

Mini Vertical Wind Turbine's Modified Design

Raja A¹, Giriprasath K², Karthik Raja R³, Adhusoodhanan V⁴, Mageshwaran G⁵

¹Assistant Professor & Head, Dept. of Mechanical Engineering, Apollo Engineering College, Chennai
^{2,3,4,5} 3rd Year Student, Department of Mechanical Engineering, Apollo Engineering College, Chennai

Abstract- This project studies the potential for portable vertical axis wind turbine system for the domestic household purposes. The application of wind energy in power generation is increasing day by day. Vertical axis wind turbines are considered to be more efficient than Horizontal axis wind turbines but with urbanization and limited access to wind in cities, Vertical axis wind turbines may offer greater advantages, as Vertical axis wind turbines are used in the house roof tops. In many high altitude regions, average wind velocity is around 5 – 8 ms⁻¹ which can be utilized for electrical energy production, but in cities, that are at lower altitudes and are congested, so in order to increase the efficiency of working the general vertical axis wind turbine blades are replaced for attaining more torque from the obtained air force. The rotation of wind turbine blades is converted into electricity by means of generator which is coupled with the shaft of rotating blades with the help of gear arrangements. This system can be implemented in moderate windy region for generation of electricity.

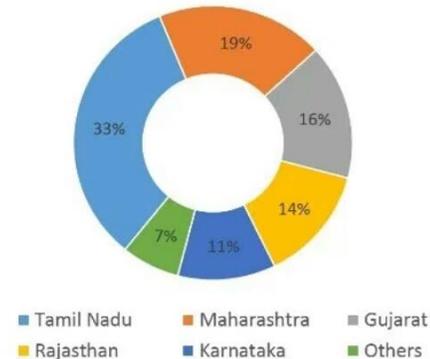
INTRODUCTION

With population increasing exponentially and our natural resources being strained by increasing in demand, it is more important than ever to invest in renewable energy. India is the fourth largest energy consuming country in the world. Thermal power is the largest power source in India. About 71% of electricity consumed in India are generated by thermal power plants. India's energy requirement will increase 4.2% every year by 2035. So, the demand will increase 30% by 2035. Coal's demand will peak in middle of the year 2020, Which is also a non-renewable energy.

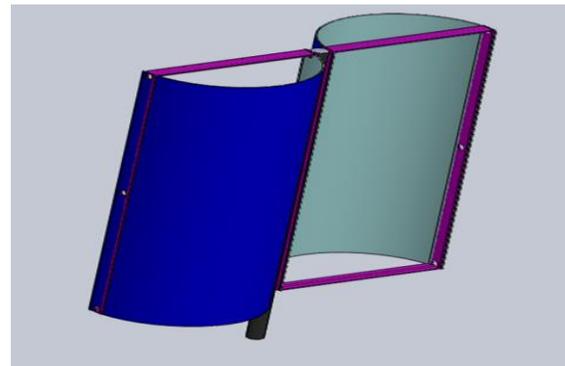
This paper will discuss about the usage of the wind energy to generate electricity. India is the world's fifth largest wind energy producer. In India the total energy produced by the wind farm is about 46,011 million KWh Which is nearly 3% of the total electricity generated. Out of that Tamil Nadu

contributes about 33% of the wind power. Total wind installed capacity in Tamil Nadu is 7633 MW.

Wind energy installations across states



In the high altitude areas, the average wind speed is about 5 - 8 ms⁻¹. But in the urban areas the average wind speed is about 3 – 5ms⁻¹. In this moderate windy areas, the installation of larger wind turbines is unfavorable. So, we need to create smaller wind turbine which will be capable of generating electricity. Actually there are two main types of wind turbines, Horizontal axis wind turbine and Vertical axis wind turbine. In the horizontal



Rotor and shaft assembly

axis wind turbine, the rotation of rotor is about the horizontal axis (i.e., parallel to ground). In the vertical axis wind turbine, the rotation of rotor is about the vertical axis (i.e., perpendicular to ground). When it comes to the smaller wind turbines,

horizontal axis wind turbine requires more wind power than the vertical axis wind turbine. Hence vertical axis wind turbines are more suitable for lower altitude areas. A typical construction of wind turbine, the rotors are fixed with shaft and the rotor's shaft are connected to gear arrangement where the speed can be increased, the pinion is connected to the dynamo. Whenever the dynamo rotates, the electricity will be generated which can be stored in battery for the domestic house hold purposes.

In the conventional wind turbine, the rotor blades are made out of metals like aluminum and other composite alloys to make them less weighty. At the same time, it increases the cost very much so we decided to overcome this problem by replacing the metal part of the rotor blades into a polypropylene sheet blades which are thermoplastics and are manufactured by using the recycling the waste plastics. As a result, we developed a frame that will hold up the polypropylene sheets in a desirable position. As the polypropylene sheets are flexible there is no need to shape them but only have to bolt them with the frame. The geometry of the blade should have good resistance to the flow of wind. Due to this material replacement, the weight of the turbine rotor is reduced to a considerable amount. It also reduces the overall cost for the installation of the wind turbine.

Some of the important properties of polypropylene are listed as follows: It can withstand high temperature. They have high stiffness, good rigidity/impact balance, chemically inert, etc., They are manufactured by using the recycling of unwanted waste plastic articles. So, the pollution will be reduced.

From our experiment we concluded that the replaced rotor has good improvements than the existing wind turbines for the moderate windy regions. The vertical axis wind turbines are portable and they are also having the low initial installment cost and no periodic maintenance is required. They are omnidirectional i.e. they accept the wind from any direction; and generator, gear box, etc., can be placed on the ground.

DESIGN OF THE WIND TURBINE

Dimension for the blade

Diameter of the curve in the blades, d = 0.33 m

Diameter of the rotor, D = .68 m

Height of the blade, h = .75 m

Wind speed, v = 3 ms⁻¹

Belt's law,

$$P_w = \frac{1}{2} \rho A v^3$$

$\rho = 1.2 \text{ kg/m}^3$ is the air density

$$A = h \times D$$

$$P_w = 8.26 \text{ W}$$

Power by blade shaft

$$P_r = M \omega = 2\pi N M_t / 60 \text{ W}$$

$$N = 80 \text{ rpm}$$

$$M_t = 0.1667 \text{ N-m}$$

$$P_r = 1.39 \text{ W}$$

Betz coefficient should be less than or equal to 0.593

Betz coefficient $C_p = 0.593$

$$C_p = \frac{P_r}{P_w}$$

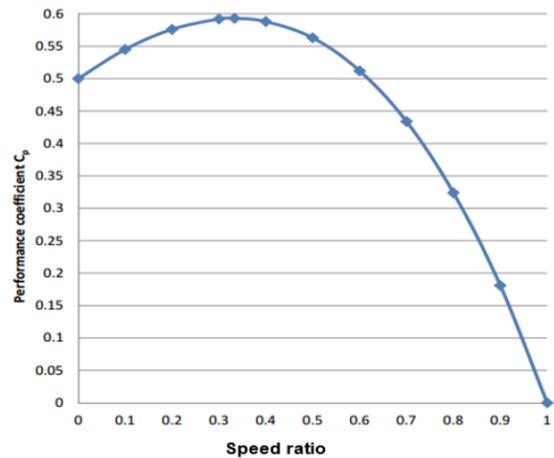
$$C_p = \frac{1.39}{8.26}$$

$$C_p = 0.17 < 0.593$$

Tip speed ratio, λ

$$\lambda = \frac{\omega R}{u}$$

$$\lambda = 0.62$$



$$\text{Experimental power, } P_{\text{exp}} = V \times A$$

$$= 3 \times 1$$

$$P_{\text{exp}} = 3 \text{ W}$$

REFERENCE

[1] Mertens, S., "Wind Energy in the Built Environment," Multi-Science Publishing Co. Ltd, Brentwood, UK, 2006.
 [2] Darrieus, G. J. M., "Turbine Having its Rotating Shaft Transverse to the Flow of the Current," US Patent 1,835,018, December 1931.

- [3] Klimas, P. C., “Darrieus Rotor Aerodynamics,” Transactions of the ASME. Journal of Solar Energy Engineering, Vol. 104, 1982, pp. 102–105.
- [4] Brown, R. E., “Rotor Wake Modelling for Flight Dynamic Simulation of Helicopters,” AIAA Journal, Vol. 38, No. 1, 2000, pp. 57–63.
- [5] Toro, E., “A Weighted Average Flux Method for Hyperbolic Conservation Laws,” Proceedings of the Royal Society of London, Series A: Mathematical and Physical Sciences, Vol. 423, No. 1864, 1989, pp. 401–418.
- [6] Leishman, J. G., and Beddoes, T. S., “A Semi-Empirical Model for Dynamic Stall,” Journal of the American Helicopter Society, Vol. 34, No. 3, 1989, pp. 3–17.
- [7] Gupta, S., and Leishman, J. G., “Dynamic Stall Modelling of the S809 Aerofoil and Comparison with Experiments,” Wind Energy, Vol. 9, No. 6, 2006, pp. 521–547.
- [8] Beddoes, T. S., “A Third Generation Model for Unsteady Aerodynamics and Dynamic Stall,” Westland Helicopters Ltd., RP-908, 1993.
- [9] Niven, A. J., and Galbraith, R. A. McD., “Modelling Dynamic Stall Vortex Inception at Low Mach Numbers,” Aeronautical Journal, Vol. 101, No. 1002, 1997, pp. 67–76.
- [10] Hand, M. M., Simms, D. A., Fingersh, L. J., Jager, D. W., Cotrell, J. R., Schreck, S., Larwood, S. M., “Unsteady Aerodynamics Experiment Phase VI: Wind Tunnel Test Configurations and Available Data Campaigns,” National Renewable Energy Laboratory (NREL), USA, NREL TP-500-29955, 2001.
- [11] Fletcher, T. M., Brown, R. E., Kim, D. H., and Kwon, O. J., “Predicting Wind Turbine Blade Loads using Vorticity Transport and RANS Methodologies,” European Wind Energy Conference, Marseille, France, 16–19th March 2009.
- [12] Fletcher, T. M., and Brown, R. E., “Simulating Wind Turbine Interactions using the Vorticity Transport Equations,” 28th ASME Wind Energy Symposium, Orlando, Florida, USA, 5–8th January 2009.
- [13] Strickland, J. H., Smith, T., and Sun, K., “A Vortex Model of the Darrieus Turbine: An Analytical and Experimental Study,” Sandia National Laboratories, USA, SAND81-7017, June 1981.
- [14] Scheurich, F., Fletcher, T. M., and Brown, R. E., “Simulating the Aerodynamic Performance and Wake Dynamics of a Vertical-Axis Wind Turbine,” Wind Energy, manuscript under review, September 2009.