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Design, Analysis & Power Generation through Axis Wind Turbine

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Abstract: This project produces an investigational exploration of a Savonius rotor wind turbine adapted for household electricity generation. The design process and justification of the new machine will be described. The innovative technology turbine collects wind energy and converts it into electricity, which in turn produces a 12 volt output which is used to charge one heavy duty battery. As a result, the home is served simultaneously by the wind turbine and the utility. In this study, a small electricity generator has been specifically designed for household installation. We are using a savonius rotor. This type of rotor (which is of the vertical axis variety) is chosen instead of a horizontal axis machine due to its simplicity and reliability. The S-rotor has been designed using an analytical method and confirmed by natural wind testing. The design process and justification will be described in the paper.
Keywords: - Savonius, VAWT, Wind Turbine, S-rotor, Household Turbine.

I. INTRODUCTION

We know that there is enough wind globally to satisfy much, or even most, of humanity's energy requirements if it could be harvested effectively and on a large enough scale. Vertical axis wind turbines (VAWTs), which may be as efficient as current horizontal axis systems, might be practical , simpler and significantly cheaper to build and maintain than horizontal axis wind turbines (HAWTs). They also have other inherent advantages, such as they are always facing the wind, which might make them a significant player in our quest for cheaper, cleaner renewable sources of electricity. VAWTs might even be critical in mitigating grid interconnect stability and reliability issues currently facing electricity producers and suppliers. Additionally, cheap VAWT's may provide an alternative to the rain forest destruction for the growing of bio-fuel crops. This paper describes some research findings of a particular original VAWT design and argues for increased research and development of this technology.

II. OBJECTIVES

A. Evaluate the best blade offset by field testing using a small prototype model.
B. Produce a turbine capable of generating 10% of the household's electricity.
C. Build a fully functioning 100 watt household turbine.
D. Show that using the Savonius turbine for household generation is available option.

A. Generally Household Electricity Consumption

The electricity consumption was monitored in my household over the course of five months, and was then averaged out for a one month period. The calculations are shown below:
[1] Average Monthly Electricity consumption=328.69 KWh/month.
[2] Average Yearly Energy
Consumption =328.69 x 12
=3944.28 KWh/year.
[3] Average Day Energy consumption
= [3944.28/(24x365)]x1000
= 450.26 Watt/hr.
[4]For 10% of the electricity produced by the
[4.1]Wind for 2 person
= 0.1x450.26=45.03Watt/hr

[4.2]For 4 person in a house will be
=2x45.03= 90.06 Watt/hr

Considering power losses as 10 Watt/hr
So,
[5]Turbine capacity=90.06+power loss
=100 Watt/hr
Our ultimate aim is to contribute at least 10% of the household electricity consumption.
Therefore turbine will be designed for 100 watt/hr

III. CONCEPT OF DESIGN

The concept is let homeowners generate their own clean power, thereby reducing Carbon Dioxide emission. In addition, by putting the wind to work, the household electricity bill should be decreased.

After studied various literatures we have conclude that the design of one turbine rotor in a unit. In rotors, the magnetic arrangement will be provided to the disk attached to the bottom side of rotor and upper side of fixed disc located below it. This magnetic arrangement will act as a replacement for generator. The center solid shaft will mounted which supports the bearing used to rotate hollow shaft and also support to stand the whole set up. The base will be provided to support the unit on roof of house. There will be separate battery unit which can store the charge.

IV. METHODOLOGY

It include the sequence we have followed to made this design effective and without any drawback.

Power to be generated
↓
Area of blade for power
↓
Design of blade
↓
Design of blade platforms
↓
Design of bearing & shaft required
↓
Design of generator
↓
Design of rigid base platform
↓
Design of electrical Battery charging circuit
↓
Analysis
↓
Fabrication
↓
Experimental testing by using multimeter, torque transducer, Anemometer.

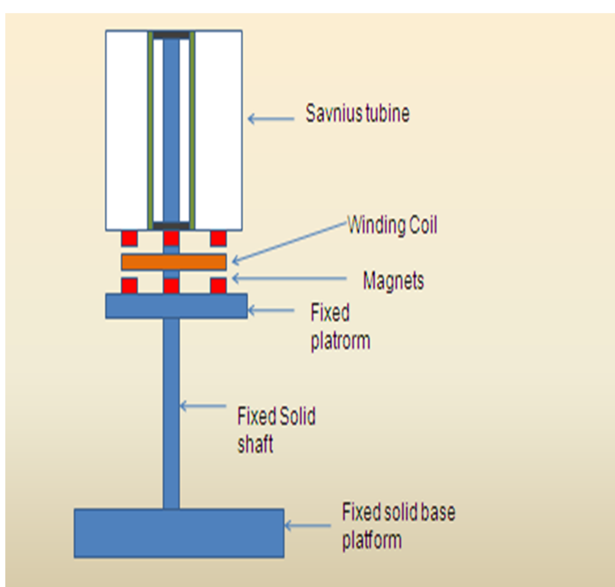
A. Construction

Main Components of VAWT & Selection Criteria for their material

1) *Rigid base:* We have decided to provide square shape base of better thickness to provide support at the base to the whole set up, which will very useful to stand the VAWT unit on the roof of the house. The material we are using for this is Mild steel.

2) *Rigid Centre Shaft:* It is that part which passes through hollow shafts of turbine and it stands on the rigid base It must be capable to absorb the radial and axial forces coming from rotor. So, the material using for shaft is SAE 1030 Steel for maintaining required strength.
3) *Turbines:* The number of turbine rotor we are using here is one. After comparing the available categories of shapes of blade of rotor, We have finally decided to used SAVONIUS rotor semicircular blade shape due to its large surface area for impact of wind and easier construction. The no. of blade containing in rotor will be 6. The material for the blades of rotor will be Aluminum sheet due to its corrosive resistive property and other properties comparing to steel or plastic.
4) *Circular Platforms:* There are 3 circular platform i.e. For top and bottom of rotor and for fixed platform. These circular platforms will help in restriction for wind to go outside of turbine for maximum utilization of wind power content in the wind. The fixed platform at bottom of rotor and the bottom platform of the rotor located will carry the generator arrangement. The material suggested for these platforms is hard plastic or fiber.
5) *Hollow Shafts:* There is one hollow shaft for turbine. The hollow shaft will rotate with the help of blades attached on it from its exterior side. This rotation will carried out with the help of Bearings mounted on rigid centre shaft. The material decided for the hollow shaft will be SAE 1030 STEEL.
6) *Bearing:* There will be 2 no. of bearing. Out of which, both two for hollow shaft. These bearing will located between hollow and centre solid shaft and for the purpose of smooth and free rotation of hollow shaft. The roller bearing of bearing no. 0112 will be used.
7) *Generator:* We are incorporating the arrangement of magnets and coils as the replacement for separate generator.
   a) Magnets- There will be 24 brushless permanent magnet. 12 magnets on each disk of platform located on bottom of lower side turbine and top of upper fixed circular plate. These magnets will arrange in alternate North South Pole manner on both disk.
   b) Coils- The no. of coils will be 12. It will place between magnetic arrangements on both disks. 3-phase connection will be there, three phase means connect one wire with four coils at an angle 120^0. It will be trapezoidal in shape and made up of COPPER.
8) *Bolts:* There will be four bolts for the hole drilled in the four corners of rigid base platform. It will helpful in fixing the set up on the roof. The material for bolt will be Mild Steel.
9) *Storage Battery-* The type chose will be 12 volts lead Acid Heavy Duty battery which is similar to car battery but with heavy plates and special separators. It's life is 8-10 years and efficiency is 70-75 percent.

B. Block Diagram Representation of VAWT



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C. Design and Formulation

1) *Power Coefficient Analysis:* This hypothesis is reproduced to show the relationship between the power coefficient (Cp) and the wind speed, Which expresses the basic theory of the Savonius wind machine. Principally the power that the rotor can extract from the wind (Pw) is less than the actual available from the wind power (Pa). In order to calculate the performance of this wind machine, its configuration is essentially important.

a) According to the Kinetic Energy, KE = ½ mv^2

b) The available power, Pa from the wind is:

Pa = ½ mv^2 When m= Pav Pa= ½ pAv3

c) The power coefficient Cp is given by:

Cp = *Pw/ Pa*

Therefore:Power extracted from the wind, *Pw*=Cp x Pa = Cp x ½ pAv^3

Power by air impact = cp x 1/2 x density x area x v^3

This is the standard wind equation that is used in this documentation.

d) To Calculate Area (A) =?

A= (power x 2)/(Cp x density x v3) A= (100 x 2)/(0.245 x 1.225 x 10^3) A= 0.666m^2

Where, Cp= *Pw/ Pa= 3*

e) To Calculate Shaft Rotation ($\dot{\omega}$) =?

The equation below is used whereby the radius value R (D/2) is manipulated to obtain w. It is assumed that the value of X (tip speed ratio) is equal to 1, to eliminate X in the equation below.

$$X = R\,\omega / V$$

ω = rotational speed (rads/s);

R = radius of rotor (m);

V = average wind speed, assume 10 m/s.

ω = V/R, R is varied between 0.2 and 0.55 meters, a reasonable range baring in mind the speed of rotation.

To calculate the height (h) =?

The equation below is used to calculate h:

Area (A) = height (h) x diameter (D)

For compact design the diameter of blade varying from 0.4to1m

Following table from 0.4to1m diameter calculation

Table no.1

Sr. no.	Blade dia.	Blade radius	Rotational speed	A=0.666m^2 100watt (10%)
	D(m)	R(m)	ω(rad/sec)	H(m)
1	0.4	0.2	477.5	1.67
2	0.5	0.25	382	1.33
3	0.6	0.3	318.3	1.11
4	0.7	0.35	272.2	0.95
5	0.8	0.4	238.8	0.83
6	0.9	0.45	212.2	0.74
7	1	0.5	191	0.67

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V. CONCLUSION

The study of wind turbine technology is carried out. The design and the effectiveness of a wind turbine depends on blade design, wind availability, type of rotor selection. Thegenerator will produce 100 Watts at 10 m/s wind speed (from the results in Table 1) in various size of dimensions as per analytical design method . From these results, the following values have been obtained: D; w; h. Furthermore the value of the Area A can be gained, since A = D x h. A generator and rotor can now be selected to fit in with the requirements of the wind turbine. The selection process is used to pin point: power rating (Watts) and generator speed (rpm). From the above calculations it is deemed that the blade of dimensions: 0.8 x 0.83 metres (100 Watts) is the most appropriate for the development process. This assumption is based on a few key issues, namely:

1. A need to generate 100 Watts (10%) of the household energy by the wind resource available.
2. The overall structure will be of a more square shape, which should be more pleasing to the eye.
3. High possibility of buying an off the shelf blade.
4. A fast enough shaft rotation, so that purchasing gears will not be a problem.

This performance is satisfactory for fairly high wind areas. The performance of the wind generator depends upon the quality of construction and components used. The simple and optimum design for the household windmill is suggested.

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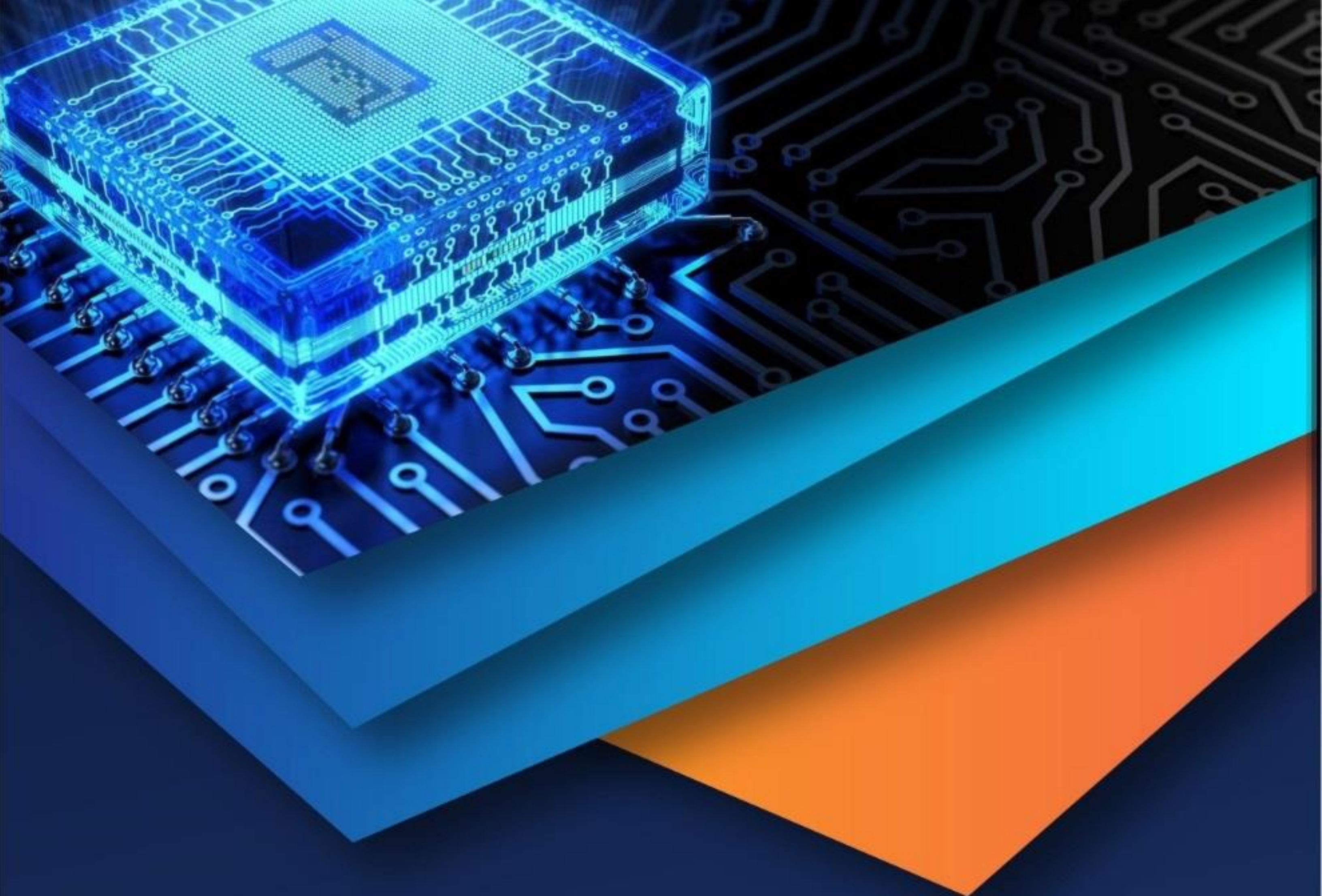

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