Power Generation using Maglev Windmill

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Abstract— This project implementation of Vertical Axis Wind Turbine (VAWT) to generate the electricity. In this project we uses the Magnetic Levitation Technique for highest power generation. With the merits of conventional VAWT, the merits of starting at low wind-speed, higher efficiency, low noise emission, etc. are also discussed. In this Maglev technique, ball bearings are replaced by permanent magnets to reduce the frictional losses. Using this effect wind turbine blades are placed on a rod for obtaining stability during rotation. Power is then generated by using an axial flux generator, which has incorporated the utilization of permanent magnets and a set of coils.

Key words: VAWT, Permanent Magnet, Magnetic Levitation, Wind Turbine, Energy, Wind Power

I. INTRODUCTION

Now a days energy demand increases an important factor in development of human resource is the Energy. In old days, we uses the conventional wind energy sources. It is a non-polluting energy source. As there are two types of wind turbines viz. Horizontal Axis Wind Turbine (HAWT) and Vertical Axis Wind Turbine (VAWT).The merits for vertical-axis wind turbine (VAWT) can be noted such as requirement of minimum cost, easy installation, easy maintenance, and the capability to accept wind from all directions. Compared with the traditional horizontal axis wind turbine, this type is levitated or suspended with the help of magnetic levitation directing vertical on a rotor shaft. This technology is utilized as an efficient replacement for ball bearings having its application on the traditional wind turbine. This technology is usually implemented with permanent magnets and is used in between the rotating shaft of turbine blades and base of wind turbine system. The entire rotor weight of wind turbine is balanced by magnetic bearings. The friction of the bearings is eliminated and hence need for bearing lubrication is also eliminated with decrease in the maintenance cost. Further, this magnetic suspension eliminates mechanical vibration reducing noise. As low friction reduces starting torque of turbine, the magnetic bearings facilitates by producing power at lower wind speed as compared with use of conventional bearings. Normal VAWT requires very different adjusting mechanism for blades making its structure complicated, costly in fabrication and wastage of power. But comparing with traditional VAWT the blades of magnetic VAWT are constructed for automatic pitch adjustment and hence requirement of any equipment is eliminated. The adjustment of blade pitch is performed naturally during rotation for the necessary angle of attack. This results in production of maximum thrust of wind force improving the efficiency.

II. LITERATURE REVIEW

A. Wind Power

Wind is considered as another form of solar energy because of its origination from difference in heating of atmosphere by sun. The winds relevant to applications of wind turbines are local winds and planetary winds. The second one is most available. Hence it constitutes as important consideration in locating the sites for proper working of wind turbines. The locations of these winds are generally along sea Shore Mountain, valleys and open plains. The wind force may be very strong. During the ancient period, human harnessed this force for important usage like the propulsion of ships using sails before the invention of the engines, in windmills for grinding grain or pumping water for cause of irrigation. At the beginning of the twentieth century concept of electricity found its use and windmills got converted into wind turbines with the rotor coupled to an electric generator. Electricity generated from the wind does not produce Carbon Dioxide emissions and therefore does not contribute to the greenhouse effect.

B. Types of Turbines

Wind Turbines are divided into two classes: horizontal axis wind turbines (HAWTs) and vertical axis wind turbines (VAWTs).

1) Horizontal Axis Wind Turbines

Horizontal axis wind turbine can be visualized as conventional box fan, a set of blades connected to a shaft that is parallel to the ground; however, function of turbine is the opposite of a box fan. It normally consists of two to three blades connected to a shaft that is connected to a generator which will produce energy from shaft work. There are two main types of HAWTs, ones that face into wind and ones that face away from wind. Turbines that face into wind require a rudder or some other type of mechanism to be able to self-orientate to face incoming wind. Those that face away from the wind do not need this rudder to self-orientate, however they suffer from a vibration due to support tower blocking part of wind flow.

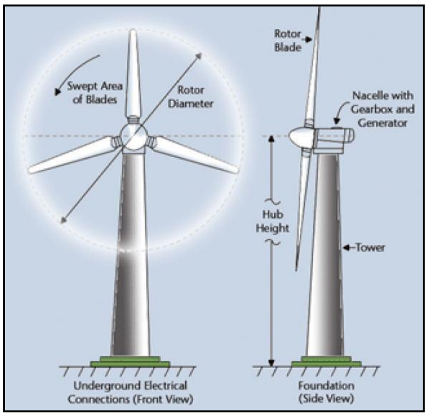

Fig. 1: Horizontal Axis Wind Turbines

C. *Vertical Axis Wind Turbine*

More recent developments in Wind turbine technology have focused on vertical axis Wind turbines (VAWTs), speeds and shifting to lift-only characteristics at rotor speeds approaching or exceeding local Wind speed. An improved VAWT capable of harnessing Wind from a full 360 degrees of rotation about the vertical axis would be one such device. Desirably, the VAWT should also harness vertically impinging Wind and cyclonic Wind. The VAWT also should minimize inefficiencies arising from frictional losses. Preferably, the VAWT materials should maximize strength and durability but have a low cost of manufacture so as to be economically available to consumers for use in individual households. 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 direction unlike the HAWTs that depend on lift forces from the wind similar to the lift off concept of an airplane. 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.

Vertical axis wind turbines are further subdivided into two major types namely the Darrieus model and the Savonius model. Pictured above in figure 1 is an example of the 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 9m blades, two or three of them bent into a c-shape on the shaft. The Savonius model was invented by Finnish engineer Sigurd Savonius and an example is shown in Figure 2.

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. 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. Vertical axis wind turbines operate on same principle of converting rotational movement due to wind into shaft work, which is then converted into electricity through the use of a generator. VAWTs contain a shaft that is perpendicular to ground. Unlike the HAWTs, the VAWTs can catch the wind regardless of the position that they are facing, which can lead to them being more versatile. Also, VAWTs are able to function in more irregular wind patterns than HAWTs are able to. There are two primary blade designs that are used for VAWTs that operate on different principles: the Savonius type and the Darrieus type.

1) *Savonius Turbine Type*

Finnish engineer Sigurd Savonius invented the Savonius model. Savonius type blade design uses aerodynamic drag from wind to rotate the blades and produce power. Savonius type blades are rugged and simplistic. This can reduce costs since they are easier to manufacture, need less maintenance, and can last longer in harsher environments. However, they are roughly half as efficient as other lift type such as the Darrieus designs.

Fig. 2: Savonius Vertical Axis Wind Turbine

2) *Darrieus Turbine Type*

French aeronautical engineer, Georges Darrieus invented this turbine. Darrieus type blades use lift forces from wind to rotate the blades. The blades have an airfoil shape, and instead of being oriented horizontally as they would be on an airplane, they are oriented vertically. The air that travels along the outside of the curve must travel at a greater speed than the air on the inside of the blade. This creates an area of lower pressure on the outside of the blade, and therefore a net force on the blade to the outside. By controlling the angle of the blade, this net force causes the blade to rotate.

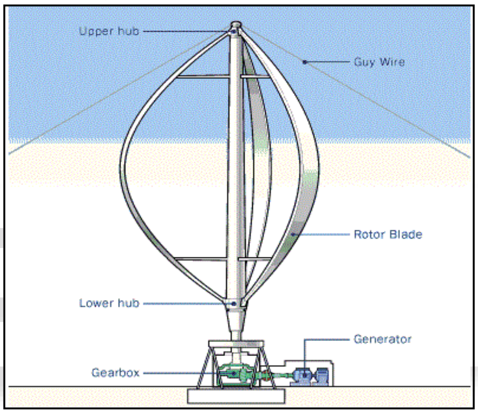

Fig. 3: Darrieus Vertical Axis Wind Turbine

There are many different variations of the traditional Darrieus type, also referred to as the “egg-beater” type; these variations include the Giromill (or the “H-Type” Darrieus), the Gorlov helical turbine, and the cycloturbine. Due to the blade going into the wind as opposed to with the wind (as it does in the Savonius type blade), it can spin faster than the speed of the wind, which results in a higher efficiency. However, this higher efficiency comes with a great cost. The blade is harder to manufacture than a Savonius blade, increasing the cost of production. Also, normal Darrieus type VAWTs are not self-starting, and thus needs to have a motor or other solution to bring it up to a sufficient speed where it can start producing its own energy.

III. SYSTEM MODELLING

A. *Wind Power Generation*

When the air strike the blade of the turbine, due to the action of repulsive force of the magnet the rotation of the blade increase resulting in rotation of the shaft. Hence induced emf is generated in the generator. Output of turbine is AC power. The bearing arrangement is totally replaced by the neodymium magnet which gives high repulsive force. With the help of this force small amount of air pressure gives maximum rotation which results in large power generation.

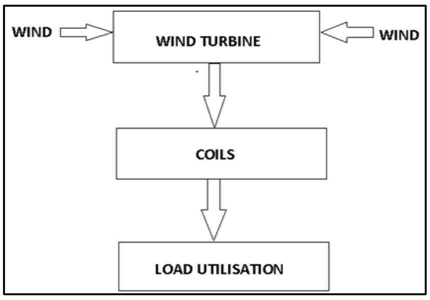

Fig. 4: Block diagram of Wind Power Generation

B. Power from Wind Turbine

The power rises as cube of the wind velocity and can be calculated with respect to area in which the wind and wind velocity is available. When wind is in motion the energy produced is kinetic energy. Hence the power from turbine is related to the kinetic energy produced.

Kinetic Energy =1/2 MV^2

The volume V' flowing in unit time through an area A, with wind speed V is denoted by AV and mass M is the product of Volume V' and density ρ so: M = ρAV

Putting the M in equation of kinetic energy we get:

Kinetic Energy = ½ (ρAV)V2 =1/2 (ρAV3)

But Power is nothing but the kinetic energy generated by the turbine.

Hence, Power = ½ (ρAV)V2 =1/2 (ρAV3)

Where: Air Density (ρ) = 1.225 kg/m3

Area (A) = Swept Area of turbine blades

Velocity (V) = wind speed in m/s

C. Generator

The generator converts mechanical energy of the shaft into electrical energy output. While designing the axial flux generator observation can be noted that the operating capacity of generator depends on permanent magnet alternators. For these generators air gap is arranged in perpendicular direction to rotating axis and hence produces magnetic fluxes in parallel direction to rotating axis.

D. How Power is generated

Wind turbines serve as a means to transform the kinetic energy of wind into power. This process begins when wind contacts the turbine blades and transfers some of its kinetic energy to them, forcing them to rotate. Since the blades are connected to the main shaft through the rotor, the shaft rotates as well, creating mechanical energy. The main shaft is usually connected to a gear box which rotates a parallel shaft at about 30 times the rate of the main shaft. At high enough wind speeds, this amplification creates sufficient rotational speeds for the generator electrical output. Generators generally used in turbines are off-the-shelf and use electromagnetic induction to produce an electrical current. In these generators permanent magnets are arranged surrounding a coil. The shaft connects to the magnet assembly, spinning it around the stationary coil of wire and creating a voltage in the wire. The voltage is what drives the electrical current out of the wire and into power lines to be distributed.

E. Magnetic Suspension (Levitation)

1) Principle

Magnetic levitation can be explained as technology which suspends or levitates an object with the help of magnetic forces for getting support without any contact and low friction during motion. Due to absence of mechanical contact in the magnetic bearing, advantages of no wear and tear, suitability for long-term use in any environment, absence of mechanical friction, low noise, less amount of power loss and absence of lubrication or sealing can be achieved. Therefore, this technology is beneficial for high speed applications to satisfy the objective of eliminating mechanical problems power loss.

2) Use of Magnetic Levitation in Wind Turbine

In recent years, due to rapid growth in the use of material for designing permanent magnet, the magnetic suspension using permanent magnets are approaching towards wind turbine application leading to reduction in the cost as well as stringency of wind power. Due to use of magnetic levitation concept the advantages marked below has obtained:

- Reduction in starting wind speed Due to elimination of friction the power output is increased for the same value of wind speed. Hence reduction in starting speed is obtained.
- Due to utilization of magnetic levitation, design of the conventional wind turbine rotor has largely been affected.

The use of conventional bearings is based upon careful lubrication for greater service life and higher reliability. With the reduction in operational cost as well as maintenance cost of the bearings reduction in the downtime of turbine is achieved improving the overhaul efficiency.

F. Construction of Prototype

1) Magnet Selection

The four configurations in commercial list of magnets are based on formation of their material each configuration of magnet consisting with them its own magnetic properties. Neodymium Iron Boron (Nd-Fe-B) is the new invention in commercialized magnets which constitute highest magnetic properties compared to other magnets at room temperature.

2) Magnet Placement

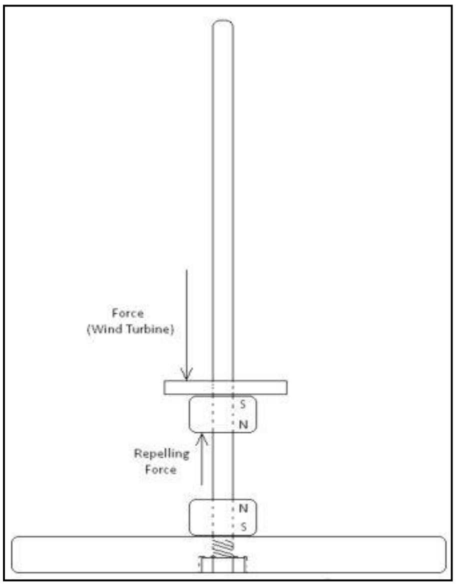

Fig. 5: Magnet Placement of Nd-Fe-B Magnet

Two ring shaped neodymium (NdFeB) magnets are arranged at middle of shaft by which necessary suspension between stator and rotor is obtained. Similarly disc magnets having parameters 10 mm in diameter and 4 mm height are placed as one North Pole and one South Pole one after the other, along the rotor circumference of 40 cm diameter. These magnets supply the useful flux which is utilized for the power generation.

G. Blade Design

Savonius type blade design is used because they are rugged and simplistic reducing cost. The manufacture is easier, less maintenance, and durable in harsher environments. This design was obtained from aluminum sheet and due to the flexible nature of the metal sheet, desired shape was obtained. The blade was designed for height of 400mm.

IV. CONCLUSIONS

The technique of magnetic levitation for wind turbine successfully worked. The maglev horizontal wind turbine has more efficiency than the conventional horizontal wind turbine. By using the maglev technology the power output of turbine is 1GW while the output of conventional power plant is 5MW. The efficiency of is improved by utilization of magnets helping to spin with fast speed with negligible friction as it cancels out the stress on the shaft of the turbine. This modern design of turbine gives more power output with higher efficiency compared to conventional wind turbine. For avoiding the vibration of the rotor, shaft was used. The standard windmills having set of 1000 windmills powers 5 lakhs homes while single maglev wind turbine is capable supplying power to 7.5 lakhs homes. The required area for single maglev windmill is less than 100 acres while field of 1000 windmills require more than 64,000 acres. From this observation we can say that a single maglev wind turbine is economical compared to Conventional wind turbine.

V. FUTURE SCOPE

In past days VAWT had to be start by giving excitation. Our project aspect is to make self-starting wind turbine. And second one is to reduce the power fluctuation due to the uneven wind. So, that we get constant power supply. For that, we will put a gear-box between turbine & rotor shaft. Power generated from this turbine can be utilized in remote places where traditional method of supplying power is costlier. Power generated from turbine can be efficiently used for Street/domestic lighting and domestic appliances.

REFERENCES

[1] Magnetically Levitated Wind Turbine for Power Generation Chinnu Sara Thomas1, Dhanya Varghese2, Jayalakshmi S3, Sonu Savy4 Thomas George5, Rini Varghese P6 Students, Dept. of EEE, Mar Baselios Institute of Technology and Science, Nellimattom, Kerala, India 1,2,3,4 Assistant Professor, Dept. of EEE, Mar Baselios Institute of Technology and Science, Nellimattom, Kerala, India 5,6.

[2] Power Generation Using Maglev Windmill Harshal Vaidya1, Pooja Chandodkar2, Bobby Khobragade3, R.K. Kharat4 1 Student, Department of EEE, Marathwada Institute of Technology, Maharashtra, India 2 Student, Department of EEE, Marathwada Institute of Technology, Maharashtra, India 3 Student, Department of EEE, Marathwada Institute of Technology, Maharashtra, India 4 Assistant Professor, Department of EEE, Marathwada Institute of Technology, Maharashtra, India.

[3] 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.

[4] Liu Shuqin,"Magnetic Suspension and Self-pitch for Ver-tical-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.

[5] 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".

[6] 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.

[7] Vishal D Dhareppgoaland MaheshwariM Kona-gutti," REGENEDYNE Maglev Wind Power Generation", SARC-IRAJ International Conference, 16th June 2013, Pune, India, ISBN: 978-81-92747-8-3.