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Vertical Axis Wind Turbine

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Abstract -**The main objective of this paper is to design the vertical axis wind turbine. The design of the turbine will include the study of various vertical axis wind turbines. Various wind turbines converting wind energy to a rotary motion have been already suggested and practiced. Among them, the horizontal axis wind turbine is required to have the propeller rotating disk always rightly aligned with the wind direction, whereas the vertical axis wind turbine is Omni-directional, is not influenced at all by the wind direction and is better in respect of the configuration and operation.**

Keywords : **Wind Turbines, Vertical axis wind turbines, Horizontal axis wind turbines, Renewable energy**

I. INTRODUCTION

A Wind turbine is a device which converts wind's Kinetic energy into Electrical power. Wind turbines are manufactured widely in vertical and horizontal axis types. Wind turbines can rotate about either a horizontal or a vertical direction. Horizontal axis wind turbine (HAWT) dominate commercially over vertical axis wind turbine (VAWT). However, VAWT does have some advantages over HAWT to utilize the available wind resources and to reduce the usage of non-renewable energy resources. Wind energy is by far the fastest-growing renewable energy resource. The wind energy industry so far has been supported by market incentives backed by government policies fostering sustainable energy resources. Large-scale wind facilities approaching the output rating of conventional power plants, control of the power quality is required to reduce the adverse effects on their integration into the network.

II. POWER AND TORQUE IN THE ROTOR

The maximum power of the rotor is estimated by using "Betz law". The windmill works on the principle of converting kinetic energy of the wind to mechanical energy. The kinetic energy of any particle is equal to one-half its mass times the square of its velocity, or ½ mV^2. The amount of air passing in unit time through an area A, with velocity V, is A.V, & its mass, m is equal to its Volume multiplied by its density ρ of air, or

$$m = \rho AV \qquad \ldots\ldots (1)$$

(m is the mass of air Transversing the area A swept by the rotating blades of a windmill type generator)
Substituting this value of the mass in the expression of K.E.

$$= 0.5\rho\, AV.V^2 \quad \text{(watt)}$$
$$= 0.5\rho\, AV^3 \quad \text{(watt)} \quad \ldots\ldots (2)$$

$\rho = 1.2\ kg/m3$ is the air density. However, there are aerodynamic and mechanical losses in the order of 50%. The swept area of the rotor is given by,

$$A = h.D \qquad \text{(Sq. m)}$$

Put this quantity in equation (2),

Then, Available wind power,

$$Ps = 0.5\rho.h.D.V^3.C_p$$
$$(C_p \text{ - Betz coefficient} = 0.593)$$
$$= 0.18.h.D.V^3 \quad \text{(Watt)}$$

"Wind machines intended for generating substantial amounts of power should have large rotors and be located in areas of high wind Speed".
The rotational speed is defined as,

$$n = (60/2\pi).\omega \qquad \text{(Rpm)}$$

Where, $\omega = \lambda.v/r$ is the angular velocity in units of radians per second, $r = D/2$ the radius of the rotor and $\lambda = 1$, the tip-speed ratio. Furthermore, the torque at the rotor shaft is given as,

$$\tau s = Ps/\omega \qquad \text{(Nm)}$$

III. DESIGNING OF WINDMILLS

A windmill is a machine for wind energy conversion. A wind turbine converts the kinetic energy of the wind's motion to mechanical energy transmitted by the shaft. A generator further converts it to electrical energy. So it is necessary to keep in mind while designing the windmill's structural part.

1.Design of Base

In this project there is a triangular pyramid base which is made up of mild steel can withstand, in a large force of the wind. The base & its height are related to cost and transmission system incorporated.

2.Design of blade

Wind turbine blades have a cup-shaped – type cross section and a variable pitch. While designing the size of the blade it is must know the weight and cost of blades on the project two blades with vertical shaft are used. If one Blade moves other blades comes in the position of the first blade, so the speed is increased.

3.Shaft Designing

While designing the shaft of blades it should be properly fitted to the blade. The shaft should be as possible as less in thickness & light in weight for the two blade, the shaft used is very thin in size are all properly fitted. So no problem of slipping & fraction is created, it is made up of hollow mild steel which is having very light weight.

4.Gear Designing

The speed ratio of two gears is 1:3 i.e., in one revolution of larger gear, the gear of generator complete 3 revolutions so the speed can increase considerably. Also, the gear should have light in weight, so no consumption of power will take place in revolving.

5. A PMDC motor

PMDC (Permanent Magnet DC motor) is a type of electric motor. A PM motor does not have a field winding on the stator frame, instead relying on PMs to provide the magnetic field against which the rotor field interacts to produce torque. Compensating windings in series with the armature may be used on large motors to improve commutation under load. Because this field is fixed, it cannot be adjusted for speed control. PM Fields (stators) are convenient in miniature motors to eliminate the power consumption of the field winding. Most DC motors are of the "dynamo" type, which has stator windings. To minimize overall weight and size, miniature PM motors may use high energy magnets made with neodymium or other strategic elements; most such are neodymium-iron-boron alloy. Miniature motors resemble the structure in the illustration, except that they have at least three rotor poles (to ensure starting, regardless of rotor position) and their outer housing is a steel tube that magnetically links the exteriors of the curved field magnets.

6. Energy storage / battery

The output of the generator is given to the battery for electric energy storage purpose. The capacity of the battery is up to 12 V. Generally this battery is lead acid type battery and also restorable. The supply of generator is given to the battery through a diode.

IV. WORKING OF VERTICAL AXIS WIND TURBINE

Lift and drag forces can be broken down into components that are perpendicular (thrust) and parallel (torque) to their path of travel at any instant. The torque is available to douse full work, while the thrust is the force that must be supported by the turbine's structure. The coefficient of performance depends on wind speed, the rotational speed of the turbine and blade parameters such as pitch angle and angle of attack. The pitch angle for a HAWT is the angle between the blades motion and the chord line of the blade, whereas for a VAWT the pitch angle is between the line perpendicular to the blades motion and the chord line of the blade. The angle of attack is the angle between the relative wind velocity and the center line of the blade. The dimensions for the VAWT being built for this project are given in the output power, torque and rotational speed of the turbine. The design will also allow for data collection regarding the effects of blade pitch angles. The sweep diameter (333mm) is larger than the height (300mm) to provide a longer chord length for the same strength. This design selection provides an increased Reynolds number for the flow over the blades, and subsequently, increases the lift, the design of the turbine will include exploration of various self-starting options, as well as the construction of both mode land full-scale turbines. The full-scalturbine will be designed such that it can be connected to a generator and a torque transducer to measure.

V. SPECIFICATIONS OF WIND TURBINE

Blade Dimensions

Height	300mm
Cup Diameter	200mm
Sweep Diameter	333mm
Thickness	1mm

Shaft Dimensions

Diameter	66.6mm
Length	500mm

Gear Dimensions

Gear 1	60mm (Dia.), 38 teeth
Gear 2	40mm (Dia.), 25 teeth
Gear 3	80mm (Dia.), 60 teeth
Gear 4	20mm (Dia.), 14 teeth

Total Height of the assembly: 1085mm

VI.MODEL LAYOUT

Fig.1 CREO Layout Design of VAWT

Fabricated Mode

Fig.2 Finished Model

Theoretical Output

For Velocity= 6 m/s

Area= h.D = 0.3 x 0.2 = 0.06

Power,

Ps= 0.18*(h.D)*V^3 = 0.18* 0.06* 6^3

Ps= 2.33 (W)

Torque,

$\omega = 6.006 * 6$

$\omega = 36.036$ (Rad/s)

n = 9.55 * 36.036

n = 344.14 (Rpm)

Now,

$\tau s = Ps/\omega$

τs= 2.33/36.04

τs= 0.065 (Nm)

For different velocities of air,

TABLE 1 FOR DIFFERENT VELOCITIES OF AIR

V(m/s)	6	12	18	24
n(Rpm)	344.1	688.28	1032.45	1376.54
ω(Rad/s)	36.04	72.072	108.11	144.14
Ps (W)	2.33	18.66	62.986	149.30
τs (Nm)	0.065	0.25	0.583	1.036

VII. CONCLUSION

The average wind speed in Tamil Nadu is of between 9 to 12 m/s. Our 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 contribute to the production of clean renewable electricity from the wind even under less than ideal setting 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 very low tech local materials and local skills in less developed countries.

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