FABRICATION OF VERTICAL AXIS WIND TURBINE FOR POWER GENERATION

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Abstract : This project is about manufacturing a Vertical Axis Wind Turbines VAWT to transfer the wind speed to a rotational motion using these turbines. Savonius wind turbine is the vertical axis wind turbine. Savonius has the three curved shaped structures. Savonius wind turbine is one of the turbines which are operated in the low speed wind. This produce the high operating torque at the low speed, it is the self-starting turbine. Savonius would use with the magnetic levitation for obtaining the high speed rotation of the generator. Magnetic Levitation is the phenomenon which is anybody is freely suspended in the air without any support with the opposed of gravitational energy. This magnetic levitation occurred due to the repulsion between the two symmetrical poles. The strong levitation is occurred with the used of permanent magnets. This project presents a review on the performance of vertical wind turbine 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.

***IndexTerms* – Wind turbine, magnetic levitation,**

1. Introduction

Now a day, the electricity is generated from conventional energy sources. These sources will be at the end of the scale. For save this sources, we will be must use the renewable energy sources. The wind energy is the one of the big energy source of renewable energy sources. The wind mill are used the wind power for produce the electricity.

Wind is the form of solar energy. Wind is created from the atmosphere of the sun causing areas of uneven heating. In conjunction with the uneven heating of the sun, rotation of the earth and the rockiness of the earth's surface winds are formed. This wind energy strikes on the blade of turbine which rotate the turbine. This rotation of turbine shaft rotates the shaft of generator which is coupled together. The mechanical energy of wind is converted into the electrical energy. The wind mill gas the various bearing, gear mechanism, which absorbs the energy in friction form.

For reducing the friction between the bearing and shaft we are use the magnetic levitation. Magnetic Levitation are suspended the shaft in air without contact with steady side part of wind mill. This totally neglects the Friction between the shaft of rotor and the stator assembly. Due to this, speed of wind power is not reduced and it passes to the generator shaft.

Vertical axis wind turbine is the best option for the acquired the wind energy from all the direction. Vertical axis wind turbine has not required any yaw mechanism. It is simple in construction. The Savonius turbine is to be used for this vertical axis wind turbine. The Savonius wind turbine is rotated at the low speed wind turbine is rotated at the low speed wind, due to the minimization of friction between shaft and stator the total wind speed of turbine observed passes to the generator. This causes the Savonius wind mill are rotated at high speed within the low wind speed.

Savonius wind turbine is used with the magnetic levitation for reducing the friction between the rotor and stator. This turbine is worked at the low wind speed. This turbine gives the maximum power than any other wind mill. We are created the design of Savonius turbine with levitation.

1.1 Savonius Turbine

The Savonius wind turbine was invited by Finnish Engineer Sigurd Johnson Savonius in 1922.The Savonius turbine is one of the simplest turbines. Aerodynamically, it is a drag-type device, consisting of two or three scoops. When we look from top side it will be appeared as the "S" shape cross section. The drag force turns the Savonius wind turbine. It has the maximum torque at the starting.

The horizontal axis wind turbine will not be used at household applications. It is difficult to construct. Savonius turbine is the best option for household power generation in the load shading region. This is constructed also on the roof floor.

1.2 Working Principle

Vertical axis wind turbine uses drag to push the curved blades to generate a torque that will make the rotor turn. Aerodynamically it is the simplest wind turbine to design and build which reduces its cost drastically compared to the aerofoil blade designs of the other VAWTs and HAWTs.

Its working principle is extremely simple. The turbine rotates because of the difference of the drag force acting on the concave and convex parts of its blades.

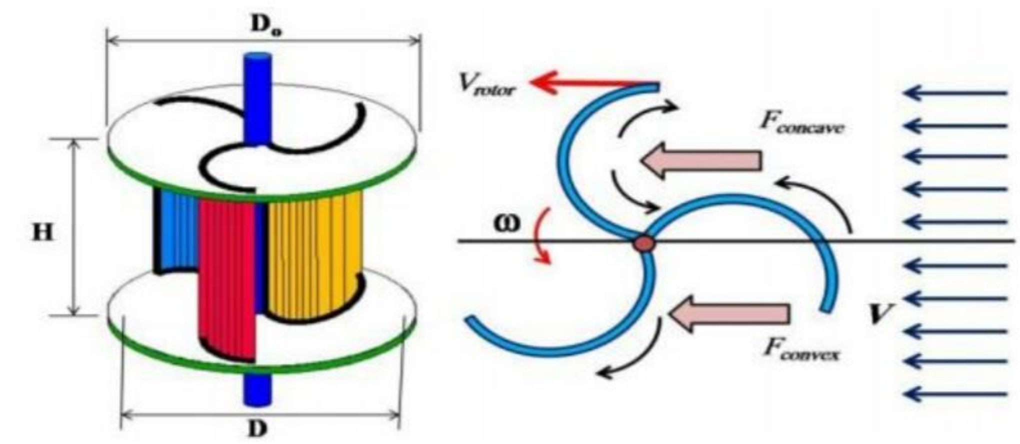


Figure 1.1 Three blade turbine

Vertical axis rotor requires 30 times more surface for the same power as a conventional rotor blade wind-turbine. Therefore it is only useful and economical for small power requirements.” This makes vertical axis wind turbine ideal for small applications with low wind speeds. Vertical axis wind turbines are hence desirable for their reliability, as they are able to work at several magnitudes of wind speed.

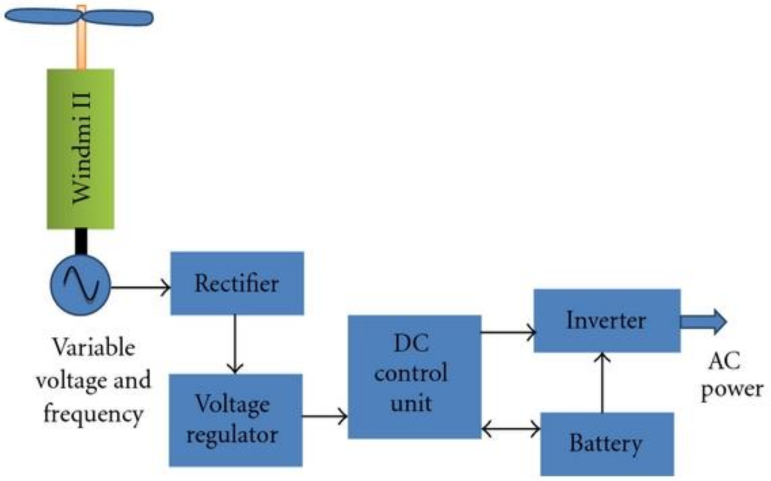


Figure 1.2 Block diagram

2. Literature Review

There are two different styles of vertical wind turbines. One is the Savonius model, which is our project is based on, and the other type is the Darrieus model. The first model looks like a gallon drum that is been cut in half with the halves placed onto a rotating shaft. The second model is smaller and looks much like an egg beater. Most of the wind turbines being used today are the Savonius models.

Renewable Energy UK website provided some information about these two model.
“A Savonius is a type of vertical axis wind turbine (VAWT) generator invented in 1922 by
Sigurd Johannes Savonius from Finland though similar wind turbine designs had beenattempted in previous centuries."

“A Darrieus is a type of vertical axis wind turbine (VAWT) generator. Unlike the Savonius wind turbine, the Darrieus is a lift-type VAWT. Rather than collecting the wind in cups dragging the turbine around, a Darrieus uses lift forces generated by the wind hitting aerofoils to create rotation.

In Jun 2015, International Research Journal of Engineering and Technology (IRJET) has Published a research titled “DESIGN, ANALYSIS AND FABRICATION OF SAVONIUSVERTICAL AXIS WIND TURBINE”.

This research discussion was to showcase the efficiency of Savonius model in varying wind conditions as compared to the traditional horizontal axis wind turbine. It evaluated some observation that showed that at low angles of attack the lift force also contributes to the overall torque generation. Thus, it can be concluded that the Savonius rotor is not a solely drag-driven machine but a combination of a drag-driven and lift-driven device.

Therefore, it can go beyond the limit of Maximum power coefficient Cp established for the purely drag-driven machines.

Some of these researched conclusions are that the vertical axis wind turbine is a small power generating unit with the help of free source of wind energy. It is designed under consideration of household use. Generally, At least 10% power of the consumption can be fulfilling by the Savonius model.
The research has also resulted that this turbine is generally suitable for 8 to 10m of height above ground level. Because at ground level velocity of air is very less. And finally the alternate option for turbine blade material is reinforced glass fibre because of its more elastic nature but it is costlier than aluminium alloy.

To have the best efficiency of the power output from our turbine, the team has done some Brainstorming in what is the most significant factor that affects the turbine, the blade angle was agreed to be the most significant one.

By doing some researches, we find an article that focusing in the turbine blade angle.
A research article published by Advances in Mechanical Engineering (AIME) with a title of "EFFECT OF THE BLADE ARC ANGLE ON THE PERFORMANCE OF A SEVONIUSWIND TURBINE". This article is focusing on how to improve the efficiency of the turbine by selecting the best blade angle. The effect of the blade arc angle on the performance of a typical two-bladed Savonius wind turbine is investigated with a transient computational fluid dynamics method. Simulations were based on the Reynolds Averaged Navier–Stokes equations, and the renormalization group turbulent model was utilized.

The numerical method was validated with existing experimental data. The results of this article indicate that the turbine with a blade arc angle of 160° generates the maximum power coefficient Cp 0.2836, which is the highest that gain from the experiment.

3. SYSTEM Design

3.1 Product Subsystems & Components

Vertical axis wind turbine VAWT are one whose axis of rotation is vertical with respect to ground. Generally as shown in figure 3.3, the main components of this turbine are:

- Blades
- Shaft
- Generator

i. Rotor Blades

In the project three blades with vertical shaft are used, it has a height & width of 300 mm & 250 mm respectively. The angle between the blades is 120 degrees. So if one Blade moves other blades comes in the position of first blade, so the speed is increases.

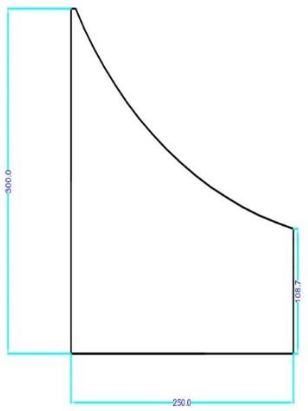


Figure 3.1 Rotor Blade

ii. Shaft

The shaft is the part that gets turned by the turbine blades. It in turn is connected to the generator within the main housing. While 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 three 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 of hollow mild steel which is having very light weight. Length of shaft & diameter are 416 mm & 10 mm respectively. And at the top and bottom ends mild steel solid rods are respectively are fixed to give strength to the hollow shaft.

iii. Bearing

The smooth operation of Shaft, bearing mechanism is used. To have very less friction lossthe 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. We have used ball bearings for the purpose of ease of maintenance. To enhance bearing effectiveness in the system, the right type should be selected. However the procedure of the selection is a science but we restricted on three simple steps:

- Confirm operating conditions and operating environment.
- Select bearing type and configuration.
- Select bearing dimensions

The correct amount of an appropriate lubricant must be present to reduce friction in the bearing was consider. As long as the sealing elements are important because of the environment surrounding our project and keep the lubricant in, and away from the dust and contaminants. On another side, the low speed of the system was considered too in the selection with axis and radial forces which is the weights of upper system.

Figure 3.2 Ball Bearing

iv. Generator

Generator has the basic function as the convert the mechanical energy into electrical energy. Generator is worked on the basis of Faraday's law of electromagnet induction. It states that, when the electricity is passed to the conductor then it produce magnetic field. In the Generator this principle are used in the opposite way. When armature is rotated in the magnetic field, then electromotive force are produce in the armature which produce current in it.

The magnets are set as opposite pole to each other with the air gap in the generator. The air gap present between magnet pole and the armature. The armature coupled with the turbine shaft. Magnetic flux lines are passes perpendicular to the axis of shaft. When the shaft is rotated, the magnetic flux lines are cut off. When the cut off this magnetic flux line, the emf are produce in the generator.

Faraday's law of electromagnet induction states that, the induced electromotive force equal to the change in magnetic flux over the change in time.

$$emf = \frac{Nd\emptyset}{dt} \quad volt$$

Specification of the generator:

- 12- volt DC supply
- 3-A current output

- 1000 rpm input
- 10mm shaft diameter
- Inbuilt voltage rectifier

v. Battery

The battery that we used in our project is The Long WPL150-12N rechargeable power guard sealed lead acid battery as shown in the below figure 3.1.5, and table 3.

Figure 3.3 Battery

Table 3.1 Battery Specifications

Brand Name	AMPTEK
Item Weight	.3 kg
Capacity	1.3Ah
Standard Use	13.5-13.8V
Initial current	0.39A
Design Life	2 Years

3.2 Magnetic Levitation

Magnetic Levitation accrued when the two similar pole are repelled without each other. Anybody will be suspended with any other support with this repulsion. This magnetic force is opposed to the gravitational force. The magnetic levitation is reducing friction between shaft and stator assembly. This replaces the bearing between the shaft and stator body.

The vertical axis wind turbine as Savonius turbine shaft is fully supported with the magnetic levitation and rotor vertically with the wind. Magnetic Levitation are performed with the used of permanent magnet as like Alnico, Ceramic, Samarium Cobalt and Neodymium Iron Boron. Ne-Fe-B is the strongest magnet than any other above magnet. Ne-Fe-B has the attractive magnetic characteristic, which offers high flux density operation and the ability to resist demagnetization.

The ring shaped permanent magnets are used for the levitation. The shaft introduced in it and the like poles are faced to each other. The shaft is used which has nonmagnetic property. The magnet has used which has configuration N52 with size inside diameter 20 mm, outside diameter 40 mm and thickness is 10 mm. This is suspended the Savonius blade with shaft.

4. SYSTEM TESTING AND ANALYSIS

4.1 THEORETICAL WIND TURBINE POWER CALUCALATION

Wind Power depends on:

- amount of air (volume)
- speed of air (velocity)
- mass of air (density)

Kinetic Energy definition:

$$K.E = \frac{1}{2} m v^2 \text{...........equ (1)}$$

Where, m = Mass

v = Velocity

Since Power is Energy per time, we can formulate equation ...1 to be

$$K.E = \frac{1}{2} m v^2 \qquad m = \frac{dm}{dt}$$

Fluid mechanics gives mass flow rate (density ×volume flux):

$$\frac{dm}{dt} = \rho \times A \times v$$

Thus, power of the wind is:

$$\frac{dm}{dt} = \rho \times A \times v$$

Taking in consideration the turbine Power coefficient, power in the wind is calculated using this formula:

$$\frac{dm}{dt} = \rho \times A \times v^3 \times C_p \text{.....................equ (2)}$$

Where:

P =Power in watts

ρ =Air density "At sea level 'air density' is approximately 1.2 Kg/m^3

A = Turbine Area inm^3 which can be calculated from the length of turbine blade.

v^3 =Wind speed, which is the velocity of the wind in $\frac{m}{s}$

C_p = Power coefficient, usually varies according to wind turbine design, ranging between 0.05 and 0.45. In this case, we are taking 0.1836 based on the selected angle 120°.

Table 4.1 EXPERIMENTAL READINGS

Wind speed m/s	Voltage (v)	Current (I)	Power (watt)
3.25	1.97	0.063	0.124
6.25	2.43	0.077	0.181
6.98	2.85	0.090	0.256
8.25	3.5	0.110	0.385
9.25	4.17	0.130	0.543
10.25	4.97	0.154	0.777
12	5.49	0.170	0.933

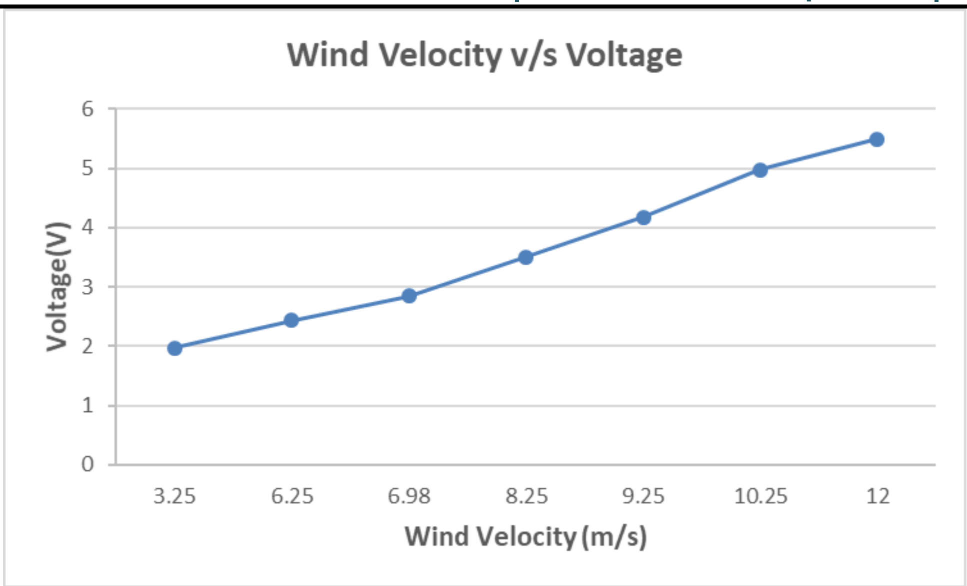
Table 4.2 THEORITICAL V/S EXPERIMENTAL GAINED POWER CALCULATION

Density $\frac{kg}{m3}$	Area m^2	Wind speed m/s	Power co-efficient c_p	Theoretical Power (watts)
1.2	0.0746	3.25	0.1836	0.255
		6.25		2.006
		6.98		2.79
		8.25		4.61
		9.25		6.50
		10.25		8.84
		12.00		14.0

Efficiency of a Turbine (η) = Output / Input.

(η) = 4.567/35.678

= 12%



4.2 Discussion

As a result, This studies (experimentally and theoretically) present a review on the performance of Savonius wind turbines and show the gap between the actual and ideal output power, where a several factors have affected clearly on the actual performance, these factors are due to external factors, lack of resources, process, geometrically, or due to human error. These factor resulted in drop of 31~ 35% between the theoretical and experiment results.

5. Conclusions and Future Scope

5.1 Conclusions

From our research we were able to come up with many important conclusions and suggestions which will profit the future advancement of individual vertical pivot wind turbines. We could outline a VAWT framework that enhanced power yield when contrasted with the past projects. From our results we were able to recommend new design aspects to improve the system and efficiency.

Inefficient wind speed was the huge impact getting the required power output, minimum speed of 12 m/s is required to have acceptable output power taking in consideration 31~35% of efficiency between theoretical and experimental results.

Even though we were able to make this design of Vertical Axis Wind Turbine but 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 the project could propel research and testing on VAWT frameworks and give knowledge for different gatherings to finish additionally testing and enhance productivity and execution of vertical pivot wind turbines.

5.2 Future Scope

The turbine performance testing and results from the research in this venture demonstrated that the split Savonius is the best plan that has been tried to this point at WPI. The reason is because of the expansive surface range of the split Savonius which empowers it to catch most maximum amounts of wind. We trust that further research ought to be finished with different Savonius plans in view of this reality. The Savonius turbine outlines are basic and modest to make, and are additionally not incredibly influenced by turbulence in the wind.

To gain the best power gain in the concept of green energy, we strongly recommend having some solar panels attached to the tree. These panels will add more power and they are easy to install and connected to the electrical components that are already added to the system.

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