EXAMINATION AND INVESTIGATION OF VERTICAL AXIS WIND TURBINE

Tariq Hassan Baharmuz[1], Shaik Abdul Imran[2], Shaik Mujahed[3], Mohammed Rafeeq[4]

[1,2,3]Students of Mechanical Engineering Department, Nawab Shah Alam Khan College of Engineering and Technology, Hyderabad, Telangana, India.
[4] Assistant Professor of Mechanical Engineering, Nawab Shah Alam Khan College of Engineering and Technology, Hyderabad, Telangana, India.

---***---

Abstract -*This Project presents the method of utilizing the turbulent winds produced by movement of the automobiles on high way by use of Vertical Axis Wind Turbine (VAWT). The turbulent winds created by the surplus flow on high Way, Can be used to generate electricity, Used for the highway lighting and the Toll gates in the High way. It also helps in providing efficient lighting to reduce the high way accidents. A vertical Axis Wind Turbine includes of a rotating Shaft to which D- shaped or curved blades are mounted. When wind strikes these blades, it causes the rotation of shaft. This rotational energy (i.e. mechanical energy) is further converted into Electrical Energy by the means of belt and pulley mechanism connected with an alternator which results in the production of Electricity. This Electricity is stored in a battery, which can be enhanced and utilize for various purposes.*

Key Words: Vertical axis wind turbine, Alternator, Battery, Renewable Energy, Power Generation, wind energy

1. INTRODUCTION

A wind turbine, or wind energy converter, is a device that transforms the wind's kinetic energy into electrical energy. Vertical axis wind turbines have the main rotor shaft set out vertically. One merit of this arrangement is that the turbine does not need to be pointed into the wind to be productive, which is a merit on a site where the wind direction is highly changeable. Also, the alternator and belt and pulley mechanism can be placed near the ground, improving approachability for maintenance work.

2. LITERATURE REVIEW

N.H. Mahmoud [1]: Has conducted an experimental analysis by using, wind tunnel experimental setup. The experimental result depicts that –Three bladed rotors are more efficient than four bladed Sovonius rotors. The rotor with end plates gives higher efficiency than the without end plates. Blades having overlap ratios are better than the blades with without overlap ratios. By increasing Aspect Ratio Coefficient of performance (Cp) will also increase. Volume 51, Issue 1, March 2012.

U.K.Saha, S.Thotla, D.Maity [2]: Has conducted that, power coefficient Cp of Savonius rotor depends on number of stages. When number of stages increased from one to two, the rotor shows better performance characteristics, however the performance gets degraded when the number of stages become three. These may be increased in inertia of rotor. So, the optimum number of stages for Savonius rotor is two. It also concludes from the experimental evidence that a two-blade system gives optimum performance. For two blade two stage Cp is about 30%, V=6-8 m/s. Department of Mechanical Engineering, Indian Institute of Technology, Guwahati 781039.

S.K.Dhiman [3]: The main advantage of Vertical Axis Wind Turbines in that it eats the air from all the directions, Thus, it does not require any yew mechanism. The blade is designed in semicircular shape so as one blade passes another blade comes in position of first. 3 blades are used so as to use of maximum utilization of wind from air and moving vehicle Vol-2, Issue-10, 2016 ISSN: 2454-1362.

3. METHODOLOGY

3.1Design of blades

The blades are design by twisting in curved shape. A curve is known as general helix or cylindrical helix. Blades sheet are used to capture the wind. The curved blades are intimated to the shaft by welding which is used for power transmission from one part to another. A shaft is a rotating machine element, routinely circular in cross section.

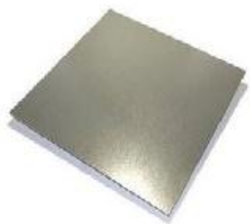

Fig -1: Galvanized iron sheet

3.2Hollow shaft

Materials: The material used for ordinary shafts is mild steel. When high strength is needed alloy of steel such as stainless steel SS304. Shafts are usually manufactured by hot rolling and finished to size by cold drawing or turning and grinding.

Fig -2: Hollow shaft

3.3Bearing

It holds the shaft and reacts as a base to the components. It also provides frictionless rotation of shaft.

Fig -3: Roller ball bearing

3.4Belt and pulley

Belts are coiled over pulleys. A pulley is a wheel on an axle or shaft that is designed to support movement and change of direction of a taut cable or belt and transfer of power between the shaft and pulley of alternator.

Fig -4: Belt and pulley

3.5 Support frame or stand

A frame is generally a composition system that supports other components of a physical construction.

3.6 Alternator

An alternator is an electrical generator that generates direct current using commutation. It is fastened to rotating shaft by the means belt and pulley.

Fig -5: Alternator

3.7 Battery

A battery is combination electrochemical cells with external connections for powering electrical appliances. It has two terminals, a positive terminal called the cathode and a negative terminal called the anode. The battery is attached to alternator by the means of connecting wires (24 volts battery is used in this project).

PROPOSED MODEL

Fig -6: Experimental Setup for Vertical Axis Wind Turbine Prototype

4. SPECIFICATION OF COMPONENTS

4.1. Design of Blades: -

Blades sheet thickness = 3 mm, Material: Plastic polymer (Polyvinylchloride).
A = D * h,
Where, A- Swept Area,
D – Diameter of blades = 0.4m,
h – Height of blades = 1m,
A = 0.4 * 1
A = 0.4 m^2.
Number of blades = 2.
Angle between the blades = 180 Degrees
Wight of each blade = 850gms.

4.2Design of Shaft: -

Outer diameter = 30 mm, Inner diameter = 24 mm,
Material: SS 304. (Stainless steel),
Density of stainless steel (ṗ) =7480-8000 Kg/m^3.
ṗ= P/A,
7485=P/ (π/4 * D ^2)
7485=940.11/0.1256.

4.3Bearing with holder plate: -

Ball and roller bearing,6206 2 RS.

4.4Belt: -

Length = 886 mm, Thickness of belt = 8.15mm, Material: Polyester cord Neoprene Jacket.

4.5Pulley: -

Outer Diameter of big pulley = 225 mm, (Single groove).
Inner Diameter of big pulley = 75 mm.
Outer Diameter of small pulley = 90 mm.
Inner Diameter of small pulley = 25 mm.

4.6Support frame or stand: -

Height = 610 mm.

4.7. Alternator: -

24 Volts/40 Amps, Auto alternator, Auto Ignition,
Diameter of alternator pulley = 85.6 mm.

4.8 Connecting wires: -

Polyvinylchloride 1mm^2, 6m

4.9Battery: -

24volts.

5. CALCULATIONS

5.1. Theoretical power calculation: -

The wind mill works on principle of converting kinetic energy of the wind in to mechanical energy. The K.E. of any particle is equal to the one half of its mass times the square of its velocity, or ½ mv2.
K.E. =½ mv2. ………………….. (1)
Where,
K.E = kinetic energy,
m = mass,
v = velocity,
"m" is equal to Volume multiplied by its density ρ of air,
Mass = ρ AV ………………… (2)
Substituting equation (2) in equation (1),
We had got,
K E = ½ ρ AV3 watts
ρ = density of air (1.225 kg/m3)
A = l*d (m^2)
D = diameter of the blade A = l*d,
A = 0.4m^2.
P=Cp*½*ṗ*A*V^3 (1)
Standard wind equation (derived from power coefficient analysis)
V=10m/s (assuming this is the wind-speed);
ṗ=1.1644kg/m^3density of air at above sea level and 30^{o}C;
Cp=0.245(24.5% from the standard Power Coefficient/Tip Speed-Ratio diagram)
Swept Area (A) = Height (h) x Diameter (D) (2)
A= 1 x 0.4 = 0.4m^2
INPUT POWER PRODUCED BY WIND,
P=Cp*½*ṗ*A*V^3
OBSERVATIONNO.1,(Taking velocity of air V = 7.75 m/s.)
P = 0.245 x ½ x 1.1644x0.4x7.75^3
P = 26.55Watts.
OBSERVATION NO.2, (Taking velocity of air V = 9.75 m/s.)
P = 0.245 x ½ x 1.1644x0.4x9.75^3
P = 52.88Watts.

5.2 Effect of number of rotor blades

The optimal tip speed ratio depends on the number of rotor blades n of the wind turbine. The smaller the number of blades, the faster the wind turbine has to rotate to extract maximum power from the wind.
For an n bladed machine, it has been empirically observed that s is equal to about half a rotor radius or:
S/r≈ ½
Or the ratio (s/r) is approximately equal to 0.5, thus we can write:
ƛ opt ≈ 2 π/n (r/s) ≈ 4 π/ n.

For n = 2, a two bladed rotor, the maximum power extracted from the wind at
Cp Max. Occurs at:
ƛ opt ≈ 4 π/2 ≈ 2 π ≈ 6.283,
Where, as for n = 3 bladed rotors, it is a lower value of:
ƛ opt ≈ 4 π/3 ≈ 1.33 π ≈ 4.19,
And for an n = 4 bladed rotors it is a further lower value of: ƛ opt ≈ π ≈3.14159.

5.3RPM Speed for 2 blade turbines is dependent on 3 parameters:

1-Rotor Diameter,

2-Wind Speed

3-Tip Speed Ratio (TSR)

TSR = (Blade tip speed) / (wind speed mph)= (for 2 blade) = 6.28 ≃ 6
Wind speed as observations mentioned below in m/s.
RPM (N) for this turbine
RPM (N) = 60 * V1 * TSR / (π * D),
At V1 = 7.75m/s.
N1 = 60 * 1.75 * 6.28 / (π * 0.4),
N1 = 2323.82RPM,
RPM (N) = 60 * V2 * TSR / (π * D),
At V2 = 9.75m/s.
N2 = 60 * 3.75 * 6.28 / (π * 0.4),
N2 = 2923.51RPM,
RPM (N) = 60 * V * TSR / (π * D),
At V3 = 5.75m/s.
N3 = 60 * 11.75 * 6.28 / (π * 0.4),
N3 = 3523.21RPM, And so on,

Table No: -1 WIND POWER INPUT

Serial No.	Velocity of Automobile (Km/h)	Velocity of Air (m/s)	Speed of Turbine (RPM)	Wind Power (Watts)
1	27.90	7.75	2323.82	26.55
2	35.10	9.75	2923.51	52.88
3	42.30	11.75	3523.21	92.55
4	49.50	13.75	4122.90	148.32
5	56.70	15.75	4722.60	222.91
6	63.90	17.75	5322.30	319.07
7	71.10	19.75	5921.99	439.54

5.4Specification of Pulley

Pulley speed ratio = Driven / Driver,
Where, Driven – no. of rotations of alternator pulley,
Driver – no. of rotations of turbine pulley,
Pulley speed ratio = 1 / 2,

5.5Output generated by the alternator

Power output = F = NP/120. (Hz of electricity produced).
Where, N - RPM,
P – No. of poles inside the alternator. (P = 8);
F1 = N1 * 8/120,
Where, N1 = 2323.82 RPM,
F1 = 2323.82 * 8/120,
F1 = 154.92 Hz.
F2 = N2 * 8/120,
Where, N2 = 2923.51 RPM,
F2 = 2923.51* 8/120,
F2 = 194.90 Hz.

Table No: -2FREQUENCY OF ELECTRICITYPRODUCED:

S. no.	Speed of Alternator (RPM)	Frequency of Electricity Produced (Hz.)
1	4647.64	154.92
2	5847.02	194.90
3	7046.42	234.88
4	8245.80	274.86
5	9445.20	314.84
6	10644.6	354.82

Average frequency F = 274.85 Hz.

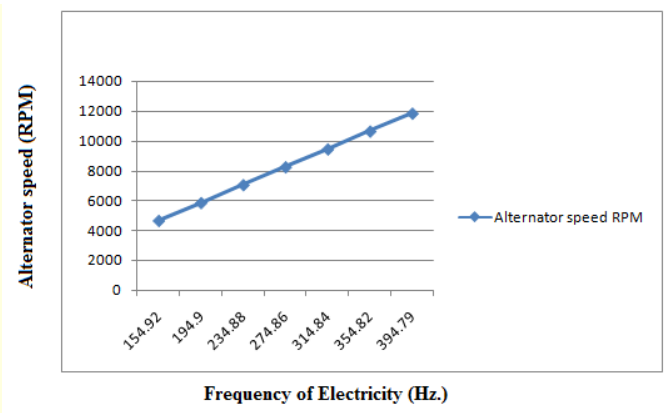

Chart -1: Frequency of Electricity (Hz) Vs Alternator speed (RPM)

The above graph Depicts Frequency of Electricity in Hz on X-axis and Alternator speed in RPM on Y-axis. The blue color line indicates Speed of Alternator. It shows that if the speed of alternator increases the frequency of electricity produced also increases.

6. RESULTS

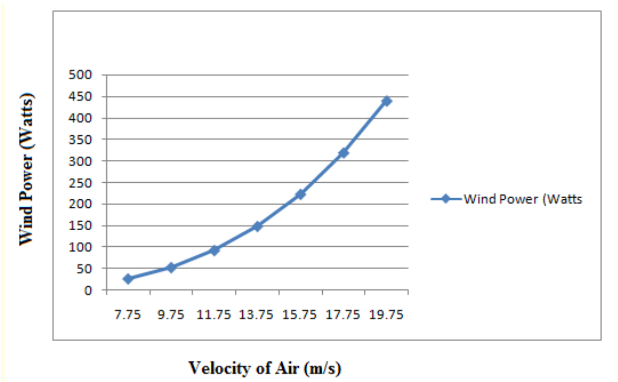

Chart -2: Wind Power(Watt) Vs Velocity of air (m/s)

The above graph Depicts Velocity of Air in m/s on X-axis and Wind Power in Watts on Y-axis. The blue color line indicates Wind Power. It shows that if the Velocity of Air increases the Wind Power gradually increases.

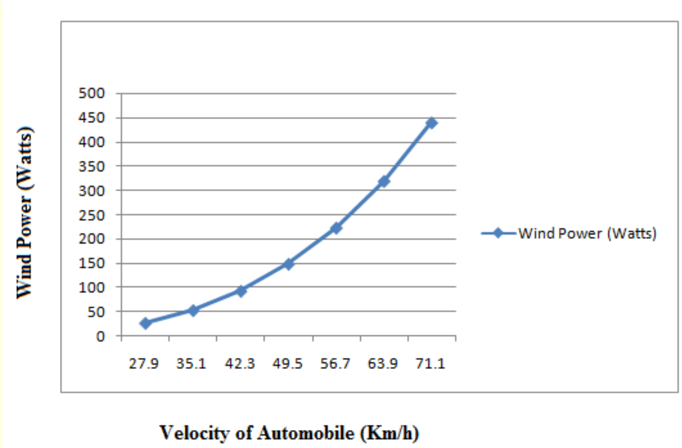

Chart -3: Wind Power (Watts) Vs Velocity of Automobile (Km/h)

The above graph Depicts Velocity of Automobile in Km/h on X-axis and Wind Power in Watts on Y-axis. The blue color line indicates Wind Power. It shows that if the Velocity of Automobile increases the Wind Power gradually increases.

7. CONCLUSIONS

In this project we attempt to study the utilization of wind by Vertical axis wind turbine. Of the numerous applications of the simplest design of a wind turbine, the turbulent winds created by the surplus flow on highway traffic can be used to generate electricity which can be used for the highway lighting and the toll gates in the highway. Also, the already installed street lights across the highways can be converted into a simple vertical axis wind turbine with a proper design without any compromise on the structural integrity and hence can act as an additional source of electricity generation utilizing the wind energy which would otherwise go in vain. This project has prototyped a simple design of a vertical axis wind turbine involving simple design of 2 blades. We have determined the frequency of electricity and wind power generated.

REFERENCES

[1]N.H.Mahmoud:-Has conducted an experimental analysis by using, wind tunnel experimental setup, The experimental results shows that –Three bladed rotors are more efficient than four bladed Sovonius rotors.Volume 51, Issue 1, March 2012.

[2]U.K.Saha,S.Thotla,D.Maity:-Has conducted that, power coefficient Cp of Savonius rotor depends on number of stages. Department of Mechanical Engineering, Indian Institute of Technology, Guwahati 781039.

[3]S.K.Dhiman:-The blade is designed in semicircular shape so as one blade passes another blade comes in the position of first. 3 blades are used so as to use of maximum utilization of wind from air and moving vehicle Vol-2, Issue-10, 2016 ISSN: 2454-1362.

[4] Eriksson,S.BernhoffH,LeijonM. Evaluation of different turbine concepts for wind power. Renewable and Sustainable Energy Reviews 2008; 12:1419–34.

[5] Marini M, Massardo A, Satta A. Performance of vertical axis wind turbines with different shapes. Journal of Wind Engineering and Industrial Aerodynamics 1992; 39:83–93.

[6] Shienbein LA, Malcolm DJ. Design performance and economics of 50-kW and 500-kW vertical axis wind turbines. Journal of Solar Energy Engineering 1983; 105:418–25.

BIOGRAPHIES

1st Author: TARIQ HASSAN BAHARMUZ

He is pursuing B-tech final year in mechanical engineering from Nawab Shah Alam Khan college of engineering and technology, (JNTUH) Telangana, India &recognized by AICTE, accredited by NAAC. He Completed his schooling in ISC (12th standard) from St. George's Grammar School (2016) Telangana, India.

2nd Author:SHAIK ABDUL IMRAN

He is pursuing B-tech final year in mechanical engineering from Nawab Shah Alam Khan college of engineering and technology, (JNTUH) Telangana, India &recognized by AICTE, accredited by NAAC. He completed his Intermediate in MPC from MS. Jr. College (TSBIE) Telangana, India.

3rd Author: SHAIK MUJAHED

He is pursuing B-tech final year in mechanical engineering from Nawab Shah Alam Khan college of engineering and technology, (JNTUH) Telangana, India &recognized by AICTE, accredited by NAAC. He completed his Intermediate in MPC from MVS Government Arts and Science College (TSBIE) Telangana, India.

4th Author:MOHAMMED RAFEEQ

He is working as Assistant Professor of Mechanical Engineering Department in Nawab Shah Alam Khan College of Engineering and Technology. He received the B.E degree in Mechanical Engineering from Khaja Banda Nawaz college of Engineering, Kalaburagi. He completed hisM. Tech in Thermal Power Engineering from PDA College of Engineering, Kalaburagi, and Karnataka, India.