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EXPERIMENTAL STUDY ON MINIATURE FABRICATED MODEL OF MAGLEV WIND TURBINE

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ABSTRACT

Conventional wind mill having a maximum efficiency of 30% and energy efficient wind mill Can operate in maximum efficiency of 45%. The remaining energy is mainly lost in friction. If theSame wind mill is operating at 50% of its maximum speed the efficiency becomes very low and the frictional loss gets increased compared to power generated. The drawback of wind mill is that it it cannot be operated at its full capacity all the time. Moreover due to friction there will be wear and tear in machines. Due to the wear and tear the performance of the machine will deteriorate and also Normal windmill can start its generation from wind speed of 3 m/s. Based on the above facts project aims at designing and fabricating wind mill using magneticlevitation method thereby energy wasted in the form of friction can be saved and also windmill using magnetic levitation can start generation from wind speed at 1.5m/s. Operation of windmill at lower speeds, increases the amount of energy harvested from the windmill. A thorough experimental investigation is tried; the results obtained will be compared with the model of conventional windturbine. Power will then be generated with an axial flux generator, which incorporates the use of permanent magnets and a set of coils.

1.0 INTRODUCTION

Renewable energy is generally electricity supplied from sources, such as wind power, solar power, geothermal energy, hydropower and various forms of biomass. These sources have been coined 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. This popularity has been bolstered by cutting edge research and ground breaking technology that has been introduced so far to aid in the effective tapping of these natural resources and it is estimated that renewable sources might contribute about 20% – 50% to energy consumption in the latter part of the 21st century, Worldwide now there is now over two hundred thousand wind turbine operating with a total name plate capacity of 432,000 MW as of end 2015. The European Union alone passed some 100000 MW nameplate capacities in September 2012; while United States surpassed 75000 MW in 2015 and china grid connected capacity passed 145000 MW in 2015 energy consumption in the latter part of the 21st century, Worldwide now there is now over two hundred thousand wind turbine operating with a total name plate capacity of 432,000 MW as of end 2015. The European Union alone passed some 100000 MW nameplate capacities in September 2012; while United States surpassed 75000 MW in 2015 and china grid connected capacity passed 145000 MW in 2015.

In this project a new technology of generating a wind power is implemented. Unlike the traditional horizontal axis wind turbine, this design is levitated via maglev (magnetic levitation) vertically on a rotor shaft. This maglev technology, which will be looked at in great detail, serves as an efficient replacement for ball bearings used on the conventional wind turbine and is usually implemented with permanent magnets. This levitation will be used between the rotating shaft of the turbine blades and the base of the whole wind turbine system. It does not need to vast spaces required by more conventional wind turbines. It also requires little if any maintenance.

2. Design of levitation system for the proposed miniature model

This chapter discusses detailed design of the magnetic levitation system for the proposed miniature model of maglev wind turbine. Design of levitation system mainly depends on the selection of magnet and magnetic force required to levitate the wind mill. Design procedure is mainly divided into two sections namely magnetic selection and magnetic force calculations.

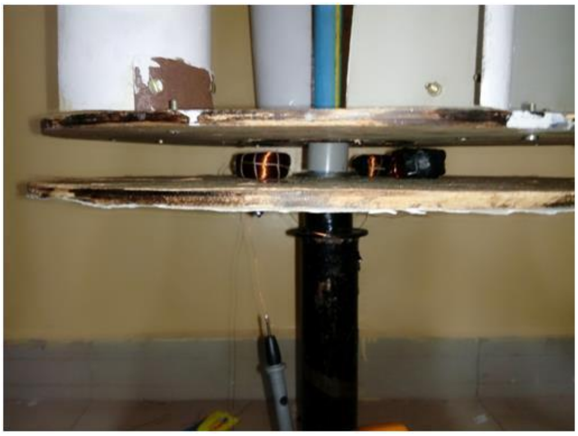
2.1 Magnet selection for the proposed model

Some factors need to be assessed in choosing the permanent magnet selection that would be best to implement the maglev portion of the design.

Nd-Fe-B Neodymium permanent magnet at room temperature exhibits highest properties of all of the magnetic materials, Has a very attractive magnetic characteristic which offers high flux density operation and the ability to resist demagnetization. This attribute will be very important because the load that will be levitated will be heavy and rotating a high speeds which will exhibit a large downward force on the axis.

Based upon the above mentioned advantages, neodymium permanent magnet is used for levitation purpose in this project.

The permanent magnets that were chosen for this application were the N35 grade magnets. These are Nd-Fe-B ring shaped permanent magnets that are nickel plated to strengthen and protect the magnet itself. For the experimentation purpose permanent magnet of basic dimension 40mmx22mmx7mm is considered along with the cost. Based upon this magnet size rotor are designed as two magnets are repels each other with rotor section levitate. The dimensions for the magnets are reasonable with a outside diameter of 40mm, inside diameter of 22mm and height of 7mm.



Levitation between stator and rotor.

Once the magnet is selected according to our requirement than we need to calculate the amount of force require to levitate the wind mill The next factor that needs to be considered is the shape and size of the magnet which is directly related to the placement of the magnets. It seems that levitation would be most effective directly on the central axis line where, under an evenly distributed load, the wind turbine centre of mass will be found as seen in Figure.

Figure shows a basic rendition of how the maglev levitation will be integrated in the proposed model. This figure shows a basic rendition of how the maglev will be integrated into the design. If the magnets were ring shaped then they could easily be slid tandem down the shaft with the like poles facing toward each other. This would enable the repelling force required to support the weight and force of the wind turbine and minimize the amount of magnets needed to complete the concept.

2.2 Magnetic Force Calculations

In this section, the force between the two selected magnets is calculated and this data will show whether or not this maglev system will be able to support the load of the wind turbine. Calculating the force between two magnets is forms a important role as it decides the weight of the turbine. The main obstacle in this permanent magnet design was finding the distribution of the magnetic flux in this magnetic "circuit". Variables that needed to be considered were the distribution in the air gap and the distortion caused by the opposing magnetic force.

To understand how to calculate the repelling force between two magnets, one must first understand how to relate the force, F that is caused by the magnet to its flux, ϕ. The relationship between the force in the air gap of a magnetic circuit and flux is clear. What was proven can now be applied to the permanent magnet concept which applies to this application.

$$F=\varphi^2/u0 \times A$$

Based upon the magnetic force required to levitate the wind turbine, rotor section is designed. Greater thickness magnet should be used to levitate wind mill because in order to harness more power. Rotor design mainly depends upon the magnets used for levitation.

3. Design of rotor and axial flux generator for the proposed model

This section provides brief design of rotor blades and axial flux generator design for the proposed model. Rotor blades design and fabrication is discussed in the first section and axial flux generator is discussed in the further section.

3.1 Rotor design

After a thorough research into both sub types of vertical axis wind turbine rotors configurations, it has been decided to base the foundation of design on the darrieus model. In this project modified version of darrieus type of wind turbine is designed and the final fabricated rotor blades design is pictured in Figure.

Design parameters like Tip speed ratio, material selection, and solidity and power co efficient are considered while fabricating rotor blades.

Fabricated rotor blades.

A standard darrieus model for this design would have created a lot of instability around the shaft and on the base which could eventually lead to top heaviness and causing the turbine to tip over. As compared to the standard design model of the Darrieus, we took a bit of a different approach in our design by modifying it with a curvature design of blades.

This design was attained with six blades cut out from PVC pipe due to its light weight and it can capture wind coming from any direction.

Number of blades used in this prototype is 6 to avoid turbulence. Each separated from one another by 45^0, once the wind blows one blade should come after each rotation. Each blade having a curvature of 180^0 to harness wind from all direction.

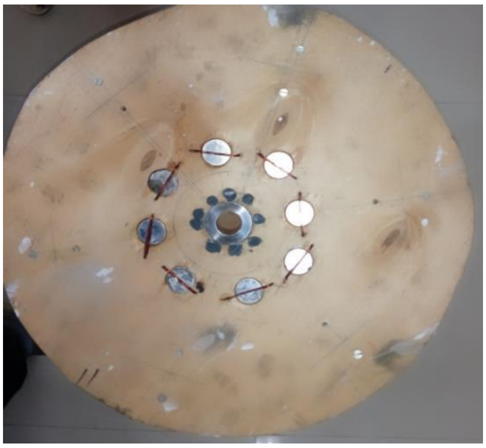
4. Design of Axial flux generator

This section briefs about designing of axial flux generator .The axial flux generator designed in this project utilizes the changing magnetic field produced by the magnets to induce a voltage.

Axial flux generator consists of rotor containing permanent magnets and stator containing coils.

4.1 Rotor Design

Rotor contains eight neodymium permanent magnets of dimension 25mmx5mm and one circular ring shaped neodymium permanent magnet of dimension 40mmx22mmx7mm used for levitation purpose also act as a magnet bearing at the bottom of the circular disc . Similar Disc type magnets of 25 mmx5mm diameter are arranged as alternate poles one after the other, along the periphery of the rotor made of plywood of 40mm diameter as in figure. Magnets are selected on the basis of B-H curve which depicts operating point of permanent magnets. Each magnet separated from each other by 15mm distance. These magnets are responsible for the useful flux that is going to be utilized by the power generation system.



4.2 Coil Design

The number of windings per coil produces a design challenge. The more windings will increase the voltage produced by each coil but in turn it will also increase the size of each coil. In order to reduce the size of each coil a wire with a greater size gage can be utilized.

Again another challenge is presented; the smaller the wire becomes the less current will flow before the wire begins to heat up due to the increased resistance of a small wire. Each one of our coils has a measured resistance of 60Ω;a smaller gage wire would further reduce this resistance.

Series of experimentation has been with coil of turns 100 and 200 and found the very less voltage of 0.2v and 0.6 volts respectively. So coil of 800 turns is selected finally for the design of stator coils for the proposed model of axial flux generator.

Four windings are used in this project each having 800 turns 30 SWG which are placed as a sandwich between two permanent magnet. Air gap of 3 cms is maintained to have proper flux leakage through the coil.

4.3 Coil Arrangement

When designing a generator the application, which it will be used for, must be kept in mind. The question must be answered, which property, the current or the voltage, is of greater importance? The problem that is produced by a larger coil is the field density is decreased over the thickness of the coil. The thickness of the coil is what reduces the flux magnitude. In our design we have chosen to sandwich the coils between two attracting magnets.

This design will increase the field density greatly improving the voltage output. The increased thickness of a coil would therefore increase the distance between the two magnets reducing the flux. A balance must be found between the amount of voltage required and the amount of current required. We have chosen to use a very high gage wire to increase the amount of voltage the generator can provide. If the generator is required to produce more current the coils can be replaced with those of a smaller gage wire. The permanent magnets we have chosen to use provide a very strong magnetic field.

In this project coils are connected in series keeping amount of voltage required. The number of turns adds to produce a greater voltage. This design choice will increase the voltage each coil will produce.

The voltage produced by each coil can be calculatedusing Faraday's law of induction:

$$V= - N\, d\varphi/dt$$

5. RESULTS AND CONCLUSIONS

Concept of magnetic levitation is successfully illustrated in this project and the design of axial flux generator and levitation system is fully incorporated in the fabricated model as shown in the figure below.

Rotor blades are designed using concept of aerodynamics and parameters like tip speed ratio, power coefficient, solidity, material used, design of blades, all are incorporated while designing and fabricating a wind turbine using magnetic levitation wind turbine.

Design details of axial flux generator and levitation system implies voltage induced in a coil depends upon the permanent magnets, which creates magnetic lines of force based upon their magnetic strength. In order to levitate a wind mill, selection of magnet plays a very important role. Magnetic force require to levitate wind mill depends upon the rotor design.

At the end of the project, the magnetically levitated vertical axis wind turbine was a success. This project demonstrates the utilization of the renewable resource (wind energy) in an efficient way. This type of generation can be used in remote places where conventional power supply is uneconomic.

The wind turbine rotors and stator levitated properly using permanent magnets which allowed for a smooth rotation with negligible friction. At moderate wind speeds the power output of the generator satisfied the specifications needed to supply the LED load. An output ranging from 5V to 60V was obtained from the magnetic levitated vertical axis wind turbine prototype.

6. FUTURE SCOPE

Voltage generated from maglev wind turbine can be increased by increasing the number of turns of the coil in proportion with magnetic lines of force obtained from the permanent magnet. Therefore greater thickness of the permanent magnets should be used while fabricating the axial flux generator.

The maglev windmill can be designed for using in a moderate scale power generation ranging from 400 Watts to 1 KW. Also it is suitable for integrating with the hybrid power generation units consisting of solar and other natural resources.

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