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DESIGN AND CONSTRUCTION OF VERTICAL AXIS WIND TURBINE

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Research Article

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ABSTRACT

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.

INTRODUCTION

Wind mills are popular names for machines that use wind to make electricity.

Wind turbines are put into different groups based on how the shaft and spinning axis are oriented. A horizontal axis wind turbine, or HAWT, is a wind turbine with a blade that is placed flat on the ground. The shaft of a vertical axis wind turbine (VAWT) is straight down to the ground.[1]

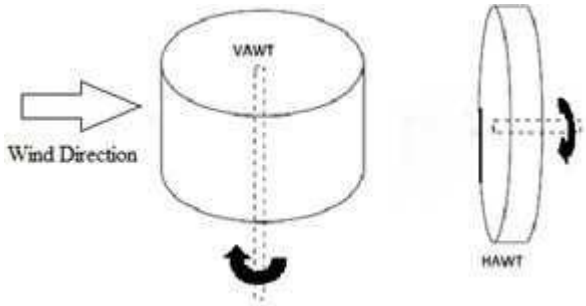


Fig 1: Configurations for shaft and rotor orientation

The rotor designs of the two versions are very different, and each has its own good points. Two main types of vertical-axis wind turbines (VAWT) are those that use lift to get power from the wind and those that use mechanical drag. The VAWTs are useful because they can handle wind from any direction. This makes their design easier and gets rid of the problem that gyroscopic forces cause on the rotor of a convectional machine as the turbine moves with the wind. The engine and drive train can also be mounted at ground level because the axis of rotation is vertical [2]. One problem with these rotors is that it's hard to control the power output by moving the blades. They also don't start themselves and have a low tip-speed ratio [3]. There is a good chance that horizontal-axis wind turbines (HAWT) are convectional wind turbines and very little chance that VAWT are not bidirectional. HAWTs have to change direction with the wind. They must have a way to turn the rotor so that it faces the wind.

LITERATURE SURVEY

Theoretical Maximum Efficiency [1]

A high rotor efficiency is needed to get more energy from the wind, and it should be achieved as much as possible while still being cheap. Moving air has energy (P) that is equal to the sum of its kinetic energy [Equation (1)]:

K E = ½ρAV3

Where, V stands for air speed

A = Area Bled by the Turbine ρ = Density of the air

No matter what the plan is, there is a real limit to how much energy can be taken out. In a flow process, the energy absorption is kept up by lowering the moving energy.and then the speed of the wind. The amount of energy captured depends on how fast the air moves over the fan. If there was 100% extraction, there would be no end velocity and no flow. Since it is not possible to have zero flow, all of the wind's kinetic energy may not be used. Most people agree with this theory, which says that wind turbines can't be more efficient than 59.3%. The maximum value of this number is 0.593, which is called the Betz limit. It is also known as the power coefficient Cp. The Betz theory says that linear speed stays the same. As a result, any spinning forces like wake rotation, turbulence from drag, or vortex shedding (tip losses) will make it even less efficient.

Practical Efficiency

In practice rotor designs suffer from the accumulation of minor losses resulting from:

Tip losses

Wake effects

Drive train efficiency losses

Blade shape simplification losses

Comparison of Different Wind Turbines

Table. 1: Comparison of wind turbines.

Ref No.	Design	Orientation	Use	Propulsion	* Peak Efficiency	Diagram
1	Savonius rotor	VAWT	Historic Persian windmill to modern day ventilation	Drag	16%	
2	Cup	VAWT	Modern day cup anemometer	Drag	8%	
3	American farm windmill	HAWT	18th century to present day, farm use for Pumping water, grinding wheat, generating electricity	Lift	30%	
4	Dutch Windmill	HAWT	16th Century, used for grinding wheat.	Lift	27%	
5	Darrieus Rotor (egg beater)	VAWT	20th century, electricity generation	Lift	40%	
6	Modern Wind Turbine	HAWT	20th century, electricity generation	Lift	Blade Qty: 1 — efficiency: 43%; 2 — 47%; 3 — 50%	

J- Type Vertical Axis Wind Turbine

A J type wind turbine works a lot like a drag type wind turbine. The low cost of making energy was our goal. The process for building other types of turbines, especially lift type turbines, was too expensive, so we chose drag type wind turbines, which are easier to build.

Wind Turbine Design Parameters: [4]

The wind turbine parameters considered in the design process are:

Swept area
Power and power coefficient
Tip speed ratio
Blade chord
Number of blades
Solidity

DESIGN CALCULATIONS

Power calculations

The wind turbine works on the principle of converting kinetic energy of the wind to mechanical energy. The kinetic energy of any particle is equal to one half its mass times the square of its velocity,

$K.E=\frac{1}{2}mv^2$ (1)

Where,
K.E = kinetic energy m = mass
v = velocity,
M is equal to its Volume multiplied by its density ρ of air

$M = \rho AV$ (2)

Substituting eq. (2) in eq. (1)

We get,

$$K E = \frac{1}{2}\rho AV.V^2$$

$$K \quad E \quad = \quad \frac{1}{2}\rho AV^3 \text{watts.}$$

Where,
A= swept area of turbine.
ρ= density of air (1.225 kg/m^3) V=wind velocity.
For 35 Watt power, calculate design parameters of turbine, P=35 watts.

Considering turbine efficiency as 25% and generator efficiency 85%, P = 35/ (0.25*0.85)
P= 166 watts.
= ½ρAV^3
For wind velocity 6.67 m/s (18mph) Density of air (1.225 kg/m3)
166 = ½*1.125*A*$(6.67)^3$
A= 1 Sq.m
A = D*H (Sq.m)
D= diameter of the blade
Taking diameter as 1 meter, height of turbine can be calculated as
H=A/D =1/1 H =1m.
Diameter and height of wind turbine are 1m and $1m^2$.

Design of Turbine Blades [6]
Wing width= diameter*0.14
= 1*0.14
= 0.140m = 140 mm
Wing chord = circumference*.09
= π*1*.09
= 0.282m = 282mm

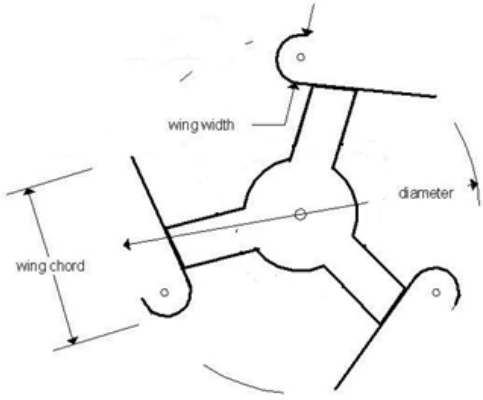


Fig 3: Blade parameters

Block diagram

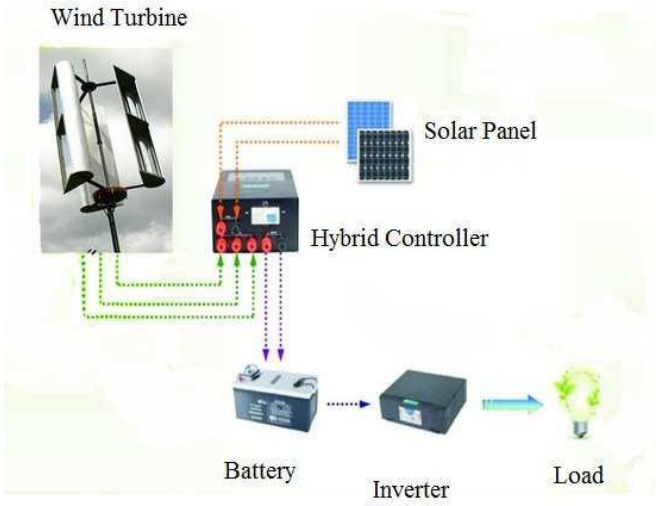
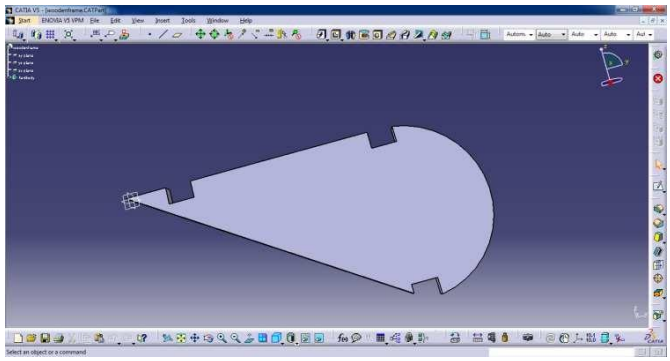


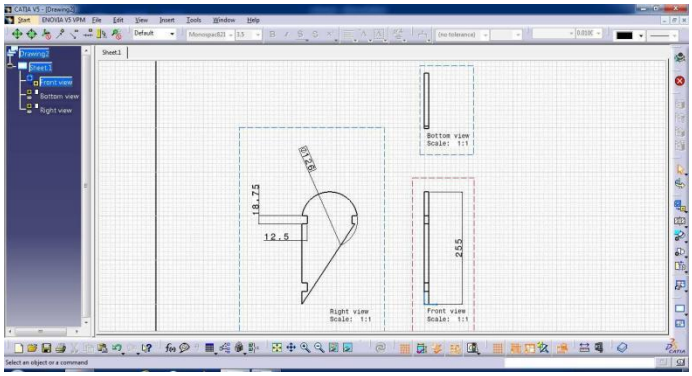
Fig. 4: Block Diagram

CAD DESIGN

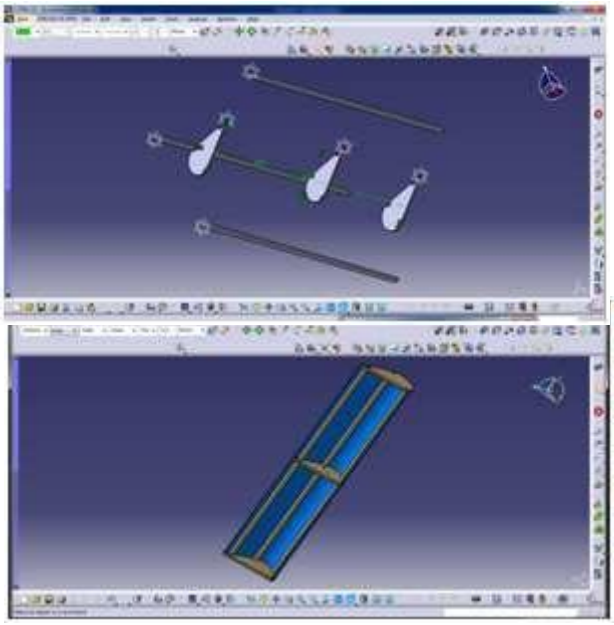
Wooden frame



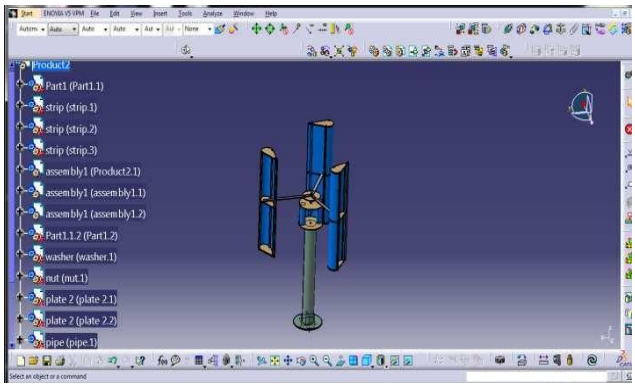
Blades



Exploded view



Assembly



DESIGN SPECIFICATIONS

Table.2: Turbine specifications

Wind rotor	Rated power	35W
	Cut in speed	3 m/s
	Rated speed	6.67 m/s
	Rotor diameter	1 m
	Swept area	1 m^2(1 m*1 m)
	Gear box type	None gear box, direct given to generator
	Brake	Not required
Generator	Generator type	DC generator

	Electric Transmission	Brushless
Turbine blade	Blade type	J-type(drag)
	Blade number	3
	Blade material	GI sheet with Wooden frame
	Hub material	MS
Blade dimension	Length	1m
	Cup radius	0.126 m
Controller	PC16877A	

Observation Table

Table 3: Observation table

Sr.No.	Speed (rpm)	Voltage (Volts)	Current (Ampere)	Power (Watts)
1	30	4.39	1.86	8.16
2	39	4.64	2.28	10.61
3	48	5.73	2.28	13.06
4	70	6.14	2.98	17.78
5	97	7.16	3.64	26.39

RESULT DISCUSSION

What was expected happened and the results were good. Theoretically, we thought the engine would be 25% efficient, but it turned out to be 23.3% efficient. The productivity went down because of mistakes in the manufacturing process and contact losses.

CONCLUSION

The work we've done and the results we've seen so far are very encouraging. They support our belief that vertical axis wind energy conversion systems are useful and could make a big difference in producing clean, renewable electricity from the wind, even in places that aren't the best for it. This project will help people in rural areas where electricity is hard to come by. In most towns, bridges are also a faster way to get to work every day, and the fact that they need to be lit up all the time makes this a good way to make energy.

FUTURE SCOPE

You can make the prototype more accurately, make the turbine blades more efficient, and use modeling tools like CFD to improve the efficiency. Wind energy from relatively light winds can be used by making alternators and dynamos that work well. Acryl Plastic Sheets are one type of material that can be used to make a cheap VWAT.

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3.P. Gipe, Wind Power, James & James, London, 2004, pp. 85–88.
Fourth, Javier Castillo wrote a bachelor's thesis in aeronautical engineering at the Tampere University of Applied Sciences in December 2011 called "Small-scale Vertical Axis Wind Turbine Design."

5. Visit www.windgenkits.com
6. Check out windstuffnow.com

The paper by T. Vishnuvardhan and Dr. B. Durga Prasad is called "Finite Element Analysis and Experimental Investigations on Small Size Wind Turbine Blades" and can be found in the International Journal of Mechanical Engineering & Technology (IJMET), Volume 3, Issue 3, 2012, pp. 493–503. 0976–6340, and 0976–6359 online.

IJMET, Volume 4, Issue 2, 2013, pp. 172–177, ISSN Print: 0976–6340, ISSN Online: 0976–6359, article by M.Z.I. Sajid, Dr. K. Hema Chandra Reddy, and Dr. E.L. Nagesh, “Design of Vertical Axis Wind Turbine for Harnessing Optimum Power”.

In the International Journal of Mechanical Engineering & Technology (IJMET), Volume 2, Issue 2, 2011, pp. 14–24, Narin Kumar Kohli and Eshan Ahuja write about performance prediction in a HAWT wind turbine. The journal's ISSN for print copies is 0976–6340 and its ISSN for online copies is 0976–6359.