

Building A Small-Scale Model of Horizontal Axis Wind Turbine

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Abstract

Since we cannot imagine a world without energy, and since numerous studies have demonstrated that fuel consumption at our current level is unsustainable and harmful to the planet, it is imperative to take this into account when designing any system. As fossil fuels are often the only or primary source of energy in many nations, there is no need to completely eliminate their use. It is instead necessary for technology efficiency to be enhanced, clean energies to grow, and consumption to be lowered in order to achieve a generational balance.

In this situation, it was decided to construct a miniature wind rotor that would work as a teaching aid for engineering students. A computer-programming model has been created to build the turbine that, based on simplified nautical ideas, enables calculating the geometry of the blades depending on some beginning conditions, estimating the rotor power, and determining the operating curves for the rotor.

Keywords: prototype, power generation, energy transformation, rotational movement.

1. INTRODUCTION

The production, distribution, and use of alternative and renewable energies as energy substitutes for energy derived from oil and coal not only improves environmental protection and maintenance, but it also reduces economic and social crisis resulting from the depletion of non-renewable energy reserves around the world. In order to raise social awareness to use clean, renewable energy sources in schools and at home, these social benefit transitions must be part of each culture's traditions and culture richness. According to the social obligation, with the community, and for future generations, a small contribution will be made to this renovation.

Professionally, these developments have repercussions and provide continuity in the teaching process. This is an important point of contact; for example, as an additional effort to convey the achievements of the academy to the community, whether it be local or distant. A prototype generator system for wind energy was designed as part of this study, contributing to the promising study of this form of renewable energy. Since the wind circulation speed is adequate, wind energy use has been on the rise around the world. This is mainly due to the fact that there are adequate values of wind speed. It offers a panoramic fertile environment for exploring that potential of existence of wind currents with excellent circulating speeds; however, the world has strategic points where winds reach sufficient speeds for the conversion of wind energy into electrical power to be explored.

The current development can be seen as an approximation to the study of alternative energies, which can be an effective alternative to current sources of energy, either due to its less polluting effect, or more fundamentally because it could be renewed. The developing of the world must take advantage of alternative energies in a practical way; even though the world has good sources of general energy supply, such as hydroelectric plants; the impacts on the environment and on the population around it should also be considered.

There are some positive effects that can be achieved with current energy sources, but they are not eternal. Therefore, it is a priority of the government to promote the use of alternative energy sources for society and the environment, with a sustainable nature, with full coverage, and open everything in accordance with the new global vision of a clean, emissions-free world. The lack of electricity in the areas "Unprotected" from this benefit, in Huila or its time efficiency in other parts of the department, shows us that this energy is vital for our development; and this project uses a renewable resource such as wind power to solve this problem in a small but significant way.

2. LITERATURE REVIEW

Historical evolution

Over three thousand years ago, wind-powered mills were used to grind grain and pump water. Man has relied on the wind for energy ever since. During the 18th century, steam engines were invented, resulting in an industrial revolution,

and fossil fuels were introduced; wind power was relegated to the background. Thermal machines dominated technological development in large industrial cities, while it was only used in rural areas (Nath and Rana, 2011). The current situation has brought about a growing awareness of the environmental impact of combustion on our health and environment. On the one hand, the elapse of fossil resources as a source of energy has led to an increase in the importance of energy sources already in disuse, such as wind and hydro, in the last 50 years. Current wind turbines are highly efficient thanks to developments in materials and aerodynamics. Scientists such as Albert Betz and Hermann Glauert contributed significantly to the development of wind turbines during the 20th century (Thomas and Robbins, 1980).

Wind resource

Wind technology must overcome the high wind variability without a doubt as one of its greatest obstacles. Wind is the movement of air masses in the atmosphere that the big electric companies look for when installing generator mills. Different atmospheric pressures cause this movement between two geographical points. Since the pressure of a gas increases with temperature, the density of air and atmospheric pressure are lower in areas near the equator, which are hotter and receive more radiation from the sun. Atmospheric pressure increases as a point of equator gets further from the equator. When mixing with cold air masses, the air currents tend to rise and circulate through the atmosphere to fall again. In their movement, the currents are affected by the rotation of the globe due to the Coriolis Effect (Burton et al., 2011). There are multiple factors that alter current formation and give the wind its unpredictable character, despite the fact that the causes and effects may seem straightforward.

Wind variability

Wind currents are affected by many external factors, as has been mentioned. There are many factors that affect the wind, including landforms, vegetation, seasonal temperature changes, or the aforementioned coriolis effect. The Weibull distribution attempts to estimate the likelihood of a certain wind regime occurring in a specific place in spite of the difficulty of predicting the intensity of air currents in the long term. For a given period of time, the distribution function indicates how likely it is that a wind speed will exceed a limit value. Chalmers and Spooner (1999) use probabilistic models to estimate wind intensity and calculate the production of wind farms.

Displacement local air currents are far from orderly and smooth due to roughness of the ground and variations in temperature.

Turbulence

The local air currents are far from being smooth and well-organized because of the unevenness of the terrain and temperature changes, and have a turbulent character as a result. The magnitudes of a fluid in motion rapidly and erratically fluctuate, creating turbulent flow. Despite the fact that the average wind speed is generally steady, a wide range of speeds can be seen during the day around that average speed (Garcia-Sanz et al., 2012).

This disorganized flow has a significant impact on how well a wind turbine works because it generates negative vibratory loads, strains, and components that can lead to material fatigue. On the other side, the wind gusts will affect the machine, causing it to revolve faster and deliver different amounts of energy at different times.

However, despite their many benefits, wind energy and other renewable energy sources can occasionally be constrained by their high production costs, which are far greater than those associated with obtaining energy from fossil fuels. Therefore, it is crucial for governments to promote and encourage their development. Backing up Following the lead of India, the Ministry of Industry announced the elimination of premiums to renewables in 2014, which resulted in significant losses and a large number of jobs for businesses that previously relied on investing capital in the industry (Wang et al., 2013).

Recognizing the enormous room for advancement, research organizations devoted to the advancement of wind technology concentrate their studies on lowering prices, raising efficiency, lessening effect, or improving power quality. On the other side, a lot of businesses have made investments in offshore wind farms, which, although being a nascent technology, offer a ton of promise. The majority of engineering schools throughout the world are aware of the rising interest from the renewable business and already include degrees and master's programs in renewable energies, particularly wind energy, in their curricula (Ackermann and Söder, 2000).

3. METHODOLOGY

The following method may have been used to conduct this study:

- a. Researching alternative energy sources, particularly wind energy, and gathering bibliographic information. A question was raised about the study of inventions centered on wind turbine designs, wind energy gathering, and its transformation. Information was gathered from internet sources at domestic and international institutions with specialist groups conducting this type of study.
- b. A review of the physical concepts used in the planning, building, and installation of the wind turbine prototype.
- c. Developing design-related hypotheses.

The information gathered was compiled and examined in the second step in order to determine what materials may be utilized to construct the wind turbine. next choose the stuff to create conceivable assumptions regarding the most

successful prototype model. Following the design of the wind turbine model, the device was built and tested in accordance with the unique features of the environment where the experiments were conducted.

Materials:

The most recent technical developments in wind turbines have increased their efficiency and decreased their cost, following the path of energy patents for renewable energies. A device that converts mechanical energy into electrical energy is an electric generator. Although there are several methods to categorize wind turbines, the prototype was developed using readily available materials with increased resistance. The supplies utilized were:

30 cm long, 24 cm broad, and 1.2 cm thick iron stage.

A single tube that is 10 cm long, 2.3 cm in diameter, and 0.2 cm thick.

One 98 centimeter long, 1.8 cm in diameter, and 0.2 cm thick galvanized tube.

One 108 centimeter long, 1.5 cm wide, and 0.2 cm thick galvanized tube.

PVC pipe, 1 3", length 41.5.

50 cm length PVC pipe, 1 6".

1 set of ball-bearing bicycle cups

1 metal platform, 7 cm in diameter and 0.1 cm thick.

1 acrylic platform, 0.2 cm thick and 7 cm in diameter.

1 1/4-inch by 14-cm long rod.

3 1" x 1/4" bolts with nut.

jig nut, washer, and six 1" by 5/16 bolts.

1 Elephant bicycle dynamo, 12 V, 6.0 W.

1 Akita YV12V.C brand 12V motorbike battery.

1 Cup, 21 mm by 1 1/2. White 12-gauge wire measuring 250 cm.

one 12-volt lamp

Design and development of components: The design, production, and assembly of each component that makes up the wind turbine are described below:

Foundation

The management depends on the basis, which is itself. When a wind turbine must sustain significant proctoring from turbulence, a wind generator ensures that it will remain stable. It must also support the weight of the turbine and tower to provide this stability.

For this purpose, an iron plate with the dimensions of 30 cm in length, 24 cm in breadth, and a weight of 12 kg was cut into the prototype's base (see figure 1). This phase offers resistance to aid in dispersing the pressures that the tower's base is susceptible to.

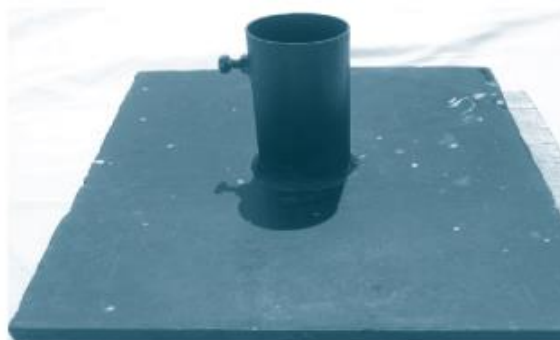


Figure 1. The plate and tower base that will support the other parts are visible on the wind generator's surface foundation.

Depending on the kind of soil or tower in which they were installed in the device, the foundations may be shallow or deep. A foundation was set up for the prototype, making use of the benefits of this: Since there is no requirement for excavation to place the wind turbine, this design will enable the machine to be moved as needed.

Windmill mast or tower

The wind turbine tower has enough strength to support the majority of the installed materials. A galvanized tube measuring 98 cm high, 1.8 cm in diameter, and 0.3 cm thick was used. A zinc coating is applied to iron or steel as a corrosion-prevention measure.

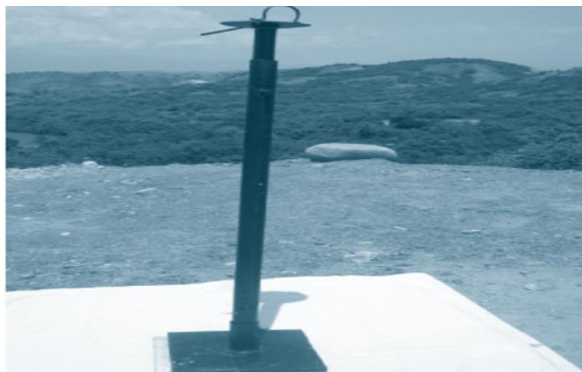


Figure 2. placement of a tower on a base.

A coaxial tube with a smaller diameter that fits within the original tube and has the following measurements: 108 cm high, 1.5 cm in diameter, and 0.3 cm in thickness is used to carry the tubes. Then, two screws were placed horizontally to apply pressure to the second mast, allowing it to maintain the proper height even after the first tube was removed.

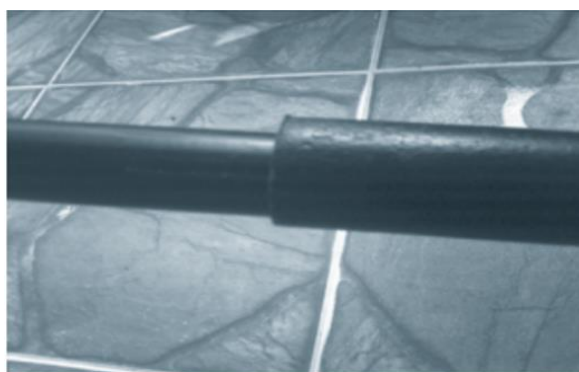


Figure 3. Coaxial tubes that make up the tower.

The weather vane, dynamo, and propeller must all be supported by the tower in order to withstand the wind's forceful turn.

Platform

The platform, which is made of an iron plate with a thickness of 0.1 cm and a radius of 7.0 cm, is the base where the dynamo is installed. A dynamo is an electric generator designed for the transmission of electricity through the phenomenon of electromagnetic induction, which generates an electric current. The platform rotated on its own guidance after being fastened to a pair of spectacles using ball bearings.

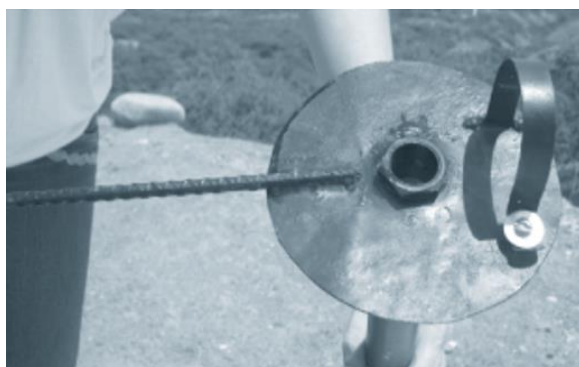


Figure 4. Platform connected to the ball bearing set of the tower.

The installation was done at the proper distance, balancing the weight of the wind vane and the dynamo.

The Wind's Rudder or Tail (weather vane)

The prototype wind vane can move easily and maintain balance with the turbine of the prototype 8 because it is the right weight to resist the force of the wind.



Figure 5. A weathervane that is mounted to the platform and secured to the iron bar.

The Dynamo

It was decided to utilize a bicycle dynamo, which infrequently generates direct current at 12 volts of potential difference. Small and low in weight, the bicycle dynamo comprises a fixed armature magnet and a movable center inductor, which spins taking the moving wheel. The dynamo was mounted on the platform stage, secured with a clamp, and placed at the proper distance from the vane to maintain balance.

A motor that occasionally provides adequate voltage is employed as the dynamo. What you need for an effective wind turbine is an engine that delivers the potential difference necessary for the prototype while operating at a low frequency. The complex model includes a 12-volt dynamo with a 325 rpm frequency.

Rotor:

The major component of a wind turbine, the rotor consists of the hub and the blades.

Blades

These blades had a length of 41.5 cm and were constructed from PVC tubing. Its base is 7.0 cm in width, and its end is 3.0 cm in length. These are the proper steps to take in order to get high performance.

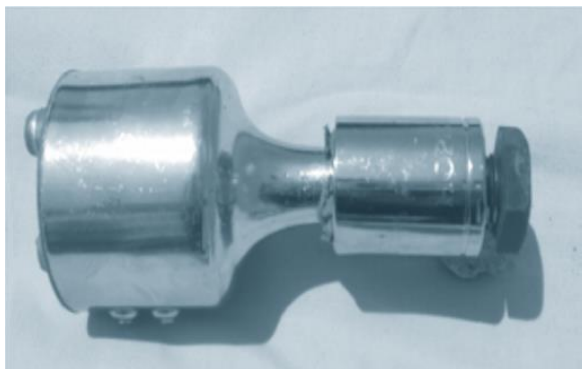


Figure 6. Bicycle dynamo attached to the platform of the wind.



Figure 7. Final design of the blades made with PVC tube.

It was vital to take into account technical criteria based on historical ratios while manufacturing the blades, as it is well known that bending and torsion subject the blades to severe strains. Due to the enormous forces that must be conveyed to the axis, they are also prone to considerable fatigue. The shovel's assembly is made easier and it also begins Fall readily in the presence of mild winds thanks to the PVC blades, which were cut from 160mm pipe with a diameter and angled along the shovel at a 15o angle. It is desirable for the system to spin for a lengthy period of time, even for a few rotations, as opposed to turning extremely quickly on days when there are strong winds and needing additional time to halt.

The tube was divided into four equal halves for the fabrication of the blades. The first one was created and utilized as a model for the others. Ultimately, there were four blades produced—three for the wind turbine and one spare. They trim the edges like blades to "cut" the airflow and reduce resistance in order to increase aerodynamics.

Blade base or hub

A spherical acrylic shell with a radius of 7.0 cm and a thickness of 0.3 cm was cut in order to attach the blades to the motor in the next phase.

The material was chosen because it was lightweight and simple to work with. The wheel quickly attached to the motor shaft, creating an expansion between the hub and the motor by fitting a 21 mm by 12" cup.



Figure 8. Blade bases, or bushings, conform to 1" by 5/16 screws to hold blades.

4. TESTING AND COMMISSIONING OF THE WIND TURBINE

Since the wind speed increases quickly with height, becomes less turbulent, and increases in speed as it climbs centimeters relative to the ground, a location high enough, inside the city of Neiva, was searched to ensure the wind turbine acquired the appropriate performance (Mueller, 2005).

Finding out how strong the wind is where the wind installation will be installed is crucial. Because of this, the information on wind speed and related factors was directly extracted from the webpage, which states that winds with speeds between 3.4 and 5.2 m/s are categorized as Type 3 forces with mild designation.

The minimum temperature, average temperature, and maximum temperature for the whole month of November are all 22 degrees Celsius. This month's rainfall has been fairly consistent, averaging 250 mm over 19 days. These statistics allow it to be confirmed that the winds at the prototype's start-up were some of the best of the whole year.

The prototype rotor is kept stationary for 42 seconds during this start-up before slowly starting to spin until he reached the required number of revolutions for the prototype to produce 12 V in direct current, which was then transported to the battery where it was stored and the installed lamp was turned on.

In order to raise the tower's height and ultimately the amount of wind energy accessible, during the second test of the prototype, two more meters were added to the house's 3 meters by ejecting the coaxial tube from the main tube. The highest value that might be reached at startup is this height of 5 meters.

The rotor turned on within two seconds of being positioned at this height, rotating steadily and uniformly, producing the same number of revolutions as in the previous test, and projecting the same amount of 12 V, which was required to turn on the bulb.

The beginning speed, which commonly ranges from 3 to 4 m/s, is the lowest wind speed at which the blades will revolve and produce useable power.

No sonic effect or unevenness caused by the turbine was present. The battery and generator did not cause them any difficulty; I am unsure of the cause. The putting in March was successful as a consequence.

As a result, a home wind turbine was acquired. co, suited to many house forms, and which shown climate conditions resistance.

5. CONCLUSIONS

The shortage of resources necessary to analyze the energy generation process of a wind turbine is the driving force behind this research. understanding of mechanics, computer programming, computer-aided design, electrical

engineering, aerodynamics, and manufacturing while working to create a prototype that closely resembles the operation of a wind turbine. The design and construction of the wind turbine are briefly discussed here, along with some of the goals that were attained.

- There is a direct current wind turbine prototype that can be mass produced to provide power to Northern India's underserved rural communities.
- The right use of all natural resources must become widely known through basic education, with programs that promote societal good being proposed.
- Technical challenges were faced during the wind turbine's design, construction, and commissioning, but they were successfully solved.
- The expansion of this degree work will act as a basis for getting the class to follow you if you are more interested in supporting these initiatives at other educational levels.

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