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Power Generation by Hybrid VAWT System for Highway Applications

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ABSTRACT

The rapid growth of renewable energy generation is increasing to meet the demand for electricity. In this paper, the generation of electricity is achieved by using vertical axis wind turbine using the force created by moving vehicles. For that purpose, wind turbines are placed at the center of the highway for the generation and utilization. There are two types of the axis is available in wind turbines, horizontal and vertical axis. The horizontal axis is commonly used but it is not applicable for highway applications. There are some types of turbines are available in the vertical axis. In this paper, two types of turbine blade model are made as a hybrid in VAWT (Vertical Axis Wind Turbine) which increases the efficiency in wind energy utilization. Due to this hybrid model, drag and lift are increased and rotate automatically even with low wind speed. The power generated by this VAWT can be utilized for highway applications, and then the excess power will be injected into the grid or local area. The power is stored in the battery bank which is placed under the windmill and utilized at the night time for lighting purpose on the highway. Q-Blade software is used to design the blade shape and the efficiency improvement is verified by Q-Blade.

Keywords: *VAWT, Alternator, S and D Blade, Geared PMDC, Aerodynamics, Q-Blade Software.*

1. INTRODUCTION

Energy plays a vital role in our day to day life. Without the energy, it is impossible for a man to survive in the world. Considering the future demand use of renewable energy is very important. In renewable energy there are many methods are present. Some of the renewable resources are eco-friendly. Some of the non-renewable resources are causing pollution while utilizing. Some of the renewable energies are mostly in use namely Geothermal, Biomass, Solar, and Wind. The wind energy is one of the rapidly increasing sources of energy. The major issue with this technology is fluctuation in the source of wind. The present design of Wind mills cannot be implemented in our normal surroundings due to huge structure and its cost is high. It is not much sensitive to all wind directions but it needs some supporting equipment for guiding the Turbine along with the wind direction. In traditional design and methodology, the efficiency is achieved up to 30-40% and yet developing. The major thing which matters in the traditional way is increase cost of design, transportation, installation, and maintenance.

This paper concentrates on the wind energy is induced by the vehicles and using that energy, the wind turbine can get the wind power. In highways, lots of vehicles are passing each and every minute. Mostly the wind energy induced rate is high in heavy vehicles like trucks, cars, minivans, and buses. In the middle of the highway, these turbulence rate is high due to the vehicles. By using the vehicles wind force the turbine gets the kinetic energy for the energy conversion.

2. LITERATURE SURVEY

Some work has been done previously to generate energy from highways. In wind energy, there are many ideas and several prototypes are done and implemented with particular details regarding that paper or ideas.

Using VAWT the generation of (power) electricity using the energy induced by a vehicle in the highway. If the generator is modified to high rating the generation will be higher [1] [2].

Developing a new application for wind generators in highways, Using wind turbines in the highway in order to store, provide and distribute electricity for the highway and surrounding areas. Electricity generation with low cost, more lifetime [3] [4].

VAWT is designed with less weight and more stiffness. The power developed using VAWT is used for street lights and remaining powers are stored in battery [5] [6].

Vertical Axis Highway Wind Mill Using Magnetic Levitation, use of Mag-Lev technique, the efficiency of the project is get improved because it reduces the frictional losses and increases the rotational speed. The maglev wind turbine is able to rotate

at minimum wind speed. Electricity generation with low cost, more lifetime, generation in minimum wind force [7].

Study and Development of Hybrid Wind Turbine for Highway Side Application, in this paper the two different types of blades are combined as hybrid to achieve the high efficient VAWT [8] [9].

From the survey, the VAWT model can be designed and the calculations were made according to these references and also with the survey for the wind velocity and the foil standards were considered accordingly.

3. OBJECTIVES

The main aim of the paper is to generate the power with high efficiency. This is achieved by coupling two types of the turbine in VAWT. It increases the efficiency of the of the wind mill. It combines Darrieus and Savonius VAWT. Due to this coupling direction sense is not required it rotate in all the direction based on wind flow. Drag and lift of blade are increased rotational per second even in low-speed turbine will rotate. The main advantages of using VAWT are that they do not have to be turned into the wind stream as the wind direction changes. It also reduces the global warming.

The needs for succeeding in this objective there are several important things are required to achieve. They are calculations for designing the turbine, power calculation, wind velocity, wind density for the region and simulation details using Q-blade (or some other simulation tool), wind tunnel result for the blades, and wind drag and lift analysis.

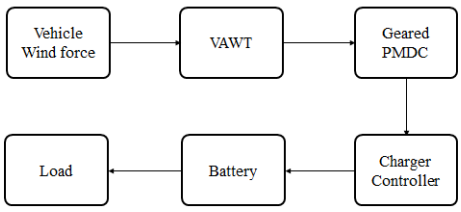

Fig.1 Block Diagram

4. DESIGN AND CONSIDERATIONS

In the design of hybrid vertical axis wind turbine, the blade models of Darrieus and Savonius are combined together to get the high lift and drag. For the design of the NACA foil design, this blade design is achieved. Under the NACA this design is called as low lift and high drag blade.

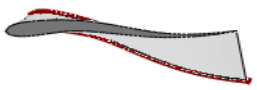

Fig.2 Blade Design

From the fig.2 the hybrid model is shown, this structure is done under the Q-blade air foil design and simulation software.

Dimensions of the blade:

- Length = 40cms
- Breadth = 15cms
- Twist = 20º

Depending upon the reliability and the availability this prototype is developed by using the following materials. The materials namely aluminum alloyed metal sheet, shaft, gear, PMDC 24v 300rpm generator.

5. WIND SURVEY

In highways, most of the vehicles are heavy like trucks, buses in the case of cars and minivans the wind turbulence is low when we compared with the trucks and buses.

According to the survey, the average wind velocity of trucks and buses creates half of its own speed. While in the cars and minivans the turbulence created is low due to its aero dynamical design. Under the normal climate condition, the average wind density is 1.225kg/m^3, and the average wind velocity is 1.3m/sec form the ISA (International Standard Atmosphere).

From this data, the wind energy rate will be 15.31joules accordingly. With these data, the target will be achieved. PMDC generator is used for the conversion; the generated power is stored in the battery bank with the help of charger controller.

6. SIMULATION AND RESULT

i. Software Used

Q-Blade software is used for the design and analysis. It is one of the open source software for the design and simulation for the vertical and horizontal axis turbine. It consists of the respected parameter for the test and analysis.

ii. Formulas Used

The kinetic energy,

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

Where,

A = swept area,
D = density of air,
v = Velocity of air

Power Generated for Darrieus Model,

$$P = \frac{1}{2} \text{ x } Cl \text{ x } K \text{ (in watts)}$$

Where

Cl = coefficient of lift

Power Generated for Darrieus Model

$$P = \frac{1}{2} \text{ x } Cd \text{ x } K \text{ (in watts)}$$

Where

C = coefficient of drag

From the respected calculations, the result has shown that hybrid turbine model is 2.75 times higher efficient than the individual models.

iii. Simulation Results

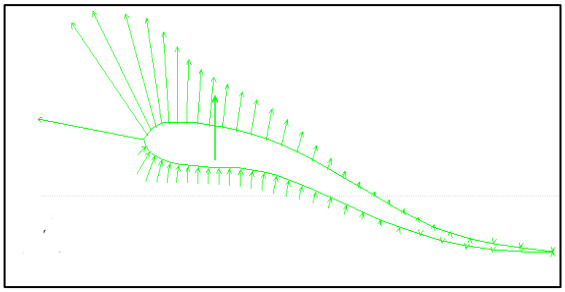

Fig.3 Pressure in foil

The respected design and parameters the drag graph is shown in the fig.4

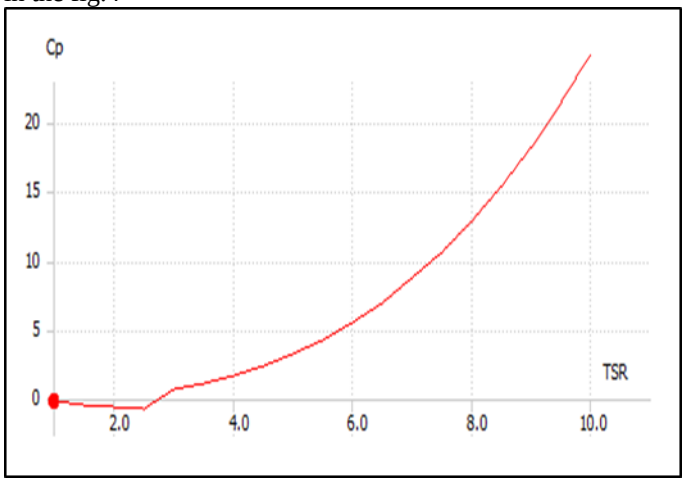

Fig.4 Power coefficient vs tip speed ratio

The Power graph is shown below in the fig.5.The result is tested at the various speeds and the TSR.

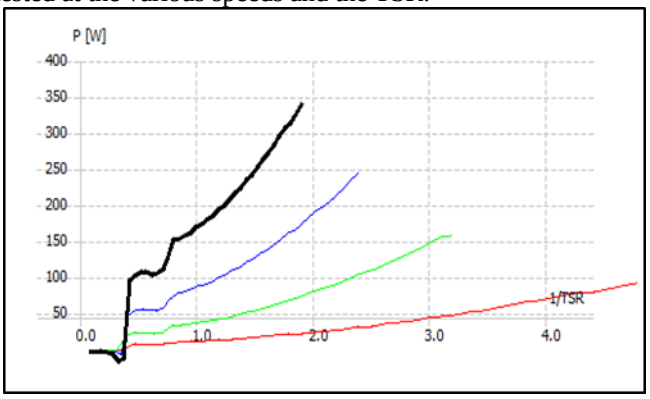

Fig.5 Power vs tip speed ratio

The drag and the lift graphical representation is given below for the hybrid system. The drag represents the Savonius model and the lift represents the Darrieus model of the VAWT. The fig.6 represents the Lift vs Drag of the hybrid model.

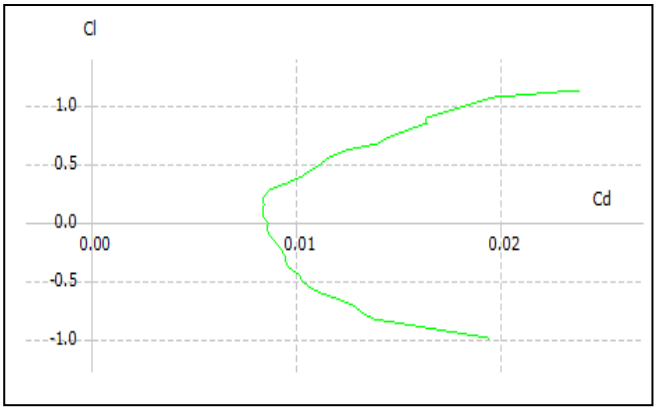

Fig. 6 Lift vs Drag

The Hybrid model's wind tunnel test picture was shown in the below fig.7

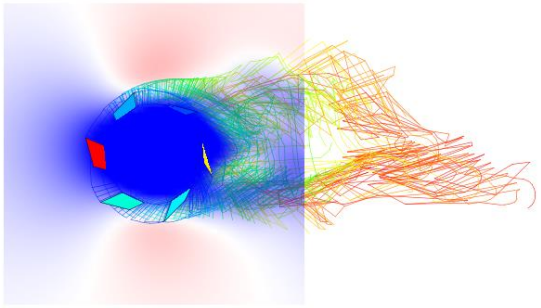

Fig.7 Wind tunnel test

From the figure, the red coloured area represents the drag, Blue coloured area represents the lift, and thread-like lines represents the aged wind which was utilized by the turbine.

7. CONCLUSION

Therefore, the energy can be converted into electricity even from the moving vehicles on the highway. This project can also be developed by changing the number of blades and with the materials used. This is applicable for the entire region, and the regional parameters also are taken in to account for the better results. Hence this hybrid model has achieved 2.75 times higher efficiency from the existing model, in the simulation with the wind tunnel tests and the lift and drag parameters, 1.25 times higher efficiency is achieved.

This idea does not require any limitations and large space like nuclear or other types of power plants, it is possible to be built in any highway around the globe and produce more electricity. This type of power plant is the best solution for controlling the global warming.

8. FUTURE SCOPE

In the top of the wind mill the solar panel can be fixed with high power lamp for the purpose of lighting. By using this solar panel the electricity produced by the wind mill can be saved and used for nearby home towns. The same setup can be installed at the roof tops of the buildings to supply electricity for the houses. It can be used anywhere it always eco-friendly. For increasing the energy and power of the wind turbine replace the old wind turbine by alternate one. This replacing is known as repowering, this repowering is also a viable solution for increasing the output.

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