ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 9, September 2017

Study and Development of Hybrid Wind Turbine for Highway Side Application

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ABSTRACT:Fast moving vehicles on highways create huge wind turbulence along with it. A proper placed and well-designed wind turbine can generate electrical power with this wind turbulence. Generated electricity can be used in any applications. This paper shows a model for highway side wind turbine. A combination of two different vertical axis wind turbine (VAWT) is used to design hybrid wind turbine. The results shows several VAWT drawbacks can be removed with the help of hybrid model. This paper also analyse the efficiency of hybrid wind turbine and shows that the efficiency of Darrieus and Savonius wind turbines increases as they combined together as hybrid turbine. A prototype model has been developed and analysed in real environment for feasibility and practicality of the system

KEYWORDS: Hybrid Model, Highway Power, Charge Controller, HAWT, HSWT.

I.INTRODUCTION

On highways, vehicle moves faster than the usual. Moving vehicles on the highway create wind turbulence. When a vehicle moves on highway, it disturbs the wind present over that highway. Vehicle creates low wind pressure field and big vertex behind it while moving. The wind disturbed by the vehicle intend to cover that space created by the moving vehicle and creates huge wind turbulence at highways [1][4]. The direction of the wind turbulence is always moving along the vehicle to the centre of low pressure field. Turbulence presents at the highways along with normal breeze creates a strong wind effect near the highways. This wind effect can be easily feel by any one on the highway side.Wind turbulence at the highways is directly depends upon size and speed of the automobile along with the traffic frequency [2].

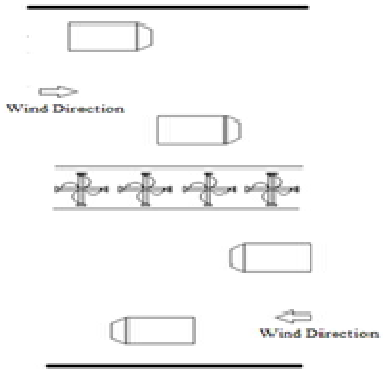

Fig. 1. Description of Wind Turbulence Generation

For highway side application, wind turbine should have capability to utilize moderate wind speed. For this purpose, it needs to have high initial torque for initial starting and high rotational capability for high wind speed [5]. All these parameters can be obtained by the combination of two VAWT turbines- Savonius and H type Darrieus Turbine. They work on two different phenomenon Drag and Lift phenomena. Savonius has S like shaped blades, this work on the drag force which acts parallel to the direction of wind flow. Whereas the H type Darrieus rotor work on the lift force that is the force which act perpendicular to the wind direction

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II. LITERATURE SURVEY

Some work has been done previously to generate green energy from highways. Zarkesh and Heidari [1] have given a model having a concrete frame at centre which include two small wind turbines placed adjacent to each-other. Each turbine is working for only one direction of vehicles have low efficiency. In another work Mr.Mukesh [2] have proposed a single rotor based wind turbine to extract highspeed wind. Proposed turbine which works on only drag force phenomena can be placed at high point or along with divider. Mr.Chavda,et.al. [3] shows a model prepared with aluminium sheet for lesser weight higher mobility and higher flexibility. Prasanth and Sudheshnan [4] have presented a unique model for extraction of power from moving vehicle by placing a turbine on roof top. All these efforts has been done in order to achieve a better reliable and flexible source of green energy from fast moving vehicle on highways.

III. DESIGN CONSIDERATION

Combination of two different turbines enhances the efficiency of power generation in road side application. Different materials are used to manufacture both the turbines. The selection of material is based on the availability, reliability and cost [3].

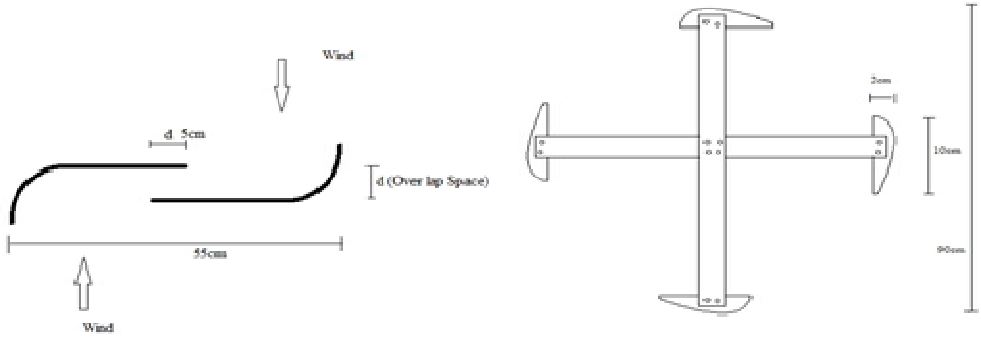

Fig. 2. Savonius and Darrieus Turbine

A. Designing of H type rotor:

Component used: Wooden airfoils, wooden cross shaped wood, Nut bolts, L shaped Aluminum connectors

- Dimension of airfoil= 90*1*7cm
- Dimension of turbine (l*b*h) = 100*100*90cm

B. Designing of Savonius:

Component used: Aluminum sheet, L-shaped connectors

- Length of turbine= 55cm
- Overlap Space= 5cm
- Ratio of Bend and Straight Blade= 1:1 (15cm:15cm)

Darrieus turbine is not self started, so to make it to start at low wind speed an external model is used along with it. They are very suitable to generate power at high wind velocity due to its structure and lift forces. Savonius turbines provide high torque at low wind speed but these turbines have limited rotational speed due to its heavy structure at high wind. Two different wind turbine structures are combined with each other to form hybrid turbine. This hybrid turbine has capability to generate high initial torque and high rotational speed for low and high wind velocity respectively.

IV. POWER CALCULATIONS

The power generated by the turbine depends upon the various parameters that are wind speed, density of air, mass of the air. Kinetic energy of wind is given as

$$K = \frac{1}{2} * m * v^2 \text{ (in watts)} \quad (1)$$

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Here, m= mass of the wind, v= velocity of wind
Mass flow rate is depends upon the swept area of wind turbine, velocity of wind and density of wind so,

$$m = A * v * D \quad (2)$$

Here, A = area swept by rotating blade, D = density of air, v = velocity of air
Therefore from (1) and (2)

$$K = \frac{1}{2} * A * D * v^3 \text{ (in watts)} \quad (3)$$

Based on equation (3), Darrieus turbine theoretical power,

$$P = \frac{1}{2} * Cp * A * D * v^3 \text{ (in watts)} \quad (4)$$

Cp is the lift force coefficient. Based on equation (3), Savonius turbine theoretical power,

$$P = \frac{1}{2} * Cd * A * D * v^3 \text{ (in watts)} \quad (5)$$

Cd is the drag force coefficient. In case of hybrid turbine, area A = l*b
Therefore theoretical power,

$$P = \frac{1}{2} * (Cp + Cd) * l * b * D * v^3 \text{ (in watts)}$$

Generally Cp=.35 and Cd=.20 which shows efficiency of hybrid turbine is 1.25-2 times greater than Darrieus and Savonius turbines [6].

V. RESULT AND ANALYSIS

Present work results with the mechanical hardware along with the electronic hardware. This mechanical hardware consists of the hybrid wind turbine model. Figure 3 shows the implemented model for hybrid wind turbine

Fig. 3. Final Prototype of HSWT

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This Hybrid model is tested and analysed in real world environment. Output of the system is measured as the power generated by highway side wind turbine. Voltage is the key parameters for battery charging purpose so the chart given for power generation for specific time with shows its values in volts. 24V, 300rpm, 10Amp geared DC Motor/Generator is used to generate power for this turbine. Voltage level generated by HSWT on 10th July 2014 is shown in the figure 4. Result shows us during peak traffic time as office hour, power generation is also increases to its peak for a single unit. This system can generate energy during no traffic time with the help of generalize breeze. With the help of grid cluster network and facility the HSWT can make a significant impact on street lightning or blackout problems in road side areas

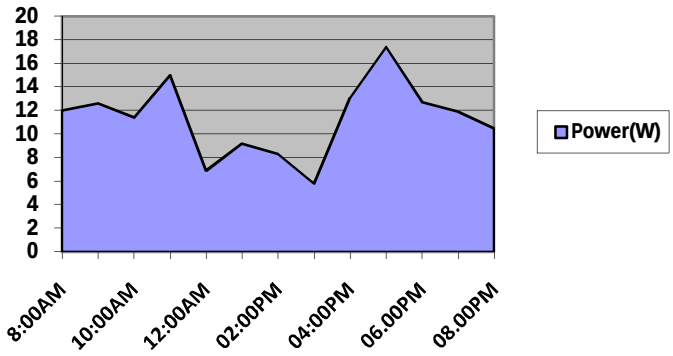

Fig. 4. Power generation by wind turbine on highway side testing

Performance comparison with available wind turbine is shown in Table I. It shows comparison between designed hybrid wind turbine and various available with turbine based on the theoretical, structural and on field results.

Table I. Comparison Chart with Other Turbines

Properties	3 Blade VAWT	Darrieus HAWT	Savonius VAWT	Hybrid Turbine
Direction Sense	Required	Not Required	Not Required	Not Required
Suitable for Wind Speed	Moderate	High	Low	Moderate
Starting Methodology	Self-Starting	Not-Self Starting	Self-Starting	Self-Starting
Maintenance	Not Easy	Easy	Easy	Easy
Efficient	High	High(high speed)	Low	Moderate
Lift/Drag Coefficient	0.46 (Approx.)	0.35 (Approx.)	0.20 (Approx.)	0.20-0.40(Approx.)

VI. CONCLUSION

Wind is a cost effective, green, renewable energy resource for power generation. Highway side application of wind turbine with improved efficiency can help us to reduce a gap between demand and supply of power. An efficient hybrid wind turbine is designed to use in road side application for energy generation. This turbine is specially designed to generate energy by utilization of natural wind and wind turbulence created by the moving vehicles on the highway. Winds from all the direction are utilized by this turbine. This turbine is self-starting, easy to installation, low in cost and suitable for both high and low wind speed. Turbines show 2.75 and 1.57 times better efficiency than the Savonius and Darrieus turbines respectively. Practical testing is also done on the highway for feasibility analysis of the system. With the proper attention from local authorities highway side implementation can provide a reliable source of energy in remote areas.

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