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ENERGY GENERATION USING MAGNETIC LEVITATION

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ABSTRACT

Our world today is facing the crisis of depletion of energy resources, while the rate of consumption of energy is multiplying annually. At this stage, the concept of a free energy generator gives hopes to many scientific minds. Alas, energy can never be free. We always have to pay a price, either in the form of mechanical effort, heat, magnetic strength, nuclear decay,etc.Sure, we can't make energy free for consumption, but we can surely increase the efficiency of the energy generating element. The technology of magnetic levitation has provided us with scientific miracles like Maglev trains, Hyperloops, and high efficiency bearings for industrial purpose.

Keywords: Vertical axis wind turbine, Power generation, Maglev, Wind power, Bearings

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I. INTRODUCTION

Human have invented thousands of machines and appliances that utilize energy to make the daily works easier, for instance to heat our house, to get ourselves from place to place. Some of this machines use electricity, while others, like automobiles use the energy stored in gasoline. Much of the energy supply comes from coal, oil, natural gas, or radioactive element. In fact, all these natural resource deposits took millions of years to form. They are considered nonrenewable which means once they are removed from the ground, they are not immediately replaced within the human timescale. This current issue is frequently discussed at the level of whole world in order to look for solution. Nowadays, we will ultimately need to search for renewable or virtually inexhaustible energy for the human development to continue. Renewable energy is defined as the energy generated by the natural resources such as wind, sun light, water which are quickly replace itself and is usually in never ending supply.

The exploration of renewable energy is the only approach to reduce our dependence on fossil fuels. Among those renewable energy resources, wind energy is the only resource that will be concerned in this paper. Wind energy was first harvested centuries ago, when early windmills were used to power millstones, pumps, and forges. More recently, the wind is harnessed by using a special collector, called wind turbine to produce a clean, safe source of electricity. Various designs have been proposed in order to create a high efficient wind turbine which able to generate maximum electric power.

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. The varying output voltage obtained at this juncture will then be passed through a DC-DC converter to achieve a steady output DC voltage.

II. LITERATURE REVIEW

Sahishnu R. Shah, Rakesh Kumar , Kaamran Raahemifar, Alan S. Fung, Wind power has become one of the fastest emerging renewable energy technologies for electricity generation, and the total installed capacity has reached 487 GW (about 4% of the global electricity) by the end of 2016 (Kumar et al., 2018). The development of an effective wind turbine (WT) design, especially for an urban area, is critically needed to increase the penetration of wind power technology in cities and semi-urban areas. Substantial wind is blown in urban areas with a potential of power, viz. highway, railway track, and between/around the high-rise buildings. The wind is blowing continuously with varying intensity in all these areas, and an effective turbine design must include all the sitespecific changes in the wind speed, direction, and turbulence. The design intended that the turbine should have low cut-in wind speed, lightweight, and can be easily moveable. The dragbased machine should be capable of harnessing energy from the non-directional wind at low cut-in speed, which makes it a better choice for many urban applications. The blades were attached to the hub with the help of three steel bars, and each bar is welded to the center to provide stability to the design. The blade was fabricated from flattened trapezoidal profiled galvanized (GI) steel sheet of equal dimensions (width of each blade = 0.8 m; height of each blade = 1.3 m; the angle between the cross-arm = 120; total height=1.5 m). A 12 gauge GI sheet has been chosen due to inherent material properties, viz. good tensile and compressive strength, rugged, high stiffness to weight ratio, good resistance to corrosion, and durability. The mild steel is used for the hub, which is connected to the main shaft. The main shaft is also made of a mild steel rod. The shaft is passed through the two bearings and connected to the shaft of the generator with the help of a coupling arrangement. The generator is rested on the wooden base, which is supported by the three steel bars on the ground. The shaft is connected to an AC permanent magnet generator (PMG) to produce the electrical output. An electrical converter is used to convert low voltage AC into high-quality DC power for battery charging. The rectifier provides a constant voltage at the battery terminal. The other parts of the machine are a mechanical shaft, stator, two magnet rotors, and a rectifier. The electrical outputs were measured by transducers and subsequently fed to the dump load (12 V DC batteries). The current and voltage were recorded with high accuracy at the outlet of the rectifier, and an anemometer was used for the measurement of wind speed. The accuracy of measured power was estimated 0.5%, whereas the accuracy of anemometer was taken from the product specifications (3%). The simplest design of VAWTs is the Savonius rotor, which works like a cup anemometer. The design has been accepted because it requires relatively low cut-in wind speeds. Savonius rotors are a drag-type machine, consisting of two or three blades. Savonius rotors with four shapes were tested, and their relative rotational performances have been analyzed. The experiments were conducted for the curved, straight, aerofoil, and twisted blade shapes. [1]

Muhammad Azim A Jalil, Mohammad Faizal Mohd Shariff, Just like windmills, wind turbines take the advantage of the wind energy and transform it into different form of energy. In this case study, wind turbine converts the kinetic energy of the wind into electrical energy. Wind turbines are used for various applications, from harnessing energy for an entire city to a small power genera-tion for personal use.

The HAWT concept has already been used as early as 5000 B.C. where people extracting the energy from the wind to move boats along the Nile River. Since then, the wind turbines have gone through significant innovation and improvisation in their design for optimum performance. HAWT consists of blades that extract wind energy on horizontal axis and are parallel to the ground. By facing the wind flow perpendicularly, the blades work and turn due to aerodynamic lift. HAWT is the most popular choice of wind turbine and has received more funding for research and development since it offers significant advantage over VAWT. HAWT have a greater efficiency then VAWT when extracting energy from the wind force due to its design that allows it to ex-tract the energy through the full rotation of the blades when placed under consistent wind flow. It is also immune to backtracking effect.

However, HAWT has a major disadvantage, which is the fact that it must always be pointed in the wind direction to work efficiently. With unpredictable wind direction, extra mechanism is required to make sure the blades will always be facing the wind direction to extract maximum power output. Small wind turbine usually uses a simple wind vane to position itself into the direction of the wind stream. For larger wind turbine, it consists of a yaw meter to de-termine the correct position of the wind flow and a yaw motor to position the turbine into accurate direction of the wind. Be-cause of this disadvantage, HAWT works excellently in environ-ment with consistent and low turbulence wind as it does not need to change its orientation too frequent. [2]

Michael C. Savage , In a simulated rural boundary layer, the wind environment in the centre of a radial building complex has been investigated to examine the feasibility of situating a vertical axis windmill there. The windmill would take advantage of the wind augmentation occurring between the buildings to contribute to the energy needs of the complex.

An optimum design spacing has been located for the larger of two building models used, together with a recommended windmill diameter. The estimated power output compares favourably with predictions for an identical machine situated in the undisturbed atmosphere. Tests simulating the location of an actual windmill between the buildings indicate that the effect on the resultant airflow would he negligible.
A rural boundary layer simulation was chosen for this work since a rural terrain would probably offer more space for a building complex than an urban centre, and the fact that wind power sites are almost always of a rural nature. The vortex generators were based on Counihan's original design. [3]

Rakesh Kumar, Kaamran Raahemifar, Alan S. Fung ,Global warming, energy scarcity, rapid depletion of fossil fuels and exponential growth in the energy demand in several developing countries has created an excellent opportunity for large-scale acceptance of renewable energy technologies. Wind energy has become one of the fastest emerging renewable energy technologies, with the total capacity by the end of 2016 reaching 487GW (about 4% of global electricity). The technology and manufacturing infrastructure of wind turbines have advanced enough for further rapid deployment. As per the 2013 IEA roadmap, about 18% of global electricity needs will be met by wind energy by 2050. Most of the progress was anticipated on large onshore and offshore projects (MW capacity) far from urban areas, where the wind is most intense, consistent and unperturbed. On the other hand, there is considerable wind in the urban areas with a significant potential for power, viz. road dividers, side of railway tracks, top and around the high-rise buildings. The development of an efficient wind energy system closer to the point of use meets the local power demand, minimizes the use of diesel/gas-based electricity generation, reduces the strain on the existing grid infrastructure, incorporates the sustainability in the cities, supports the local economy, and addresses the environmental concerns.
The use of chaotic wind flow to generate electricity has been a challenge to the researchers, developer, planner, and considerable work has been done on the subject in the recent decades. The studies were focused on the turbine aerodynamics, blade materials, modelling, simulation, test methods, performance validation, grid integration, and environmental aspects. Several other studies were emphasized on the development of an effective wind resources assessment methodology, equipment, and computational programs. This review paper presents some significant findings on VAWTs from published resources, government reports, non-profit organization publications, and manufacturer's literature. The manuscript has evaluated the information objectively and presents the scope and limitations of VAWTs development. The paper also highlights commercial activities on VAWTs in different parts of the world. It was noted that the opportunities of urban wind turbines are enormous; however, it is evident that further research is critical to improving turbine designs, reducing cost, and making available resource assessment tools for urban conditions. [4]

Harshal Vaidya, Pooja Chandodkar, Bobby Khobragade, R.K. Kharat , An important factor in development of human resource is the Energy. As conventional energy sources are exhausting rigorously, the development of inexhaustible and renewable energy resources, like wind, solar is essential for human life. The wind power been utilized by human being for a greater time period and the technology linked with it is more modified compared to other non-polluting energies. Today wind power is attracting the benefits of power sector and their application is entering into quicker development. 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. [5]

III. PROBLEM STATEMENT

- In today's world, energy consumption rates are increasing dramatically. Hence, it is important to find new ways to efficiently generate energy.
- The friction between moving and sliding parts reduce the energy generation efficiency in conventional wind turbine. This can be achieved by the use of magnetic levitation technology.

IV. DESIGN

The purpose of this project was to create Magnetic levitation weight reduction structure for a vertical wind turbine generator includes a frame, a fixed permanent magnet, an axle, a revolving permanent magnet, a blade hub, and a generator. The fixed permanent magnet fixed to the frame has a first repulsive surface. The axle is connected to the frame. The revolving permanent magnet fixed to the axle has a second repulsive surface in relation to the first repulsive surface of the fixed permanent magnet. Both the first and the second repulsive surfaces repel with each other. The blade hub and the generator are connected to the axle. When the revolving permanent magnet is rotated, the axle functions as a balance center. An out structure supports the stator and the rotor is placed over turbine head.

The main components of the system are the maglev zone, blade hub and Auxiliary Current (AC) generator. It will convert the kinetic energy from the wind to the electricity for usage. A modified roof ventilator is used as wind turbine. The main function of the free spinning roof ventilator is to provide fresh air in roof space and living area all year round 24 hours a day free of charge. The new idea of the magnetic levitation helps to improve the turbine speed and electrical production. This modification has benefits of the better air ventilation, but also has extra electricity supply for load appliances.

The concept behind wind turbine vents is that the turning blades will help force air out of the attic. The blades or vanes are shaped to allow for maximum wind catching ability, resulting in rotation at minimal winds speeds of 8 kph or lower. This project demonstrates the utilization of the renewable resource (wind energy) in an efficient way. This type of generation can be used in remote places where conventional power supply is uneconomic. The methodology can be used for hybrid power generation. Generated power by this method can be used ON and OFF grid. The power so generated can be effectively used for Street/domestic lighting and domestic appliances. Inclusion of inverter the power generated can be used for both AC as well as DC loads.

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. The Maglev wind turbine, which was first unveiled at the Wind Power Asia exhibition in Beijing, is expected take wind power technology to the next level with magnetic levitation. Magnetic Levitation (Maglev) into turbine system in order to increases the efficiency. If the efficiency of a wind turbine is increased, then more power can be generated thus decreasing the need for expensive power generators that cause pollution. Since one of the main complaints about wind turbines is the sound they produce, this is a huge advantage over other turbine designs. 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 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. 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. 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.

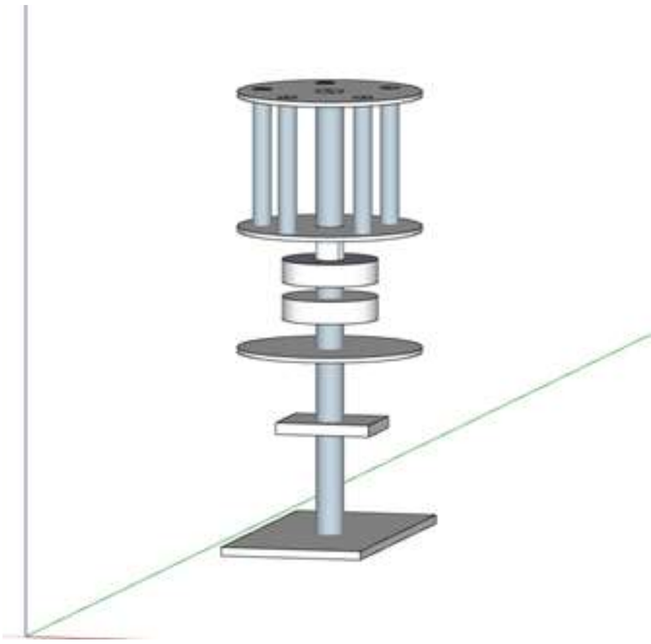

Figure 4.1.CAD Model

Design consists of application of scientific principle, technical information, and imagination for development of new mechanism to perform specific function with maximum economy and efficiency. Hence careful design approach has to be adopted. The total design work has been split into two parts.

4.1 System Design

4.2 Mechanical Design

4.1 System Design

System design is mainly concerns the various physical constraints and ergonomics, space requirements, arrangement of various components on frame at system, man-machine interaction, no. of controls, position of controls, working environments, of maintenance, scope of improvement, weight if machine from ground level, total weight of machine and a lot more. In system design we mainly concentrated on the following parameter:-

4.1.1 System Selection Based On Constraints
Our machine is used in small-scale so space is major constrain. The system is to be very compact so that it can be adjusted in small space.

4.1.2 Arrangement Of Various Components
Keeping into view the space restrictions all components should be laid such that their easy removal or servicing is possible. Every possible space is utilized in component arrangements.

4.1.3 Man Machine Interaction
Friendliness of machine with the operated that is operating is an important criterion of design.

4.1.4. Chances Of Failure
Losses incurred by owner in case of any failure are important criterion of design. Factor of safety while doing design should be kept high so that there are less chances of failure. Moreover periodic maintenance is required to keep unit healthy.

4.1.5 Servicing Facility
Layout of components should be such that easy servicing is possible. Those which require frequent servicing can be easily disassembled.

4.1.6 Scope Of Future Improvement
Arrangement should be provided in such way that if any changes have to be done for future scope for improving efficiency of machine.

4.1.7 Height Of Machine Elements From Ground
All the elements of the machine should be arranged to the height from where it is simple to operate by operator. Machine should be slightly higher than the waist level, also enough clearance should be provided from the ground for cleaning purpose.

4.1.8 Weight Of Machine
Total weight depends on the selection of material of all components as well as their dimensions. Higher weight will result in difficulty in transportation; it is difficult to take it to workshop because of more weight.

4.2 Mechanical Design:
In mechanical design the components are listed down and stored on the basis of their procurement, design in two categories namely.

4.2.1 Parts To Be Purchased
Mechanical design phase are very important from the view of designer as whole success of project depends on the correct design analysis of the problem.
Many preliminary alternatives are eliminated during this phase. Designer should have adequate knowledge about physical properties of material, load stresses and failure. He should identify all internal and external forces acting on machine parts. These forces may be classified as,
a) Dead weight forces
b) Friction forces
c) Inertia forces
d) Centrifugal forces
e) Forces generated during power transmission etc.
Designer should estimate these forces very accurately by using design equations. If he does not have sufficient information to estimate them he should make certain practical assumptions based on similar conditions which will almost satisfy the functional needs. Assumptions must always be on the safer side. Selection of factors of safety to find working or design stress is another important step in design of working dimensions of machine elements. The correction in the theoretical stress values are to be made according in the kind of loads, shape of parts & service requirements Selection of material should be made according to the condition of loading shapes of products environment conditions & desirable properties of material provision should be made to minimize nearly adopting proper lubrications method.

V. 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. The Vertical Axis Wind Turbine (VAWT) with magnetic levitation performed better than the conventional wind turbine. Tests results VAWT model has lower starting wind speed compare to conventional one. The rotational speed of maglev VAWT is higher. The time taken for the maglev wind turbine to stop rotating is longer than that of conventional. Therefore, the Maglev wind turbine is more suitable for power generation application. 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 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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