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Design and Simulation of Vertical Axis Wind Turbine for Highway Electrification

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***Abstract*— The present day situation is having high demand for power consumption. The effective way and efficient way of generating power is being restructured day by day. This paper presents the method of developing the VAWT for generation of power efficiently for highway electrification.**

Index terms— HAWT, VAWT, NACA Foil, Aero Dynamics

1. INTRODUCTION

The demand for power is ever increasing. Fulfilling of these demand is an important factor. Considering ecological and environmental factors, the use of renewable energy is finding its significance. Specially the wind energy is finding its application in the recent years, due to few drawback of solar energy source.

The horizontal axis wind turbine (HAWT) having its application towards medium and high scale of power generation, the vertical axis wind turbine (VAWT) is being used for small and medium scale of power generation.

In this paper we are present a concept of developing a VAWT for highway electrification. The movement of vehicle in anti parallel direction of road will produce a sufficient amount of wind to generate power for highway electrification, as the wind produced due to fast moving vehicle will be tangential to the wind blades. The power generated can be used for street lights, toll plaza, or even can be connected to grid. In the later section we discuss the designing and simulation of VAWT

2. BLOCK DIAGRAM

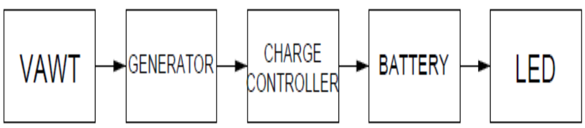

Figure 2.1: Block Diagram of VAWT for Highway Electrification

3. DESIGN AND SIMULATION

Optimum design of the turbine is very important in the development of this concept. Design of the vertical axis turbine for the highway wind power generation is discussed. Before starting the design of the wind turbine, it should be made sure that sufficient wind energy is generated by the moving vehicles on the highways for the operation of the turbine. So, wind readings were taken in the highway.

Q-blade software was used for the construction and simulation of the wind turbine blades. The aerodynamics of a wind turbine is influenced by far field conditions far up and downstream from the rotor. At the same time, they depend on small scale turbulent flow conditions around the blades. This implies the need for a large simulated domain as well as a fine special resolution. National Advisory Committee For Aeronautics (NACA) is airfoil shapes for aircraft wings.

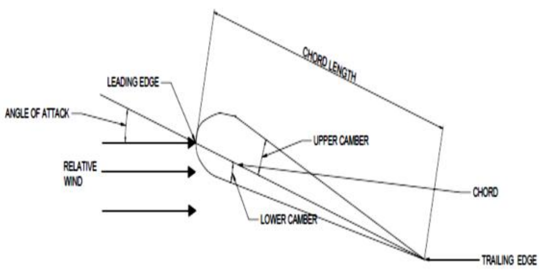

Figure 3.1: NACA Foil

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The NACA four-digit wing sections define the profile by: The NACA 0015 airfoil is symmetrical, the 00 indicating that it has no camber. The 15 indicates that the airfoil has a 15% thickness to chord length ratio: it is 15% as thick as it is long. The NACA 2412 airfoil has a maximum camber of 2% located 40% (0.4 chords) from the leading edge with a maximum thickness of 12% of the chord.

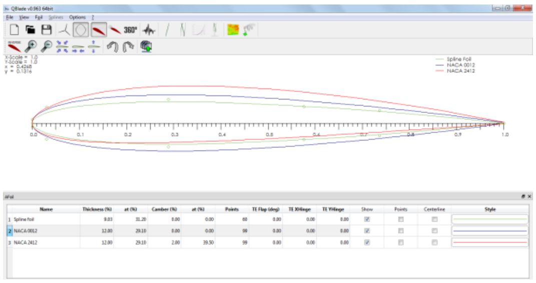

Figure 3.2: Plot Of NACA Foil 2412 And 0012

The camber line is shown in red, and the thickness – or the symmetrical airfoil 0012 – is shown in purple.

Equation for a cambered 4-digit NACA airfoil

The simplest asymmetric foils are the NACA 4-digit series foils, which use the same formula as that used to generate the 00xx symmetric foils, but with the line of mean camber bent. The formula used to calculate the mean camber line is:

$$y_c = \begin{cases} \frac{m}{p^2}\left(2p\left(\frac{x}{c}\right) - \left(\frac{x}{c}\right)^2\right) \ldots\ldots 0 \le x \le pc \\ \frac{m}{(1-p)^2}\left((1-2p) + 2p\left(\frac{x}{c}\right) - \left(\frac{x}{c}\right)^2\right) pc \le x \le c \end{cases}$$

where:

- m is the maximum camber (100 m is the first of the four digits),
- p is the location of maximum camber (10 p is the second digit in the NACA xxxx description).

For this cambered airfoil, because the thickness needs to be applied perpendicular to the camber line, the coordinates (x_U, y_U) and (x_L, y_L), of respectively the upper and lower airfoil surface, become:

$$x_U = x - y_t sin\theta, \;\; y_U = y_c + y_t sin\theta$$

$$x_L = x + y_t sin\theta, \qquad y_L = y_c - y_t sin\theta$$

Where

$$\theta = \arctan\left(\frac{dy_c}{dx}\right)$$

$$\frac{dy_c}{dx} = \begin{cases} \frac{2m}{p^2}\left(p - \left(\frac{x}{c}\right)\right) \ldots\ldots\ldots\ldots\ldots 0 \le x \le pc \\ \frac{2m}{(1-p)^2}\left(p - \left(\frac{x}{c}\right)\right) \ldots\ldots\ldots\ldots pc \le x \le c \end{cases}$$

Table 3.1: Readings Taken From The Survey

Day	Average m/s	Day	Average m/s	Day	Average m/s
1	3.04	15	4.92	29	2.49
2	3.17	16	4.28	30	2.07
3	1.82	17	4.09	31	3.07
4	1.94	18	3.02	32	3.24
5	1.225	19	2.27	33	2.64
6	2.48	20	2.44	34	2.48
7	2.72	21	2.06	35	2.44
8	2.29	22	2.7	36	2.17
9	2.57	23	2.53	37	2.28
10	3.4	24	2.31	38	2.32
11	3.92	25	2.49	39	3.56
12	3.23	26	2.32	40	2.79
13	3.3	27	3.88	41	2.75
14	3.74	28	2.87	42	2.54

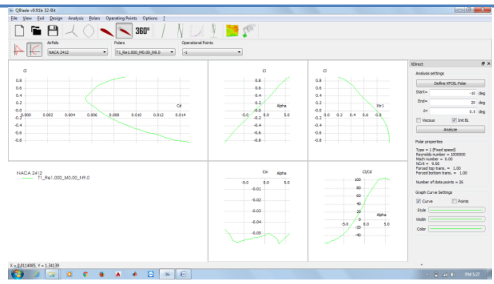

Figure 3.3: Graph Showing The Co-Efficient Of Performance

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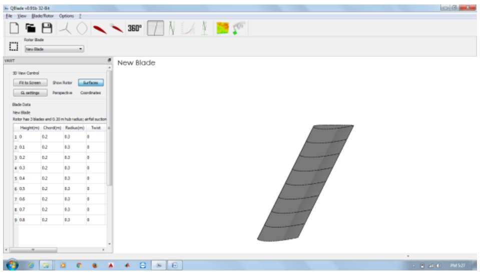

Figure 3.4: Simulation Of Blade Using NACA 2412

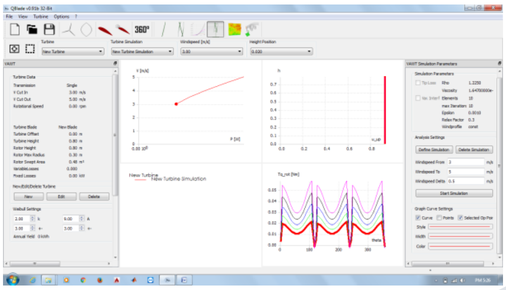

Figure 3.5: Simulation Graph From 3 m/s To 5 m/s

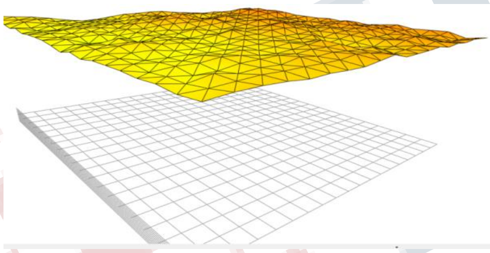

Figure 3.6: Simulated Graph Of Acquired Wind Field

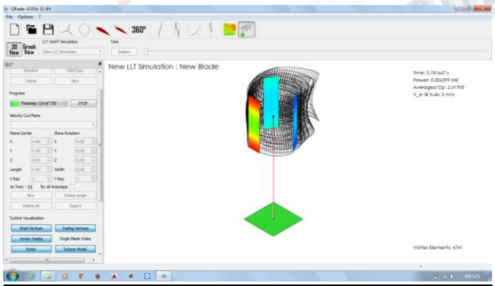

Figure 3.7: simulated VAWT with output obtain max 1KW

4. SUMMARY

The proposed model of vertical axis wind turbine is one of the good sources of renewable energy. The energy generated by moving vehicles can be utilized to generate electricity.

The flow of wind depends on the intensity of moving vehicles, size of the moving vehicles and speed of vehicles therefore a survey was done on Tumkur highway for 42 days to get the average wind speed on the location. The wind velocity obtained during the survey was 3m/s.

The design and simulation of the wind blade is done with the help of survey. The simulation result is giving up to 1KW of power

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