Design and Fabrication of Magnetically Levitated VAWT

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***Abstract* - Magnetic levitation or magnetic suspension is a method by which an object is suspended with no support other than magnetic fields. Magnetic pressure is the only effect acting on object overcoming gravitational and any other acceleration effect. The principal advantage of a magnetic levitation windmill over a conventional windmill is that mechanical friction is completely eliminated due to floating of rotors. That makes the rotation possible in very low wind speeds. .**

The goal of this project is to build the vertical axis wind turbine to generate electricity by using wind energy. This type of vertical axis wind turbine will generate electricity without using generator or alternator, But by the application of magnetic levitation concept. This wind turbine is designed to withstand all the forces by wind and keeps rotating even at low wind force. This type of vertical axis wind turbines has three wings. The wings are designed to accept wind from any directions.

Keywords: - Vertical axis wind turbine, Wind energy, Magnetic levitation, Magnet, Power generation.

1. INTRODUCTION

Among the renewable energy sources Wind Energy is one of the fastest growing at the rate of 30% annual graph. Wind Energy is considered renewable due to their continuous replenishment and availability for use over and over again. The popularity of renewable energy has experienced a significant upsurge in recent times due to the exhaustion of conventional power generation methods and increasing realization of its adverse effects on the environment.

A wind turbine basically draws the kinetic energy from the wind and converts this power to electrical energy by means of a generator .This project focuses on the utilization of wind energy as a renewable source. Wind power accounts nearly 8.6% of India's total installed power generation capacity and generated 28,604 million KWh in the fiscal year 2015-16 which is nearly 2.5% of total electricity generation.

The aim of this project is to design and implemet a magnetically levitated vertical axis wind turbine system that has the ability to operate in both high and low wind speed conditions. The choice for this prototype is to showcase its efficiency in varying wind condition and contribute to its steady growing popularity for the purpose of mass utilization in the near future as a reliable source of power generation.

2. TYPES OF WIND TURBINE

There are many types of wind turbine exist today and their design are usually based on the one of the two categories: Horizontal axis wind turbine (HAWT) and Vertical axis wind turbine(VAWT).As the name signifies,each the turbine is been classified by the orientation of their rotor shaft the HAWT is more conventional and common type everyone is come to know whereas the VAWT quite unpopular.

2.1 Hawt

The HAWTs usually consist of two or three propeller-like blades attached to a horizontal and mounted on bearings the top of a support tower. When the wind blows, the blades of the turbine are set in motion which drives a generator that produces AC electricity. For optimal efficiency, these horizontal turbines are usually made to point into the wind with the aid of a sensor and a servo motor or a wind vane for smaller wind turbine applications.

2.2 Vawt

Vertical axis wind turbines are further subdivided into two major types namely the Darrieus model and the Savonius model. In vertical axis wind turbines, the concept behind their operation is similar to that of the horizontal designs. The major difference is the orientation of the rotors and generator which are all vertically arranged and usually on a shaft for support and stability. This also results in a different response of the turbine blades to the wind in relation to that of the horizontal configurations.

2.3 Magnetic Levitation

In selecting the vertical axis concept for the wind turbine that is implemented as the power generation portion of this project, certain uniqueness corresponded to it that did not pertain to the other wind turbine designs. The characteristic that set this wind generator apart from the others is that it is fully supported and rotates about a vertical axis. This axis is vertically oriented through the center of the wind sails, which allows for a different type of rotational support rather than the conventional ball bearing system found in horizontal wind turbines.

3. PROJECT OBJECTIVE

The main aim of this project is to build the vertical axis wind mill to generate electricity by using wind energy. This type of vertical axis wind mill will generate electricity without using generator and alternator. By the application of magnetic levitation electricity will be generated and also magnetic levitation reduced wind mill weight acting by the gravitational force. The main advantage of this wind mill is its cost is very low as compared to other. This type of vertical axis wind mill has multiple blades, which are attached to the shaft. The blades are will be designed like they should accept wind coming from all the direction.

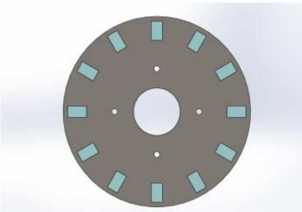
4. DESIGN AND MANUFACTURE OF COMPONENTS

4.1. Stator

It is a stationary element of the wind mill which consists of enameled copper coil windings. It is been placed in between the two rotor.

4.2 Rotor

A rotor is rotating part of a mechanical device. In this case rotor disc rotate by means of wind energy, Here we are using two rotors.



4.3 Blades

The blades are designed on the basis of airfoils. Three bladed turbine designs with airfoil blades outperform and are more efficient at lower speeds then the equivalent flat plate design. Same turbines, but with a protective shroud and a funnel that accelerates wind speed. Funneling wind into an enclosure increases the rotation rate of the turbine significantly. Hence, flat bladed design with shroud and a funnel performs better than the air foil design.

3D figure of the blade used in this project is shown below:

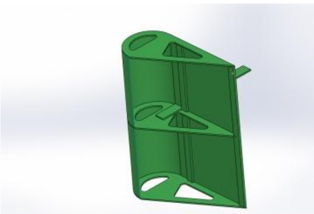


Fig. blade

Blade is made from sheet metal of thickness 1mm, wound over. Blade angle taken is 31 degree. And metal frame used are of mild steel of 3mm thickness. By considering the center of mass blade is supported in the triangular plate and bolted at three sides with the bolts.

5. CALCULATIONS

5.1 Standard Values,

Normal velocity of wind (v) = 6 m/s

Blade angle (θ) = 31°

Density of air (p) = 1.125 kg/m³

5.2 Power Coffecient

The power co-efficient is the percentage of power received by the wind turbine through the swept area of the turbine blades.

$C_{\square} = 4 \times (v_{\square}^2 / v_u^2) \times [1- (v_{\square} / v_u)]$

v_u = velocity of wind as it approaches the wind turbine.

$v_{\square}$ = velocity of wind as it passes through the swept area of the wind turbine blades. Maximum theoretical possible co-efficient of power is called BETZ LIMIT. Most turbines have power co-efficient between 0.3 and 0.4.

5.3 Wind Turbine Power

Wind Turbine Power = (Wind present inside blade) + (Normal velocity of wind)

$= \frac{1}{2} \times mass \times v^2$

$= p \times$ Wind striking surface area (A) $\times v^3$

(Watt ‣ KW- non dimensional constant k multiply)

$k = 2.14 \times 10^{-3}$

Kinetic Energy $= \frac{1}{2} \times k \times p \times A \times v^3$ KW

$= \frac{1}{2} \times 2.14 \times 10^{-3} \times 1.125 \times 715310 \times 10^{-6} \times 6^3$ KW

= 0.185 KW (area of blade is taken from the standard dimension of fabrications)

FIELD DENSITY (B)

Surface area of Magnet,

$A(surface) = l \times b$

l = length of magnet

b= width of magnet

h= thickness of magnet

Magneto motive force = (H × h) Ampere

Flux = B × A(surface) × cosθ (weber)

RELUCTANCE (Rm)

Permeability of free space ($\mu_\circ$) = ($4\Pi \times 10^{-}7$) N/A²

d= distance between magnets

$Rm = 2d / (\mu_\circ \times A(surface))$ ampere turns/weber

Using Ohm's law we can find the value of the flux (Φ0) and therefore the field density. The reluctance is divided by the value of the flux found about to find the slope. This slope will intersect the H-B characteristic which determines our operating point.

If the generator is rotating at velocity (v) 0.63m/s or 50 rev/min the change in time iscalculated below using the radius (r) of a coil.

$dt = r/v$

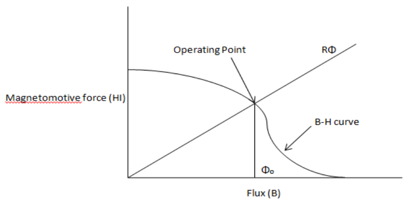
From these values we can now calculate the maximum voltage given turns (N) per coil.

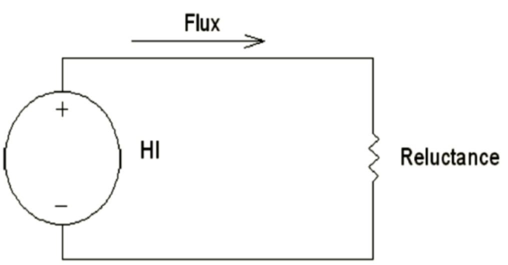
$V = (d\varphi / dt)$

6. MATERIAL DESCRIPTIONS

S.NO.	DESCRIPTION	MATERIAL USED	DIMENSIONS IN 'mm'
1.	Stator	Ply wood	Outer diameter 220
2.	Rotor Disc	Mild Steel	Outer diameter 200
3.	Blades and Wings	Stainless Steel Sheet	Height of the blade 45
4.	Solid Shaft	Mild Steel	Diameter 30
5.	Triangular plate	Mild Steel	Side 260
6.	Base Assembly	Mild Steel	Diameter of the base150
7.	Fasteners	Standard	M6

CIRCIUT ANALOGY



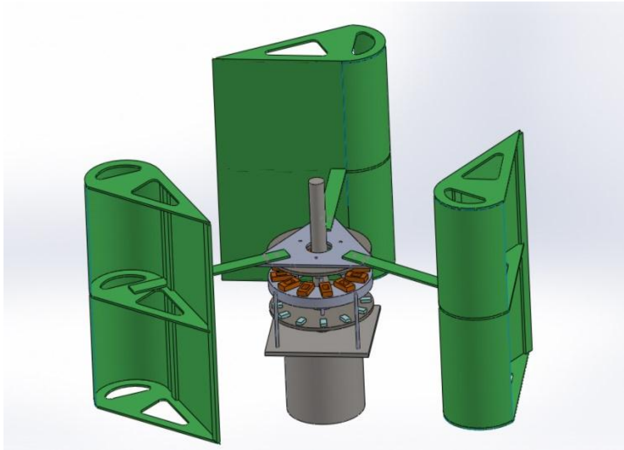


Magneto motive force vs flux

7. DIMENSIONAL DETAILS OF VAWT

1. Blade
   Blade height = 45mm
   Blade angle = 31°
   Blade wing thickness = 3mm
2. Angle plate = 60*60*60 mm
   Angle plate thickness = 3mm
3. Rotor = 200mm (diameter)
   Bolt diameter = M6
   Magnet (neodymium N45) = 20*12*5mm
4. Stator = 220mm (diameter)
   Central core = 70mm
5. Coil type (enamelled) = gauge 24
   Number of turns = 120 turns
   Coil dimension = 34*34*12mm
6. Square plate = 221*221mm
7. Hollow cylinder = 90mm (outer dia), (50mm inner dia)
8. Central shaft = 30mm diameter
9. Ball bearing at the triangular plate and thrust bearing at lower rotor plate.

8. DESIGNED MODEL



9. ADVANTAGES

The fabricated project has the following advantages:

- ❖ As the rotor is floating in the air due to levitation mechanical friction is completely eliminated.
- ❖ This turbine is able to utilize wind with starting speed as low as 1.5 m/s and they also could operate in winds exceeding 40 m/s.
- ❖ The blades are designed to accept winds from all direction eliminating the need of yaw mechanism.
- ❖ This type of wind mill will generate electricity without using generator or alternator.
- ❖ Thus, the cost of generator or alternator is eliminated.
- ❖ The design of this project is simple, compact and light weight compared to general wind turbines.
- ❖ These small turbines are almost inaudible and are less likely to kill birds.
- ❖ Their use in military bases is contemplated because they are shorter and interfere less with helicopter operations and with radar.

10. CONCLUSION

Thus at the end of the project, the magnetically levitated vertical axis wind turbine was a success. The rotors that were designed harnessed enough air to rotate at high wind speeds while keeping the Centre of mass closer to the base yielding stability. The wind turbine rotor levitated properly using permanent neodymium magnets, which allowed for a smooth rotation with negligible friction producing the electro motive forces which are cut by stator winding generating the electric energy.

11. FUTURE SCOPE

The vertical axis wind turbine with magnetic levitation may be mounted on residences. Here it can be erected on roof top with very efficient and practical approach. House owner would be capable of extraction of free and clean energy with a minimized utility cost.

Power generated from this turbine can be utilized in remote places where traditional method of power supply is costlier. Power generated from turbine can be efficiently be used for street/domestic lightings and domestic appliances.

The environmental factors like wind direction, corrosion, water vapour, intrusion, thermal expansion, mechanical load, summer-winter climate change, ageing and component derating which degrades the performance can be considered for estimating a more practical and accurate design.

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