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HIGHWAY VERTICAL AXIS WINDMILL FOR POWER GENERATION

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ABSTRACT

Energy is essential for driving and enhancing the life cycle. The use of energy is proportional to humanity's progress. A wind-capturing device comprising a generator is driven by a wind draft created by traffic passing nearby at high speeds. The device uses vertically mounted savories-type rotors attached to electrical generators to capture the wind and produce electrical energy. The electrical generators may be installed in such a way that they are close to vehicular passages (e.g., highway overpasses, tunnels, or train rails). The vanes and their associated generators are rotated by the wind draught caused by the traffic to produce electrical energy. It is a replacement for current power generation devices that use high-speed wind energy generated by highway cars, as well as solar and vibration energy to create electricity that may be used to power road lights, to power toll gates, and to charge the batteries of electric vehicles.

Keywords: Highway Wind Turbine, Impact Wind Energy.

I. INTRODUCTION

As India has one of the largest road networks, there are always high numbers of vehicles running at high speeds on roads. When highway vehicles move at high speed then wind turbulence is generated and also vibration is generated. So, why not utilize this wind turbulence and vibration to create useful energy which otherwise gets wasted. Also, the highway road is divided with help of a divider and its space is empty and is not used for any purpose. So, why not use this space too for a utilizable purpose.

Energy cannot be generated or destroyed, according to the concept of energy conservation; it can only be changed from one type of energy to another. So if we install a wind turbine on the highway then we can utilize this wasted energy to get electrical energy. Further on installing a solar panel, solar energy is also utilized.

This generated electrical energy can be used in lighting the road lights, providing power to toll gates, charging car batteries, providing power to nearby villages, and also promoting the use of a renewable source of energy in place of a non-renewable energy source.

II. FUNCTION AND SYSTEM DESIGN

Wind energy generation is growing rapidly worldwide and will continue to do so for the foreseeable future. A unique method of recovering part of the energy spent by automobiles travelling at high speeds on our country's roadways. We know how much air turbulence fast-moving vehicles, particularly trucks, cause. This would include placing vertical axis wind turbines in the middle of the highways, which would be powered by the flowing air created by passing vehicles. The power generated by spinning these turbines might be used to light up the roadways and operate toll gates to prevent accidents. Excess energy might be sent back into the system or used to power adjacent settlements. VAWT along the middle of the traffic lanes can generate a significant amount of power from the turbulence created by cars and trucks passing by. While we'll never recover much of the energy used to push air out of the path of a sixteen-wheeler, even a small portion of it might be a substantial source of energy. On the valley roadways, average vehicle speeds are around 70 mph. With an increase in wind turbulence speed, this power generation estimate will grow exponentially. We think that the wind stream formed by our principal method of transportation across the highways will provide an annual average wind speed substantially above the baseline of 10 mph.

The wind turbines depicted in the proposal operate quietly. There is certainly enough consistent traffic volume in many built-up regions to create a steady breeze for much of the day.

"If these devices were placed along railway lines, particularly in the subterranean rail network, they might capture the energy emitted by passing trains and use it to power buildings above, but it would be a somewhat variable power source."

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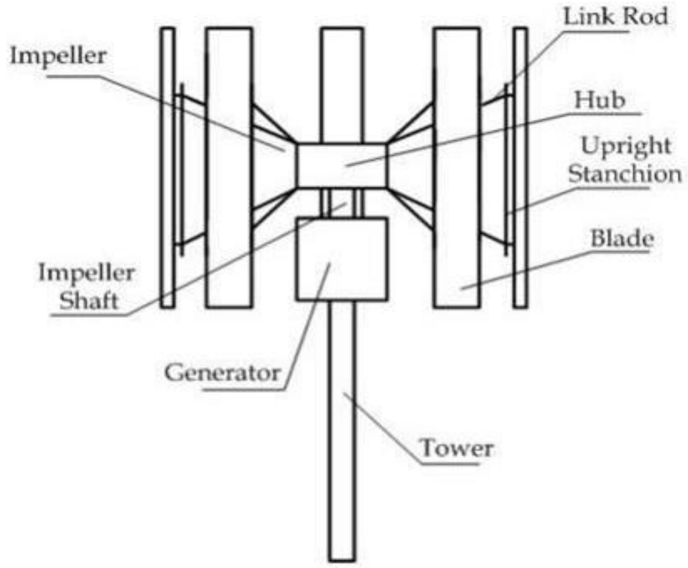


Fig: Highway Vertical axis wind Turbine

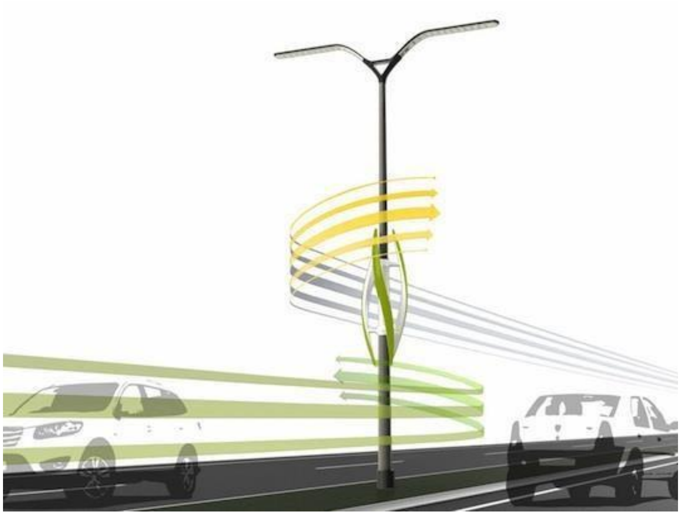


Fig: Prototype of turbine

2.1. Vertical axis wind turbine

- This type of wind turbine occupies less space due to which we can fit it in space between two roads.
- Power generation does not depend on the direction of wind & it is major an advantage of this turbine. Simple in construction.
- Hence best suitable turbine for our project since it satisfies all three basic needs.
- Further, we have used Savonius blade design for the blade design.

2.2. Generator

- It will convert the mechanical energy (rotational) obtained from the turbine into electrical energy. It will be a DC generator.
- It is a small capacity generator that will be capable of producing power up to 100 watts.

2.3. Solar panel

- It converts solar energy to electric energy.
- This solar panel is made using mono PERC cells to generate optimum energy when sunlight impinges on the panel.
- It weighs 3 kg and its dimensions are 430mm x 635mm.
- It generates 50-watt power.

2.4. Battery

- It will help us to store the electrical energy to light up road lights during maintenance or in raining season. Battery type.
- Battery capacity 35Ah.
- Voltage output 12v.

2.5. Frame and fixed plates

- A fixed frame will help us to hold all equipment in the proper place.
- Fixed plates will help us to direct the airflow in the turbine to increase efficiency and reduce the drag on the opposite side.
- Frame material: Square iron rods and Galvanized steel sheet.

2.6. Control unit

- It will measure the output received from the solar panel and turbine and store the data and display it whenever needed.
- It will consist of an Arduino circuit and a small display.

2.7 Transmission assembly

- The transmission assembly includes a shaft, bearings, timing gears, and a chain drive.
- Shaft will transmit the torque to the generator.
- Bearings will help to obtain the friction-free motion of transmission assembly.
- The gear assembly will help us to obtain the desired reduction ratio and speed.

III. METHODOLOGY

Fabrication

The fabrication of a vertical axis wind turbine (Savonius type) is made up of many pieces that must be built as part of the main assembly. The pieces of VAWT to be fabricated are listed below.

Base

The foundation is composed of 1-inch thick plywood that is 6 feet long and 3 feet broad. The base's construction seeks to provide the turbine with strong support against the high-speed wind. It is meant to decrease turbine vibrations caused by turbulent winds. The rotor is held in place by the base, which has a fixed shaft that runs perpendicular to the rotor. The power-producing device is likewise housed in the base.

Frame

Mild steel rectangular [20cm*40cm] pipes are used to construct the frame. Two six-foot pipes are joined to the base perpendicularly. Two four-foot-long pipes are joined to the base in a parallel configuration. L clamps with appropriate nuts and bolts are used to secure these rectangular pipes. The turbine's structure is intended to give the necessary strength and support against the spinning of the blades and the force of the wind.

Blades

In this project 5 inch, half-cut PVC pipes are used as turbine blades. The blades are approximately 3mm thick. A total of five blades of identical length are employed. A set of three, four, and five blades is used to do the analysis. Clamps with nut and bolt arrangements are used to mount these blades perpendicular to the rotor [cycle wheel].

Rotor

The rotor is made up of the cycle's two front wheels. To prevent corrosion, these wheels are composed of stainless steel. The wheels have a diameter of 300 cm. A ball bearing is used in these wheels, which provides for effortless rotation. One wheel is mounted to the top of the frame, while the other is attached to the bottom. They are held in place by a fixed shaft.

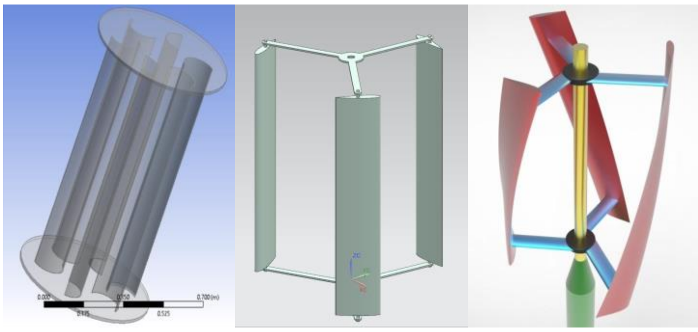
Generator

The Dynamo of the car is used to produce electricity of 12 volts.

Drive system

The power is sent from the turbine to the generator through a belt drive system. The gear ratio is set at 1:10.

IV. MODELING AND ANALYSIS



Cup type rotor	Darrieus H-type rotor	Darrieus Helical type rotor
It uses drag force to rotate.	The lift force is what makes this rotor operate.	This rotor works due to the lift force.
The rotor blades are long and cup-shaped.	The rotor blades are straight and have an aerofoil design	The rotor blades are helical shaped and also have an aerofoil design.
The support structure increases the weight of the product.	The design is lightweight.	The design is lightweight.
Requires more number of revolutions for same power output.	Requires less number of revolutions for same power output.	Requires less number of revolutions for same power output.
Very easy to manufacture and cost-efficient.	Easy to design and manufacture but high in cost.	Difficult to manufacture and high in cost.
It has high starting torque.	It has low starting torque.	It has very low starting torque.
Minimum required wind speed of 9m/s.	Minimum required wind speed of 2m/s.	Minimum required wind speed of 1-1.5m/s

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Low-speed rotor.	High-speed rotor.	High-speed rotor.
Low efficiency.	High efficiency.	High efficiency.
Suitable location: near train tracks, national highways.	Suitable location: state highways, open ground areas.	Suitable location: state highways, national highways, elevated areas.

READINGS FROM ANEMOMETER AND SOLAR PANEL

College Students Parking	**5m/s**
College Main Gate	**2.5m/s (not considered)**
State Highway	**8m/s**
National Highway	**12m/s**
Kukma Railway line	**15m/s**

V. RESULTS AND IMPLEMENTATION

Calculations The power in the Wind

The kinetics ideas may be used to calculate the wind's power. The windmill operates by transforming the kinetic energy of the wind into mechanical energy. Any particle's kinetic energy is equal to one-half its mass multiplied by the square of its velocity, or 12 mv2. The volume of air traveling over an area A at a velocity V in unit time equals A. V, and its mass M is equal to its Volume multiplied by its velocity.

the density of air, or

m = AV……………….(1)

(m is the mass of air transferring the area A swept by the rotating blades of a windmill type generator Substituting this value of the mass in the expression of K.E.

Substituting this value of the mass in the expression of K.E.= ½

$AV.V^2$ watts= ½

AV^3 watt…………. (2)

The power available is proportional to air density (1.225 kg/m3) and is proportional to the intercept area, according to the second equation. In horizontal axis aero turbines, the region is generally circular with a

$$A = \frac{\pi D^2}{4} \quad (Sq.\,m)$$

diameter of D.

Wind velocity vs. power output

Power output= (1/2) Av^3

- At that height and location, the air density is,

(normally 1.225 kg/m3) A- Swept area by blades=3.33 each V- Wind velocity in m/s.

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S.No	Wind Velocity(m/s)	Output(Watts)
1	3	55.09
2	4	130.53
3	5	254.95
4	6	440.55
5	7	699.59

Graphs:

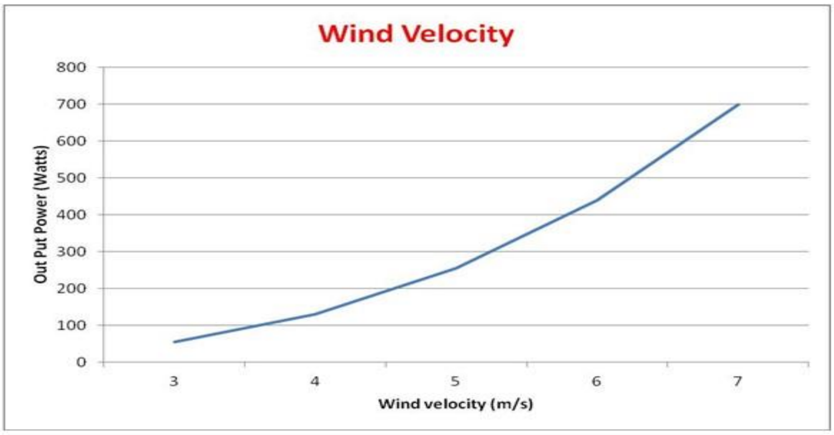

Fig: Wind Velocity vs. Power Output

Motor speed vs. output voltage

The maximum speed of the generator is 500rpm. If the generator rotates at full speed it gives an output of 14.5 volts.

Table: Motor speed vs. output voltage

S.No	Speed(rpm)	Voltage(V)
1	125	3.625
2	250	7.25
3	500	14.5

Graphs:

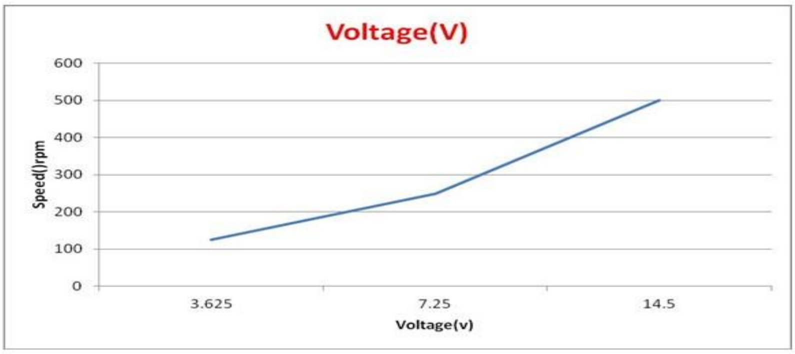

Fig: Motor Speed vs. Output Voltage

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For 6 Blades

The vertical axis windmill is designed with a various number of blades and also the different angles of twist of the blade. The following figures show the various results with a different number of blades and different angles of twist of the blade. The experiment was carried out for six blades, three blades, and two blades. These three patterns of the turbine were again tested with the various angle of twist of the blade.

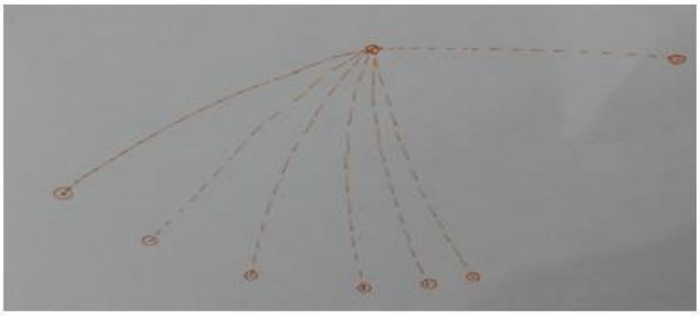

Fig: 7.3 Blades profile for various angle of twist

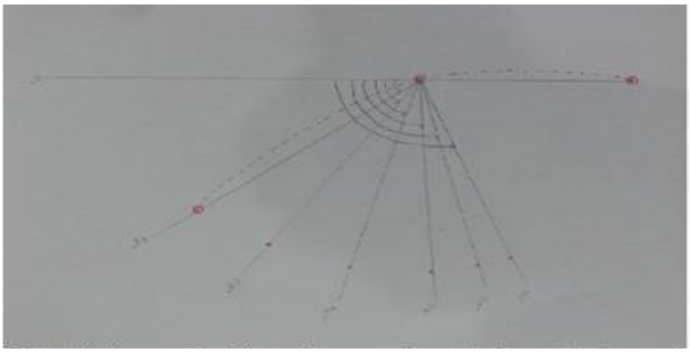

Fig: Blades profile for the various angle of twist with the angle

Angle and the maximum speed for 6 blades

The below figure shows the turbine with six blades and with some angle of twist. This design was tested with a various angles of twist. The outcome of the experiment is shown in the below table with a graph.

Fig: Turbine with six number of Blades

Graphs:

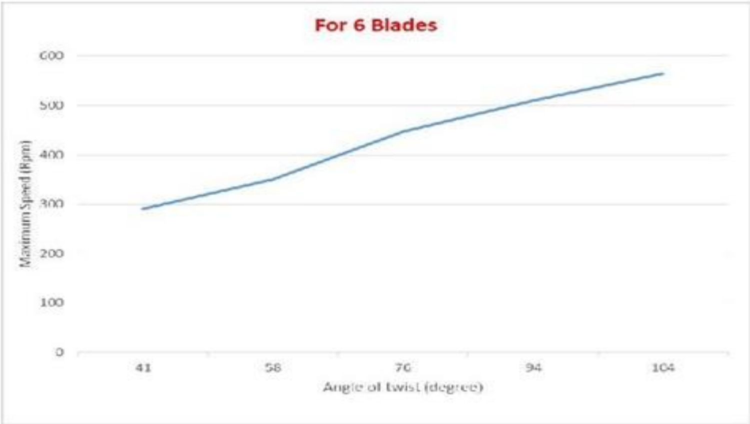

Fig: Maximum speed vs. Angle of twist for six blades

The graph above demonstrates how the maximum speed of a vertical axis windmill varies with the angle of twist. As shown in the chart the maximum speed goes on increasing from the initial value of the angle of twist.

For 3 Blades

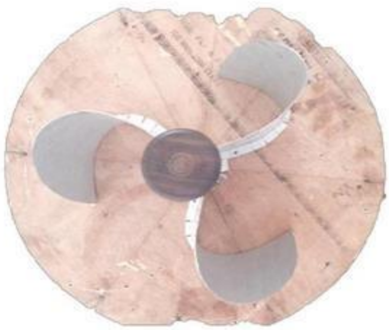

Table:7.4 Angle and maximum speed for 3 blades

S.No	Angle(degree)	Maximun Speed(RPM)
1	41	250
2	58	289.9
3	76	342
4	94	400
5	104	473.5
6	110	438

Graph:

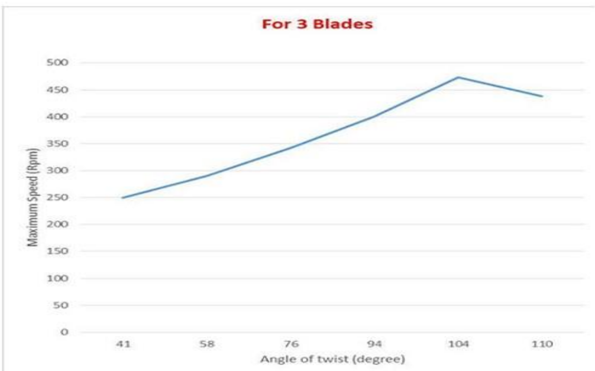

Fig: Maximum speed vs. Angle of twist for three blades

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The graph above demonstrates how the maximum speed varies with the angle of twist for three blades. The graph depicts the variation in maximum speed as a function of twist angle. The maximum speed rises with the angle of twist at first. It rises to a certain point, as seen in the diagram. In this example, the maximum speed rises to 104 degrees before falling.

7.6 For 2 Blades

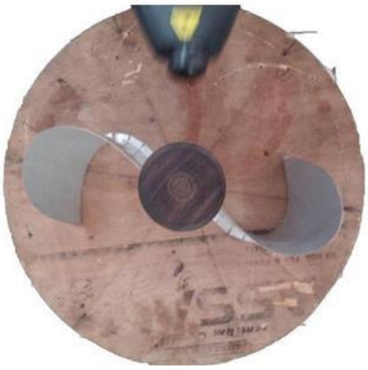

Table:7.5 Angle and maximum speed for 2 blades

S.No	Angle(degree)	Maximum Speed(RPM)
1	41	211
2	58	228
3	76	239
4	94	248
5	104	279
6	110	276

Graph:

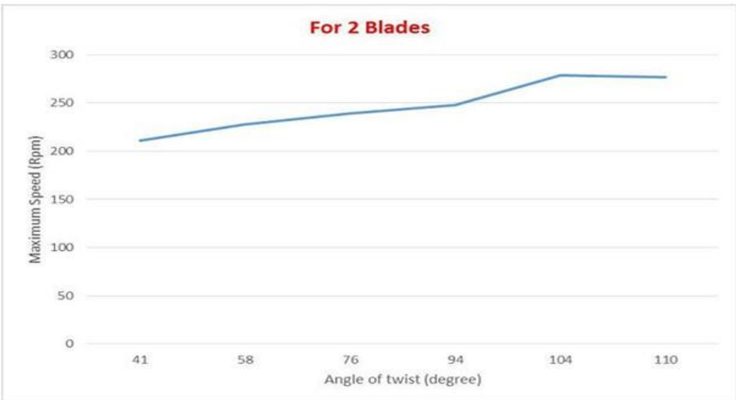

Fig: Maximum speed vs. Angle of twist for two blades

The above chart shows the variation of the maximum speed with the angle of twist for two blades. The chart pictures the change in maximum speed with the angle of twist. Initially, the maximum speed increases with the angle of twist. It increases up to some particular value as shown in the figure. In this case, the maximum speed increases up to 104 degrees and then it decreases.

Discussion

1. Rotational Speed of the Turbine is proportional to the number of blades.
2. The rotational speed of the turbine increases with the increase in the angle of bend of the blade, but from a certain angle of bend its speed decreases.

3. From our experiment we found the optimum angle of bend lies between 104^0 and 110^0.
4. With the increase in the number of blades the complexity also increases.

VI. APPLICATION

The turbine's rotational axis is vertical or perpendicular to the ground in vertical axis wind turbines. Vertical axis turbines, as previously stated, are generally used in modest wind projects and residential purposes. Aside from electrical power generation, SB-VAWT has a variety of other uses. Wind energy can be converted to mechanical and thermal energy at the point of energy conversion. As a result, the SB-VAWT energy system can be utilized for water pumping, heating, and cooling, among other things

- To light up road lights and signals.
- To charge electric vehicles.
- Supply electricity to nearby villages.
- Supply electricity to metro/railway stations.

VII. CONCLUSION

From our project, many conclusions can be drawn about the efficiency of the VAWT and its improvement. The power output and the efficiency of the VAWT are expected to be higher with the addition of VGs in comparison with those of a VAWT without VGs. As for the construction of the VAWT, the materials and dimensions are chosen based on the literature review and the calculations made, which helped with increasing the overall efficiency of the VAWT.

Future experimental data and findings will be used to evaluate those assumptions, allowing for a better knowledge of the direct impacts of the materials, dimensions, and new elements, as well as a more comprehensive comprehension of the theories involved.

VIII. FUTURE SCOPE

1. By fixing solar panels in this vertical axis wind turbines will increase efficiency.

2. Fixing more in series or a parallel manner will give more efficiency.

The wind energy can be tapped to a full extent when the force acting on the blade of the turbine which is coming in the opposite direction of the wind is minimized. This can be achieved when there are some holes on the blade which are closed when the wind is pushing the turbine and the holes are opened when the blade of the turbine is coming in the opposite direction of the wind. The experiment setup is placed at the base level and the same setup may be tested at a different height. It has been tested with one profile of blade and the profile of the blade may be changed for better efficiency.

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