Study of Application of Aero-Leaf Wind Turbine

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Abstract – *Wind energy is one of the most important sources of renewable energy generation in recent time. With increase in demand of electricity to provide facilities at numerous places, today we also see an increase for various methods to utilize renewable sources of energy. The proposed paper, Application of Aero-leaf wind turbine is based on the idea of how to use wind energy in a more effective and efficient manner. Wind energy is a carbon free source of energy generation. An Aero-leaf is an independent source of electrical energy generation. This paper presents the idea about using a leaf shaped turbine appropriately so that maximum energy can be generated without much expense. As a solution to the requirement of high electricity and its dependability on hydropower and natural gas, proper application will help to reduce load on other form of electricity generation techniques. By provision of an aero-leaf we can save huge amount of fossil fuel, electricity and capital.*

Key Words: aero-leaf, carbon free, innovative technique, proper provision, saving land, natural gas and capital.

1. INTRODUCTION

With increase in population and pollution there is a need to generate electricity by sustainable and renewable energy sources. Most turbines used today are windmills which require large space and constant high speed wind for electricity generation. Hence, to use wind force in an optimum manner there is need to come up with an ideal structure and concept to obtain better efficiencies by these methods. Today with increase in usage of electricity for various purposes such as advertising banners, street lights, bus stations, restaurants and hotels, railway stations, offices and residential buildings, there is a need to reduce load on the main supply of electricity generation. With the help of modern techniques and software we can think of more effective solutions to deal with this problem. In recent times there have been new ways coming up to make use of micro wind turbine and its benefits but this lacks thorough research and development. Aero-leaf wind tree when first introduced was in the form of a tree which required a wide space for installation. Also with increase in land cost and shortage for implementation of energy generating plant, an alternate solution in the form of aero-leaf wind turbine has been thought of. The aim of this paper is to explain in detail about all the parameters involved in an efficient aero-leaf wind turbine to generate electricity in public spaces.

2. OBJECTIVES

The following mentioned objectives are set to achieve by this paper:

- To capture a major amount of wind and utilize it for various applications.
- To design aero- leaf turbines that could generate power at highways, express-ways and other major roads.
- To reduce load on main electricity supply division by proper fabrication and installment of turbine to reduce requirement of land
- To generate more power without use of heavy, large blades.
- To reduce the requirement of land/space to install turbines.

3. AERO-LEAF

The primary function of a wind turbine is to convert kinetic energy from wind to mechanical and thereby to finally electrical energy. Aero-leaf wind turbine is basically a modified version of wind turbine which generates electricity as it is receives wind from all directions. Flexibility of aero-leaf turbine helps to achieve maximum energy. Installation of such turbines should be in a location where wind with sufficient velocity approaches the turbines from any particular direction about the vertical axis and it rotates as per the direction of tangential force produced by the wind. Hence, aero-leaf turbine is designed by considering vertical axis rotation where two leaves facing in opposite directions to each other rotate around a single vertical axis. This further helps in continuous rotation of aero-leaf and get high output power.

The Aero-leaves are majorly made up of nylon fiber, molded into the shape of leaf to obtain a bucket-like structure. As both the leaves attached to a single axis are facing the opposite direction, when the wind approaches the curved portion of the leaf, the force produced will rotate it around the vertical axis. The ring structure will be attached to a steel plate and pole, forming a base for the leaf to rotate freely. The motion will not be disturbed until wind stops in that particular direction. Thus this technique will not require use of large blades for generating current as the leaf itself will help to generate current. Also very less surface area is required to install it as it is provided on the roof surface or place it with support of an object already installed on land.

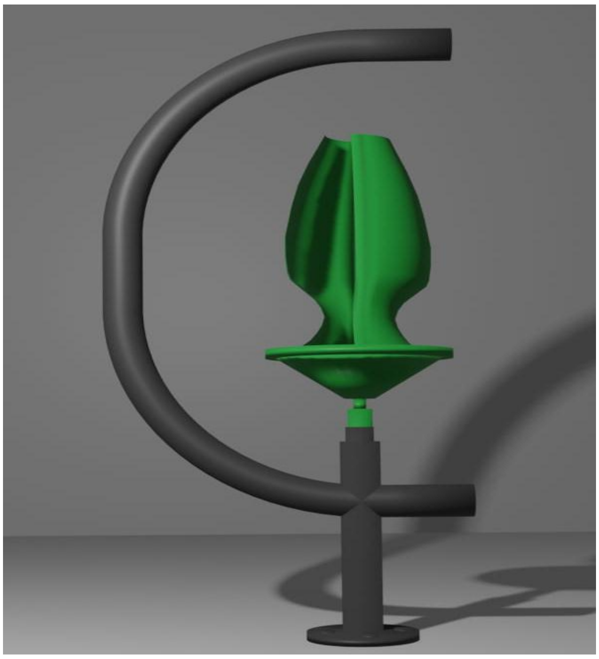

Fig -1: C- Shaped framework for aero leaf turbine

4. VERTICAL AXIS WIND TURBINE (VAWT)

- The rotating axis of the blades is perpendicular to the direction of wind.
- The main rotor shaft runs vertically in VAWTs.
- VAWTs are mainly beneficial in areas with turbulent wind flow such as rooftops, coastlines, cityscapes etc.
- The rotor can accept wind streams from any direction.
- Inspection and maintenance is easy.
- They can operate even at low wind speeds.

BENEFICIAL FACTOR OF VAWT

Power generation efficiency	Above 70%
Wind resistance capability	Strong
Noise	0-10db
Starting wind speed	Low
Failure rate	Low
Cable stranding problems	No

Fig -2: Ring structure for aero leaf wind

5. COMPONENT PARTS

Material	**function**
Nylon Fiber	For aero-leaf structure
Steel	For ring structure
Generator	To convert kinetic energy into electrical energy
Battery	To store and supply energy
Inverter	Converts DC current to AC current
Control box	To control the operation and monitor the performance.

6. ESTIMATED POWER CALCULATIONS

We know, the drag force acting on a turbine is given by,

$$F = C_D \frac{1}{2} \varrho A \mathcal{V}^2$$

∴ The power developed by the turbine is,

$$P_{input} = F \times \mathcal{V} = C_D \frac{1}{2} \varrho A \mathcal{V}^2 \times \mathcal{V} \quad ... [1]$$

Where, ϱ = Density of air = $1.2\, kg/m^3$

A = As 4 turbines are mounted on 1 pole hence, all of these will contribute in power generation thus area = $4 \times (0.3 \times 0.3)$ m

$\mathcal{V}$ = Velocity of rotation of turbine in m/s

C_D = Maximum power coefficient given by Webster ≅ 0.59
Take $C_D = 0.40$

We also know, the Power required to light an LED Bulb is nearly 80 Watts. Assuming the Efficiency of Power Generation as 85%. Therefore, the power to be developed by the Turbine can be given as,

$$\eta = \frac{P_{output}}{P_{input}}$$

$$\therefore\ P_{input} = \frac{80}{0.85} \cong 100\, Watts$$

Thus, the velocity with which the turbine should rotate so as to generate sufficient power to light an LED bulb can be given by equation [1],

$$100 = 0.4 \times \frac{1}{2} \times 1.2 \times 4 \times (0.3 \times 0.3) \times \mathcal{V}^3$$

$$\therefore \mathcal{V} = 10.5\, m/s$$

Further as there four leaves connected on each turbine and when it rotates about the vertical axis due to the wind action the effective total diameter of 0.6m considering two leaves in diametrically opposite direction act on it. Thus, while converting this tangential velocity into RPM using this equivalent diameter we get,

$$\mathcal{V} = \frac{\pi D N}{60}$$

$$\therefore N = \frac{10.5 \times 60}{\pi \times 0.6}$$

$$\therefore N = 334.39 \cong 335\, RPM$$

Thus, we get the result that the turbines will generate sufficient power to light an LED bulb while rotating with a velocity of 10.5m/s and speed of 335 RPM.

Accordingly, if we repeat the similar calculations for various wind speeds with respect to power developed by the turbine as the wind velocity would not be constant over the entire design life. Then, with this we plot a graph of Wind speed versus Power developed by the turbine which can be presented as graph shown in fig-3.

7. APPLICATIONS

7.1 Roadways: Highways, Major roads

The aero-leaf wind turbines can be installed on the street light located along the median of the road or edge of the road as the turbine will receive wind from both sides. Such light poles are generally separated by few meters

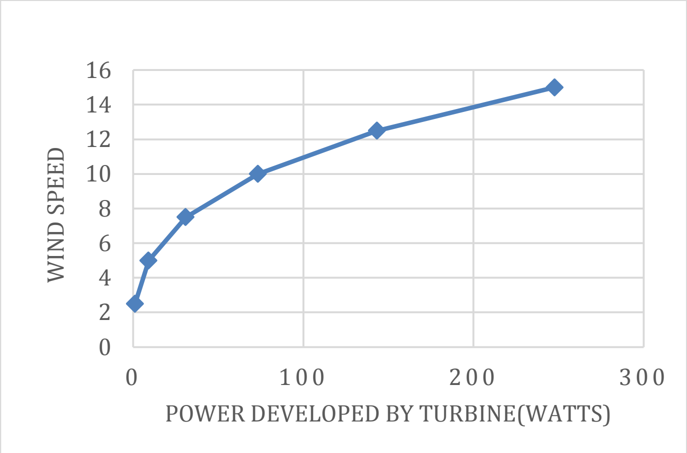

Fig -3: Graph of Power vs Wind Speed

from each other. The pole of such street light will act as a support for the aero-leaf turbine to stand and generate as the wind hits the turbine. The rotation of the turbine totally depends on the wind speed and RPM power of the turbines. The aero-leaves will be mounted on ring-type structure for support; this structure will be attached to the pole. The Whole structure is detachable to carry out maintenance and repair work if needed.

These aero-leaves will rotate day and night whenever the wind blows and also store energy for the time of excess requirement. Unlike solar panels, the aero-leaf wind turbine doesn't get affected if there is no presence of sunlight or weather is dark and cloudy. As all the components are covered and protected it will not get much affected by rain or wind.

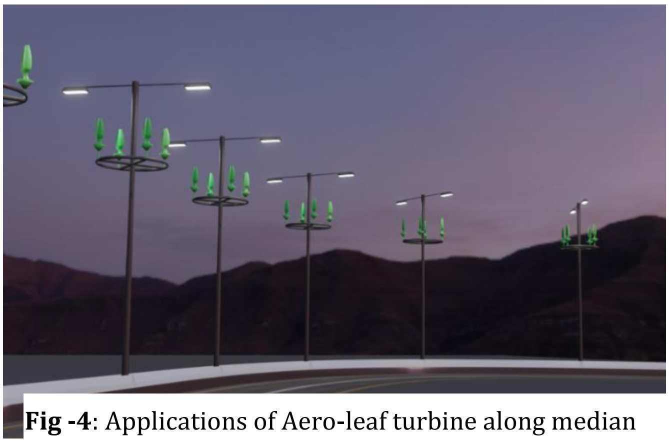

Fig -4: Applications of Aero-leaf turbine along median

7.2 Stations and Yards: bus, railway (and e-cars)

Aero-leaves can also help to generate current in small areas having multiple applications or requirements such as advertising banners, ATMs, e-counters, lights for bus station, in parking area etc. this aero-leaf if installed properly in large empty strips of land can serve many small purposes for which are now dependent on main power supply. With proper calculations for the average wind speed near sea shore or yard, installment of aero-leaves can also serve as a solution to many small power problems.

If we plan for the future, it can be useful for electric cars. About 60-65 aero-leaves can generate a huge amount of electricity needed to run e-cars.

Similarly, aero- leaf can also be useful for:

- hotel and restaurants
- parking areas
- public parks and children playgrounds
- malls and shopping centers
- high- rise buildings
- small factories/ industry

8. CONCLUSIONS

The project highlights the topic of proper framework and installment of aero-leaves. If we provide aero-leaf wind turbines on the road median or any roof surface, we can generate a good amount of electricity and this will help to reduce load on the main supply division. By above calculation we can say that this is the most effective way to use wind force and generate electricity. It has no demand for land and blades hence, providing this turbine in major public spaces with proper protection and measurement will be the most useful and appropriate way to generate electricity. By this project we are also making sufficient use of renewable energy source and reducing stress on non- renewable energy sources. This project will help to reduce carbon footprints. This method will also generate employment and give a good aesthetic view to the city. The idea of making use of space already in use instead of occupying new space will help the city in future.

9. ACKNOWLEDGEMENT

We would like to express our gratitude to Sigurd Johannes Savonius who invented vertical axis wind turbines and gave us wide scope to think more on vertical axis wind turbines. The idea of leaf shaped structure helped us to think innovative and unique.

We would like to thank Jerome Michaud Lariviere, founder of New wind. His idea of using height to harness wind proved to be beneficial for urban cities. It helped us to think about making use of height and pole structure to place the aero-leaf.

We would also like to thank Saeth Geirsson, Founder and CEO, Icewind, for taking the idea of VWAT to new level and coming up with innovative and effective solutions. His work helped us to design the framework for aero-leaf wind turbines and think of generating current for major public spaces.

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