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Evaluation of Vertical Axis Maglev Wind Turbine

[1]Nikhil Dabhade, [3]Krunal Sonare, [2]Hemant Kotangale,
[4]Nitin S. Sawarkar

Research Scholar,Department of Department of Mechanical Engineering Priyadarshini College of Engineering,Nagpur, India
Research Scholar,Department of Department of Mechanical Engineering Priyadarshini College of Engineering,Nagpur, India
Research Scholar,Department of Department of Mechanical EngineeringPriyadarshini College of Engineering,Nagpur, India
Assistant Professor Department of Mechanical Engineering Priyadarshini College of Engineering, Nagpur, India

Abstract: *This project dwells on the implementation of an alternate configuration of a wind turbine for power generation purposes. Using the effects of magnetic repulsion, spiral shaped wind turbine blades will be fitted on a rod for stability during rotation and suspended on magnets as a replacement for ball bearings which are normally used on conventional wind turbines. Power will then be generated with an axial flux generator, which incorporates the use of permanent magnets and a set of coils.*

Keywords: *Lane Departure Warning system, Lane detection, Lane Tracking.*

I. 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. Facts from the World Wind Energy Association estimates that by 2010, 160GW of wind power capacity is expected to be installed worldwide which implies an anticipated net growth rate of more than 21% per year.

This project 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 this major qualifying project 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.

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 project.

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.

II. Literature Review

Magnetic pressure is used to counteract the effects of the gravitational and any other accelerations. The rotor is floating in the air due to levitation, mechanical friction is totally eliminated. That makes the rotation possible in very low wind speeds. Maglev wind turbines have several advantages over conventional wind turbines. For instance, they're able to use winds with starting speeds as low as 1.5 meters per second (m/s). Also, they could operate in winds exceeding 40 m/s. The Wind turbines are classified on the basis of different ways. Following are the main criteria's to classify the wind turbines: On the basis of amount of electrical power output small size turbines: These wind turbines produces electrical power output up to 2 kW[1]. These turbines may be used for low power applications or at remote places. Medium Size Turbines: These wind turbines produces electrical power output in the range of 2 kW to 100 kW. These turbines are used for residential or for local use. Large Size Turbines: These wind turbines produces electrical power output more than 100 kW. These turbines are used to generate power for distribution in central power grid On The Basis of Rotor Axis Orientation Horizontal Axis Wind Turbine, Vertical Axis Wind Turbine[2].

The blade of a HAWT is subject to a gravity-induced reversing stress at the root of the blade, which is not the case for VAWT blades, VAWTs have an inherent torque ripple. The torque ripple is caused by the continuously changing angle of attack between the blades and the apparent wind, The performance of a wind turbine depends on the power coefficient, CP, which states how much of the power in the wind that is absorbed by the wind turbine[3].

III. Formulation

A. Wind Power

Undoubtedly, the project's 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. 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.

B. Magnetic Levitation

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. 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.

C. AC-AC Conversion

In order to begin the analysis of AC-AC converters it is important to first understand the concept behind a converter. Over the years, alternating current has been the common choice of power supply. AC is popular because the voltage can be easily stepped up or down using a transformer. Due to the inherent properties of a transformer, AC voltage cannot be altered using this type of equipment. Transformers operate due to a changing magnetic field in which the change in magnetic flux induces a current. Direct current cannot provide a changing magnetic field therefore a transformer with an applied AC input would only produce heat.

D. 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 Savonius model and the l design will look like above picture but till now design is not yet final. 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.

Figure 1 Wind Rotors Side View

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.1, 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.

IV. 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.

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