manual rotation of the rotor, and second is from an AC source. It was found out the system is functional; it can store power so it can charge phones as well.



Functionality Test: Wind Tubine Source (left), AC Source (right)

The second test was to measure the output of the generator at a rotor rotational speed. The first location for testing was at Caray-caray, Naval, Biliran, along the road where there is sufficient and constantly blowing wind. After several tries, a range of 4V to 6V from the generator was computed by the use of a multi tester, which corresponds to 140 rpm to 300 rpm speed of the rotor.

Generator power produced over rotational speed testing

The third test was conducted at Villaconsuelo, Naval, Biliran, an ideal house to install the wind power bank. The wind on the rooftop is constant, clear and not turbulent. A phone can be charged anywhere in the house, from first floor to the rooftop depending on the owner's choice, while the body is continuously supplying power at the rooftop. The calculated minimum wind speed that the turbine starts to spin using an ideal cup anemometer was at 10 kph, not far from 8 kph which is the ideal minimum wind speed for small turbines according to research for conventional wind turbines. As soon as the turbine receives this speed, it starts spinning and after several tests, the average rotational speed of the rotor was 400 rpm, with this the generator generates up to a maximum of 7V and 1A, producing 7W generator power.

Wind speed calculation using a cup anemometer

Rooftop installation and testing

The final testing was made after finishing the construction of the device. The testing was conducted at the University campus at normal weather condition using several measuring devices for conducting the test. The rotor rotational speed was measured using tachometer and simultaneously the voltage and current output was measured using voltage multi-tester. After these tests, needed data were gathered to determine the performance of the wind power bank. The data were stated and summed up under the generator output section. The minimum voltage requirement of the power bank circuit from the generator to start charging the battery is 5V. As tested, the generator generates 5V as the rotor reaches a rotational speed not less than 425 rpm. A 20 kph wind speed is sufficient to drive the rotor at this rotational speed.

Test Results

TEST	LOCATION	MEASURING DEVICE	WIND SPEED (kph)	ROTOR SPEED (rpm)	VOLTAGE (V)
1	Caray-caray, Naval, Biliran(along the road)	analog multi-tester, manual counting	(not measured)	140 to 300	4 to 6
2	Villaconsuelo, Naval, Biliran (house rooftop)	cup anemometer, analog multi-tester, manual counting	10 to 20	350 to 450	3 to 7
3	NSU Main Campus (motorpool building)	cup anemometer, digital multi-tester, digital tachometer	20 to 25	240 to 778	4 to 8

CONCLUSION AND RECOMMENDATION

Conclusions

The findings of this research indicate a positive response that a wind powered mechanism can be a mechanical source of a power bank. With an efficiency of 52.30% in terms of power conversion, this wind powered mechanism is an efficient mechanical input. Subsequently, this wind power bank has the advantage among other power banks because it uses renewable energy source, it has low initial cost, it reduces electrical power consumption, and it is as efficient as any other power banks.

However, efficiency of the wind power bank under its minimum wind speed to spin did not fit into the range. It means that the faster the wind, the more power it could give. This wind power bank's performance is dependent on the amount of wind it receives.

Recommendations

After obtaining the results discussed above that answer to the problems presented in determining if wind power is a good energy source for battery and phone charging, the researchers have arrived at the following recommendations to further improve the study:

1. The study has focused only on the functionality of a simple wind power bank prototype. In lined with this, the researchers highly recommend using other varieties of wind power banks like modifying its size as well as considering some other factors. It is recommended to make a smaller one to be more easy to carry but with sufficient wind like riding a vehicle when travelling in long distances. It can also be modified to larger size to produce and store more power for charging stations.
2. Moreover, if the future researchers may come into the probability of making efficient chargers, researchers recommend using highly efficient mechanical design of turbine components like the mechanical strength of blades,
3. The yawning and brake mechanism of the turbine. It is also recommended to design a stable circuit with lesser but effective components. Using more electric components means that energy is not delivered well since components absorb it to use for their own purpose.
4. Lastly, for future studies, it is recommended to use brand new products and much newer materials. It is also recommended to focus more on possibilities of utilizing the wind energy as future energy source for any electrical devices.

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