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Design and analysis of highway windmill electric generation

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Abstract: **-** The work deals with designing a portable highway wind turbine, which is to be contribute towards the global trend in wind energy production in a feasible way. Wind turbines are traditionally employed in rural areas; the main goal the work is to design a wind turbine that can be used in cities. In particular, the turbines will use the wind draft created by vehicles on the highway to generate electricity. The idea is to offset the amount of pollution created by burning fossil fuels by introducing a potential source of clean energy. As the automobiles moves from highways/expressways, there is a creation of pressure column on both the sides of the road. This pressure column is created due to imbalance of high pressure/low pressure energy band created by the automobiles. Due to this pressure band wind flow and create pressure thrust. The pressure thrust is sufficient to generate electricity through designed wind turbine.

Keywords: *- Bridge rectifier circuit Center shaft, Chord, Highway Wind turbine, Pressure thrust*

I. INTRODUCTION

Wind energy is the fastest growing source of clean energy worldwide. This is partly due to the increase in price of fossil fuels. The employment of wind energy is expected to increase dramatically over the next few years according to data from the Global Wind Energy Council. A major issue with the technology is fluctuation in the source of wind. There is a near constant source of wind power on the highways due to rapidly moving vehicles. The motivation for this project is to contribute to the global trend towards clean energy in a feasible way. Most wind turbines in use today are conventional wind mills with three airfoil shaped blades arranged around a vertical axis. These turbines must be turned to face into the wind and in general require significant air velocities to operate. Another style of turbine is one where the blades are positioned vertically or transverse to the axis of rotation. These turbines will always rotate in the same direction regardless of the fluid flow.

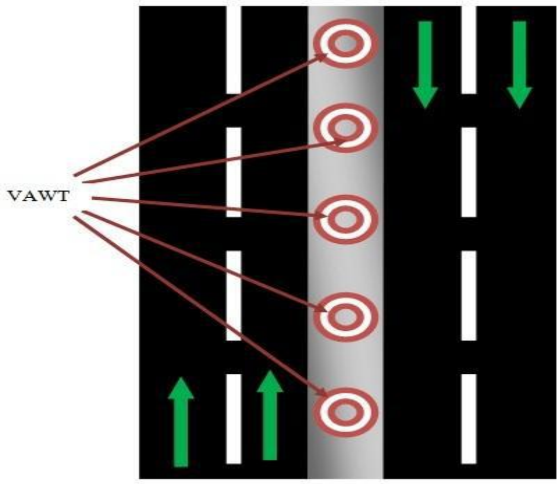

Figure 1 Turbine on highway divider

A very novel way of re-capturing some of the energy expended by vehicles moving at high speeds on our nation's highways We know how much air turbulence is generated by vehicles moving at speed particularly trucks. This would involve mounting vertical axis wind turbines at the centre of the roads that would be driven by the moving air generated by the passing traffic. The excess energy generated could be fed back into the grid or power up the villages nearby. While we'll never recover much of the energy wasted pushing air out of the way of a sixteen wheeler, even a fraction could be a significant source of power. Average vehicle speeds on the valley highways are approximately 70 mph. This power production estimate will increase exponentially with an increase in wind turbulence speed. We believe that the wind stream created over the freeways by our primary mode of transportation will create an average annual wind speed well beyond the baseline of 10 mph. In Fig. 1 shows rough sketch of highway wind turbine located on divider. Power generation is less in the downwind sector of rotation. Consideration of the flow velocities and aerodynamic forces shows that, nevertheless, a torque is produced in this way which is caused by the lift forces. The breaking torque of the drag forces in much lower, by comparison. In one revolution, a single rotor blade generates a mean positive torque but there are also short sections with negative torque.

II. WORKING PRINCIPLE

2.1 Wind induced by moving vehicles in the direction of the wind turbine

The moving vehicles may be all types of light or heavy vehicles running on road, such as two, three, four wheelers or even bigger vehicles. If the wind is properly directed towards the wind turbine blades, optimum electricity may be generated. The desired direction of wind is obtained by a means for channeling wind, in the direction of the wind turbine. Channeling of wind in a desired direction may be obtained by, at least one truncated cone or pyramid shaped housing or a pair of planar members converging towards the blades of the wind turbine. Aerodynamics is the science and study of the physical laws of the behavior of objects in an air flow and the forces that are produced by air flows. The shape of the aerodynamic profile is decisive for blade performance. Even minor alterations in the shape of the profile can greatly alter the power curve and noise level. The aerodynamic profile is formed with a rear side, is much more curved than the front side facing the wind. Two portions of air molecules side by side in the air flow moving towards the profile at point A will separate and pass around the profile and will once again be side by side at point B after passing the profile's trailing edge. As the rear side is more curved than the front side on a wind turbine blade, this means that the air flowing over the rear side has to travel a longer distance from point A to B than the air flowing over the front side.

Figure 2: Rotation of wind turbine

III. CONSTRUCTION

3.1 Blades: Wind turbine blades have on aerofoil type cross section and a variable pitch. While designing the size of blade it is must to know the weight and cost of blades. The ideal wind generator has an infinite number of infinitely thin blades. In the real world, more blades give more torque, but slower speed, and most alternators need fairly good speed to cut in. 2 bladed designs are very fast (and therefore perform very well) and easy to build, but can suffer from a chattering phenomenon while yawing due to imbalanced forces on the blades. 3 bladed designs are very common and are usually a very good choice, but are harder to build than 2-bladed designs .Going to more than 4 blades results in many complications, such as material strength problems with very thin blades. Even one-bladed designs with a counterweight are possible.

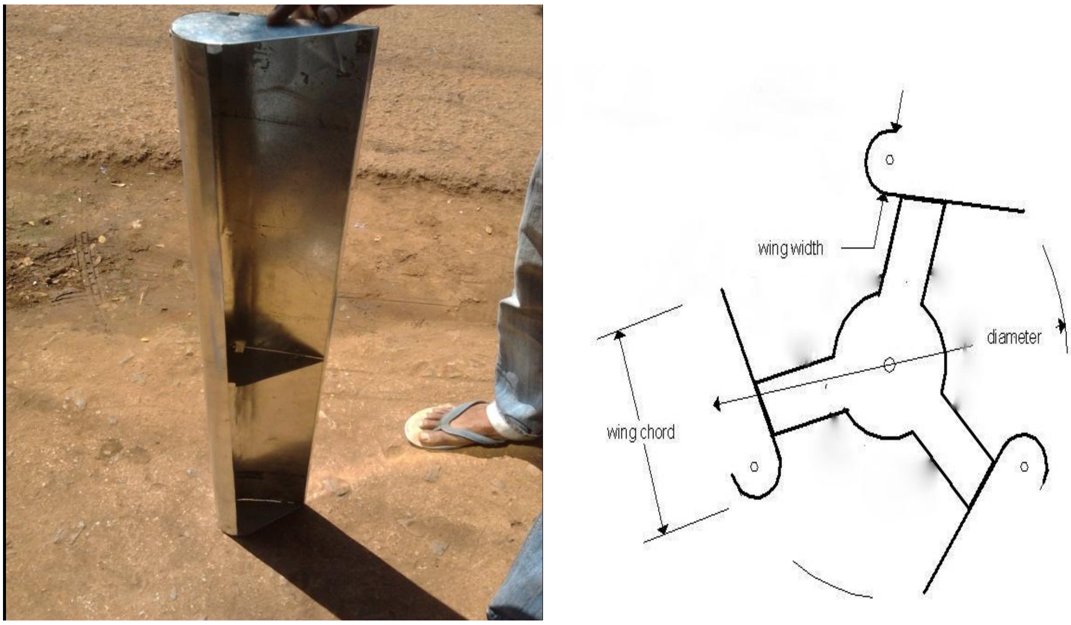

Figure 3 Turbine Blade

This number defines how much faster than the wind speed the tips of your blades are designed to travel. Your blades will perform best at this speed, but will actually work well over a range of speeds. The ideal tip speed ratio depends on rotor diameter, blade width, blade pitch, RPM needed by the alternator, and wind speed. Higher TSRs are better for alternators and generators that require high rpm but the wind speed characteristics at your particular site will make a big difference also. If in doubt, start in the middle and change your blade design depending on measured performance. The sketch and photo of designed blade is shown in Fig. 3.And Detail dimensions of blade is shown in Tab. 1.

Table 1 Designed Blade Dimensions

Sl.No.	Descriptions	Dimension
1	Length	1000 mm
2	Width	163.10 mm
3	Wind chord	163 mm
4	Wing width	76.72 mm

3.2 Center Shaft

The shaft of the turbine consists of a single 1500mm length of steel measuring 25mm in diameter. The use of steel over a lighter metal such as cast iron was based on the availability of materials. The top and bottom ends mild steel of length 1inch each are respectively are fixed to give strength to the hollow shaft. A solid shaft rotating at 75 rpm is assumed to be made of mild steel. The yield strength of a mild steel shaft material (C50) from design data is 380Mpa [1]. (380/ (2x 2)) The safe load is 300N (Approx 30Kg).The shaft of length 1500mm is subjected to bending and torsion stresses. The diameter of shaft taken is 25 mm is safe after testing both bending and torsion [2] .

3.3 Generator: For generation of electricity from the designed our vertical axis wind turbine, we chose a dynamo which has the capacity to light a bulb of 12 V. The selected dynamo is shown in Fig. 4.

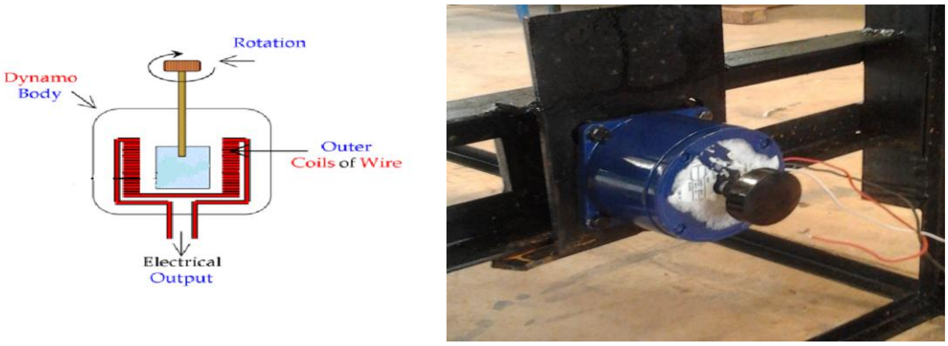

Figure 4 Generator

3.4 Bearing: For the smooth operation of Shaft, bearing mechanism is used. To have very less friction loss, the two ends of shaft are pivoted into the same dimension bearing. The Bearing has diameter of 2.54cm. Bearings are generally provided for supporting the shaft and smooth operation of shaft. The Fig. 5 shown the ball bearing used in the turbine.


Figure 5 Ball Bearing

3.5 Electrical Components: The charge controller is there to prevent damage to the batteries. If the batteries are near to full charge, but the wind is blowing strongly, the charging current needs to be reduced to prevent damage to the battery. The 1 Amp diode bridge rectifiers is shown in Fig. 6.

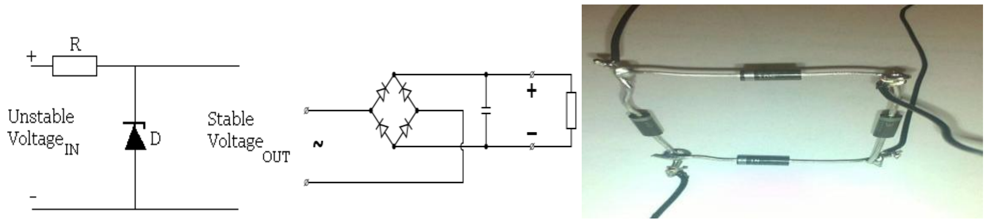

Figure 6 Amp diode bridge rectifier

The charge controller will divert some power from the generator away from the battery and into a dump load. This can be anything from a series of bulbs to a heating coil in the simplest systems this excess energy is wasted using this circuit we can store energy in battery without reverse flow and current.

IV. RESULTS

The results are taken on the basis that, 100 vehicle travelled at average speed of 70 km/hr at regular average wind speed of 4.5 m/s for the duration of 2hrs. The electric power generated from designed wind turbine is approximately 200 Watt –hr.

V. CONCLUSION

Conclusively, 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.

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