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## Full Length Research Article

# DESIGN AND ANALYSIS OF VERTICAL AXIS WIND TURBINE

[1]Selvam, M., [2]Ramesh, R., [3]Palanisamy, R., [3]Mohan, A. and [3*]Muthu Manokar, A.

[1]Department of Mechanical, Veltech Multi Tech Dr.Rangarajan Dr.Sakunthala Engineering College, Avadi, Chennai - 600 062
[2]Nehru College of Engineering and Research centre, Thrissur- 629708
[3]Department of Mechanical, Veltech (owned by R.S trust), Avadi, Chennai - 600 062, India

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**ABSTRACT**

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.



## INTRODUCTION

The recent surge in fossil fuels prices, demands for cleaner energy sources, and government funding incentives, wind turbines are becoming a more viable technology for electrical power generation. Fortunately there is an abundance of wind energy to be harnessed. Currently, horizontal axis wind turbines (HAWT) dominate commercially over vertical axis wind turbines (VAWT). However, VAWT do have some advantages over HAWT. The main objective of our work is to improve the output of the wind power generation produce electric power using vertical axis wind turbine, Currently, horizontal axis wind turbines (HAWT) dominate the wind Energy market due to their large size and high power generation characteristics. However, vertical axis wind turbines (VAWT) are capable of producing a lot of power. The mechanical power generation equipment can be located at ground level, which makes for easy maintenance Alex Emanuel, *et al* (March 2007) says 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.

***Corresponding author: Muthu Manokar, A.,**
*Department of Mechanical, Veltech (owned by R.S trust), Avadi, Chennai - 600 062, India*

A converter will then be used to regulate the varying voltage from the rectifier to output a steady DC voltage. His impressive intellection and insightfulness was a major contributing factor to the success of our research. U.K. Saha *et al* (2009) says the low rotational speed and low power production, Savonius rotors are lagging in terms of technology from horizontal axis wind turbines. It is, however, believed that with some design. Modification of the blades, the Savonius types of machines may be quite useful for small-scale power requirement. Preliminary investigation in this direction led the development of a new blade shape with a twist for the Savonius rotor span. The twisted blade fabricated from sheet metals has shown its potential as compared to the other conventional blades. In this investigation, twisted blades fabricated from bamboo strips have been tested to find it operational feasibility. Experiments with bamboo bladed rotor Show a slightly low rotational speed as compared to the earlier tested twisted metallic blades. However, the low cost and the ease of fabrication. These sheets are cut to a dimension of 550 mm × 350 mm, and all the edges have been stitched properly to ensure proper strength and durability. Both the surfaces of the blades are covered with paper sheets for a good surface finish. In order to ensure the required geometric profile, holes were drilled at the top corners of the blades, which were then pulled by a thin wire to make the required curvature. Similar technique has been used at two other locations along the blade height to maintain the desired twist angle. The rotor assembly consists of a cylindrical solid mild steel shaft where blades are clamped by means of strips. The shaft consists of three equally spaced mild steel strips to hold the aluminum brackets.

S. Rauta, *et al* (2009) says the wind power and its potential that can be harnessed in the future to meet the current energy demand. With detailed description of the wind turbine and the wind generator focus has been given on the interconnection of the generators with the grid and the problems associated with it. The use of power electronics in the circuitry and their applications has also been emphasized. In the end a voltage stability analysis has been done with respect to various models of the wind turbines to find the best way to clear faults and have optimum output. The study of wind turbine and its characteristics showed that how it can be properly designed and used to get the maximum output. The power electronic circuitries have helped the concept of wind power a lot. Without them this concept would have been too expensive and farfetched. With the thrusters and converters being used not only the operations have been smoothened but also the efficiency has been increased to a great extent. From the voltage stability analysis it was showed that how a doubly fed induction generator has superior characteristics than a simple induction generator. This report also showed the integration of wind farms with the transmission grid and the problems associated with it and the probable solutions that can be applied to solve them and have a better performance.

P N Sankar *et al* (1998) says the development of vertical axis wind turbines hutted on the Darricusrtiior, on the analytical side, a performance analysis was developed which permits the estimation of the machines A5 in high wind turbine using curved wooden blades was designed, fabricated multi tested. Among the advantages of this arrangement are that generators and gearboxes can be placed close to the ground, which makes these components easier to service and repair, and that VAWTs do not need to be pointed into the wind. Major drawbacks for the early designs (Savonius, Darrieus and giromill) included the pulsatory torque that can be produced during each revolution and the huge bending moments on the blades. Later designs solved the torque issue by using the helical twist of the blades almost similar to Gorlov's water turbines. A VAWT tipped sideways, with the axis perpendicular to the wind streamlines, functions similarly. A more general term that includes this option is "transverse axis wind turbine". For example, the original Darrieus patent includes both options. Drag-type VAWTs, such as the Savonius rotor, typically operate at lower tip speed ratios than lift-based VAWTs such as Darrieus rotors and cycloturbines. A unique, mixed Darrieus - Savonius VAWT type has recently been developed and patented. The main benefits obtained are improved performance at lower wind speeds and a lower r.p.m. at higher wind speeds resulting in a silent turbine suitable for residential environments.

**Experiment set up and working**

**Table 2.1. Specifications of the wind turbine**

| BLADE DIMENSIONS | SHAFT DIMENSIONS | PULLEY DIMENSIONS |
|---|---|---|
| Height - 1000mm | Diameter – 20mm | Turbine pulley – 300mm |
| Diameter - 1200mm | Length – 1300mm | Generator pulley – 25mm |
| Thickness - 0.8 mm | | Center Distance of Pulley - 300mm |
| Angle - 45 ° <br> Angle b/w blades - 60° | | |

**Design of Assembly**

The components of the full-scale VAWT are Base, Blades, Shaft, Bearings, Pulley and Belt, alternator and battery.

**Design of Base**

In this project there is a pole base which is made up of mild steel can be with stand, in large force of wind. The base & its height are related to cost and transmission system incorporated. So the height of our base is 1600mm. & width at bottom is 1400mm & at top is 1400mm.

**Design of Blade**

Design of blade Wind turbine blades have on aero foil – type cross section and a variable pitch. While designing the size of blade it is must to know the weight and cost of blades in the project Three blade with vertical shaft are used, it has a height & width of 1000mm & 370mm respectively. The angle between two blades is $60^0$. So if one Blade moves other blades comes in the position of first blade, so the speed is increases.

**Shaft Designing**

Shaft designing 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 blade, the shaft used is very thin in size are all properly fitted. So no problem of slipping & fraction is created, it is made up is having very light weight. Length of shaft & diameter are 1300mm & 20mm respectively. And at the top and bottom ends mild steel.

**Design of Bearing**

Design of Bearing For the smooth operation of Shaft, bearing mechanism is used. To have very less friction loss the two ends of shaft are pivoted into the same dimension bearing. The Bearing has diameter of 20mm. Bearing are generally provided for supporting the shaft and smooth operation of shaft. Greece is used for bearing maintenance

**Designing of pulley**

Designing of Pulley the speed ratio between two pulleys is 1:12, i.e., in one revolution of larger pulley, the pulley of generator completes 12 revolutions so the speed can increase considerably. Also the pulley should have light in weight, so no consumption of power will take place in revolving. For the project, the dimension of larger pulley is 300mm. and for pulley required for generator is 25mm. So in one revolution of larger pulley, the second pulley completes 12revolution. It is made up of mild steel. It should be properly attached to the shaft of blades. So no friction will take place. The thickness of pulley is 15mm. For the driving purpose, belt is used, which is placed in these two pulleys.

**Brushed DC generator**

Brushed DC generators are commonly used for home built wind turbines. They are backwards from a permanent magnet generator. On a brushed motor, the electromagnets spin on the rotor with the power coming out of what is known as a commutator. This does cause a rectifying effecting outputting lumpy DC, but this is not an efficient way to “rectify” the power from the windings, it is used because it’s the only way to get the power out of the rotor. A good brushed motor can reach a good efficiency, but are typically at most 70%. The capacity of the generator is up to 4.6 V. There are many great advantages to using a brushed motor. One of the biggest reasons is because typically you can find one not requiring any gearing and still get a battery charging voltage in light wind.

**Energy storage / battery**

The output of generator is given to the battery for electric energy storage purpose. The capacity of the battery is up to 12 V. Generally this battery is lead acid type battery and also restorable. The supply of generator is given to the battery through a diode.

**Working of vertical axis wind turbine**

Vertical axis wind turbine (VAWT) has two or three blades, in which the main rotor shaft runs vertically. These blades are wrapped around the shaft and the generator is mounted at the base of the tower. The output power generated by wind generator is measured by using multi meter. The experimental power output is noted in table 2.2

**Fig. 1. Experimental Setup**

## RESULTS AND DISCUSSION

The average natural wind speed to be 6 m/s. Density of air is 1.204 kg/m3.Turbine 1.2 m in diameter and 1.0m height, the power of the wind is given by,

$Pw= \frac{1}{2} \rho A u^3$

where

Pw - power of the wind (W)
ρ - Air density ($kg/m^3$)
A - Area of a segment of the wind being considered ($m^2$)
U - Undisturbed wind speed (m/s)
A= D lb

Where

A- Swept area ($m^2$)
D-diameter of the turbine (m)
Lb- length of the turbine Blades (m)
$A= (1.2) * (1.0)=1.2m^2$
$Pw=1/2 * (1.204) * (1.2) * (6)^3$=156.03watt

**Table 2.2. Comparison between Theoretical and Experimental mechanical power**

| Wind Velocity (m/s) | mechanical power (W) (Theoretical) | mechanical power (W) (Experimental) |
|---|---|---|
| 4.5m/s | 65.8watt | 48.8 watt |
| 5.5m/s | 120.18watt | 102.3 watt |
| 7.5m/s | 304.76watt | 260.68 watt |
| 10m/s | 722.40watt | 610.74 watt |

From the output it is clear that, the output of actual and theoretical mechanical power varying the reason is power losses in turbine and generator. Main reason for varying power output of wind turbine is natural wind speed, it varies continuously.

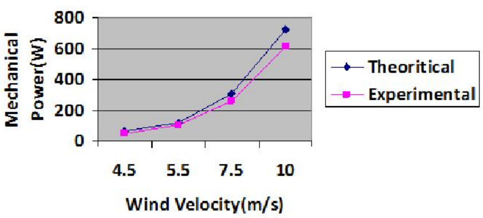


**Fig. 2. Comparison between Theoretical and Experimental mechanical power output**

### Conclusion

Our work and the results obtained so far are very encouraging and reinforce the conviction that vertical axis wind energy conversion systems are practical and potentially very contributive to the production of clean renewable electricity from the wind even under less than ideal sitting conditions. It is hoped that they may be constructed used high-strength, low- weight materials for deployment in more developed nations and settings or with very low tech local materials and local skills in less developed countries

## REFERENCES

U.S. Department of Energy. "Wind and Hydrop ower Technologies Program" Retrieved fromhttp://eereweb.ee. doe.gov/windandhydro/ wind_how.html in November, 2005.

Chang, Professor L. 2005. "Advanced Topics in Environmental Engineering -Wind Power," Ch 4. University of New Brunswick. Retrieved from http://www.ece.unb.ca/ powereng/courses/EE6693/ index.html in October, 2005.

Kirke, Brian Kinloch, 1998. "Evaluation of Self-Starting Vertical Axis Wind Turbines for Stand-Alone Applications". Griffith University, Australia. Retrievedfromhttp://www4.gu.edu.au:8080/adt-root/public/ adt-QGU20050916.120408/ on November 1, 2005.

Sheldahl, Robert E., Klimas, Paul C., 1981. "Aerodynamic Characteristics of Seven Symmetrical Airfoil Sections Through 180-Degree Angle of Attack for Use in Aerodynamic Analysis of Vertical Axis Wind Turbines", Sandia National Laboratories, Albuquerque, NM., USA.

Reuss, R.L., Hoffmann, M.J., Gregorek, G.M., December 1995. 'Effects of Surface Roughness and Vortex Generators on the NACA 4415 Airfoil, The Ohio State University, Columbus, Ohio, USA. Retrieved from http://wind.nrel.gov/OSU_data/reports/7x10/ N4415_7x10.pdf on November3,2005.

Pawsey, N.C.K., 2002. "Development and Evaluation of Passive Variable-Pitch Vertical Axis Wind Turbines", School of Mechanical and Manufacturing Engineering, The University of South Wales, Australia.

P N Shankar "Development of vertical axis turbine" Proc. Indian Acad. Sci,, Vol.C2,Pi.i ,March 1998,pp. 49-66. National Aeronautical Laboratory, Bangalore 560 017

Johnson, Dr. Gary L. (November 21, 2001) "Wind Turbine Power – Ch 4. Wind Turbine Power, Energy and Torque." Retrieved from http://www.eece.ksu.edu/~gjohnson/ wind4.pdf in October 2005.

PROF. S. Rauta, "Winds as a renewable source of energy" 11may2009 National Institute of Technology Rourkel-769008, Orissa. Vol.2, 6-13 may 2009 Page(s):2009 – 2014.

U. K. Saha, "Twisted bamboo bladed rotor for savonius wind turbines" Journal of thermal Science Vol. 18, No. 1 (2009) 5457 National Climatic Data Center, U. S. Department of Commerce.

Professor Alex Emanuel, "Magnetically levitated vertical axis wind turbine" Journal of Energy, Vol. 7, No. 4, march 2007.

Mazharul Islam, David S.K. Ting and Amir Fartaj.2008 Aerodynamic Models for Darrieus- Type Straight-bladed Vertical Axis Wind Turbines. Renewable & Sustainable Energy Reviews, Volume 12, pp.1087-1109.

Siegfried Heier. 2006. Grid Integration of Wind Energy Conversion Systems, Second Edition. Wiley, Chap. 2, pp.31-44.

Migliore, P.G. "Comparison of NACA 6-Series and 4-Digit Airfoils for Darrieus Wind Turbines," Journal of Energy, Vol. 7, No. 4, 1983.

Hwang, I.S., Hwang, C.S., Min, S.Y., Jeong, I.O., Lee, Y.H. and Kim, S.J. "Efficiency Improvement of Cycloidal Wind Turbine by Active Control of Blade Motion," 16th International Conference on Adaptive Structures and Technologies, Paris, France, 9-12 October 2005.

Yun, C.Y. "A New Vertical Take-off and Landing Aircraft with Cycloidal Blades System: Cyclocopter," Ph.D. thesis, Seoul National University, Korea, 2004.

Wheatley, J.B. "Simplified Aerodynamic Analysis of the Cyclogiro Rotating-wing System," Technical Notes NACA No.467, 1933.

Boschma, J.H. "Modern Aviation Applications for Cycloidal Propulsion," AIAA, Aircraft, Technology Integration and Operations Forum, Los Angeles, CA, 2001.

Kirke, Brian Kinloch, 1998. "Evaluation of Self- Starting Vertical Axis Wind Turbines for Stand- Alone Applications". Griffith University, Australia. Retrieved fromhttp://www4.gu.edu.au: 8080/adt- root/public/adt-QGU20050916.120408/on November 1, 2005.

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