International Journal of Engineering & Technology, 7 (4.38) (2018) 1666-1668

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Comparison of Energy Output of Multi-Angle Positioned Windmill Propeller Blades

Elymer John S. Lanuza*, Michael C. Pacis, Ronald Vincent Santiago , Gorgonio S. Vallestero II

School of EECE, Mapua Institute of Technology
Muralla St. Intramuros, Manila, Philippines
**Corresponding author E-mail: rvmsantiago@mapua.edu.ph*

Abstract

Electrical energy is one of the basic things that humans need to survive. As the earth's population grows and the number of technology that utilize electricity increases, the earth's supply of fossil fuels and other limited energy sources are fast depleting. Electrical energy is a critical element of almost everything that affects human's daily routine. That is why most Filipinos expect the aid of electrical energy to improve their lives, and are aware that in each usage, unforeseen energy expense reduces the funds intended for other needs or necessities. Along with these principles, windmill is one of the options the Philippines is now trying to tap. Based on past studies, there are many types of windmills. Most of them have horizontal or vertical shaft. A horizontal shaft is level to the ground or pointing straight parallel with the ground. A vertical shaft on the other hand is upright or a little bit tilted in perpendicular alignment with the ground. A similar study was done showing that at 0 degree there was no amp or energy produced. At 15 degrees there was also no ammeter reading for energy produced. The reading at 30 degrees was the first blade pitch to produce a reading on the ammeter. The 30 degree blade pitch produced 6 amps of energy. The 45 degree blade pitch produced a reading on the ammeter of 12 amps of electric power. The 60 degree blade pitch produced the highest reading on the ammeter. It generated 15 amps of energy. A reading of 10 amps was produced from the 75 degree blade pitch. At 90 degrees no energy was produced on the ammeter.

Keywords: *Windmill Blades, Vertical Shaft, Horizontal Shaft*

1. Introduction

Electrical energy is one of the basic things that humans need to survive. As the earth's population grows and the number of technology that utilize electricity increases, the earth's supply of fossil fuels and other limited energy sources are fast depleting. Thus, the world is now looking to renewable energy sources such as solar power, hydroelectric power, and wind power as alternative sources [1-3, 5]. Windmill is one of the options the Philippines is now trying to tap. The goal of this study was to find out which of the three angles was most efficient and produced higher output (voltage and current). This was based on the usual concepts of energy propagation through windmills which are based on sizes of the blades and its pitch angle.

2. Problem Statement

As the earth's population grows and the number of technology that utilize electricity increases, the earth's supply of fossil fuels and other limited energy sources are fast depleting. If the usage rate continues to rise, these sources will run out in the fairly near future. Thus, the world is now looking to renewable energy sources such as solar power, hydroelectric power, and wind power as alternative sources. Most scientists are looking forward to enhance these renewable energy sources to make them as efficient as possible. Electrical energy is a critical element of almost everything that affects human's daily routine.

3. Aims of the Research

The general objective of this research was to study and observe different power outputs of the windmill blades if it they are tilted at 75°, 60°, and 45° and determined which angle orientation produced the higher power output that can replace the conventional 90° orientation. The specific objectives of this research were to:

- Study wind behavior and make a wind profile by using an anemometer in the testing site
- Design the shape and size of the blades for the wind turbine and the materials that should be used for the prototype.
- Simulate the turbine outputs with a windmill calculator or by the empirical formula $P = K \times D \times A \times V^3$; where $K = 16/27$ of the wind's power, D is air density (kg/m^3), A is the swept area or fan diameter, and V is the wind velocity
- Construct a prototype of the multi-angled blades for the wind turbine
- Test the prototype wind turbine and measure the outputs in terms of both current and voltage.

4. Materials and methods

Humans have been taking advantage of the energy in the wind for ages. Sailboats, ancient windmills and their newer cousins, the electrical wind turbines, have all captured the energy in the wind

with varying degrees of effectiveness. What they all do is use a device such as a sail, blade or fabric to "catch" the wind. Sailboats use energy to propel them through the water. Wind mills use this energy to turn a rod or shaft.
A simple equation for the wind power is described below. This is instantaneous and does not take time generating power into consideration [4].

$P = 1/2\ \rho\pi r2V^3$
where: ρ = Density of the Air
r = Radius of your swept area
V = Wind Velocity
From this formula it can be seen that the size of the turbine and the velocity of the wind are very strong drivers when it comes to power production. If the velocity of the wind or the area of the blades is increased the power output also increases. The density of the air also has some impact, cold air is denser than warm air. More energy is produced in colder climates as long as the air is not too thin. The peak power production of the wind turbine can be calculated using this equation. It will be way off as it leaves out a number of variables that impact the actual power output of the turbine. This includes things like how well the blades transform the energy in the wind and the efficiency and type of generator that are used.Blade design and engineering is one of the most complicated and important aspects of current wind turbine technology. Today engineers strive to design blades that extract as much energy from the wind as possible throughout a range of wind speeds and gust yet durable, quiet and cheap.
The large scale production of energy from the wind is not futuristic or far-fetched, it is happening now.
Some recent research shows that one of the major failures of the renewable energy movement is that people do not realize renewable energy technologies are viable and available right now. This is especially true of wind energy and needs to be emphasized.
It is also important to have some discussion about the limits of wind energy and some of the benefits/challenges it will pose to communities where it is sited. These challenges include view shed impacts, proper site plan to avoid migration pathways, noise, and the intermittent nature of the resource.
To ease the construction of the system, a conceptual framework, as shown in figure 1, is formulated to have organizational process of constructing the blades of the windmill, in accordance to the objective of the study. This framework serves as a guide to what actions must be done to meet the desired output of the system.
Figure 2 shows the step-by-step in developing the system. At the operation of the wind generator, energy was stored in the battery. Voltage output and current output of the generator were measured at loaded condition which were taken at the load side of the charge controller connecting the battery, inverter and the load. This parameters was then observed in 90°, 75°, 60° and 45° configuration and later on compared to determine which of this configuration was the most efficient to use. After this, all load were disconnected from the wind charge controller and the voltage at no load condition was measured for the analysis of the percent voltage regulation of the system.

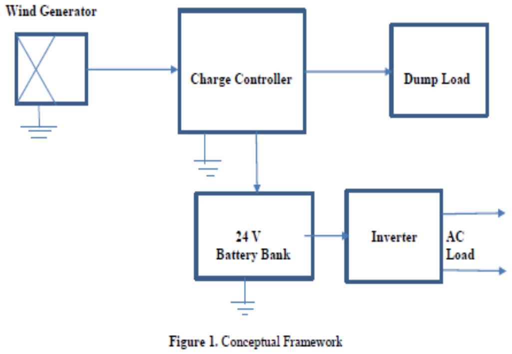

Figure 1: Conceptual Framework

5. Results and Discussion

The wind turbine was in good condition and working properly. The wind in the location was considered slow and intermittent, but due to the lightweight design of the wind turbine blade and body, it was sufficient to drive the turbine and produce an output. The wind speed, output voltage and power of the turbine were varied with respect to time. This was where the behavior of the wind turbine output was observed during no load condition with respect to 90°, 75°, 60°, 45° angle positions.
A voltmeter was at hand to measure the voltage of the wind generator depending on the wind speed for the no load condition. After 30 trials, there were obtained with different wind speeds using digital anemometer and 30 voltage outputs of the wind generator for 90°, 75°, 60° and 45° configuration. Due to low wind speed in the testing area, the motor rpm was low at 4.5 m/s the generator produced 2.4 volts. These voltages were not sufficient to charge the battery. Also there was a point in the trials that the wind was 0 m/s which made the motor to produce an output voltage of 0 volt. During the initial testing, the maximum wind speed was 5.1 m/s.

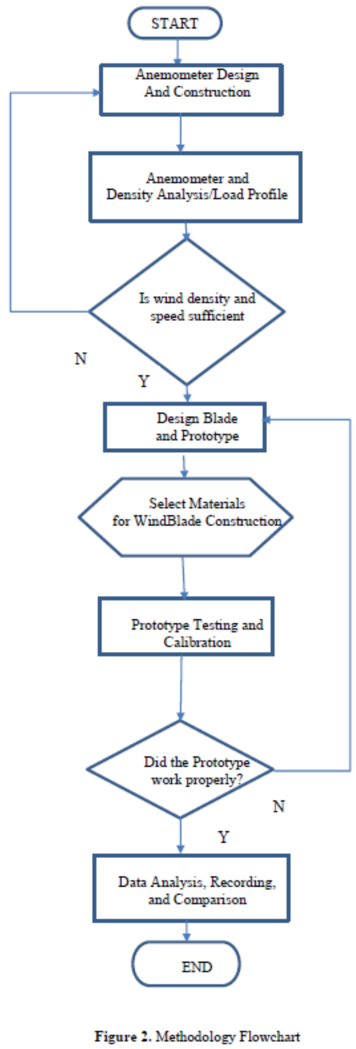

Figure 2. Methodology Flowchart

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Based on the data gathered, it was proven that the wind speed was directly proportional to the output voltage of the generator. As the wind increased, where the wind was stronger, the output voltage also increased.

6. Conclusions

After tests were done in different configuration, it can be seen that the 45° configuration gives the highest power output generated. Also, this data was consistent from the comparison of voltage regulation, among all configurations. Forty five degrees configuration had the lowest average percent voltage regulation of 3.12% which indicated that this configuration was the most efficient to use.

If the design of the wind turbine was to be considered, the 90° configuration was the most convenient. At 90°, the generator was always facing against the wind in all 360° direction, while on the 75°, 60°, and 45°, in order to get the most accurate data; the wind generator was placed against the wind facing one direction where in the wind was mostly available. And the generator needed to be locked in one direction to prevent it from moving around the other direction. Sudden rotation of the generator could alter its angle orientation. So design wise, the horizontal orientation or the 90° orientation was still convenient implement.

Forty five degrees configuration was the most efficient to use in terms of power output generated and lowest average Percent voltage regulation, while 90° was the most convenient in terms of gathering the data and design making.

Acknowledgements

The journey of idea to accomplish this study is a long and laborious one. The researchers feel a deep sense of gratitude to God for the following people along the way. To Mapua University for giving us the opportunity and budget to present this paper and beloved parents, for their steady flow of love, understanding, wise counsel and trust that influenced the researchers to strive more and persevere. To God be the glory!

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