International Journal of Engineering Innovation & Research
Volume 6, Issue 5, (September) ICEMS-2017, ISSN (Online) : 2277 – 5668

International Conference on Advances in Engineering Management & Sciences - ICEMS -2017

Design and Fabrication of Vertical Axis Wind Turbine for Power Generation

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***Abstract* – A defined study has been carried out to find the potential for installing roof-mounted Vertical axis wind turbine (VAWT) systems on house roofs. VAWT power generation equipment can be located at ground level, which makes for easy maintenance. Also, VAWT are Omni - directional, meaning they do not need to be pointed in the direction of the wind to produce power. The various changes in the design of Thread mill rotor have been made in order to improve efficiency and power output. Wind energy is particularly appealing way to generate electricity because it is essentially pollution free. In our VAWT as a turbine we can use bicycle wheel and PVC pipes as a blades.**

The cost of power generation from wind forms has now become lower than diesel power comparable to thermal power in several areas especially near coasts. And the wind flow will depend on the velocity of the air, size of the bicycle rim and intensity of the air flow. So a detailed survey has to be done for studying these distributions. Based on the studies made an optimal wind turbine design has to be made. The wind power harnessed through this technique can be used for household purpose, street lighting, traffic signal lighting, toll gates etc VAWT would have many advantages over an different wind turbines. Though the tip speed ratio is a still a little low for use as an electrical generator, the research demonstrated a simple way to enable a VAWT to be self-starting and achieve higher efficiencies.

***Keywords* – Vertical axis wind turbine, Bicycle Rims, House Roofs, Thread Mill Rotor, PVC Pipes.**

I. Introduction

Wind results from air in motion. Air in motion arises from a pressure gradient. On a global basis one primary forcing function causing surface winds from the poles toward the equator is convective circulation. Solar radiation heats the air near the equator, and this low density heated air is buoyed up. At the surface it is displaced by cooler more dense higher pressure air flowing from the poles. In the upper atmosphere near the equator the air thus tend to flow back toward the poles and away from the equator. The net result is a global convective circulation with surface winds from north to south in the northern hemisphere. Wind energy is rapidly emerging as one of the most cost-effective forms of renewable energy with very significant increases in annual installed capacity being reported around the world. An important reason for this lack of interest in wind energy must be that wind, in India area is relatively low and vary appreciably with the seasons. Data quoted by some scientists that for India wind speed value lies between 5 kmph to 15-20 kmph. These low and seasonal winds imply a high cost of exploitation of wind energy.

II. Procedure for Paper Submission

A. Review Stage

Dr.S.B.Barve and Piyush Gulve are published a journal on VAWT. The principle objective of this project is Rural Electrification via hybrid system which includes wind and solar energy. Our intention is to design a wind turbine compact enough to be installed on roof tops. So we decided to design a vertical axis wind turbine (VAWT) over Horizontal Axis Wind Turbine (HAWT). Advantages of VAWT over HAWT are compact for same electricity generation, less noise, easy for installation and maintenance and reacts to wind from all directions. The wind turbine designed to generate electricity sufficient enough for a domestic use. The electricity generated will be stored in the battery and then given to the load. This project emphasizes on electrification of remote areas with minimum cost where load shading still has to be done to meet with demand of urban areas. (1)

R.Ramesh, M.Selvam, R. Palanisamy, A. Mohan & A. Muthu Manokar are published a journal on VAWT. Vertical axis wind turbine power generation equipment can be located at ground level, which makes for easy maintenance. Also, VAWT are Omni -directional, meaning they do not need to be pointed in the direction of the wind to produce power. Finally, there is potential for large power generation with VAWT because their size can be increased greatly. However, there are also downfalls to the VAWT. Firstly, boundary layer affects from the ground influence the air stream incident on the VAWT, which in some cases leads to inconsistent wind patterns. Secondly, VAWT are self-starting; currently, an outside power source is required to start turbine rotation until a certain rotational speed is reached .The main objective of our work is to design and build a self-starting vertical axis wind turbine. This report outlines the first term efforts in the design of our full-scale VAWT, which is to be built early in the second term does not have large lift coefficients at low Reynolds numbers. It was concluded that a profile with large lift at low speeds used along with passive pitching could achieve self-starting status. As a result, three blade profiles were tested and compared over the testing in the wind tunnel and the blade profile that offers the best performance for self-starting.(2)

Shraddha R Jogdhankar and S.D.Rahul Bhardwaj are published journals on VAWT. It is well known that we rely on the nonrenewable resources such as fossil fuels, oils, natural gas, etc. which will certainly get exhausted some day. So keeping these things into consideration we thought of generating power using non-conventional sources which is abundantly available naturally and has zero threat for extinction. Among the various non-convention methods for generation of electric power, wind has found its place to be efficient. Wind Energy being renewable resource of energy has got much attention for power generation, nowadays. Having a nature of abundance unlike employment of resources in conventional methods satisfies the growing needs. Wind energy depends upon natural terrains which have wind potential, though these terrains are not found even in nature everywhere, but those which have, are the places that can be harnessed for high potential power generation. Taking into consideration the geographical attributes of our region, the vertical axis windmill will be efficient for power generation. The basic reason for using VAWT is that, it does not consider the wind direction and operates at low wind speed.

Ashwin Dhote and Prof. Vaibhav Bankar are published journal on savonius vertical axis wind turbine. In recent era, research and development activities in the field of renewable energy, especially wind and solar, have been considerably increased, due to the worldwide energy crisis and high global emission. The horizontal axis wind turbine cannot be used for household purpose. So, Savonius vertical axis wind turbine can be better option as it operate in low wind condition also. The choice for this model is to showcase its efficiency in varying wind conditions as compared to the traditional horizontal axis wind turbine and contribute to its steady growing popularity for the purpose of mass utilization in the near future as a reliable source of power generation.

B. Final Stage

The power in the wind can be computed by using the concept of kinetics. The wind will works on the principle of converting kinetic energy of the wind to mechanical energy. We know that power is equal to energy per unit time. The energy available is the kinetic energy of the wind. The kinetic energy of any particle is equal to one half it's mass times the square of its velocity, or 0.5 m V2. The amount of air passing in unit time, through an area A, with velocity V, is AV, and its mass m is equal to its volume multiplied by its density □ of air,

$$m=\rho AV$$

(m is the mass of air transverse the area A is the area of swept by the rotating blades of a wind mill type generator).

Substituting this value of the mass in the expression for the kinetic energy, we obtain, kinetic energy = 1/2 □AV.V2 watts.

$= 1/2\ \rho AV^3$ watts (1)

Equation (1) tells us that the maximum wind available the actual amount will be somewhat less because all the available energy is not extractable-is proportional to the cube of the wind speed. It is thus evident that small increase in wind speed can have a marked effect on the power in the wind.

Equation (1) also tells us that the power available is proportional to air density 1.225 kg/m3 at sea level). It may vary 10-15 percent during the year because of pressure and temperature change. It changes negligibly with water content. Equation also tells us that the wind power is proportional to the intercept area. Thus an aero turbine with a large swept area has higher power than a smaller area machine; but there are added implications. Since the area is normally circular of diameter D in horizontal axis aero turbines, then A = (π/4) D2, (sq.m), which when put in equation (1) gives,

Available wind power $P_w = ½\ \rho\pi/4\ D^2\ V^3$ watts

$= 1/8\ \rho\pi\ D^2\ V^2$ (2)

The power extracted by the rotor is equal to the product of the wind speed as it passes through the rotor (i.e. Vr) and the pressure drop □p. in order to maximize the rotor power it would therefore be desirable to have both wind speed and pressure drop as large as possible. However, as V is increased for a given value of the free wind speed (and air density), increases at first, passes through a maximum, and the decreases. Hence for the specified free-wind speed, there is a maximum value of the rotor power.

The fraction of the free-flow wind power that can be extracted by a rotor is called the power-coefficient; thus

Power of wind rotor
Power coefficient= ----------------------------
power available in the wind

Where power available is calculated from the air density, rotor diameter, and free wind speed as shown above. The maximum theoretical power coefficient is equal to 16/27 or 0.593. This value cannot be exceeded by a rotor in a free-flow wind-stream.

I.COMPONENTS OF VERTICAL AXIS WIND TURBINE

- 2 bicycle rims - 22 inch
- 3 PVC pipes - 4 inches by 8 feet
- 1 treadmill motor - eBay – 6000 RS
- 4 inch pulley
- 12 screws to screw the blades to the rims
- 2x4's as required for building the frame (4 - 8 ft long)
- 2x6 - to mount the treadmill motor
- 6 inch post bracket - hang top bicycle rim
- V belt - length dependent on setup (85 ")


Working of Vertical Axis Wid Turbine

The Vertical Axis wind turbine (VAWT) main rotor shaft is set vertically and the main component located at the base of the turbine. Among the advantages of arrangement of that the thread mill motor can be placed close to bottom of the turbine which makes these components is a to service. The Blades suspended perpendicular to the ground and form of a natural semicircular shape. Because the blades are connected at both ends and can be much lighter lower cost. VAWT's also do not need to be pointed into the wind since the blade arrangement Omni-Directional. This considered reduce the cost in complexity of the equipment and the control need for orientation. With a three axis rotor design the turbine is self-starting and can produce power at low speed wind.

With balanced approach, a VAWT'S produces much lower stress and support structure and the height of tower is below a average wind capture zone which also assists in reducing cost .The rim has selected to direct drive thread mill motor to produce maximum power output through a pulley and the v-belt, reduce complexity to eliminate the cost of gears. These advanced thread mill motor can operate at varying rotational speeds which allows the turbine to be controlled at varying turning velocities to maximize power output. Then that power output can be stored in a battery and utilized.

Experimental setup vertical axis wind turbine.

III. MATH

In the vertical axis wind turbine the shaft is subjected to rotor, and rotor blades. When wind is striking the blade of the rotor, then it is starts rotate about its axis. During this condition shaft subjected to twisting moment and bending moment. To overcoming this we can recommend some factors which are helpful for selecting the proper shaft and shaft material. Generally wind having kinetic energy, i.e product of mass of air to the Velocity of the wind.

The energy possessed by wind is, Pw = ½ ρAV^3 watts

Here, ρ ---Density of the wind (air) =1.029 kg/m3

A --- Swept area of blade m2 = π *r*length (m2)

= 3.14*0.048 *2.44

= 0.3676m2

V ----Velocity of air in m/sec = 6 m/sec

(The velocity of air taken by "THE BOOK OF WIND DATA FOR 50 YEARS" Under the region of Kurnool district)

Now,

Power in the wind (Pw) = ½ (1.029*0.3676*6^3)

= 40.86 Watts.

DAY	TIME	VELOCITY (m/s)	POWER (watts)
21/03/2017	10:00 AM	4	12.104
	01:00 PM	5	23.641
	05:00 PM	6	40.86
22/03/2017	10:00 AM	4.2	14.012
	01:00 PM	6.8	59.468
	05:00 PM	5.4	29.782

This is another factor the system engineer must consider for heavy machinery, structures, materials, blades and other apparatus will have to be moved into any chosen Wind Turbine site.

5.Nearness of site to local centre/users

This obvious criterion minimizes transmission line length and hence losses and costs. After applying all the previous sitting criteria, hope fully as one narrows the proposed Wind turbine sites to one or two they would be relatively near to the users of the generated electric energy.

6.Nature of ground Ground condition should be such that the foundations for a Windmill, destroying the foundations for a Windmill are secured. Ground surface should be stable. Erosion problem should not be there, as it could possibly later wash out the foundations of a Wind Turbine, destroying the whole system.

7.Favourable land cost

Land cost should be favourable as this along with other sitting costs, enters into the total Wind Energy Converting system cost.

8.Characteristics of wind power site

The characteristics of a good wind power site may be summarized as follows

1.A site should have a high annual wind speed.
2.There should be no tall obstructions for a radius of 3 km.
3.An open plain or an open shore line may be good location.
4.The top of a smooth, well rounded hill with gentle slopes lying on a flat plain or located on an island in a lake or sea is a good site.

IV. Helpful Hints

Estimation of Wind Data and Energy

The site choice for a single or a spatial array of Wind Turbine is an important matter when wind electric is looked at from the systems points of view of aero turbine generators feeding power into a conventional electric grid. If the Wind turbine sites are wrongly or poorly chosen the net wind electric generated energy per year may be sub optimal with resulting high capital cost for the Wind Turbine apparatus, high cost for wind generated electrical energy, and no returns on investment. Even if the Wind Turbine is a small generator not tied to the electric grid, the sitting must be carefully chosen if inordinately long break even times to the avoided. Technical, economic environmental, social, and other factors are examined before a decision is made to erect a generating plant on a specific site. Some of the main considerations are discussed below.

1. High annual average wind speed

A fundamental requirement of the successful use of Windmill obviously is an adequate supply of wind has stated above. The wind velocity is the critical parameter. The power in the wind Pw, through a given cross sectional area for a uniform wind velocity v, is Pw=Kv3

Where K is a constant. It is evident; because of the cubic dependence on wind velocity that small increases in V markedly affect the power in the wind, Example, Doubling V, increases Pw by a factor of 8. It is obviously desirable to select a site for Wind turbines with high wind velocity. Thus a high average wind velocity is the principal fundamental parameter of concern in initially appraising a Wind turbine site. For a more detailed estimate value, one would like to have the average of the velocity cubed.

Anemometer data is normally based on wind speed measurements from a height of 10m. For the most accurate assessment of wind power potential it is absolutely essential that anemometer data be obtained at the precise site and hub height for any proposed Wind Turbine.

Strategy for sifting is generally recognized to consists of
1. Survey of historical wind data,
2. Contour maps of terrain and wind are consulted.
3. Potential sites are visited.
4. Best sites are instrumental for approximately one year.
5. Choose optimal site.

2. Wind structure at the proposed site

The ideal case for the Wind Energy Converting System would be a site such that the V(t) curve was flat, i.e. a smooth steady wind that blows all the time; but a typical site is always less than ideal. Wind especially near the ground is turbulent and gusty, and changes rapidly in direction and in velocity. This departure from homogeneous flow is collectively referred to as "the structure of the wind".

3.Altitude of the proposed site

It affects the air density and thus the power in the wind and hence the useful Wind Turbine electric power output. Also, as is well known, the winds tend to have higher velocities at higher altitudes. One must be careful to distinguish altitude from height above ground. They are not the same except for a sea level Windmill site.

4.Distance to Roads or Railways.

This is another factor the system engineer must consider for heavy machinery, structures, materials, blades and other apparatus will have to be moved into any chosen Wind Turbine site.

5.Nearness of site to local centre/users

This obvious criterion minimizes transmission line length and hence losses and costs. After applying all the previous sitting criteria, hope fully as one narrows the proposed Wind turbine sites to one or two they would be relatively near to the users of the generated electric energy.

6.Nature of ground Ground condition should be such that the foundations for a Windmill, destroying the foundations for a Windmill are secured. Ground surface should be stable. Erosion problem should not be there, as it could possibly later wash out the foundations of a Wind Turbine, destroying the whole system.

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LIST OF MATERIALS

Sl. No.	***Name of the Parts***	***Quantity***	***Materials***
01.	Blades	3	Polyvinyl
02.	Frame structure	9 Feet	Chloride
03.	Generator	1	wood
04.	Bearing	2	Permanent
05.	Connecting	-	DC
06.	Wire	1	M.S
07.	Pulley	2	Cu
08.	Bicycle	7.5 Feet	iron
09.	wheel(Rotor)	1	Stainless
	Shaft		steel
	V belt		PVC
			Rubber

Scope of Paper

•Our concern with the gearing and start-up winds speed held true. The beast would only run under extreme wind conditions. We are looking for a bigger pulley for the treadmill motor and will need to retest.

- Environmentally favorable VAWT'S can be utilized for array of applications including:
- Electricity generation
- Pumping water
- purifying and Desalinating of water by reverse osmosis
- Heating and cooling using vapor compression heat pump
- mixing and Aerating of water bodies
- Heating water by fluid turbulences

V. Conclusion

This project work has provided us an excellent opportunity and experience, to use our knowledge. We gained a lot of practical knowledge regarding, planning, purchasing, assembling and machining while doing this project work. We feel that the project work is a good solution to bridge the gates between institution and industries.

At this early stage of development there is a great deal of excitement and potential regarding domestic wind turbine, but until the installed costs start to approach the target prices, the turbines will remain as potential. The "VERTICAL AXIS WINDMILL POWER GENERATION" is working with satisfactory conditions. We are able to understand the difficulties in maintaining the tolerances and also quality. We have done to our ability and skill making maximum use of available facilities.

Thus we have designed and developed a "Vertical axis windmill" which helps to know how to achieve non-conventional power generation. Compare to the horizontal axis windmill our model is easy to modelling and power generation. Vertical axis windmill achieves less cost and requires low wind for same power production from horizontal axis windmill. This will react to wind from any direction and they required less structural support. This configuration also eases installation and maintenance. Thus the output voltage from the generator can be increased by using the pulley and belt system.

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