# Design and Fabrication of Windmill Using Magnetic Levitation

[1]Nitin Sawarkar, [2]Sumedh Dongre, [3]PG.T.Dhanuskar,[4]Deepak Hajare
[1,2,3,4]*Assistant Professor, Department of Mechanical Engineering, Priyadarshini College of Engineering, Nagpur, Maharashtra, India.*
nitinsawarkar304@gmail.com

***Abstract:*** *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% energy consumption in the latter part of the 21st century. This research focuses on the utilization of wind energy as a renewable source. In the United States alone, wind capacity has grown about 45% to 16.7GW and it continues to grow with the facilitation of new wind projects. The aim of research is to design and implement a magnetically levitated vertical axis wind turbine system that has the ability to operate in both high and low wind speed conditions. Our choice for this model is to showcase its efficiency in varying wind conditions as compared to the traditional horizontal axis wind turbine and contribute to its steady growing popularity for the purpose of mass utilization in the near future as a reliable source of power generation.*

**Keywords:** *Magnet, levitation, renewable energy, wind turbine*

## I. INTRODUCTION

Renewable energy is generally electricity supplied from sources, such as wind power, solar power, geothermal energy, hydro power and various forms of biomass. These sources have been coined renewable due to their continuous replenishment and availability for use over and over again. 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. The conceptual design also entails the usage of spiral shaped blades and with continuing effective research into the functioning of sails in varying wind speeds and other factors, an efficient shape and size will be determined for a suitable turbine blade for the research. With the appropriate mechanisms in place, we expect to harness enough wind for power generation by way of an axial flux generator built from permanent magnets and copper coils. The arrangement of the magnets will cultivate an effective magnetic field and the copper coils will facilitate voltage capture due to the changing magnetic field. The varying voltage obtained at this juncture will then be passed through a AC-AC converter to achieve a steady output AC voltage.

This section introduces and provides a brief description of the major components and factors that will contribute to an efficiently functioning wind turbine. These factors are wind power, the generator, magnet levitation and the AC-AC converter. Later sections will provide an in-depth look into the essence of each factor and its function and importance to the overall operation of the vertical axis wind turbine. Undoubtedly, the project ability to function is solely dependent on the power of wind and its availability. Wind is known to be another form of solar energy because it comes about as a result of uneven heating of the atmosphere by the sun coupled with the abstract topography of the earth's surface [3.1]. With wind turbines, two categories of winds are relevant to their applications, namely local winds and planetary winds. The latter is the most dominant and it is usually a major factor in deciding sites for very effective wind turbines especially with the horizontal axis types.

The basic understanding of a generator is that it converts mechanical energy to electrical energy. Generators are utilized extensively in various applications and for the most part have similarities that exist between these applications. However the few differences present is what really distinguishes a system operating on an AC motor from another on the same principle of operation and likewise with AC motors. With the axial flux generator design, its operability is based on permanent magnet alternators where the concept of magnets and magnetic fields are the dominant factors in this form of generator functioning. These generators have air gap surface perpendicular to the rotating axis and the air gap generates magnetic fluxes parallel to the axis. In further chapters we will take a detailed look into their basic operation and the configuration of our design.

***A. Magnetic Levitation***

Also known as maglev, this phenomenon operates on the repulsion characteristics of permanent magnets. This technology has been predominantly utilized in the rail industry in the Far East to provide very fast and reliable transportation on maglev trains and with ongoing research its popularity is increasingly attaining new heights. Using a pair of permanent magnets like neodymium magnets and substantial support magnetic levitation can easily be experienced. By placing these two magnets on top of each other with like polarities facing each other, the magnetic repulsion will be strong enough to keep both magnets at a distance away from each other. The force created as a result of this repulsion can be used for suspension purposes and is strong enough to balance the weight of an object depending on the threshold of the magnets [3.2]. In this project, we expect to implement this technology for the purpose of achieving vertical orientation with our rotors as well as the axial flux generator.

***B. Principle of magnetic levitation for AC current friction-less*** **:-**

There are currently three known maglev suspension systems. In this project report, we will be covering the basic principals of Electrodynamics Suspension Systems (EDS), Electromagnetic Suspension Systems (EMS) and Inductrack. The three suspension systems each have different characteristics and special features. While EDS and EMS both use only the interaction of magnets and superconductors, Induct rack uses coils on the track underneath the train body. All three suspension systems work under the same principal of magnetic levitation covered in this project report.

## II. WIND POWER AND WIND TURBINES

### A. Wind Power Technology

Wind power technology is the various infrastructure and process that promote the harnessing of wind generation for mechanical power and electricity. This basically entails the wind and characteristics related to its strength and direction, as well as the functioning of both internal and external components of a wind turbine with respect to wind behavior.

***A. The Power of Wind***

As mentioned earlier the effective functioning of a wind turbine is dictated by the wind availability in an area and if the amount of power it has is sufficient enough to keep the blades in constant rotation. The wind power increases as a function of the cube of the velocity of the wind and this power is calculable with respect to the area in which the wind is present as well as the wind velocity [4.1]. When wind is blowing the energy available is kinetic due to the motion of the wind so the power of the wind is related to the kinetic energy.

The power harnessed from the wind cannot exceed 59% of the overall power in the wind. Only a portion can be used and that usable portion is only assured depending on the wind turbine being used and the aerodynamic characteristics that accompany it [4.2].

***B. Wind Sails Design Selection***

After a thorough research into both sub types of vertical axis wind turbine rotors configurations, we decided to base the foundation of our design on the Slavonia's model and the design is look like fig.1

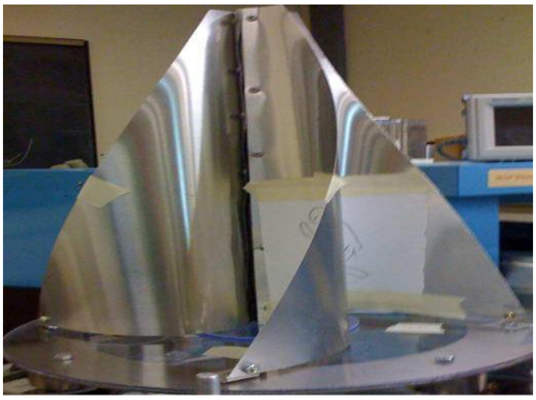

*Fig. 1 Wind Rotors Side View*

As compared to the standard design model of the Savonius, we took a bit of a different approach in our design by modifying it with a curvature design from the top of the sails to the bottom. This design was attained with four triangular shapes cut out from aluminum sheet metal and due to the flexibility of the sheet metal, we were able to spiral the sail from the top of the shaft to the base.

The main factor for our design is due to its attachment to the stator of our generator and to some extent the magnetic levitation. From Fig.2, it is observed that our streamlined design eliminates the scoop on the upper half of the Savonius model and winds down from the top of the shaft to the circumference of the circular base thus providing a scooping characteristic towards the bottom. This therefore concentrates the mass momentum of the wind to the bottom of the sails and allows for smoother torque during rotation. A standard Savonius 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.

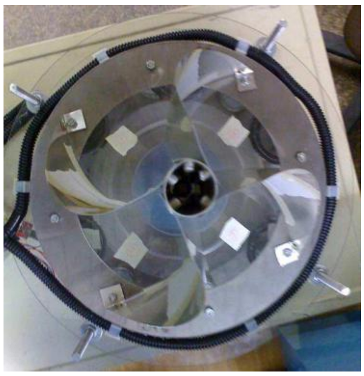

*Fig. 2- Rotors Connected to Stator*

The presence of the eight permanent magnets on the stator contributes some weight to the base of the sail thus the expectance of a little resistance in starting off the turbine and during operation as well. With our design we expect a smoother torque during rotation since the wind energy shoots for the base of the sails and will set the rotors spinning easily and freely around the shaft. This will also amount to minimal to no stress on the levitation of the rotors and the generator by the magnets thus increasing the efficiency and longevity of the suspension.

***C. Component specification –***

**Shaft -**

Height - 300 mm

Diameter – 19 mm (ring magnet id – 20mm)

**Disc –**

Diameter – 300 mm

Thickness – 3 mm (for less weight + stiffness)

Material – transparent (component can seen easily, no technical issues)

Centre Hole – 20mm (ring magnet id – 20mm)( to rotate friction less with balance)

**Blades –**

Material GI (strength is better than aluminum and steel )

***D. MAGNETIC LEVITATION***

In selecting the vertical axis concept for the wind turbine that is implemented as the power generation portion of this research, certain uniqueness corresponded to it that did not pertain to the other wind turbine designs as shown in fig.3. 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. This support is called maglev which is based on magnetic levitation. Maglev offers a near frictionless substitute for ball bearings with little to no maintenance.

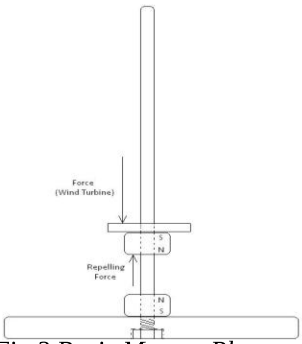


*Fig.3 Basic Magnet Placement*

The permanent magnets that were chosen for this application were the NX8CC-N42 magnets from K&J Magnetics. These are Nd-Fe-B ring shaped permanent magnets that are nickel plated to strenthen and protect the magnet itself. The dimensions for the magnets are reasonable with a outside diameter of 1.5 inches, inside diameter of 0.75 inches and height of 0.75 inches.

## III. CONCLUSION

Over all, the magnetically levitated vertical axis wind turbine was a success. The rotors that were designed harnessed enough air to rotate the stator at low and high wind speeds while keeping the center of mass closer to the base yielding stability. 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. Lastly the SEPIC circuit operated efficiently and to the specifications that were slated at the beginning of the circuit design.

After testing the project as an overall system we found that it functioned properly but there are many things that can be improved upon. The generator itself had some design flaws which we feel limited the amount of power it could output. These flaws start at the coils which were initially made too thick and limited how close the magnets attached to the stator could be positioned from each other. If the magnets were pulled in closer to one another, the magnetic field density would be much greater allowing for more power to be induced into the coils. Another setback was that the wire that was used to wrap the coils was 30 AWG and because of its small cross section it restricted the amount of current that could be drawn from the generator. Lastly, the plexi-glass that was used for the frame of the wind turbine was too elastic. Due to the fact it was not as strong as we had hoped, there was some sag in frame about the central axis where the majority of the weight and force was located. If a more heavy duty material was used in future design then it would allow for more precision in magnet placement.

In terms of large scale power production, vertical axis wind turbines have not been known to be suitable for these applications. Due to the overall structure and complexity of the of the vertical axis wind turbine, to scale it up to a size where it could provide the amount of power to satisfy an commercial/industrial park or feed into the grid would not be practical. The size of the rotors would have to be immense and would cost too much to make. Aside from the cost, the area that it would consume and the aesthetics of the product would not be desired by this type of consumer. Horizontal axis wind turbines are good for these applications because they do not take up as much space and are positioned high up where they can obtain higher wind speeds to provide an optimum power output.

The home for the magnetically levitated vertical axis wind turbine would be in residential areas. Here it can be mounted to a roof and be very efficient and practical. A home owner would be able to extract free clean energy thus experiencing a reduction in their utility cost and also contribute to the “Green Energy” awareness that is increasingly gaining popularity.

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