IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

REPSE-17

Sri Venkateshwara College of Engineering, Bengaluru

Vol. 4, Special Issue 7, May 2017

Maglev Windmill

B. M. Preetham[1], Rohit Pratap Singh[2], Srisharan Sindhe S.[3], Vishal Yadav[4]

Assistant Professor, Mechanical, Sri Venkateshwara College of Engineering, Bengaluru, India [1]

Student, Mechanical, Sri Venkateshwara College of Engineering, Bengaluru, India [2,3,4]

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 one 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, we are able to use winds with starting speeds as low as 1.5 meters per second (m/s). Also, we could operate in winds exceeding 40 m/s.

Keywords: Wind Energy, Magnetic Levitation, Power Generation, Magnets.

I. INTRODUCTION

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 the wind is created is from the atmosphere of the sun causing areas of uneven heating. In conjuction 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 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 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 to vast spaces required by more conventional wind turbines. It also requires little if any maintenance.
The Maglev wind turbine was first unveiled at the Wind Power Asia exhibition in Beijing 2007. 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 re-placing any need for ball bearings.

A. NEED FOR WIND POWER TECHNOLOGY

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. It is estimated that renewable sources might contribute about 20%-50% to energy consumption in the later part of the 21st century. 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 also increase generation capacity by 20% over conventional wind turbines and decrease operational costs by 50%. This makes the efficiency of the system higher than conventional wind turbine. The turbine uses permanent type of rare earth magnets (neodymium) instead of electro-magnets and therefore it doesn't require electricity to run. The friction between the turbine blades and the base can maximum power output.

II. WIND POWER AND WIND TURBINES

A. WIND POWER TECHNOLOGY

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.

90 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 486,790 MW as of end 2016.

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
REPSE-17
Sri Venkateshwara College of Engineering, Bengaluru
Vol. 4, Special Issue 7, May 2017

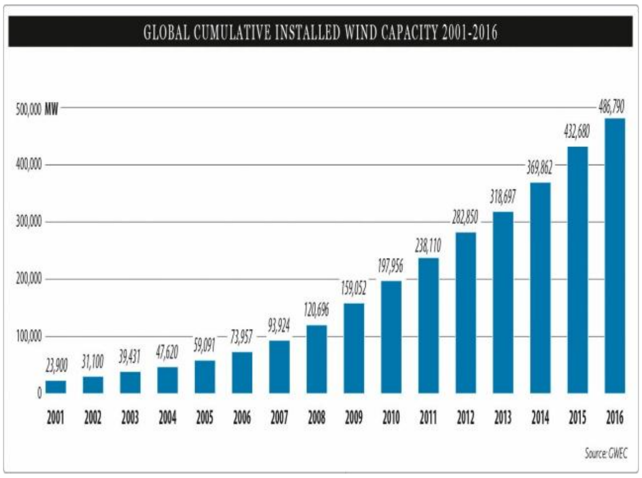

Fig. 1 Worldwide electricity generation from wind

B. 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. 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.

We know,
Kinetic Energy $=1/2\ MV^2$
The volume of air passing in unit time through an area A, with speed V is AV and its mass M is equal to the Volume V multiplied by its density ρ so:
$M= \rho AV$
Substituting the value of M in equation above we get:
Kinetic Energy$=1/2\ (\rho AV)\ V^2$
Kinetic Energy$=1/2\ \rho AV^3$
To convert the energy to kilowatts, a non-dimensional proportionality constant k is introduced where,
$K = 2.14\times10-3$
Therefore,
Power in KW (P) $= 2.14\rho AV3\times10-3$
Where:

Air Density (ρ) = 1.2 kg/ 3/2.33x 10−3 slugs/f 3 Area (A) = Area swept by the blades by the turbine Velocity (V) = wind speed in m/s

With the above equation, the power being generated can be calculated, however one should note that it is not possible to convert all the power of the wind into power for generation.
The power harnessed from the wind cannot exceed 59% of the overall power in the wind. This is the Betz limit.Coefficient of performance:-
Cp= Pt/Pa
Pt= Power of turbine
Pa= Power available

C. 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. With the vertical axis wind turbines, the concept behind their operation is similar to that of the horizontal designs.

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

REPSE-17

Sri Venkateshwara College of Engineering, Bengaluru

Vol. 4, Special Issue 7, May 2017

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. Their design makes it possible for them to utilize the wind power from every direction unlike the HAWTs that depend on lift forces from the wind similar to the lift off concept of an airplane. 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 this 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 is dependent 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.

Fig.2. Hybrid Verticl Axis Wind Turbines

III.MAGNETIC LEVITATION

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 centre of the wind sails, which allows for a different type of rotational support.

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. Nd-Fe-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. The Nd-Fe-B has a very attractive magnetic characteristic, which offers high flux density operation and the ability to resist demagnetization.

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.

If the magnets were ring shaped then they could easily be slid tandem down the shaft with the like poles facing toward each other. The permanent magnets that were chosen for this application were the N42 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 40mm, inside diameter of 20mm and height of 10mm.

A. MAGNET SELECTION

Some factors need to be assessed in choosing the permanent magnet selection that would be best to implement the maglev portion of the design. Understanding the characteristics of mag-net materials and the different assortment of sizes, shapes and materials is critical.

The four different classes are Alnico, Ceramic, Samarium Cobalt and Neodymium Iron Boron also known Nd- Fe-B. Nd-Fe-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. The 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 be-cause the load that will be levitated will be heavy and rotating a 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 where, under an evenly distributed load, the wind turbine center of mass will be found. Figure 3 shows a basic rendition of how the maglev will be integrated into the design. 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 N42 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 40mm, inside diameter of 20mm and height of 10mm.

IV. SOLAR POWER

Solar power is the conversion of energy from sunlight into electricity, either directly using photovoltaics (PV), or indirectly using concentrated solar power. Concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. Photovoltaic cells convert light into an electric current using the photovoltaic effect.

V. DESIGN

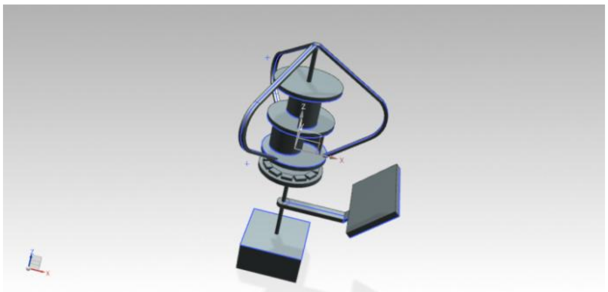

Fig. 3

VI. 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. This section includes details of modifications made.

A. MAGNET PLACEMENT

Two ring type neodymium (NdFeB) magnets of grade N-42 of outer diameter 40 mm, inner diameter 20 mm and thickness 10 mm are placed at the center of the shaft by which the required levitation between the stator and the rotor is obtained. Similar disc type magnets of 30 mm diameter and 6 mm thickness are arranged as alternate poles one after the other, along the periphery of the rotor made of acrylic of 40 mm diameter as in Figure 4. These magnets are responsible for the useful flux that is going to be utilized by the power generation system.

Fig. 4. Magnet placement

B. COIL ARRANGEMENT

26 gauge wires of 300 turns each are used as coils for power generation. 9 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.

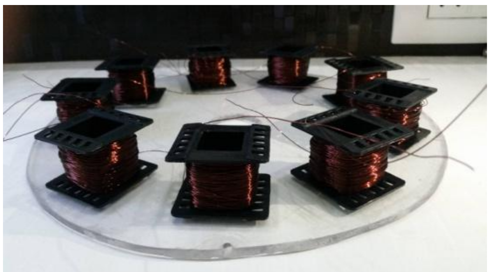

Fig.5. Coil Arrangement

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 [4]. The series connections of the coils are preferred over the parallel connection for optimizing a level between the output current and voltage. The coil arrangement is shown in figure 5.

C. LEVITATION BETWEEN STATOR AND ROTOR

In the designed prototype, the stator and rotor are separated in the air using the principle of magnetic levitation. The rotor is lifted by a certain centimetres 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. Figure 6 illustrates the magnetic levitation in our prototype.

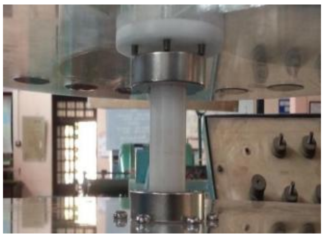

Fig.6. Magnetic levitation

D. BLADE DESIGN

The blades used in this prototype are not of the conventional type. In this prototype, this design was attained with four rect-angular shapes cut out from aluminium 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 [5]. The height of the blades was 150mm and the length is 250mm.

Fig. 7. Blade design

E. SOLAR PANEL

The wind speed at night is higher compared to day time. A solar panel is used along with the windmill to produce electricity during the day, when the wind speeds are less or during summer the solar panel gives more results. The solar panel used in the prototype has a maximum power of 10W maximum voltage of 17.83V and maximum current of 0.57A.

Fig. 8. Solar Panel

VII. CONCLUSION

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 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.

Generator satisfied the specifications needed to supply the LED load. An output ranging from 40V to 45V can be obtained from the magnetic levitated vertical axis wind turbine prototype. A modified design of savonius model wind turbine blade was used in the construction of the model. An aluminium shaft was used to avoid the wobbling movement of the rotor. Overall, the magnetic levitation wind turbine was a successful model.

A. LIMITATIONS

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 a commercial 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, this type of consumer would not desire the area that it would consume and the aesthetics of the product. 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.

B. FUTURE SCOPE

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. 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.

ACKNOWLEDGMENT

We thank almighty for bestowing upon us all his blessings for the compilation of this project. I would like to express our gratitude to Dr. Suresha, Principal, Sri Venkateshwara College of Engineering, Bengaluru and Dr. Shrishail Kakkeri, Head of the Department, Mechanical Engineering, for providing us with the guidance and facilities for the project. A deep sense of gratitude to project guide Asst. Prof. B.M. Preetham, whose overall direction and guidance has been responsible for the successful completion of this project. I express our sincere gratitude to Project coordinator Asst. Prof. Chandraprasad, for his cooperation and guidance for preparing Project. I also extend our sincere thanks to all other faculty members of Mechanical Engineering Department and our friends for their support and encouragement.

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-suspensionand-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 lightweight 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 Maheshwari M Konagutti," REGENEDYNE Maglev Wind Power Gen-eration", SARC-IRAJ International Conference, 16th June 2013, Pune, India, ISBN: 978-81-92747-8-3.