Design and analysis of vertical axis involute spiral wind turbine

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Abstract : Wind power has the potential to supply much of the energy demands of the world, and is one of the most rapidly expanding sectors of current alternative energy technology. wind turbines mostly are of horizontal axis configuration, with spinning propellers directed into the wind by a "tail" or, for larger systems, electronically controlled motors. These "lift" propulsion blades are typically of airfoil shape, which rely on the low-pressure lift from the momentum of the wind passing over the airfoil shape. The vertical axis rotor is also a "lift" device, with its airfoil-shaped "eggbeater" blades. The vertical axis wind turbine (VAWT) is primarily a "drag" propulsion device which continually diverts the mass of the wind to perform work on the sail. In this work , increase the low-speed power significantly over the horizontal axis rotating blade wind turbine mainly , because we are utilizing drag propulsion of a much greater surface area sail instead of just lift propulsion from a thin airfoil-shaped blade.

In this work design and analysis of VAWT have been performed. The performance analysis of VAWT results that the power co-efficient increased upto 0.56. Compared to other wind turbines VAWT having involute profile gives better efficiency. The vertical axis involute curve blade turbine theoretical power is compared with the experimental power. In this involute profile method, power output is improved compared to other type of blades.

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Keywords – wind power, vertical axis ,propulsion blade,air foil,lift,drag

I. Introduction

A machine that converts the kinetic energy of wind into rotary mechanical energy is known as wind turbine, is then used to do work. advanced models which have, the rotational energy is converted into electrical energy , by using a generator. wind turbines in existing are of the horizontal axis configuration, with spinning propellers directed into the wind by a “tail” or, for larger systems, electronically controlled motors. These “lift”

The propulsion blades are of airfoil shape, like airplane wings or propellers, which rely on the low-pressure lift from the momentum of the wind passing over the airfoil shape. The vertical axis rotor is also a “lift” device, with its airfoil-shaped blades. The vertical axis wind turbine (VAWT) is primarily a “drag” propulsion device which continually diverts the mass of the wind to perform work on the blade. In this project can increase the low-speed power significantly over the horizontal axis rotating blade wind turbine largely, because are utilizing drag propulsion of a much more surface area sail instead of lift propulsion from the thin airfoil-shaped blade.

A vertical axis wind turbine has many advantages over the many traditional horizontal wind turbine, especially in uneven wind conditions where a horizontal wind turbine has to change directions, which puts stresses on the bearings and tower and dissipates energy. But, the vertical axis wind turbine is propelled by wind from any direction, and gravitational stresses on the vertical axis turbine are even, allowing lighter and larger construction. This vertical-axis wind turbine incorporates 3- involute spiral blades in a configuration that utilizes the mass momentum of the wind to spin the blades around a central mast. Force is applied to the blade by the wind both entering and leaving the turbine, allowing maximum extraction of energy from the wind.

So built a series of vertical axis wind turbine prototypes, with thin aluminum printing plate vanes glued between 78-rpm phonograph records. Filmed them on Super-8 next to a wind speed anemometer, and counted revolutions, found the weak and stalling in its worst aerodynamic position, and found several new and faster vane configurations. However, the primary advantage of a vertical wind turbine is that it can operate in an environment where the wind direction is shifting very quickly. But the VAWT is propelled by wind from any direction, and gravitational stresses on the vertical axis turbine are even, allowing lighter and larger construction. This vertical-axis wind turbine incorporates 3 involute spiral blades in a configuration that utilizes the mass momentum of the wind to spin the blades around a central mast. This can be beneficial if the wind direction is variable. One benefit of using a vertical turbine is that the generator can be located closer to the ground or at the ground. This allows for easier maintenance. VAWTs can also withstand much higher winds. The main advantage of VAWT over HAWT is it's insensitivity to wind turbines and therefore can be mounted closer to the ground making it effective for home and residential purpose. VAWT is quiet, efficient, economical and perfect for residential energy production, especially in urban environments.

II. Literature Review

K.R. Ajao and J.S.O. Adeniyi are made for wind turbine blade for materials and manufacturing fact blade sheets, as this paper take some blade materials properties.

David Hartwanger and Dr Andrej Horvat are modeled for 3d wind turbine blade system using cfd The results from this initial stage of work support the use of a calibrated actuator disk methodology based on a normal fidelity CFD modelling approach. Implementing actuator momentum correlations obtained from an equivalent CFD analysis offers a potentially economical methodology for simulating complete multiple wind turbines within a specific environment.

Surya Santoso, Ha Thu Le are modeled direct-connect fixed-speed wind turbine model. The modelling includes the wind turbine aerodynamic rotor and drive-train representations which are often neglected in existing models.

The wind turbine and wind farm models presented can be used to facilitate educational activities in wind power integration studies.

Uctug MY, Eskandarzadeh are made power curve generation, wind power integration, dynamic interactions between wind turbines, power system dynamic stability and so on. In addition, the models can be expanded to include power and pitch controllers to suit other studies requiring variable speed wind turbines.

Ulas Eminoglu are made the effects of Wind Turbine Gear Systems on the power losses, voltage profile of radial distribution systems and the performance of the load flow algorithms are evaluated. It is also concluded that the incorporation of WTGSs with the proposed models into the load flow analysis does not ignificantly affect the convergence characteristics of thedistribution systems' load flow algorithms.

Gunner C. Larsen, Hengameh Kojooyan Jafari and Ahmed Radan are made Performance Testing of a Small Vertical-Axis Wind Turbine.

L.M. Fernandez a, C.A. García a,1, J.R. Saenz Steady-state and dynamics simulations were performed to illustrate the effectiveness of the present equivalent models. The results analysis demonstrates that the equivalent wind turbine with the average wind obtained from the aggregated wind turbines must be used for wind turbines with similar winds (differences in wind speeds less than 2 m/s) or when all the aggregated DFIG wind turbines receives above nominal winds.

III.METHODOLOGY

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Working of Involute Spiral Wind Turbine

Utilized a supporting frame for the all involute spiral wind turbine parts are fitted with the supporting columns. The central mast is connected to a top side of the turbine soft bearing. Then central mast is also connected to the supporting arms. The supporting arms another end is connected to the turbine base plate. The turbine base plate are supported with three supporting columns.

The turbine base plate bottom side bearing hub are welded with the bottom of the bearing.in this time misalignment of the bearing should be eliminated. The turbine shaft are fitted to the base plate and bottom side of the bearing. The turbine shaft another end connected to the central mast of the wind turbine. The turbine shaft are divided 120 degree and welded with supporting blade pieces. The wind turbine blade are configured as per the involute spiral drawings.

Then the involute spiral wind turbine blade are fixed with the turbine shaft. Then the turbine flywheel also fixed to the bottom of the turbine base plate.A small d.c generator roll on the flywheel wheel. The small knurled rollers offered considerable friction.

By using atmospheric air and flowing through the radial direction. According to the flow of air the turbine blade are moved with turbine shaft. Then the turbine flywheel also rotated. A small d.c generator small kuurled roller are toughed to the turbine fly wheel. Then d.c power will be automatically generated.

Design specification

Turbine Base plate

Base plate material : Mild steel

Plate thickness : 2.5mm

Inner circle diameter : 30mm

Outer circle diameter : 610mm

Turbine Blades:

Material : A T-6 tempered aluminum.

Height : 786 mm

Length : 915mm

Thickness : 1.5 mm

Shaft:

Material : Aluminum

Solid shaft. Diameter : 19 mm.

Length : 950mm

Bearings:

NBC Bearing

Inner Diameter : 19 mm

Outer Diameter : 50 mm

Design Calculations

Design of Shaft:

Torque acting on the solid shaft:

$$T = P * 60 / 2\pi N$$

Where,

T=Torque acting in shaft in N-mm.

P=Power in watts

N=Speed in rpm.

T = 7.91x60/2x3.14x50

T = 1.51 N-mm

Diameter of the solid shaft:

Tmax =π/16*τ*d^3

Where,

Tmax =Maximum torque available in the shaft in N-mm.

τ =Shear stress in the shaft in N/mm^2.

d =Diameter of the solid shaft.

Design of Bearings:

Roller bearings:

Co=fo*i*Z*D*le*COS α

Where Co=Basic static radial load rating.

fo=factor for roller bearings=21.6

i=Number of rows of rollers in bearing

Z=Number of rollers per row

le=Effective length

IV. Experimental Setup

Turbine base plate has been get machined for the following dimension

- Diameter- 610mm
- Thickness- 2.5mm

Mild steel shaft has been get machined for the following dimension

- Height- 950mm
- Diameter- 19 mm

The circumferential area of the shaft is made divided into 3 sections

- ((360º/ 3 =120 º)

Holes have been made in the shaft to make fix the involute spiral blade.

Three blades have been designed in the form of involute spiral blade shape.

Each blade have been designed as per the following dimensions

- Height- 786mm
- Length-915mm
- Thickness- 1.5mm

Blades have been fixed to the shaft by using the bolts & nuts.

Bearings are get attached to both the ends of the top and bottom of the shaft.

The entire set up is being fixed to the support.

The flywheel has been fixed at the bottom end of the shaft.

The d.c generator has been mounted to the supporting columns.

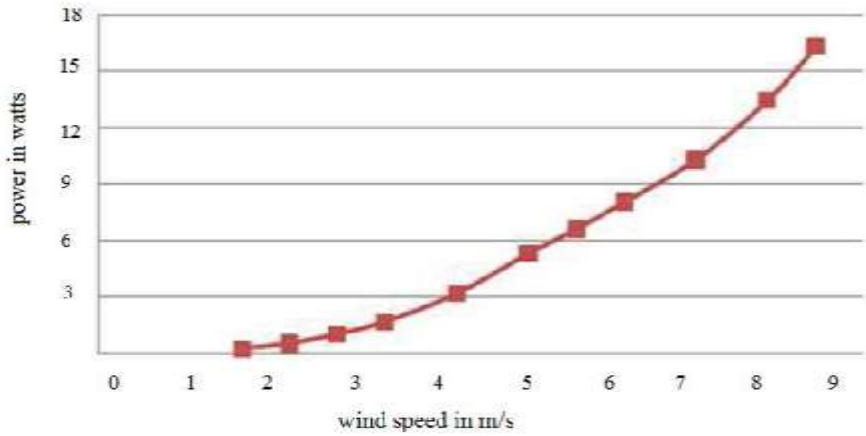
Experimental test in atmospheric wind energy:

Wind speed in m/s	Turbine rotor speed in rpm	Voltage in volt
1	0	0
2	0	0
3	20	2
4	40	4
5	55	7
6	75	10
7	90	12
8	110	14
9	130	16

Wind speed Vs power in watts

Wind speed in m/s	Power in watts
1	0
2	0
3	1
4	3
5	7
6	8
7	10
8	13
9	16

WIND SPEED VS POWER IN WATTS



Wind speed Vs turbine rotor speed in rpm

The fig shows that when the wind speed increases the power produced is increased

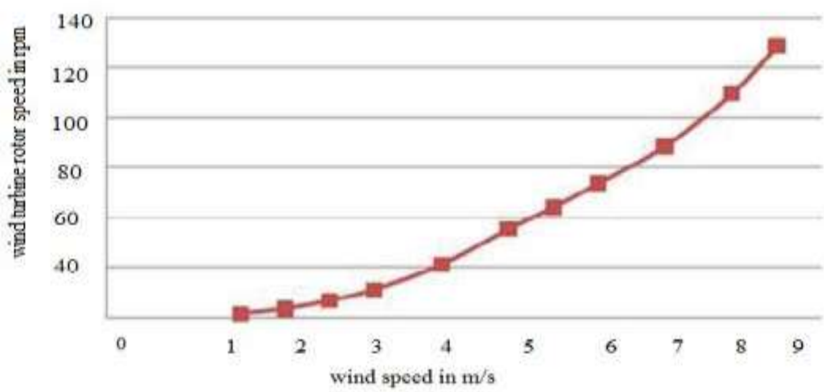
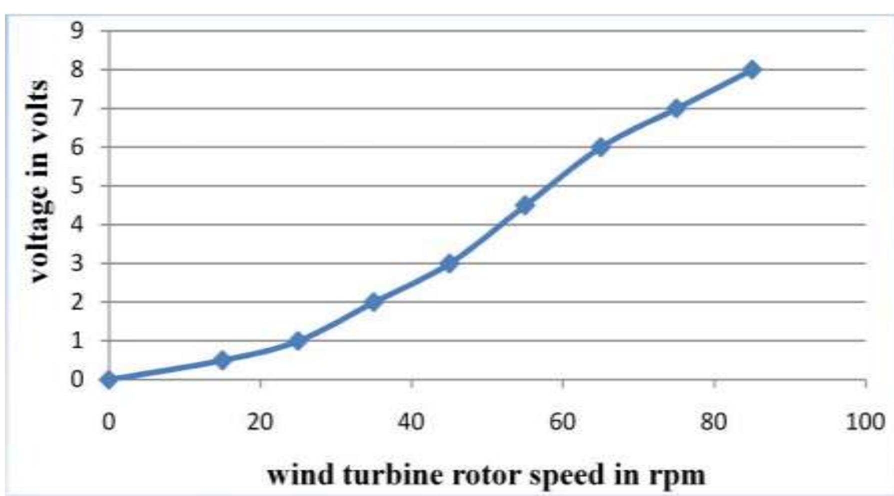


Figure shows that when the wind speed increases the wind turbine rotor speed also increases.

wind turbine rotor speed Vs voltage



It is observerbed from the figure , when the wind turbine rotor speed increases the consumption of electric power.so that the voltage is increased.

V. CONCLUSION

In this work, to increase low wind speed power of a vertical axis wind turbine, control mechanism design and its realization of model are carried out. 3 involute curved blades of 2 feet span length are used and rotor radius is fixed to vertical axis. For this model, the involute spiral blade system and the individual blade control system are applied respectively to improve its coefficient of performance. The involute spiral wind turbine is capable of generating more power. The force of each blade at the specific rotating position and several airfoils such are studied in addition to a symmetric airfoil. Involute spiral method, the power output is improved about 30% comparing with other type blade.

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