DESIGN AND FABRICATION OF VERTICAL AXIS WIND TURBINE FOR GENERATING ELECTRICITY

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Abstract - Energy is an important aspect in our every day's life. The resources we use are limited whereas the population consuming the same is increasing day by day. Wind energy is free of cost and available with ease. Tapping of wind energy is essential for the conservation of other non-renewable resources. Wind energy has been harnessed for centuries but it has only emerged as a major part of our energy solution quite recently and this project focus on utilizing wind energy by using vertical axis wind turbine (VAWT). This project aims of utilizing this wind energy in most effective manner to get the maximum electric output, and therefore we selected highway as our installation site where we can take the advantage of the moving vehicles on both the sides of the road. In the present work, turbine is design and fabricated as per the specifications, the blades used are semi-circular shape and are connected to the disc which is connected to shaft. Shaft is then coupled with the gear mechanism, and then it is connected to the DC generator, which generates the power. The power developed is stored in battery and then can be used for street lights, signal or toll and many different applications. In this project a small model has been created for testing purpose. This project also aims for maximum output with minimum cost indulges, so that the government can think over this project and can implement this type of vertical axis wind turbine on highways at low cost.

Index Terms – Vertical axis wind turbine, DC generator, Shaft, Gear mechanism

I. INTRODUCTION :

Energy is the ability to do work. While energy surrounds us in all aspects of life, the ability to harness it and use it for constructive ends as economically as possible is the challenge before mankind. Alternative energy refers to energy sources which are not based on the burning of fossil fuels or the splitting of atoms. The renewed interest in this field of study comes from the undesirable effects of pollution (as witnessed today) both from burning fossil fuels and from nuclear waste by products. Fortunately, there are many means of harnessing energy which have fewer damaging impacts on our environment.

The alternatives are,

- Solar
- Wind Power
- Geothermal
- Tides
- Hydroelectric

A windmill is a type of engine. It uses the wind to make energy. To do this it uses vanes called sails or blades. The energy made by windmills can be used in many ways. These include grinding grain or spices, pumping water and sawing wood. Modern wind power machines are used to create electricity. These are called wind turbines. Before modern times, windmills were most commonly used to grind grain into flour.

The definition for a wind turbine is it is a type of device that transforms kinetic energy mainly from the wind into electric power. There are generally two core types of wind turbines, which are the horizontal axis wind turbine (HAWT) and the vertical axis wind turbine (VAWT). One type is built with the aim of generating electricity from wind with high speeds. On the other hand, the other type is built especially for areas with low wind speeds. Wind turbines consist of a set of blades attached to a rotor hub, which together form the rotor; this rotor deflects the airflow, which creates a force on the blades, which in turn produces a torque on the shaft such and the rotor rotates around a horizontal axis, which is mainly attached to a gearbox and generator. These are inside the nacelle, which is located at the top end of the tower, along with several other electrical parts. The generator generates electricity, which is moved down from the tower and out to an available transformer, so that it can be converted from the output voltage (usually about 700V) to some voltage for either the countrywide grid (33000V) or for any personal use (about 240V).

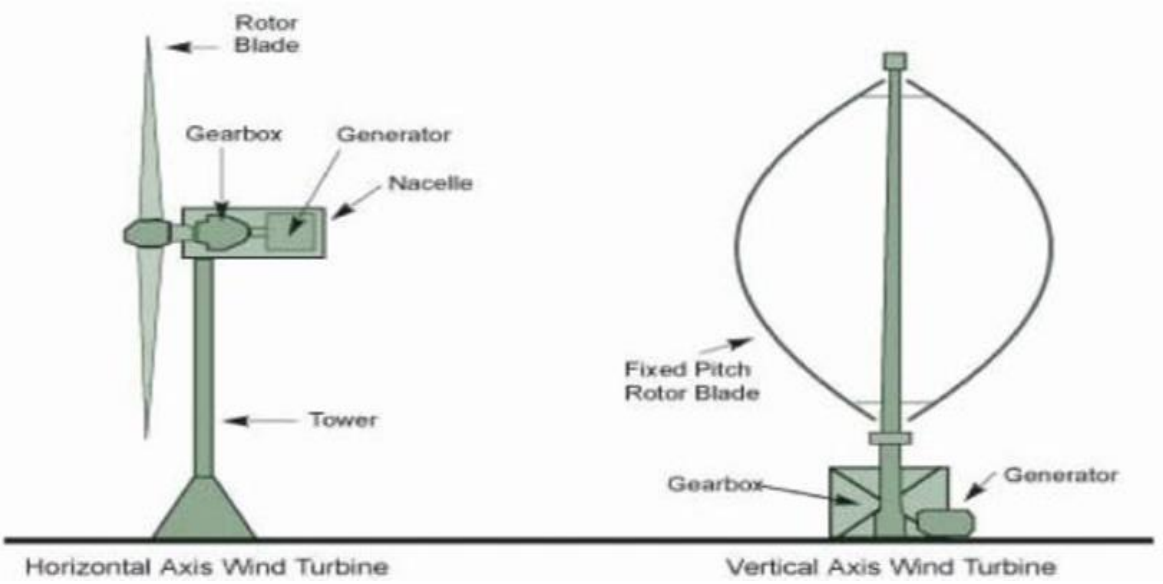

Fig.1 Wind Turbines

There are 2 types of Wind Turbines:

- **HORIZONTAL AXIS WIND TURBINES**

The horizontal wind turbine is a turbine in which the axis of the rotor's rotation is parallel to the wind stream and the ground. Most HAWTs today are two- or three-bladed, though some may have fewer or more blades. The HAWT works when the wind passes over both surfaces of the aerofoil shaped blade but passes more rapidly at the upper side of the blade, thus, creating a lower-pressure area above the aerofoil. The difference in the pressures of the top and bottom surfaces results in an aerodynamic lift. The blades of the wind turbine are constrained to move in a plane with a hub at its centre, thus, the lift force causes rotation about the hub. In addition to the lifting force, the drag force, which is perpendicular to the lift force, impedes rotor rotation.

Fig.2 HAWT

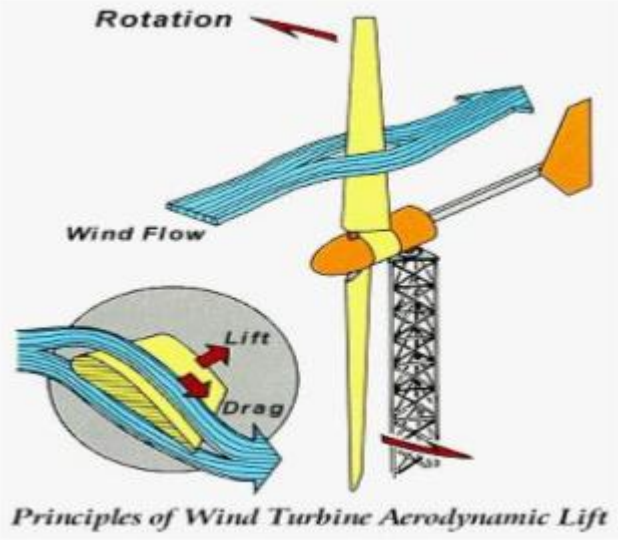

Fig.3 Working of HAWT

- Types of HAWT –

a) Upwind Turbine.

The upwind turbine is a type of turbine in which the rotor faces the wind. A vast majority of wind turbines have this design. Its basic advantage is that it avoids the wind shade behind the tower. On the other hand, its basic drawback is that the rotor needs to be rather inflexible, and placed at some distance from the tower. In addition, this kind of HAWT also needs a yaw mechanism to keep the rotor facing the wind.

Fig.4 Upwind Turbine

b) Downwind Turbine.

The downwind turbine is a turbine in which the rotor is on the downwind side (lee side) of the tower. It has the theoretical advantage that they may be built without a yaw mechanism, considering that their rotors and nacelles have the suitable design that makes the nacelle follow the wind passively. Another advantage is that the rotor may be made more flexible. Its basic drawback, on the other hand, is the fluctuation in the wind power due to the rotor passing through the wind shade of the tower. Currently high-speed propeller wind turbines are commonly used as horizontal axis turbines because of their excellent aerodynamic efficiency.

Fig.5 Downwind Turbine

- **VERTICAL AXIS WIND TURBINES**

The VAWT is a turbine in which the axis of rotor is perpendicular to the wind stream and the ground. VAWT commonly function nearer to the ground, and has the benefit of enabling placement of heavy equipment, such as the gearbox and generator, close to the ground level and not in the nacelle. However, the winds are lower near ground level hence for a similar wind and capture area, a less amount of power is generated. Another benefit of a VAWT is that it does not need a yaw mechanism, because it can harness the wind from all directions. This benefit is outweighed by numerous other limitations, such as: time varying power output because of change of power in a single blade rotation, the requirement for guy wires to support the main tower and the fact that the Darrieus VAWT are do not self-start like HAWTS.

- Types of VAWT –

a) Darrieus Turbine.

The Darrieus Turbine is composed of a vertical rotor and several vertically oriented blades. A small powered motor is required to start its rotation, since it is not self-starting. When it already has enough speed, the wind passing through the aerofoils generate torque and thus, the rotor is driven around by the wind. The Darrieus turbine is then powered by the lift forces produced by the aerofoils. The blades allow the turbine to reach speeds that are higher than the actual speed of the wind, thus, this makes them well-suited to electricity generation when there is a turbulent wind.

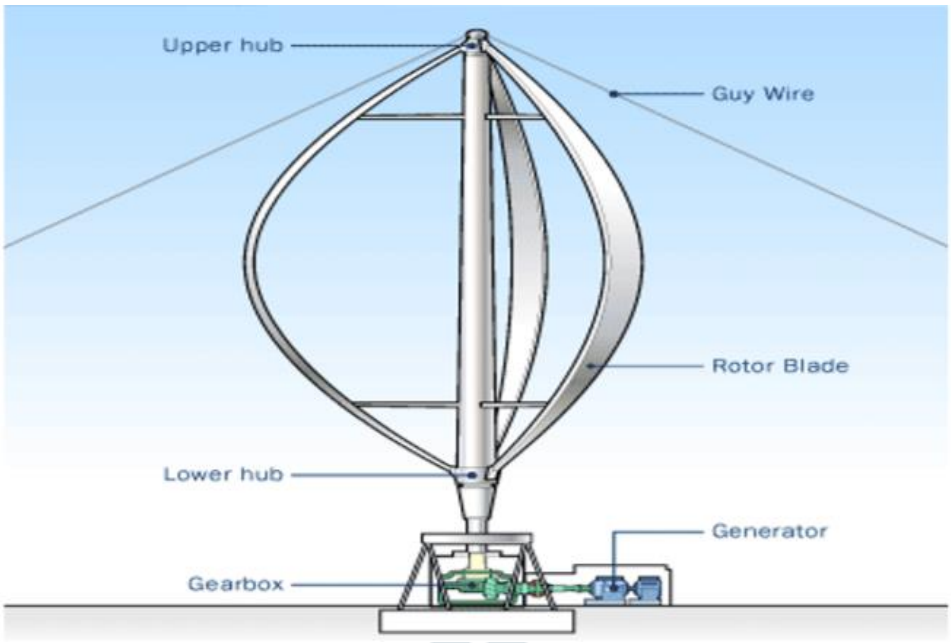

Fig.6 Darrieus Turbine

b) Savonius Turbine.

The Savonius wind turbine is one of the simplest turbines. It is a drag-type device that consists of two to three scoops. Because the scoop is curved, the drag when it is moving with the wind is more than when it is moving against the wind. This differential drag is now what causes the Savonius turbine to spin. Because they are drag-type devices, this kind of turbine extracts much less than the wind power extracted by the previous types of turbine.

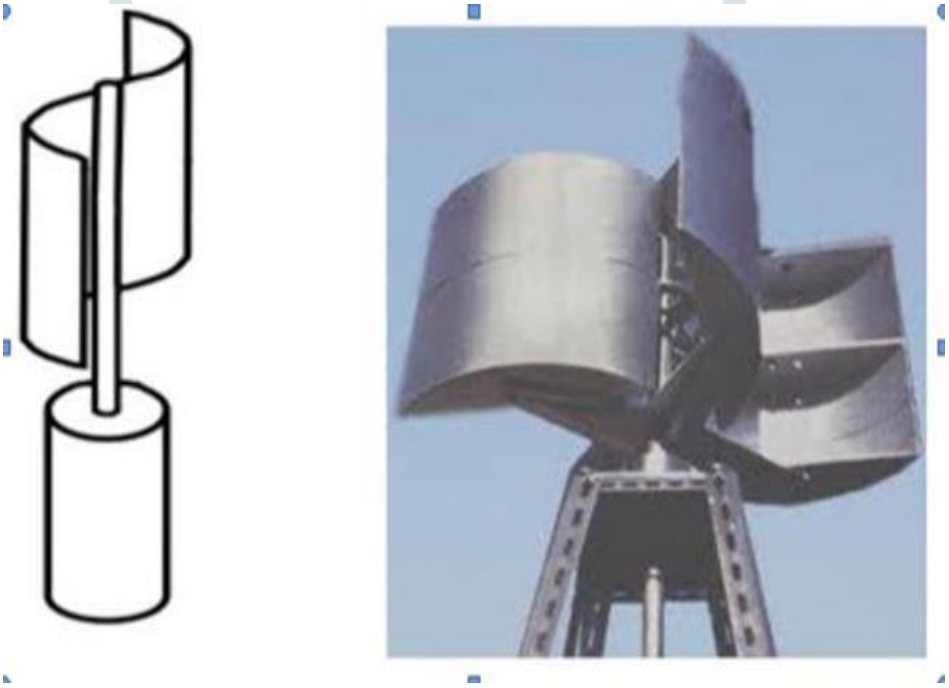

Fig.7 Savonius Turbine

c) Giromill Turbine.

Giromill Turbine is a special type of Darrieus Wind Turbine. It uses the same principle as the Darrieus Wind Turbine to capture energy, but it uses 2-3 straight blades individually attached to the vertical axis instead of curved blades. It is also applicable to use helical blades attached around the vertical axis to minimize the pulsating torque.

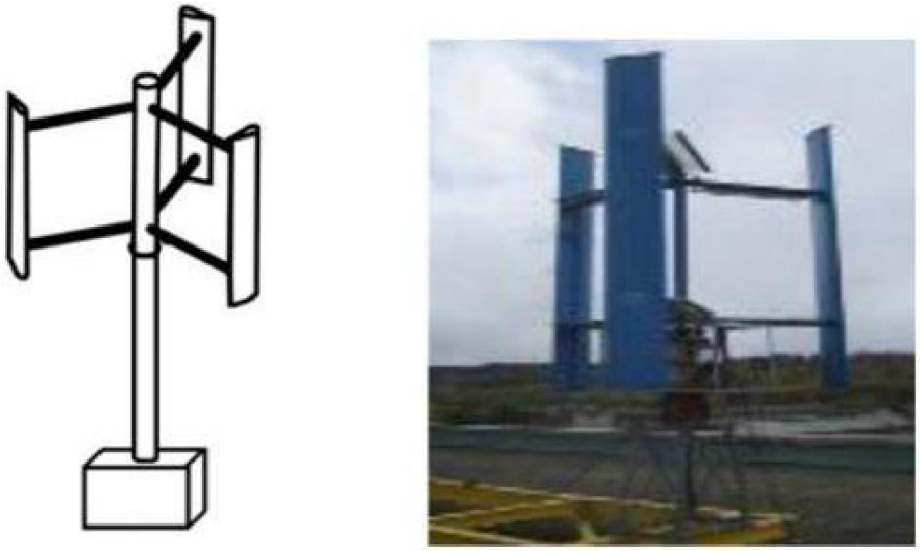

Fig.8 Giromill Turbine

II. LITERATURE SURVEY :

[1] Niranjana S. J :

He investigated the power generation by vertical axis wind turbine. In this paper the power is generated by fixing the wind mill on the road high ways. When the vehicle is passed through the road at high speed the turbine of the wind mill rotates and generates the power sources. This analysis indicates that the vertical axis wind turbine can be able to attain the air from all the directions and produces the power of 1 kilowatt for a movement of 25 m/s. The efficiency of vertical axis wind turbine can be increases by modifying the size and shape of the blade.

[2] Mr. Abhijit N Roy, Mr. Syed Mohiuddin :

He indicates that vertical axis wind mill is one of the most important types of wind mill. In this main rotor shaft is connected to the wind turbine vertically with the generator and gear box which can be placed near the ground. Performance characteristics such as power output versus wind speed or versus angular velocity must be optimized in order to compete with other energy sources which make the process economically and eco-friendly. The experimental result shows that wind turbine is placed on the top of the building in an ideal position to produces electricity. The power generation becomes easy and it is used for various applications such as street light, domestic purpose, agriculture etc.

[3] Piyush Gulve, Dr. S.B. Barve :

He studied that vertical axis wind turbine is more efficient than horizontal axis wind turbine because it requires compact space for producing same amount of electricity and less noise. The result of the paper indicates that the efficiency of wind turbine may reduce due to manufacturing error and frictional losses. It will be rectified by precising the design of the blade more aerodynamically.

[4] Arvind Kumar, Sandip Kumar Singh :

His study suggests a trend moving from fixed-speed, geared and brushed generators towards variable-speed, gearless and brushless generator technologies while still reducing system weight, cost and failure rates. They have provided an overview of different wind turbine generators including DC, synchronous and asynchronous wind turbine generators with a comparison of their relative merits and disadvantages. More in-depth analysis should be carried out in the design, control and operation of the wind turbines primarily using numerical, analytical and experimental methods if wind turbine generators are to be further improved. Despite continued research and development effort, however, there are still numerous technological, environmental and economic challenges in the wind power systems. In summary, there may not exist the best wind turbine generator technology to tick all the boxes.

[5] Sushant N. Malave and Shivraj P. Bhosale :

He concludes that extensive data is collected on wind patterns produced by vehicles on both sides of the highway. Using the collected data, a wind turbine is designed to be placed on the medians of the highway. Although one turbine may not provide adequate power generation, a collective of turbines on a long strip of highway has potential to generate a large amount of energy that can be used to power streetlights, other public amenities or even generate profits by selling the power back to the grid. This design concept is meant to be sustainable and environmentally friendly. Additionally, a wind turbine powered by artificial wind has a myriad of applications. Theoretically any moving vehicle can power the turbine such as an amusement park ride. The highway wind turbine can be used to provide power in any city around the globe where there is high vehicle traffic.

III. PROBLEM DEFINITION :

- In India the need of electricity is more than its production. The focus on energy generation from Renewable Energy Resources has increased significantly in the recent years in the wake of growing environmental pollution, rising energy demand and depleting fossil fuel resources. Different sources of renewable energy include biomass, solar, geothermal, hydroelectric, and wind energy. Among these resources wind has proved to be a cheaper alternative energy resource and hence extensive research efforts have been put to improve the technology of electricity generation through wind energy.
- Indian Renewable Energy Development Agency (IREDA) and the wind industry are working together to accomplish the improvements through various research and development programs. In areas where favourable sites exist, it has already been preferred over conventional fossil fuels resources for electricity generation. Wind power is now the world's fastest growing energy resource utilized.
- The fixed wind powered electricity generation systems in use, till now are dependent on wind direction and the force of the wind. But the wind is not available at all places and all time throughout the year. Also, the wind forces from moving vehicles is getting useless, therefore, there exists an immense need of a system for generating electricity from wind induced by moving vehicles, trains or airplanes, which is available throughout the year at various places and with sufficient force of wind.
- Therefore, this invention provides a solution to the problem for generating electricity in this manner. On keeping prime focus on the heavy-duty automobiles on highways/expressway, we found out that there is large amount of wind pressure generated on these roads due to wind disturbance/ wind turbulence created by these automobiles. As any automobile passes along the path, it creates a very huge air pressure on the nearby surrounding areas.
- Till now there is no as such technology developed and implemented in India to utilize this high-pressure column of wind so generated. With concern to this, we had tried to develop a vertical axis wind turbine which works on the principle of these highway wind energy.

IV. COMPONENTS :

a) Turbine Blades -

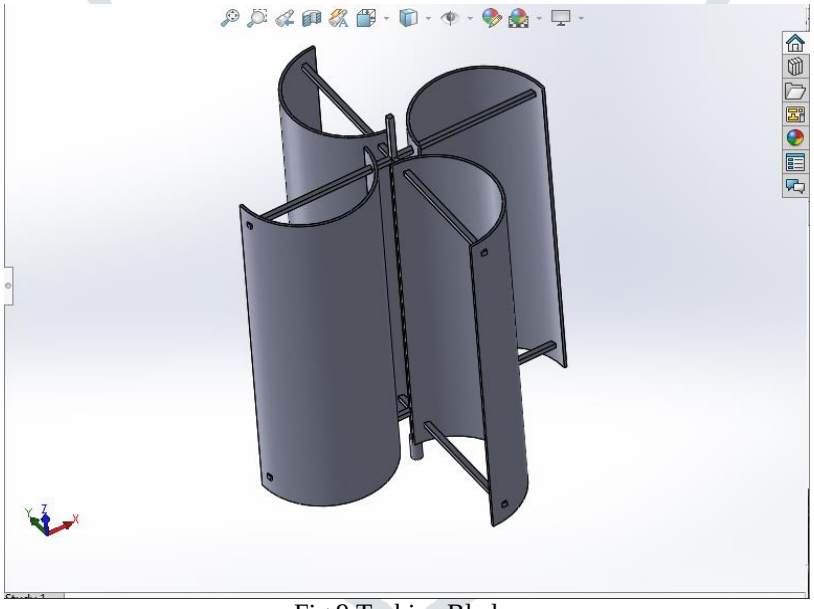

Fig.9 Turbine Blades

As per the figure we can explain the specifications of turbine blades which we have made are as follows :
Height of Blade - 24 inches (about 610 mm)
Width of Blade – 10 inches (about 254 mm)
Thickness - 10 mm
Angle - 45°
Shaft Length - 30 inches (about 762 mm)
Shaft Diameter - 20 mm

b) Base –

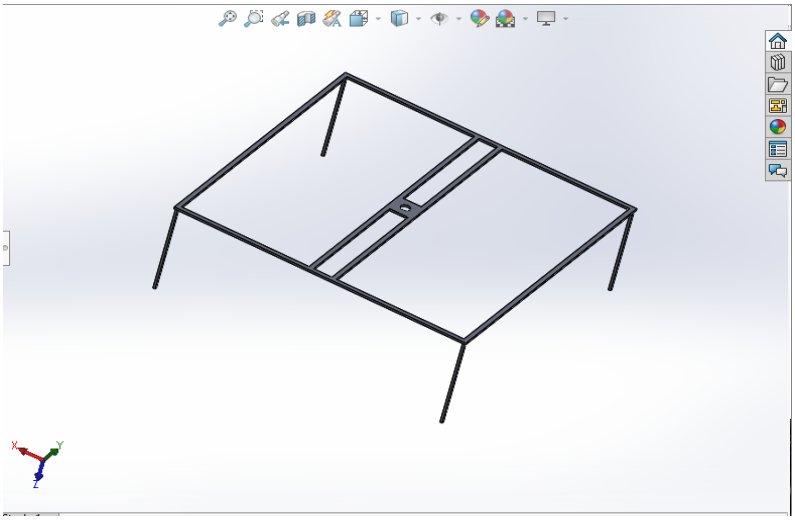

Fig.10 Base

As per figure we have made the base.

Specification:

Height: 210 mm
Width: 620 mm

c) DC Generator –

As a generator we used the DC Rotor.

Specifications:

Motor speed: 500 rpm

At this speed it gives 14.5V output.

Fig.11 Generator

d) Assembly of Model -

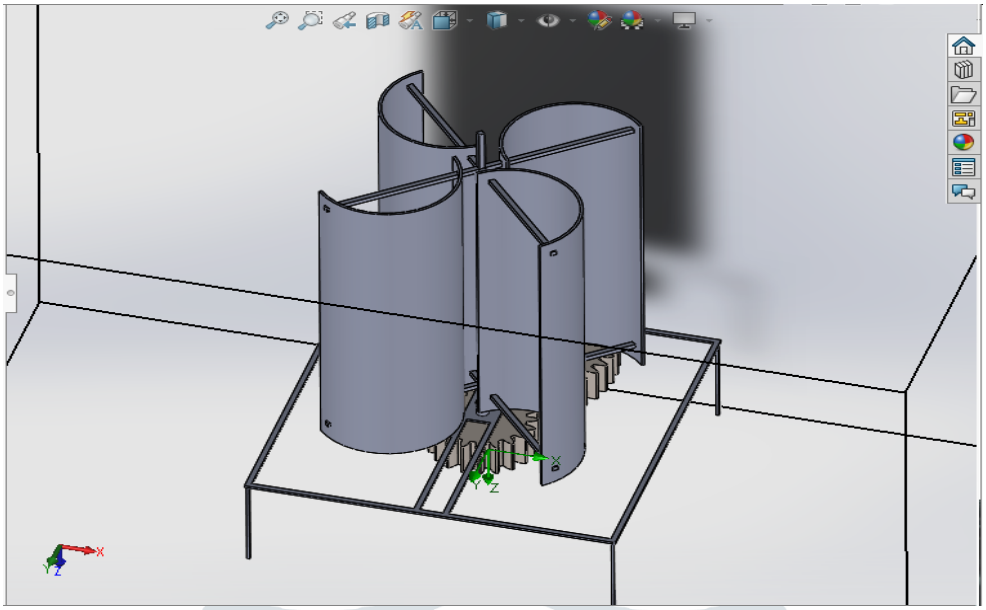

Fig12 Assembly model

V. OBJECTIVES :

- The main objective is to utilize the maximum amount of wind energy from the automobiles running on the highways. The unused and considerable amount of wind is used to drive the vertical axis wind turbine, which will use the kinetic energy of the wind to produce the electrical energy. Increased turbulence levels yield greater fluctuations in wind speed and direction.
- Unlike traditional horizontal axis wind turbine (HAWT), vertical axis wind turbine effectively captures turbulent winds which are typical in urban settings. An effort is made to fabricate a vertical axis wind mill of higher output capacity.
- Our aim is to design and fabricate the wind turbine using easily available, low cost raw materials.
- This wind turbine is made to capture the maximum of wind energy in any direction by placing it at optimum place and by considering both the cost and safety of the system. This system can be used in huge number to generate the huge amount of useful electrical energy. This energy can be stored and transferred to nearest rural places where we can fulfil the demand of electricity.
- The thought of design directs us to look into the various aspects such as manufacturing, noise, cost which leads us to our additional aim of analysing the system to overcome the usual technical glitches.
- The project brief involves the design of a small-scale wind turbine that can be easily mass produced and fitted on every highway median to aid electricity consumption.

VI. METHODOLOGY :

- This vertical axis highway windmill is placed in the highway dividers. When the air is forced by passing the vehicle from both sides the speed of a wind at the centre place is higher than the pedestrian walking lane.
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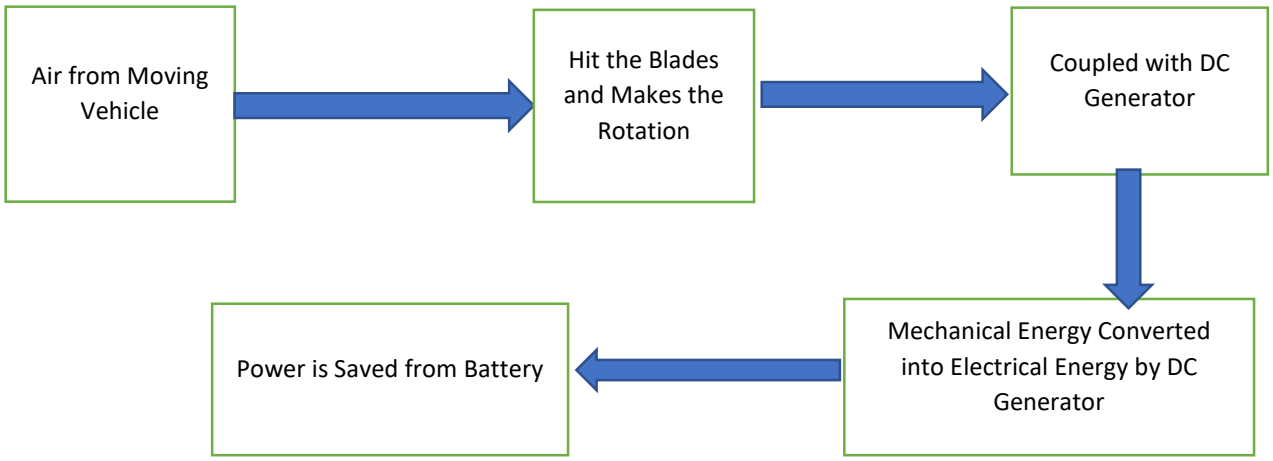

Fig.13 Block Diagram of VAWT

This energy conversion process is explained by several following steps:

Step-1: In the first step the forced wind and middle part of the highway will hit wind turbine blades and make a rotation in it. The wind turbine blade will rotate at clockwise direction even when the vehicle moves in any of the side of the highway. Because the arrangement of the wind turbine blades is in that manner.

Step-2: In this vertical axis highway windmill, the wind blade turbine is coupled with the two generators .one is in the top and the other one is at the bottom of the wind turbine blades. When the turbine blade rotates the coupled generators will produce electricity in both directions.

Step-3: Thus, the mechanical energy is converted into electrical energy by using dc generator and this produced power is stored in the battery and is utilized by application wise.

VII. ADVANTAGES OF VAWT OVER HAWT :

There are several reasons why we would choose a vertical axis wind turbine over a horizontal axis windmill.

- They are mounted lower to the ground making it easy for maintenance if needed.
- They start creating electricity at speeds of only 6 mph.
- They may be able to be built at locations where taller structures, such as the horizontal type, can't be.
- Higher power utilization-- 20% higher than HAWT.
- Lower noise level--only 27-37 DB, suitable for your living condition.
- Safer operation--Spin at slower speeds than horizontal turbines, decreasing the risk of injuring birds and also decreasing noise level.
- Simpler installation and maintenance-- besides the traditional installation site, it can be mounted directly on a rooftop, doing away with the tower and associated guy lines.

VIII. RESULTS :

The Experiments were done on the Vertical Axis Wind Turbine for finding out the Output Voltage from the wind generator.

Motor speed vs. output voltage: -

Maximum speed of the generator is 500rpm. If the generator rotates with full speed it gives an output of 14.5 volts.

Table 1. Motor Speed and Voltage Readings

SR. NO.	MOTOR SPEED (RPM)	VOLTAGE (V)
01.	100	3.34
02.	250	7.25
03.	350	10.35
04.	500	14.5

Graph –

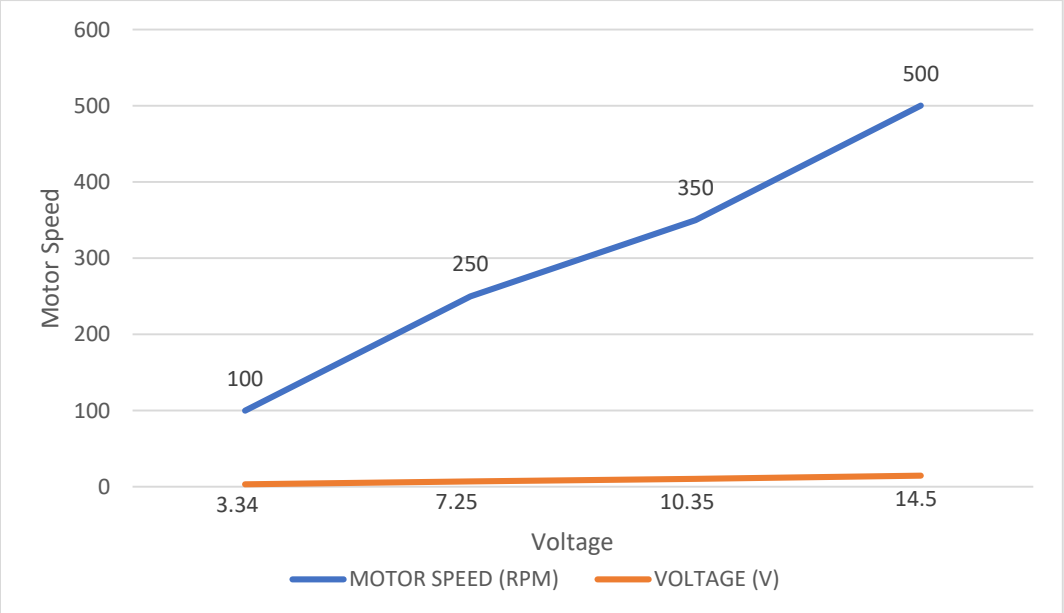

Fig.14 Motor Speed Vs Output Voltage

IX. CONCLUSION :

- By using this technology all the highways can be lightened without use of non- renewable energy resources. Also, if this method is implemented in all national highways it can able to produce large amount of power. And it can also provide job for many educated fellowships. By increasing numbers, it can develop more energy & light up the highways so that the percentage of accidents gets minimized.
- The project "Electricity Generation from Moving Vehicles on Highways" was designed such that to deliver power to switch on the emergency head lamp. The dynamo uses electromagnetic principles to convert mechanical rotation into direct current (DC) using wind energy. The system generates electrical power as nonconventional method by wind energy power using wind turbine set up.
- A careful selection has to be made for the blade profile so that the losses will be minimum and the power generation can be enhanced. Since the wind energy is not constant at all the time so the operation of the wind machine will be intermittent and the power production rate will also vary; the component should be design in such a manner so that the losses should be at minimum.

X. FUTURE SCOPES :

- By fixing solar panel in this vertical axis wind turbine will increase the efficiency.
- Fixing more in series or in parallel manner will give more efficiency.
- The wind energy can be tapped to a full extend 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 wind.
- The experiment set up is placed at the base level and the same setup may be tested at a different height. It has tested with one profile of blade and the profile of the blade may be changed for better efficiency.
- The development of effective alternators and dynamos can be used to harness wind energy from relatively small winds.
- The use of materials like acrylic plastic sheet can be used to develop low cost VAWT. If blades of larger area are used with proper strength and design, the application area of VAWT can be increased in the fields like agriculture, street lighting, hospitals etc.

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