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Research Article

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Power Generation by Vertical Axis Wind Turbine

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Abstract—

In the present work, vertical axis wind turbine (VAWT) is designed and fabricated as per the specification, the VAWT blades are designed with aerofoil shape, with less weight and more stiffness, the assembled VAWT is mounted on the highways of a divider, so that the air velocity obtained from the moving vehicle is sufficient enough to cut the turbine blades, VAWT is a special purpose wind mill, they are designed in such a way that the vehicle moving on both the sides of highway are capable to cut the blades of VAWT, the blades are connected to the shaft intern connected to the generator, it generates the power, the power developed by the VAWT is stored in battery, the power is used for some useful application. In this project a small capacity model is developed is tested in the laboratory the result obtained for a velocity of 25 m/sec the power may come up to 1W. It is also working with the low speed wind at 4m/sec to 35 m/sec.

Keywords — VAWT, Modelling, Fabrication.

I. INTRODUCTION

Wind is a natural resource and can be harnessed as an alternative energy. Wind energy is a good choice to supplement for fossil energy demand. Other than that, wind energy is a clean, abundant and can reduce the global warming problem due to the excessiveness of conventional combustion with air assisted processes. VAWT has some advantages. The heavy parts can be placed on the ground and they can be maintained easily. VAWT can capture the wind from all the directions. Asynchronous generator connected directly to the power grid is the one of the simplest methods for wind generation system. The models of each part and the control schemes are proposed. Especially, the model of VAWT is given in details including the phenomena such as tower shadow and wind shear. Simulation and experimental results verify the analysis and the conclusion. Modifier types of vertical axis wind turbine were tested and showed that this

VAWT offered a higher efficiency [2] Wind turbine may be an alternative choice for electricity generation in the areas of no electrical grid power supply. There are two types of wind turbine, vertical axis wind turbine and horizontal axis wind turbine. The vertical axis wind turbine has an assembly of rotor which revolves about its vertical axis. Compared to the more conventional horizontal axis wind turbine, this VAWT offered several advantages, such as independent from wind direction, the transmission of rotational parts can be mounted near the ground for ease of maintenance, lower acoustic noise signature and less upset of gravity induced due to non harmonic reversing stress at the root of the blade. The development of the vertical axis wind turbine has been explored over 30 years. Recently, the vertical axis wind turbines are more on attentiveness in term of optimization of power generation and cost effective.

The factors influencing the output power of the wind turbine system the tip speed ratio is very important. The optimal power controlling is to control wind turbine operating at optimal tip speed ratio and generating maximum power. But inaccuracy of the controlling will introduce unnecessary loss of the system [3].

However, the Horizontal Axis Wind Turbines (HAWT) is still the favorite configuration of turbine for electrical generation. Many types of rotor have designed and tested for evaluating the behavior and efficiency. Additional of Savonious to Darrieus type vertical wind turbine can increase the efficiency and decreased the wind speeds essentially required for starting rotation. The present work studied the effect of the operating conditions (tip speed ratio) to the starting rotation, rev up rotation, power and torque coefficients of Curved Blades Vertical Axis Wind Turbine (CB-VAWT).

Energy: Energy is the capacity of a physical system to perform work

Classification of energy

It is broadly classified into

1. Conventional energy is in practice for long duration of time and well established technology is available to tap and use them, E.g. Coal, oil, natural gas, hydro power, nuclear power etc.

2. Non-conventional energy source can be used with advantage for power generation as well as other applications in a large number of locations and situations. These energy sources cannot be easily stored and used conveniently. E.g. Solar, wind, tidal and geothermal etc.

Based upon nature, energy sources are classified as

1. Renewable energy sources are inexhaustible and are renewed by nature itself. Solar, wind, tidal, hydro and biomass are few examples.
2. Non-renewable energy sources are exhaustible within a definite period of time depending upon its usage. Fossil fuels (coal, oil, gas) and nuclear fuels are few examples.

The wind as alternative source of Energy man has needed and used energy at an increasing rate for his sustenance and well being ever since he came on this planet a few million years ago. He started to make use of wood and biomass to supply the energy needs for cooking and for keeping himself warm. With further demand for energy man began to use wind energy for sailing ships and driving windmills.

In the era of industrial revolution man started to use new source of energy, viz. coal, fossil fuels, oil, and natural gas. Using of this commercial energy has led to mans better quality of life. In past few years, it has become obvious that fossil fuel resources are fast depleting and that the fossil fuel era is gradually coming to an end at the same time it has created many problems like pollution of environment, global warming leading to destruction of many plants and animal life.

Wind energy

The Earth is unevenly heated by the sun, such that the poles receive less energy from the sun than the equator; along with this, dry land heats up (and cools down) more quickly than the seas do. The differential heating drives a global atmospheric convection system reaching from the Earth's surface to the stratosphere which acts as a virtual ceiling. Most of the energy stored in these wind movements can be found at high altitudes where continuous wind speeds of over 160 km/h (99 mph) occur.

Wind turbines

A wind turbine is a rotating machine which enables the conversion of kinetic energy in wind into mechanical energy. If the mechanical energy is used directly by machinery, such as a pump or grinding stones, the machine is usually called a windmill. If the mechanical energy is then converted to electricity, the machine is called a wind generator/ wind turbine/ wind power unit (WPU), or wind energy converter (WEC).

Virtually all modern wind turbines convert wind energy to electricity for energy distribution. The turbine can be divided into three components. The rotor component, which is approximately 20% of the wind turbine cost, includes the blades for converting wind energy to low speed rotational energy. The generator component, which is approximately 34% of the wind turbine cost, includes the electrical generator, the control electronics, and most likely a gearbox component for converting the low speed incoming rotation to high speed rotation suitable for generating electricity. The structural support component, which is approximately 15% of the wind turbine cost, includes the tower and rotor pointing mechanism

Wind mill

Windmills convert the wind into either mechanical or electrical energy. If the efficiency of a windmill can be increased, then the need for expensive, polluting power generators will be reduced. The tip speed ratio of a windmill blade is directly proportional to the energy output. If the shape of a blade and the tip speed ratio, windmill performance also increases.

II. MATERIALS AND METHODOLOGY

The Vertical Axis Wind Turbine blades and shafts are made of following materials and there mechanical and materials properties are tabulated in the table.

Table.1 Blade and shaft selection

Sl No.	Particulars	GI Sheet	Aluminium alloy
1	Cost	Low	Moderate
2	Availability	Yes	Yes
3	Manufacturing	Easy	Easy

4	Operational condition	All whether condition	All whether condition
5	Strength	Low	High
6	Durability	Low	High

Table.2 Material Properties

Material	Ultimate Tensile stress	Young's Modulus	Poisson's ratio	Density
Al	110 MPa	69 GPa	0.334	2700 kg/m^3

Variables

Wind Speed

This is very important to the productivity of a windmill. The wind turbine only generates power with the wind. The wind rotates the axis and causes the shaft on the generator to sweep past the magnetic coils creating an electric current.

Variable Control

This will be controlled by using the same artificial wind source; e.g., a conventional electric fan or hair dryer. The orientation and distance of the wind source will be stationary and shall remain constant in relation to the windmill blades.

Blade Length

The length of the blade is directly proportional to the swept area. Larger blades have a greater swept area and thus catch more wind with each revolution. Because of this, they may also have more torque.

Variable control

A single blade pattern will be used to prescribe the general size and shape of the blades. The length and width will remain constant.

Shape of Blade

This is important because if an optimum blade shape is discovered, then the overall productivity of a windmill can be increased.

Design Constraints

Size/Geometry

The final design should be no larger in diameter than about 3m, and should not be so tall as to be stable. It should be as light as possible, resulting in a low moment of inertia. This is important, as a large moment will add to the needed starting torque. The self starter should be purely mechanical and it will not rely on electronics. It must be solely wind-powered, will not run on any other source of energy.

Ergonomics/Human Factors/Safety

No human interaction should be required during normal operation. A braking mechanism must be installed, however, to shut down the turbine if wind speeds are too high, so that maintenance can take place.

Durability/Maintainability

The turbine must be able to withstand the weather over a long period, including wind speeds up to 30 m/s and temperatures ranging from -20°C to +35°C and other forms of precipitation. The whole assembly should be easy to work on, due to its compact size and relative simplicity. However, it should not be necessary to replace the blades or shaft. All other parts should be reasonably easy to replace, and even easier to inspect.

Appearance

The turbine must be aesthetically pleasing, and as quiet as possible. It's expected that a generator would add to the noise created, but it should still be tolerable, especially considering that the turbine will not be located near many people.

III. DESIGN OF VAWT

Design calculation of the VAWT is done by considering the speed of the air hitting the wings or blades of the turbine; it starts rotating, blades connected to generator that generates the power. The power is used for some useful work.

For minimum speed = 60 km/hr
= 16.66 m/s
For Maximum wind speed = 120 Km/hr
=33.33 m/s
For Average wind speed = 90 Km/hr
= 25 m/s

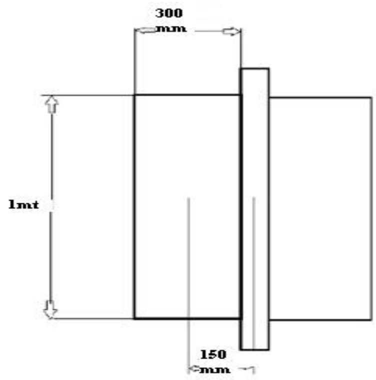

Fig 1 Radius of rotation

Power in the wind
The power of the wind is described by:
P kin= 0.5*m*v2
Where:
P kin = kinetics power [W];
m = mass flow = ρ*A*v [kg/s]
ρ = density [kg/m3]
A = area [m2]
v = speed [m/s]

The frequency distribution if the wind speed differs at different sites, but it fits quite well with the distribution.
For VAWT (Vertical Axis wind turbine) the area is calculated by

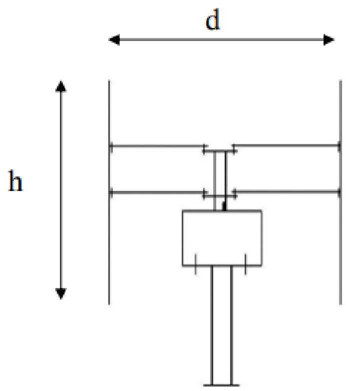

Fig.2 Front view of VAWT

A= d*h
Where d= diameter of the rotor (m)
h= height of the blades (m)
So area A= 0.6*1
A= 0.6 m^2
Power in the wind:
P kin= 0.5*m*v^2
m = ρ*A*v
= 1.184*0.6*25
m = 17.76 kg/sec
P kin= 0.5*m*v^2
= 0.5*17.76*25^2

= 5550 W

= 5.5 KW

This is the power of the shaft, the power obtained from the generator may reduce 30% because of power losses.

IV. CAD MODEL

The 3D CAD modeling of VAWT is carried out in Solid Edge v20 Software. Snapshots of assembly components are shown in Fig

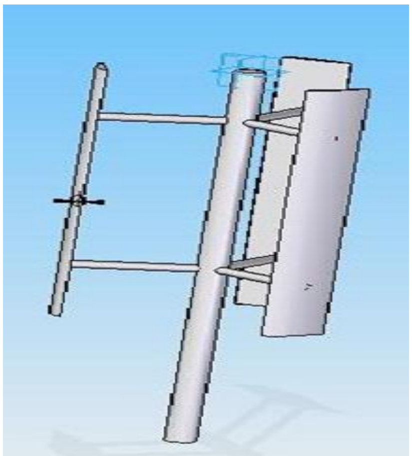

Fig 3 Assembly of VAWT

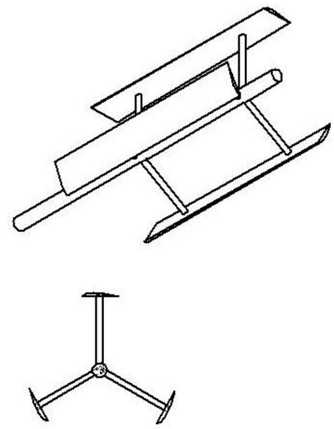

Fig 4 Detail drawing of VAWT

Design of Blades

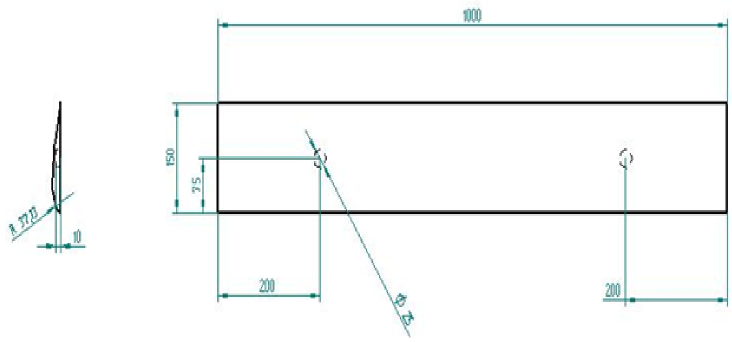

Fig 5 Detail drawing of blade

V. FABRICATION

5.1 Main Parts of Model

1. Main Shaft
2. Turbine Blades
3. Bearing
4. Gear Motor

5.1.1 Main shaft

The shaft of VAWT is made up of aluminium having a diameter of 16mm and 1 meter length, these shaft subjected to a three turbine of equal inclination at 120^0.

5.1.2 Turbine Blades

Turbine blades are made up of aluminium frame covered by Aluminium sheet for a length of 1 meter, and is fixed with the help of rivets,

5.1.3 Bearings

Bearing is a mechanical element that support for rotating shaft, and also constrains relative motion and reduces friction between moving parts. Two ball bearings of inner diameter 16mm made up of stainless steel used for the project.

5.1.4 Gear motor

An electric motor is an electric machine that converts electrical energy into mechanical energy. The reverse conversion of mechanical energy into electrical energy is done by an electric generator.12V DC Gear motor used for the project, the gear motor is mounted on the vertical shaft.

Fig 6 Final Model of VAWT

VI. RESULT AND DISCUSSION

The Experiment have been conducted in the laboratory with the help of blower with different velocity of wind speed, the wind speed is measured using Anemometer, the motor is connected with the Digital Multimeter, current and voltage is noted with the corresponding wind speed, and the power is calculated. The

Table.6 Power calculation

Wind speed in m/s	**Voltage (V)**	**Current(I) amps**	**Power P=VI (W)**
7.2	2.09	125mA	0.26
10.9	2.9	190mA	0.55
25	3.2	199mA	0.64

VII. CONCLUSION

The VAWT is designed and fabricated in such a way that the it can able to capture wind from all the direction, power developed from the project is 1W for a speed of 25m/s, the efficiency of VAWT can be increase by changing the size and shape of the blade, the theoretical and experimental result is varying because in theoretical calculation we consider the wind is hitting all the three turbine blades, practically it is hitting only one turbine at a time.

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