DESIGN OF TRAFFIC POWERED WIND TURBINE

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ABSTRACT

In countries where wind energy is less feasible, an energy harvesting device such as highway wind turbines can still be used for applications where less power is needed. This energy can be harvested using vertical axis wind turbines (VAWT) placed on the sides of the highways to make use of the vehicles moving in both directions. This work presents an experimental study of using a three-bladed helical VAWT specially designed for producing electrical energy from wind energy of moving cars on highways for lighting purposes such as the highway lights, traffic signals, and light guide lines. The wind speed of vehicles passing on a highway and wind power from the VAWT was measured at a number of sites on the highway sides in different countries. Results showed that the VAWT prototype can produce up to 48-Watts of power from vehicles moving on the highway, which produce an average wind speed of 4.4 m/s. The wind turbine power curve is produced from the measured data /and based on the best fit to the power curve, the efficiency of 34.6 percent is obtained, which is promising for further development of the work in commercial scale.

Key words: Energy harvesting; highway; renewable energy; VAWT; wind turbines

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LITERATURE REVIEW

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OBJECTIVE AND SCOPE

The main objective is to harvest and recapture 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 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 create a vertical axis wind mill of 50W capacity. Our aim is to design the turbine which will capture the maximum of wind in any direction by placing it at optimum place and height 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 fulfill 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 analyzing 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.

The design should provide the following;

- Be able to generate a non-trivial electricity supply to the streetlights when operating. Excess electricity can be fed back into the national grid or charge secondary batteries.

- The scale of the turbine should be within the limits of the Indian highways.

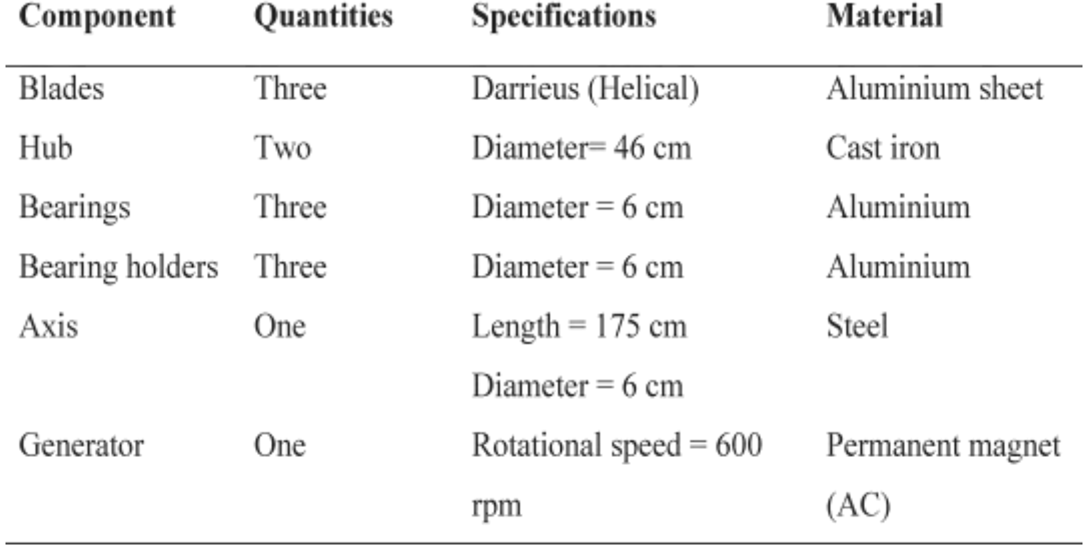
- Designed to operate at suitable wind speeds typical to India weather in highways areas.

- Possess a fail-safe system as a consequence of an over speed event.

This report will mainly focus on the computational modelling development on a Vertical axis wind turbine while providing a detailed understanding of the advantages and disadvantages of using a model-based design method, which focuses on computer simulation to predict the performance of the turbine before attempting to fabricate the turbine.

DESIGN AND METHODOLOGY

A new design of three-bladed helical VAWT model, specifically designed to be utilized on highways to generate electricity, shows the prototype of the manufactured VAWT, which was tested on highways. The turbine after manufacturing a prototype will be placed along highway in Bhubaneswar, Orissa, India ,which has high volume of fast-moving traffic. The electricity generated will be measured and stored in a battery. Because the electricity produced is direct current (DC), it will be connected to light-emitting diode (LED) with same direct current, which can be used for lighting the highway.



Component	Quantities	Specifications	Material
Blades	Three	Darrieus (Helical)	Aluminium sheet
Hub	Two	Diameter= 46 cm	Cast iron
Bearings	Three	Diameter = 6 cm	Aluminium
Bearing holders	Three	Diameter = 6 cm	Aluminium
Axis	One	Length = 175 cm Diameter = 6 cm	Steel
Generator	One	Rotational speed = 600 rpm	Permanent magnet (AC)

Prototype of 3 blade vertical axis wind turbine

An anemometer is used to measure the speed of the wind before it hits the turbine blades.

- *WIND POWER AND OUTPUT POWER CALCULATION*

Depends on the highway's car speeds, the speed of wind that hits the turbine blades is different and should be measured. This provides the expected wind power from the moving vehicles. The output power of the VAWT is separately measured to evaluate the efficiency of the wind turbine. The power available in the wind is determined by:

Wind power = $\frac{1}{2} * A v^3$.

where, v is the velocity of the wind (m/s), is the air density kg/m3; and A (m2) is the cross-sectional area that wind passes through the wind turbine. The cross-sectional area is the diameter of the rotor (D) multiplied by the multiplied by the height of rotor (H). The reference density used is the standard sea level value (1.225 kg/m3).

The power extracted by the wind turbine is determined by:

Power extracted = $\frac{1}{2} * A v^{3} * C_p$.

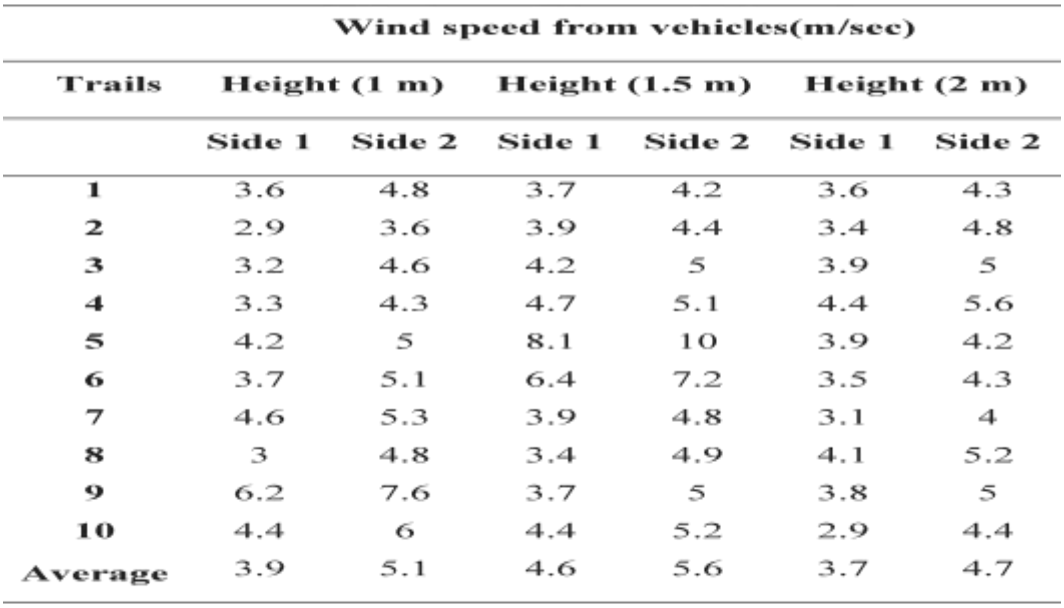
Here Cp is the power coefficient, which shows efficiency of a wind turbine design and is the efficiency of mechanical drive unit. Wind turbines cannot convert all of the wind energy into work and, unlike other generators, they can only produce energy in response to the wind that is immediately available. The maximum power that can be extracted from a given wind stream is defined by what is known as the Betz limit. The maximum value for the power coefficient is called the Betz limit (Cp-max = 0.5926), but it's hard to get this efficiency exact from wind turbine during experiment. Also, the swept area limits the volume of air passing through the wind turbine. The rotor converts the energy contained in the wind in rotational movement. ***So,*** *the greater the swept area, the greater the power output obtained for the same wind conditions.*

RESULTS AND DISCUSSION

- ***Wind Speed Measurement***

The results of wind speed measurements using a cup anemometer device are summarized in Table at three anemometer heights of 1 m,1.5 m, and 2 m. The wind speeds reported were produced by moving vehicles on the national highway.

The data was collected at 10 different trials tables**.**



Wind speed from vehicles(m/sec)						
Trails	Height (1 m)		Height (1.5 m)		Height (2 m)	
	Side 1	Side 2	Side 1	Side 2	Side 1	Side 2
1	3.6	4.8	3.7	4.2	3.6	4.3
2	2.9	3.6	3.9	4.4	3.4	4.8
3	3.2	4.6	4.2	5	3.9	5
4	3.3	4.3	4.7	5.1	4.4	5.6
5	4.2	5	8.1	10	3.9	4.2
6	3.7	5.1	6.4	7.2	3.5	4.3
7	4.6	5.3	3.9	4.8	3.1	4
8	3	4.8	3.4	4.9	4.1	5.2
9	6.2	7.6	3.7	5	3.8	5
10	4.4	6	4.4	5.2	2.9	4.4
Average	3.9	5.1	4.6	5.6	3.7	4.7

Measured wind speed of moving vehicles for two directions at high- way at three different anemometer heights from the ground base.

It can be clearly seen from the Table that when the anemometer height is 1.5 m from the ground, the average wind speed of 4.6 m/s (side 1 and 5.6 m/s (side 2) is achieved). This height leads to maximum wind energy harvesting of moving cars; hence, a hub height of 1 m provides sufficient exposure of the prototype VAWT rotor to maximum wind speeds on the highway. The data in Figure below show that the maximum average moving vehicle wind speed is 5 m/sec at anemometer height of 1.5 m. Based on that, the VAWT was set at the height 1 m so that maximum wind speed hits the middle of VAWT rotor. At a wind speed of 5 m/s, the wind power will be 207 W at the rotor swept area of the prototype VAWT; with an efficiency of around Cp = 0.3 an electrical power of 60 W is expected. With this wind speed and wind power, two 30-W LED lights will be supplied. The output power of 150 W may be needed to provide the full capacity for one lighting column; the generator can work on three light pipes of two LED lights for each.

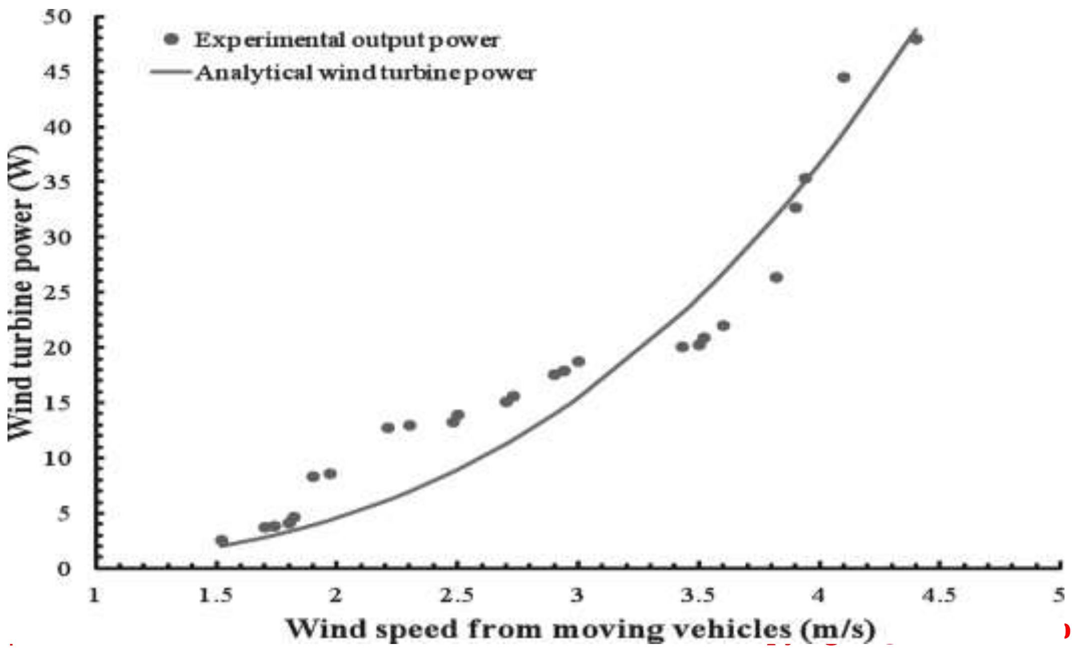


Figure: Wind speed measurements from moving vehicles at different anemometer height.

Output Power Measurements

The VAWT prototype will be experimentally tested on National highway. The wind speed readings will be by a cup anemometer at the height of 1.5 m. The output power of the wind turbine will be measured by a voltmeter and an ammeter. The measured output power and the best analytical power fit using the overall efficiency will be plotted.

It shows that the VAWT at the maximum observed wind speed of 4.4 m/s has produced 48 W electrical power compared with available wind power of 141 Watt that speed. Therefore, for such low wind speeds below 5 m/s, the VAWT overall efficiency is 34.6%, which is very promising. Figure shows the theoretical power compared to actual power obtained experimentally. It can be seen that the results are comparable.

Experimental output power and the best analytical wind turbine power fit against wind speed hitting the blades from cruising vehicles. The maximum error between experimental results and the power fit is about 1 percent. From the error analysis of the fitting function in Equation, the correlation coefficient, R = 0.95, and coefficient of determination, R2 = 0.9, are obtained. Therefore, the overall efficiency is 0.346 and the wind power extraction of the designed VAWT or the analytical output power output of the wind turbine is given by:

Power extracted = ½ A v3 (Efficiency)

This is relatively a very good achievement of the designed VAWT for such low wind speeds of below 5 m/s on the highway where the flow nature is complex.

CONCLUSION AND FUTURE SCOPE

The main aim of this project is to build a small-scale Vertical Axis Wind Turbine to generate power. These turbines are easier to construct and less investment is needed. The implementation of vertical axis wind turbine on road dividers, on side of train tracks and power supply for isolated area would be a great asset to the ministry of Non-conventional energy Resources as it would reduce the burden on the consumption of conventional energy sources. They can be installed on any highway with the width being the only constraint. Since, turbine size is small, it can harness a limited amount of wind. Therefore, they can be used for street lighting on any busy road and light up the advertisement hoardings. Furthermore, these turbines can find application in lighting up commercial buildings. Other application could be in diversions on highways, traffic lights, industrial buildings, simply in household neighborhoods.

Since the battery is portable we can use it in some other location for any low voltage purpose. Thus, there is balance between the cost and the power available. The emerging trends in the technology have shown a way to the use of non-conventional energy sources so Efficiently and a little effort at the side may find an effective solution for the boom of the electrical energy by the society.

In order to properly design a generator, there are many components that are required to be studied such as wind speed, power, current, voltage and many more. In order to calculate the important generator parameters, MATLAB script file was developed using all necessary equations. Additional constraints such as efficiency, copper and iron losses. This resulted in Successful design calculations.

Successful calculation led us to implementation of this design. MATLAB Simulink Software was used to make this VAWT simulation model. All the calculated values were Implemented and observed the output. It was significant to modify a few values to improve Output voltage and current waveforms were analyzed and compared with calculated Values.

The next step is to test each blade experimentally, both to validate the previous models as well as determine conclusively whether the new blade increases output power.

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