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Vertical Axis Wind Turbine for Highway Applications

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A B S T R A C T

This project aims of utilizing this wind energy in most effective manner to get the maximum electric output, and therefore we selected highway as our installation site where we can take the advantage of the moving vehicles on both the sides of the road. In the present work, turbine is design and fabricated as per the specifications, the blades used are semi-circular shape and are connected to the disc which is connected to shaft. Shaft is then coupled with pulley with the help of bearing, and then pulley is connected to the alternator, which generates the power. The power developed is stored in battery and then can be used for street light, signal or toll. In this project a small model has been created for testing purpose. This project also aims for maximum output with minimum cost indulges, so that the government can think over this project and can implement this type of vertical axis wind turbine on highways at low cost. Government institutions funded the research in wind technology to be adopted as the mainstream source of power production in the world. Scientists and researchers successfully designed several wind turbine prototypes which worked really good with the site conditions. By the late nineteenth century, wind energy was in operation to produce electricity. Later, this technology was enlarged and utilized as onshore wind energy. Latest developments and some risks involved in the onshore wind energy has evolved the offshore wind technology.

Keywords: Wind Energy, Wind turbine, Blades

1. INTRODUCTION

Design, fabrication and testing of a Vertical Axis Wind Turbine (VAWT) with wind deflectors will be the ongoing final year undergraduate project of us. Here, main purpose will be enhancing the performance of the VAWT by designing guide vanes and fabricating with a low cost and get more shaft torque and rpm. And also, it is supposed to be a portable wind turbine.

Energy is a hot topic in the news today: increased consumption, increased cost, depleted natural resources, our dependence on foreign sources, and the impact on the environment and the danger of global warming. Something has to change. Wind energy has great potential to lessen our dependence on traditional resources like oil, gas and coal and to do it without as much damage to the environment. Alternative energy sources, also called renewable resources, deliver power with minimal impact on the environment. These sources are typically more green clean than traditional methods such as oil or coal. In addition, alternative resources are inexhaustible.

These benefits, as well as data that suggest the drop-off of conventional oil drilling will overtake the output of new drilling by 2014, make renewable energy a viable source to pursue. The beauty of wind power is that it is derived from a virtually unlimited and inexhaustible resource: the wind. Unlike energy that relies on fossil fuels, wind energy produces far fewer carbon emissions and pollution. In addition, most wind turbines/wind farms, once established, don't have exhausting operational costs.

2 LITERATURE REVIEW

2.1. THEORETICAL STUDY OF WIND TURBINE AND PROSPECT OF WIND TURBINE

(V. Abdiwahap, M. Mohammed Ismail, S.K. Abdiaziz Ali Nur)2022

Human beings are utilizing wind energy from the early stages of human civilization for numerous processes like grinding of grains, pumping water, sailing, etc. With time, both human civilization and wind energy utilization are developing, and in this 21st century, wind energy is a popular source of Renewable Energy for electricity generation.

The increased industrialization and modernization resulted in the increased demand for electricity, To address these ongoing requirements, more and more fossil fuel-based power plants are being installed all across the globe, which is generating a massive amount of carbon dioxide and other harmful gases responsible for greenhouse gas emissions and global warming. Moreover, these fossil fuels are nonrenewable, and hence depending solely on these fuels will create scarcity of energy in the future.

In such a situation, the world is focusing and exploring various forms of renewable energy sources, like solar photovoltaic, wind, geothermal, hydro, tidal, etc. and within a short time wind energy has become a popular source of energy for generating electricity in an environment-friendly method. In this Course Project, the theoretical study of Wind Energy and Wind Turbines is carried out along with the study of wind energy potentials.

2.2. ALTERNATE RENEWABLE ENERGY SOURCE VIA WINDMILL

(A. Abhishek Patel, S. Kapil Parkhir)2010

Renewable Energy Sources are those energy sources that are not destroyed when their energy is harnessed. Human use of renewable energy requires technologies that harness natural phenomena, such as sunlight, wind, waves, water flow, and biological processes such as anaerobic digestion, biological hydrogen production, and geothermal heat. Amongst the above-mentioned sources of energy, there has been a lot of development in the technology for harnessing energy from the wind.

The wind is the motion of air masses produced by the irregular heating of the earth's surface by the sun. These differences consequently create forces that push air masses around for balancing the global temperature or, on a much smaller scale, the temperature between land and sea or between mountains.

2.3. ENERGY PROJECT IN ANDHRA PRADESH

(Greenko Wind energy Pvt Ltd)2015

Greenko Wind Energies Pvt Ltd is started by experienced engineers with more than 10years experience in executing projects and immense experience in development of Wind Power.

Projects all over India. GWEPL proposes to set up a 46.4MW Wind Power Project at Kondapalle RF and Kuderu RF, Anantapur district, Andhra Pradesh. The plant will be designed to use wind energy to produce 46.4MW ecofriendly electricity. The possibilities of wind power station near Kondapalle RF and Kuderu RF, Anantapur district, have opened an opportunity to utilize the same for the power generation. This has established an economical solution for quick augmentation of power generation efficiently through wind based power plant.

Electricity generation capacity with utilities in India had grown from 1.713 GW in December 1950 to over 272.50 GW by August 2015. India became the world's third largest producer of electricity in the year 2013 with 4.8% global share in electricity generation surpassing Japan and Russia. Renewable Power plants constituted 28.43% of total installed capacity and Non-Renewable Power Plants constituted the remaining 71.57%.

2.4. MAGLEV WINDMILL

(J. Rahul Mehara, F. Rohit Aheer)2016

This project dwells on the implementation of an alternate configuration of a wind turbine for power generation purposes. Using the effects of magnetic repulsion, spiral shaped wind turbine blades will be fitted on a rod for stability during rotation and suspended on magnets as a replacement for ball bearings which are normally used on conventional wind turbines. Power will then be generated with an axial flux generator, which incorporates the use of permanent magnets and a set of coils. The selection of magnet materials in the design of wind turbine system will be discussed. A model of wind turbine is built to perform several tests such as starting wind speed, rotational speed at constant wind speed, and time taken to stop rotation completely. The results obtained will be compared with the model of conventional wind turbine. Power will then be generated with an axial flux generator, which incorporates the use of permanent magnets and a set of coils.

2.5. DESIGN OF AEROLEAF WIND TURBINE

(M. Jazzaa, A. Abdullah, Z. Ahmed Alghoneman)2017

This project (Design of Aeroleaf Wind Turbine) is about designing and manufacturing a Vertical Axis Wind Turbines VAWT to transfer the wind speed to a rotational motion using these turbines. These turbines will be attached to a manufactured tree that will look like a modern design, which can be installed in and around any public area such as parks, roads, public facilities, or business offices. Aeroleaf Wind Turbines are designed to produce power up to 300 watts for each turbine. This project presents a review on the performance of Savonius wind turbines. This type of turbine is not commonly use and its applications for obtaining useful energy from air stream is still considered as an alternative source. Low wind speed start-up, working with any wind direction, and the less noise are some advantage of VAWT- Savonius model.

This project consists of three phases; designing, fabrication, and evaluating. An actual of gained power is reported to be 31~35% relative to the theoretical gained power due to the instability and inefficient of the wind speed.

3. BLOCK DIAGRAM

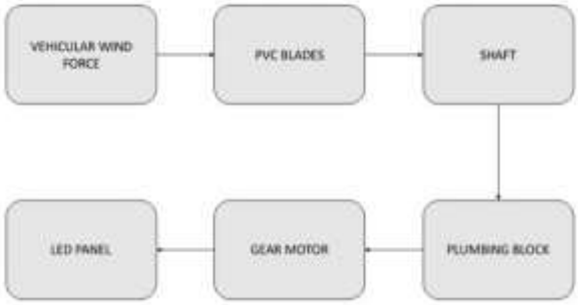

Figure 1 Block Diagram

4. ESTIMATION OF STATE OF POWER

The tip speed ratio of a wind turbine blade is the ratio of the speed of the tip of the blade to that of the wind. TSR is a vital design criterion for all lift-type wind turbines. As the blades of a wind turbine rotate they interact with the wind. If the rotation of the rotor is too slow, wind passes through the rotor swept area without interacting with the turbine blades. If the rotation is too fast then the rotor swept area acts as a barrier and deflects the wind, causing turbulence and loss of wind power. The optimal TSR for horizontal-axis, three blade turbines, which are predominantly used in onshore and offshore wind farms, is approximately 5:1 to 6:1.

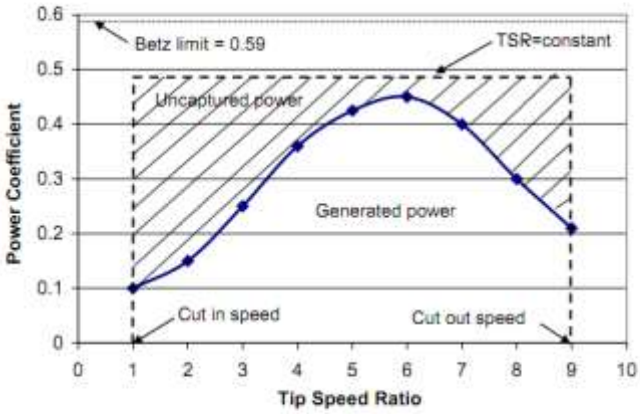

Figure 2 Graphical Representation of Tip Speed Ratio with Power Coefficient

To calculate the TSR for a VAWT you need to record the rotational speed of the rotor (ω), the radius of the rotor, and the wind speed. With these three values the TSR can be calculated with the following formula.

$$\lambda = \omega R/\nu$$

Where:

$\lambda =$ Tip-Speed Ratio

$\omega =$ Rotational Speed (radians/s)

$R =$ Radius of the Rotor (meters)

$\nu =$ Wind Speed (m/s)

As it may not be practical to record the rotational speed, a tachometer can be used to record the time period (t) for one full rotation of the rotor. The distance traveled is equal to the circumference of the rotor-swept area as tip of the blades travel 2ΠR meters every full rotation. The blade tip speed is then 2ΠR/t and this can be divided by the wind speed from a digital anemometer to give a field measurement of the tip-speed ratio.

Manufacturers often produce several different wind turbine blades that are each optimized for different wind conditions. Choosing a blade that exhibits the ideal TSR in wind conditions that are most prominent at the site is essential in achieving peak energy efficiency from the wind turbine.

5. ESTIMATION THE EFFICIENCY OF VAWT

Lot of researches has done for increasing efficiency of the Vertical Axis Wind Turbine. They have developed basic wind turbines and discover significant parameters that directly involve to changing performances of turbines. Some of them are blade solidity, lift force, drag force and angle of attack. And also they introduce system integration with a wind deflector.

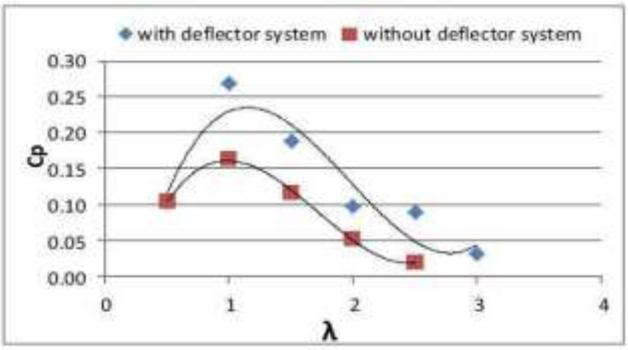

Figure 3 Power Coefficient of Turbine

The starting torque and power coefficients characteristics of Horizontal axis wind turbines (HAWT) are higher than the vertical axis wind turbines (VAWT). Because of this reason commercial wind power market fills with HAWT. Anyhow, small vertical axis wind turbines are more appropriate to urban environments because the reduced risk associated with their slower rate of rotation and the lower noise pollution compare to their horizontal axis wind turbine.

In research, a deflector system which can guide the wind towards the vertical axis wind turbine blades has been introduced to increase the power coefficient, and tested with CFD.Information of the Wind turbines and deflectors were collected and we selected vertical axis wind turbine for our project. Because of that, they can be packed closer together in wind farms, allowing more in a given space, they are quiet in operation, they produce lower forces on the support structure and especially they do not require as much wind to generate power.

6. REQUIRED COMPONENTS

6.1 MS STEEL

The outside square frame is made of Mild Steel.

Mild steel is a type of carbon steel with a low amount of carbon – it is actually also known as “low carbon steel.” Although ranges vary depending on the source, the amount of carbon typically found in mild steel is 0.05% to 0.25% by weight, whereas higher carbon steels are typically described as having a carbon content from 0.30% to 2.0%. If any more carbon than that is added, the steel would be classified as cast iron.

6.2 CONCRETE ROD (REBAR)

The Concrete rod is used to connect the PVC Blades and Steel Shaft.

Rebar (short for **reinforcing bar**), known when massed as **reinforcing steel** or **reinforcement steel**, is a steel bar used as a tension device in reinforced concrete and reinforced masonry structures to strengthen and aid the concrete under tension. Concrete is strong under compression, but has weak tensile strength. Rebar significantly increases the tensile strength of the structure. Rebar's surface features a continuous series of ribs, lugs or indentations to promote a better bond with the concrete and reduce the risk of slippage.

6.3 TURBINE BLADES

Blade selection is one of the major step in the design of a wind turbine. Blades convert kinetic energy from the wind into rotational energy in the turbine shaft. Vertical axis wind turbines are of generally two types- drag machines and lift machines. Drag machines move slower than the wind, have low efficiency and are self-starting.

Various iterations were made for the design of the blade of turbine and concluded on particular design of the blade.

A blade is designed with the help of PVC pipes. Holes are made on the base section and vertical end portion to make the necessary arrangement for fixing with other part of the turbine. The design of the blade plays a vital role in proper functioning of turbine.

6.4 SHAFT DESIGNING

While designing of the shaft of blades it should be properly fitted to the blade. The shaft should be as possible as less in thickness & light in weight for the six blade. The shaft used is very thin in size are all properly fitted so no problem are slip ping & fraction is created, it is made up of hollow aluminum which is having very light weight.

6.5 PLUMBING BLOCK

For the smooth operation of Shaft, bearing mechanism is used. To have very less friction loss the two ends of shaft are pivotedTo have very less friction loss the two ends of shaft are pivoted into the same dimension bearing.

The Bearing has diameter of 2.54cm. Bearing are generally provided for supporting the shaft and smooth operation of shaft. Greece is used for bearing maintenance

6.6. GEAR MOTOR

A gearmotor, also called a gear motor or a geared motor, is a combination of a gear system or gearbox and an electric motor. Geared motors are efficient because you will only have to mount and operate one system, instead of several. Sometimes inaccurately called "gears motors," or even geared motors, gearmotors generally combine an efficient motor, such as an Electrically Commutated Motor, with a gear reducer or gearhead.

Serial no	**Components**	**Dimensions**	**Type**	**Quantity**
1	Square Pipe	12 ft	MS Steel	1
2	Plumbing Block	1 inch	-	2
3	Shaft	3 ft	MS Steel	1
4	Turbine	3 ft & 6Kg	PVC	6
5	Concrete rod	1 ft	Cast Iron	12
6	Gear Motor	-	Step up	2
7	LED Panel	-	-	1 (14 LED 's)

Table 1 Hardwarer Specification

After designing we were thinking about the fabrication of the wind turbine which will take more time from the time plan. In fabrication steps material was selected & doing welding, fixing, fasting, bending of sheet metals etc…

Figure 4 Project Installation

7. CONCLUTION

The vertical axis wind turbine increases the efficiency and production volume while compared with horizontal axis wind turbine. This will reduces the area required for the installation of wind turbine by fixing the vertical and horizontal wind turbines in a single tower. It will accumulate more number of wind towers at less area compared to HAWT. The implementation of vertical axis wind turbine will solve the issue on the usage of fossil fuels and highly helpful for the environment to safeguard from global warming.

The VAWT is designed and fabricated in such a way that the it can able to capture wind from all the direction, power developed from the project is 1W for a speed of 25m/s, the efficiency of VAWT can be increase by changing the size and shape of the blade, the theoretical and experimental result is varying because in theoretical calculation we consider the wind is hitting all the three turbine blades, practically it is hitting only one turbine at a time.

Even though we were able to make improvements to the previous work that was handed down to our group, there is a never ending process to always improve upon inventions and new designs. Wind turbines are a start for society to lessen the damage done to the earth by not using energy sources that produces pollution. Hopefully this project was able to advance research and testing on VAWT systems and give insight for other groups to complete further testing and improve efficiency and performance of vertical axis wind turbines.

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