International Engineering Journal For Research & Development

Vol.3
Issue 2

E-ISSN NO:-2349-0721

Impact factor : 2.25

DESIGN AND FABRICATION OF VERTICAL WIND TURBINE FOR POWER GENERATION AT HIGHWAY MEDIANS

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ABSTRACT

The main objective is to harvest and recapture the maximum amount of wind energy from the automobiles running on the highways. In most cities, highways are a faster route for everyday commute and in need of constant lighting makes this an efficient way to produce natural energy. 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 500W 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 medians to aid electricity consumption.

Keywords

Aerodynamics, Darrieus and Savonius, highway medians, involute, spiral blade, power generation, vertical axis, wind turbine.

Introduction

The function of connecting rod is to transmit the thrust of the piston to the crank shaft.Role of connecting rod in the conversion of reciprocating motion into rotary motion.A four-stroke engine is the most common type.The four strokes are intake,compression, power ,and exhaust. Each stroke requires approximately 180degrees of crank shaft rotation,so the complete cycle would take720degrees.Each stroke plays a very important role in the combustion process.In the intake cycle,while the piston moves downward,one ofthe valves open.This creates a vacuum,and an air-fuel mixture is sucked into the chamber. During the second stroke compression occurs.In compression both valves are closed,and the piston moves upward and thus creates a pressure on the piston.Then extstroke is power.During this process the compressed air-fuel mixture is ignited with a spark,causing a tremendous pressure as the fuel burns.The forces exerted by piston transmitted through the connecting rod moves the crank shaft.Finally, the exhaust stroke occurs.In this stroke,the exhaust valve opens,as the piston moves backupwards,it forces all the air out ofthe chamber and thus which completes the cycle of crankshaft rotation.

I.INTRODUCTION

If the efficiency of a wind turbine is increased, then more power can be generated thus decreasing the need for expensive power generators that cause pollution. This would also reduce the cost of power for the common people. The wind is literally there for the taking and doesn't cost any money. Power can be generated and stored by a wind turbine with little or no pollution. If the efficiency of the common wind turbine is improved and widespread, the common people can cut back on their power costs immensely.

Since its creation, man has constantly tried to improve the windmill. As a result, over the years, the number of blades on windmills has decreased. Most modern windmills have 5-6 blades while past windmills have had 3~8 blades. Past windmill also had to be manually directed into the wind, while modern windmills can be automatically turned into the wind. To utilize the available wind resources and reduce the usage of non renewable energy resources, wind energy is by far the fastest-growing renewable energy resource. These wind turbines can be used to provide constant lighting. In most cities, highways are a faster route for everyday commute and in need of constant lighting makes this an efficient way to produce natural energy.

This vertical-axis wind turbine incorporates 4 involute spiral blades in a configuration that utilizes the mass momentum of the wind to spin the blades around a central shaft. Force is applied to the blades by the wind both entering and leaving the turbine, allowing maximum extraction of energy from the wind.The unique nature of the involute spiral is that the wind is increasingly diverted into and out of a central vortex with no constriction in the path, only pushing the surfaces around. Other advantages to this particular design will be covered below at the base.

II.DESIGN STRATEGY

- 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.

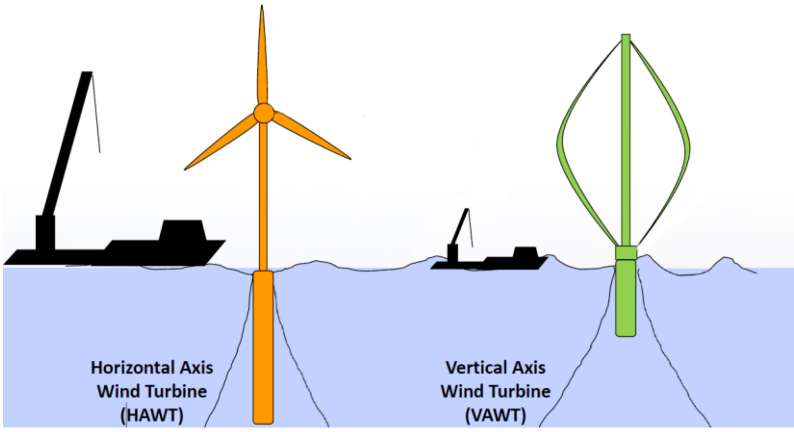


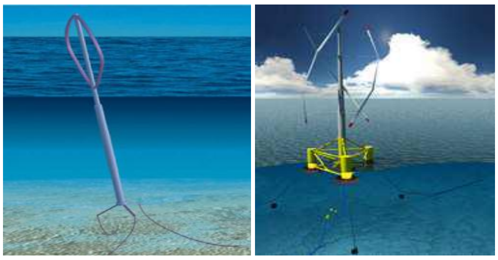
Figure 2. 1: **Graphical impression of floating HAWT and VAWT**

Figure2.1 gives an impression of some advantages. The support rig of a VAWT is shallower, resulting in a lower weight and therefore lower costs [46]. Other advantages are:

• Independence of inflow direction, meaning that no yaw mechanism is needed

• Generator is located in the base of the structure, making it more accessible, which can lead to a reduction of the maintenance cost

• The center of gravity is closer to the ground, because the rotor is mounted on the base and the generator is moved down, which leads to a smaller floating support structure, as seen in Figure 2.1 These advantages give the opportunity to start an investigation. Four parties began to develop a new design that can be used offshore; SNL, DTU, Nenuphar and Wind Power Ltd. An overview of their concepts is displayed in Figure 2.2. The Deep Wind turbine is the only one which is similar to the original Darrieus Design. The design proposed by Nenuphar is a twisted H-rotor. The most abstract design is the Aero generator by Wind Power Ltd, where the blades are mounted on a long beam, such that they have a longer arm to create torque. Still the rotor design is a big issue, especially the relation between swept area and rotor mass.



a) DeepWind b) Nenuphar

Figure 2.2 : **Future perspective of VAWT designs**

An optimizer in combination with a structural solver is used to determine the topology and the internal structure of the blade at a given load condition. After a design is found an aeroelastic solver can be used to check for flutter, which is a self-starting oscillation caused by the interaction of unsteady aerodynamics and structural dynamics. In the end a design will be found that is capable of a 20 year lifetime and a low mass.

III. MATERIALS FOR WIND TURBINE

A wide range of materials are used in wind turbines. There are substantial differences between smaller and larger machines and there are projected changes in designs that will accommodate the introduction of new material technologies and manufacturing solutions.

Physically, chemically and mechanically aluminium is a metal like steel, brass, copper, zinc, lead or titanium. Aluminium is a very light metal with a specific weight of 2.7 g/ cm2, about a third that of steel. Its strength can be taken to the application required by modifying the composition of its alloys. Aluminium naturally generates a protective oxide coating and is highly corrosion resistant. Aluminium is a good reflector of visible light as well as heat, and that together with its low weight makes it an ideal material for reflectors in, for example, light fittings or rescue blankets. Aluminium is more strong wtensile strength of 70 to 700 MP depending on the alloy and manufacturing process [3]. Extrusions of the right alloy and design are as strong as structural steel. This means that the moment of inertia has to be three times as more for an aluminium extrusion to achieve the same deflection as a steel profile.

IV.METHODOLOGY

Fabrication of vertical axis wind turbine (Involute Spiral) consists of different parts which are needed to be fabricated as parts of main assembly. Following are the parts of VAWT, to be fabricated.

•Blades- fabrication of blade consists of aluminium blades, steel pipes, aluminium sheet circular cross section base.

•Housing- fabrication of Housing consists of circular metal disc, bearing and metal rods.

•Adjustable Shaft- fabrication of adjustable shaft consists of hallow shaft, threaded solid shaft and guide rod.

•Lower column- fabrication of column consists of selecting the shaft and welding of supporting discs.

•Base- fabrication of base aims at providing a strong support to the turbine. Hence have flexibility in design in accordance with supporting strength.

Apart from the parts said above, certain materials and components are required during main assembly of Vertical Axis Wind Turbine, such as aluminium strips, threaded rod, bolts for fastening, rivets, bearing and metal paste.

Specification of the generator:

- 12-15 volt DC supply
- 2-5 A current output
- 300 rpm input
- 8mm shaft diameter

- Inbuilt voltage rectifier

Transmission system:

- The chain and sprocket system is used as the transmission system in this wind mill.
- The gear ratio of sprocket and cassette is **1:3**

Fig: 4.1 Wind turbine at highway medians

Fig 4.2: Vehicle passing through wind turbine

V. ANALYSIS

Solid Edge is a computer-aided design (CAD) system for mechanical assembly, part modelling, and drawing production. Developed by STREAM Technology [6] with an interface that ensures maximized user productivity and return on investment. Solid Edge has separate environments for creating parts, constructing assemblies, and producing drawings. Each environment is self contained.

The Darrieus wind turbine is a type of vertical axis wind turbine (VAWT) used to generate electricity from the energy carried in the wind. The turbine consists of a number of curved aerofoil blades mounted on a vertical rotating shaft or framework. The curvature of the blades allows the blade to be stressed only in tension at high rotating speeds. There are several closely related wind turbines that use straight blades. This design of wind turbine was patented by Georges Jean Marie Darrieus, a French aeronautical engineer in 1931. There are major difficulties in protecting the Darrieus turbine from extreme wind conditions and in making it self-starting.

Fig: 5.1 Darrieus Wind Turbine

Parameters	Values
Number of blades(N)	3
Rotor radius (r)	1.25m
Height of rotor (h)	3
Chord (c)	0.4m
Aerofile profile	NACA0015
Free stream wind speed	6,8,10m/s

Savonius wind turbines are a type of vertical-axis wind turbine (VAWT), used for converting the force of the wind into torque on a rotating shaft. The turbine consists of a number of aerofoils, usually—but not always—vertically mounted on a rotating shaft or framework, either ground stationed or tethered in airborne systems.

Fig:5.2 Savonius Wind Turbine

Parameter	Value
Power generated	41.4W
Swept area	$0.72m^2$
Rated wind speed	12 m/s
Aspect ratio	2
Tip speed ratio	1.0
Number of blades	2
Diameter –Height	60cm -120cm
End plate diameter	120cm
Blade thickness	2mm
End plate thickness	20mm

VI. RESULT AND DISCUSSION

Data has been collected by the use of digital anemometer at different location on the highway medians. The changes were recorded at different height and different location. The graph given below gives the actual data collected in highway for wind velocity at different height during certain interval of time.

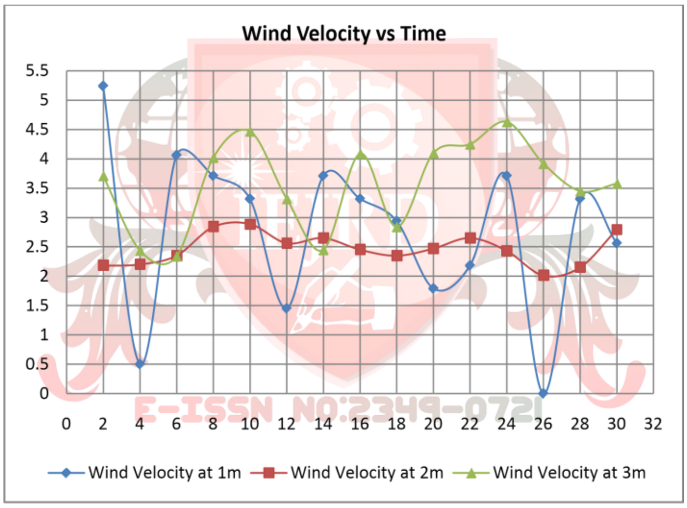


Fig: Graph between wind speed v/s time

The input power can be calculated by using the formula

P= M*ω

Where, M- Input torque

ω- Angular velocity

The angular velocity can be calculated by knowing the rpm of the blade shaft and the torque can be calculated by knowing the velocity of the wind.

Theoretically, the power output of any wind turbine is,

$$P_a = \frac{1}{2} \rho A V^3 \text{ in watts}$$

ρ- Air density at that particular height and location, (normally 1.225 kg/m^3)

A- Swept area by blades.

V- Wind velocity in m/s

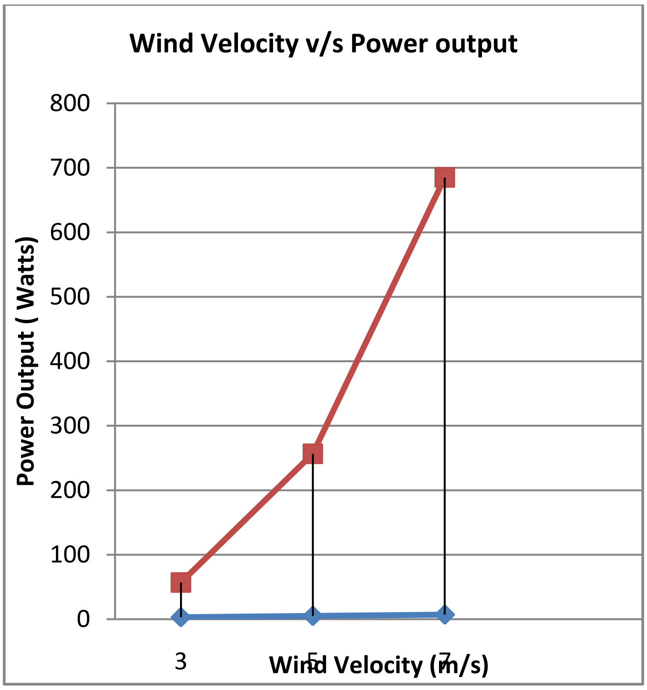
Table: Wind velocity and the power output

SR.NO	WIND VELOCITY(m/s)	POWER OUTPUT(Watts)
1	3	56.9
2	5	256.5
3	7	685.0

Practically,

At 3 m/s wind velocity turbine is rotating at 110rpm which accounts for 68.9 watts according to the equation. Hence one can obtain an output of 60-90 watts with an average wind speed of 3-5m/s.

The graph given below gives the actual data collected in highway at different wind velocity.



VII. CONCLUSION

The work and the results obtained so far are very encouraging and reinforce the conviction that vertical axis wind energy conversion systems are practical and potentially very contributive to the production of clean renewable electricity from the wind even under less than ideal sitting conditions. It is hoped that they may be constructed used high-strength, low-weight materials for deployment in more developed nations and settings or with recyclable materials and local skills in less developed countries. The Involute wind turbine designed is ideal to be located at the highways medians to generate electricity, powered by wind. The heavy vehicle traffic gives it an advantage for more wind opportunity. With the idea of putting it on highway medians, it will power up street lights and or commercial use. In most cities, highways are a faster route for everyday commute with different places and in need of constant lighting makes this an efficient way to produce electrical energy.

An economical, small scale Vertical Axis Wind Involute Turbine is fabricated using aluminum sheet and mild steel materials etc. From test results of Vertical Axis Wind Turbine over a wide range of wind speeds, it is noted that this turbine produces 40 watts for a wind speed of 3-3.5 m/s and which can be even increased by following measures.

- Optimizing the design of blades so as to give better aerodynamics.
- Using a best alternator which produces more voltage for low rpm.
- Using gear mechanisms to increase rpm for alternator input and hence can have higher power output.
- Structural fabrication should be more accurate in order to have proper functions of windmill.
- Using fixed base system to reduce the weight of the whole system.

Thus a small scale turbine for energy needs can be satisfied with optimized involute shape Vertical Axis Wind Turbine or combination of Darrieus and Savonius type of Vertical Axis Wind Turbine.

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