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Magnetically Levitated Wind Turbine for Power Generation

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ABSTRACT: Magnetic levitation, maglev, or magnetic suspension is a method by which an object is suspended with no support other than magnetic fields. Magnetic pressure is used to counteract the effects of the gravitational and any other accelerations. The principal advantage of a maglev windmill from a conventional is, as 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. Currently the largest wind turbines in the world produce only five MW of power while, one large maglev wind turbine could generate one GW of power.

KEYWORDS: Renewable Energy, Wind Energy, Magnetic Levitation, Power Generation, Magnets.

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.

Wind is a form of solar energy. It is a natural power source that can be economically used to generate electricity. The way in which wind is created is from the atmosphere of the sun causing areas of uneven heating. In conjunction with the uneven heating of the sun, rotation of the earth and the rockiness of the earth's surface winds are formed. The terms wind energy or wind power describes the process by which the wind is used to generate mechanical power or electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity. The wind turbine is used for conversion of kinetic energy of wind into electrical energy. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity.

The Maglev wind turbine design is a vast departure from conventional propeller designs. Its main advantages are that it uses frictionless bearings and a magnetic levitation design and it does not need vast spaces as required by the conventional wind turbines. It also requires little if any maintenance. The unique operating principle behind this design is through magnetic levitation. Magnetic levitation is supposedly an extremely efficient system for wind energy. The vertically oriented blades of the wind turbine are suspended in the air replacing any need for ball bearings. Maglev Wind turbine has the features of no mechanical contact, no friction etc. minimizing the damping in the magnetic levitation wind turbine, which enables the wind turbine start up with low speed wind and work with breeze. 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. It would

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also increase generation capacity by 20% over conventional wind turbines and decrease operational costs by 50% [1]. This makes the efficiency of the system higher than conventional wind turbine. It reduces maintenance cost and increases the lifespan of the generator.

II. WIND POWER & WIND TURBINES

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 behaviour. Wind power, as an alternative to fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation and uses little land. Any effects on the environment are generally less problematic than those from other power sources. 83 countries around the world are using wind power on a commercial basis. Worldwide there are now over two hundred thousand wind turbines operating, with a total nameplate capacity of 365.4GW as of end 2014.

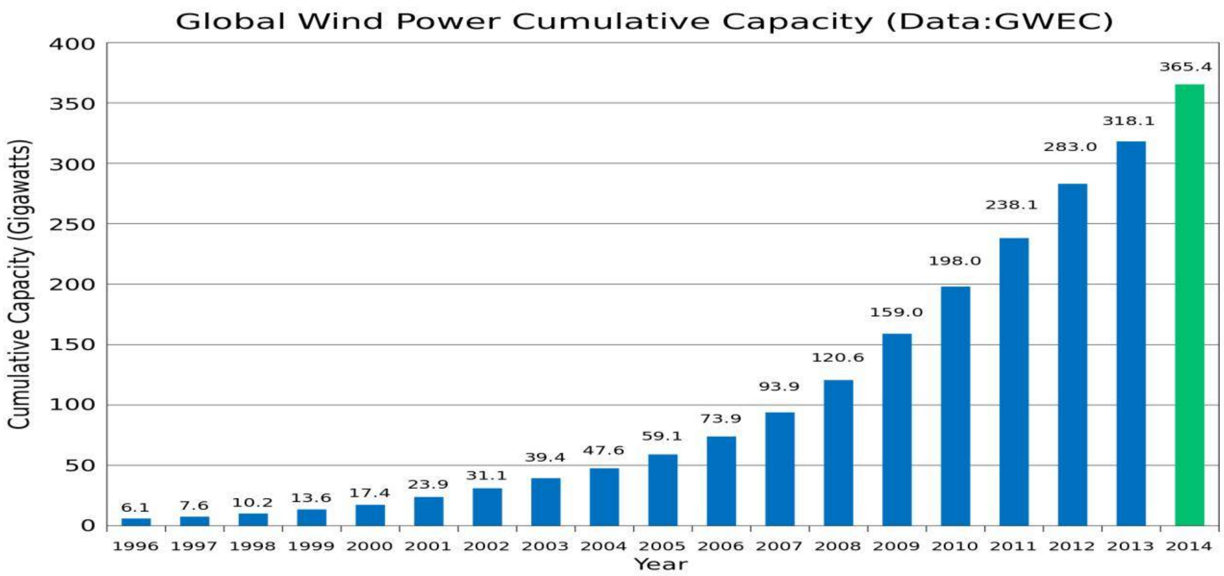

Fig.1 Electricity Generation from Wind

Types of Wind Turbines: Many types of turbines exist today and their designs are usually inclined towards one of the two categories: horizontal-axis wind turbines (HAWTs) and vertical-axis wind turbines (VAWTs). As the name pertains, each turbine is distinguished by the orientation of their rotor shafts. The former is the more conventional and common type everyone has come to know, while the latter due to its seldom usage and exploitation, is quiet unpopular. 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 servomotor or a wind vane for smaller wind turbine applications. With the 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. Their design makes it possible for them to utilize the wind power from every

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direction unlike the HAWTs that depend on lift forces from the wind similar to the lift off concept of an airplane [3]. Vertical axis wind turbines are further subdivided into two major types namely the Darrieus model and the Savonius model. Darrieus Model which was named after designer and French aeronautical engineer, Georges Darrieus. This form of design is best described as an eggbeater with the blades, two or three of them bent into a c-shape on the shaft. Finnish engineer Sigurd Savonius invented the Savonius model. The functioning of this model depends on drag forces from the wind. This drag force produced is a differential of the wind hitting by the inner part of the scoops and the wind blowing against the back of the scoops. Like the Darrieus model, the Savonius turbines will work with winds approaching in any direction and also work well with lower wind speeds due to their very low clearance off the ground.

III. WINDMILL

This section introduces and provides a brief description of the major components and factors that will contribute to an efficiently functioning wind turbine. Those factors are wind power, generator, magnetic levitation, power generation, induced EMF, magnetic flux.

Wind Power: Undoubtedly, the paper's ability to function is solely depending 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. These winds are usually found along shore lines, mountain tops, valleys and open plains. The former type will find in regular environments like the city or rural areas, basically where settlements are present. This type of wind is not conducive for effective power generation; it only has a lot of worth when it accompanies moving planetary winds.

Generator: 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 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.

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 on-going 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 [2]. In this paper, we expect to implement this technology form the purpose of achieving vertical orientation with our rotors as well as the axial flux generator.

Power Generation: When designing a generator it is important to have a firm grasp of the basic laws that govern its performance. In order to induce a voltage in a wire a nearby changing magnetic field must exist. The voltage induced not only depends on the magnitude of the field density but also on the coil area. The relationship between the area and field density is known as flux (Φ). The way in which this flux varies in time depends on the generator design. The axial flux generator uses the changing magnetic flux to produce a voltage. The voltage produced by each coil can be calculated using Faraday's law of induction, $V = -N\,(d\emptyset/dt)$

Induced EMF: In order to explain how an axial flux generator is designed the elements that produce an electromotive force or voltage must be described. An induced EMF is produced by a time varying magnetic field. Michael Faraday

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performed experiments with steady currents and a simple transformer in hopes of producing a voltage from a magnetic field. He discovered that a constant magnetic field would not induce a voltage but a time varying field could. This was an important discovery known as electromagnetic induction, a discovery that is fundamental in the design of a generator. It is this relative motion of a magnetic field producing a voltage that allows us to be creative in the ways we produce electricity.

Magnetic Flux: The magnitude of the magnetic flux is greatest when the coil in a magnetic field is perpendicular to the field. In the design of an axial flux generator it is best to keep the coils perpendicular to the field produced by the permanent magnets. In many conventional motors a winding rotates inside a magnetic field. The number of windings is increased so that each winding is positioned close to 90 degrees to the field. In our design the angle between the coils and the field does not change, instead the field itself varies with time.

Faraday's law of induction states that the induced electromotive force is equal to the change in magnetic flux over the change in time. $V = -N\,(d\emptyset/dt)$

IV. MAGNETIC LEVITATION

In selecting the vertical axis concept for the wind turbine that is implemented as the power generation portion of this paper, 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.

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. The four different classes are Alnico, Ceramic, Samarium Cobalt and Neodymium Iron Boron also known Nd- Fe-B. NdFe-B is the most recent addition to this commercial list of materials and at room temperature exhibits the highest properties of all of the magnetic materials. Nd-Fe-B 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 high speeds, which will exhibit a large downward force on the axis. 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.

If the magnets where 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. The permanent magnets that were chosen for this application were the N52 magnets. These are Nd-Fe-B ring shaped permanent magnets that are nickel plated to strengthen and protect the magnet itself. The dimensions for the magnets are reasonable with an outside diameter of 28mm, inside diameter of 10mm and height of 12.5mm.

V. PROTOTYPE

Some modifications are made in order to overcome the limitations of theoretical design of magnetically levitated vertical axis wind turbine and a prototype is constructed.

Magnet Placement: Two ring type neodymium (Nd-Fe-B) magnets of grade N52 of outer diameter 28 mm, inner diameter 10 mm and thickness 12.5 mm are placed at the shaft, by which the required levitation between the rotor and the base is obtained. Similar disc type magnets of 30 mm diameter and 4mm thickness are arranged as alternate poles one after the other, along the periphery of the rotor. These magnets are responsible for the useful flux that is going to be

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utilized by the power generation system.

Blade Design: The turbine we used in this prototype is a turbine ventilator. We took a bit of a different approach in our blade design. The base diameter of the blade is 615mm.The top diameter is 480mm.Vortex blades are of industrial grade aluminium. There are 42 blades. Height of the blade hub is 430mm.Base with shaft has a diameter of 610mm.Total height of the shaft is 600mm.

Fig 2: rotor

Fig 3: stator

Fig 4: final model

Coil Arrangement: 28 gauge wires of 1000 turns each are used as coils for power generation. 12 sets of such coils are used in the prototype. These coils are arranged in the periphery of the stator exactly in a line to the arranged disc magnets. The coils are raised to a certain height for maximum utilization of the magnetic flux. Each set of such coils are connected in series aiding to obtain maximum output voltage. The series connections of the coils are preferred over the parallel connection for optimizing a level between the output current and voltage [4].

Levitation of Rotor: In the designed prototype, the base and rotor are separated in the air using the principle of magnetic levitation. The rotor is lifted by a certain centimeters in the air by the magnetic pull forces created by the ring type Neodymium magnets. This is the principal advantage of a maglev windmill from a conventional one. That is, as 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.

Final Model: The overall structure of prototype is shown in the fig 4. Output voltage obtained from the prototype is measured using a multimeter. In the DSO we got a sine wave. A bridge rectifier is used for converting the AC to DC and we got an output of 30V. LED load of 4W is connected to the turbine and current is measured to be 0.25Amps.

RESULTS AND DISCUSSIONS

TABLE I

STARTING WIND SPEED OF WIND TURBINE MODEL

Wind Turbine Model	Starting Wind Speed(m/s)				Average(m/s)
Maglev	1.3	1.5	1.6	1.4	1.45
Conventional	4.3	4.5	4.7	4.4	4.475

TABLE II
ROTATIONAL SPEED OF WIND TURBINE MODEL AT CONSTANT WIND SPEED

Wind Turbine Model	Rotational Speed(RPM)				Average(RPM)
Maglev	62	65	64	66	64.25
Conventional	23	27	26	29	26.25

TABLE III
TIME TAKEN BY WIND TURBINE MODEL TO STOP ROTATION

Wind Turbine Model	Time taken(s)				Average(s)
Maglev	19	14	18	13	16
Conventional	1.8	1.5	1.6	1.4	1.575

In the DSO we got a sine wave. Output voltage obtained from the prototype is measured using a multimeter. A bridge rectifier is used for converting the AC to DC and we got an output of 30V. A LED load of 4W is connected to the turbine and current is measured to be 0.25Amps.

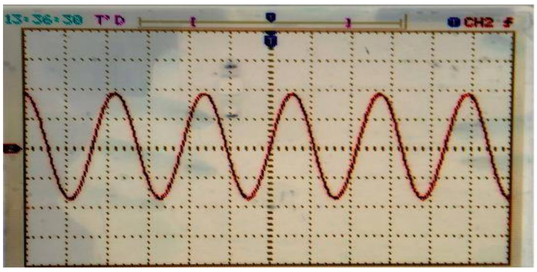

Fig.5 Sine wave from DSO

VI.CONCLUSION

The rotors that were designed harnessed enough air to rotate at low and high wind speeds while keeping the centre of mass closer to the base yielding stability. The wind turbine rotor levitated properly using permanent magnets, which allowed for a smooth rotation with negligible friction. A steel shaft is used to avoid the wobbling movement of the rotor. Overall, the magnetic levitation wind turbine was a successful model.

APPENDIX

No.	Component	Specification
1	Nd Fe B Disc type (24)	30 mm dia 4mm thick
2	Nd Fe B Ring type (2)	outer dia 28 mm inner dia 10 mm 12.5mm thick
3	Coil (12)	1000 turns 28 gauge copper wire
4	Turbine Ventilator	
5	Blade Hub	Base Dia 615mm Top Dia 480mm Height:430mm 42 blades
6	Base with shaft	Base dia 610mm Height: 600mm

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REFERENCES

[1]Dinesh N Nagarkarand Dr. Z. J. Khan, "Wind Power Plant Using Magnetic Levitation Wind Turbine",International Journal of Engineering and Innovative Technology (IJEIT) Volume 3, Issue1, July 2013.
[2]Liu Shuqin, "Magnetic Suspension and Self-pitch for Vertical -axis Wind Turbines", ISBN:http://www.intechopen. Com/books/fundamental-and-advanced-topics-in-wind-power/ magnetic suspension and-self-pitch-for-vertical-axis Wind-turbines. 2011.
[3] Maglev Wind Turbine Technologies, Inc. (MWTT) & Off Grid Technologies, Inc. (OGT)," Vertical Axis Wind Turbine 200 Mega Watt off Shore Wind Farm (VAWT off Shore JV) - City of Evanston, Illinois Lake Michigan Project".
[4] M. A. Mueller and A. S. McDonald,"A light weight low speed permanent magnet electrical generator for direct Drive wind turbines", Institute for Energy Systems, Institute for Energy Systems,Edinburgh University, Edinburgh University, Edinburgh, UK.
[5]Vishal D Dhareppgoaland MaheshwariM Kona-gutty," REGENEDYNE Maglev Wind Power Generation", SARC IRAJ International Conference, 16th June 2013, Pune, India, ISBN: 978-81-92747-8-3.