ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 8, Issue 3, March 2019

Design and Development of ENLIL Turbine For Highways Electrification

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ABSTRACT: ENLIL is a vertical axis wind turbine that transforms highways into renewable energy sources by using the dynamics of the city. Enlil will generate energy by using the winds created by the vehicles as well as the natural winds. This turbine uses the wind pressure generated by the fast moving vehicles on roads such as big trucks and busses that helps to rotate its blade. It is designed with vertical long blades such that it will use the utmost quantity of wind energy. Enlil turbine covers the lesser space on the ground and is simple to handle and can easily be assembled and disassembled which makes it more durable. Solar Panel is also fixed at the top of the turbine to generate electricity. In this paper the design of an axial flow permanent magnet synchronous generator is discussed which converts the mechanical energy from the blades to electrical output of approximately 100 watts**.**

I.INTRODUCTION

Over the past 25 years, use of conventional renewable energy sources has increased and the use of new renewable energy sources as well. But it couldn't meet up the energy demand, hence hybrid renewable energy systems came into use. A hybrid energy system, or hybrid power, usually consists of two or more renewable energy sources used together to provide increased system efficiency as well as greater balance in energy supply. ENLIL is a vertical axis wind turbine that generates electricity from wind energy. It also has solar panel to capture extra energy from sunlight. It is designed to capture the energy created by modern cities like wind created from passing vehicles. Enlil turbine can be fixed in parks, near seashores, rooftops, households but the roads are the ideal locations for the device. The big vehicles like bus will offer a great deal of wind energy. The turbine is designed vertically with long blades. The Generator is designed to convert the obtained mechanical energy into electrical energy. The Generator designed is permanent magnet synchronous generator due its high efficiency and greater lifetime when compared with other generators. The speeding of vehicles on the highways can provide enough wind for these turbines to work all day and night without stopping. The space it consumes is also smaller than other traditional methods. It can significantly decrease our dependence on fossil fuel for electricity. The turbine is designed vertically with long blades. The device is capable of producing approximately 100 watts per hour of electricity. A single ENLIL turbine can provide the average daily electrical desires of two households. The wind energy which is getting wasted is utilized by this method for producing electricity.

II. LITERATURE REVIEW

Enlil Turbine– Gelecegin YenilenebilirSehirleri, Deveci Tech Team. The turbine is designed vertically with long blades. Solar panels are fixed at the top of the turbine to generate extra electricity. The product is still in its developmental phase. The Deveci Tech team is still improving their design to make it more efficient and well-built before it hits the roads.

Permanent Magnet Machines- A Aleksashkin, A Mikkola (2008): This paper is a literature review which describes the construction of state of the art of permanent magnet generators and motors constructing and discusses the current

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and possible application of these machines in industry. Permanent magnet machines are a well know class of rotating and linear electric machines used for many years in industrial applications. A particular interest for permanent magnet generators is connected with wind mills, which seem to be becoming increasingly popular nowadays.

III.DESCRIPTION OF THE PROJECT

A. Objective

The proposed method is to design and develop a hybrid renewable energy system comprising of a vertical axis turbine and solar panels for electric energy generation and to utilize the wind energy provided by speeding vehicles for running the turbines day and night. The main objective is to generate electricity in hybrid renewable energy resources by ENLIL turbine so, it can produce the electricity in any wind blowing areas. Most of the electricity demands of countries like Denmark, Norway comes from renewable energy resources over a long time. Indian government allows the offshore wing plants recently for power generation as the energy demands are increasing drastically. With this example people can realise how far our country need to go to match the developed nations. This method utilizes both wind and solar energy for its operation of power generation, which is a great advantage.

B. Existing System

Normally we generate renewable electricity in many ways like wind energy, solar energy and hybrid energy. In hybrid energy, energy from solar and wind are combined but it cannot be installed everywhere. Because the overall size of the plant will be large and maintenance problem arises. Some of the limitations on existing methods are, cost and maintenance is high, transportation problem, larger blade size and need of high starting torque.

Fig.1. Existing Hybrid Power Generation.

C. Proposed Solution

In this proposed solution we can install this turbine anywhere as the size is small and also the generator used is permanent magnet synchronous machine which requires only minimum torque during starting. This turbine can be kept at any places like seashores, buildings and normally in wind vicinity areas. The proposed turbine is fixed on roads by utilizing the wind produced by the moving vehicles.

IV. BLOCK DIAGRAM

The blades in the wind turbine are connected in the shaft which is coupled to the generator. During air force the blades rotate and in turn which rotates the shaft and hence generator produces AC power as output. This AC power is converted to DC Power in rectifier unit and stored in battery. Solar panel extracts solar energy from sun light and converted into electrical energy. The DC output from rectifier and solar panel are given to voltage regulator to eliminate fluctuations and to obtain constant voltages. Thus the battery supplies to the load. The microcontroller programming is carried out for timing and control of load operations.

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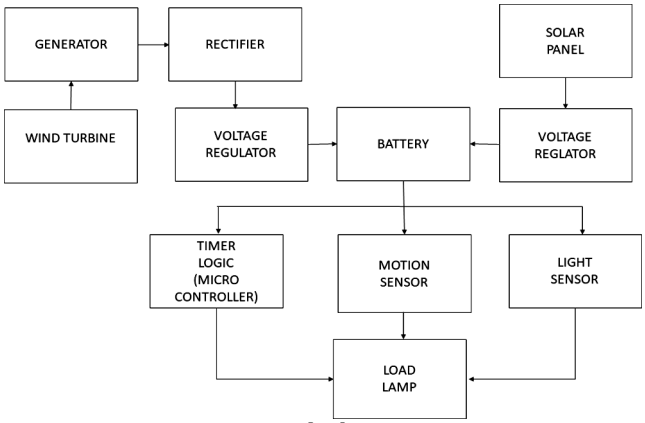

Fig.2.Block Diagram

i. Vertical Axis Wind Turbines

A vertical axis wind turbine is a type of wind turbine where the main rotor shaft is set transverse to the wind while the main components are located at the base of the turbine. This arrangement permits the generator and casing to be located close to the ground, facilitating service and repair. VAWT's don't ought to be pointed into the wind, that removes the necessity for wind sensing and orientation mechanisms.

ii. Permanent Magnet Synchronous Generator

A permanent magnet synchronous generator is a generator where the excitation field is provided by a permanent magnet itself instead of a coil. The term synchronous refers here to the actual fact that the rotor and magnetic field rotate with the identical speed, as the magnetic field is generated through a shaft mounted permanent magnet mechanism and current is induced into the stationary coil.

iii. Rectifier

A rectifier is an electrical device that converts alternating current to direct current, which flows in only one direction. This process is known as rectification, since it "straightens" the direction of current. Physically, rectifiers take variety of forms, including vacuum tube diodes, mercury-arc valves, stacks of copper and selenium oxide plates, semiconductor diodes, silicon-controlled rectifiers and other silicon-based semiconductor switches.

iv. Voltage Regulator

A voltage regulator is a system designed to maintain constant voltage level automatically. It may use a simple feed-forward design or may include negative feedback.. Depending on the design, it may be used to regulate one or more AC or DC voltages. Electronic voltage regulators are found in devices such as computer power supplies where they stabilize the DC voltages used by the processor and other components.

v. Solar Panel

A solar panel absorbs sunlight as a source of energy to generate electricity. Photovoltaic modules represents the photovoltaic array of photovoltaic system that generates and supplies solar electricity in commercial and residential applications.

vi. Battery

A battery is a electric device of one or more electrochemical cells. When it is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode. The negative terminal is the source of electrons that will flow through an external electric circuit to the positive terminal. When a battery is connected to an external electric load, a redox reaction converts high-energy reactants to lower-energy products, and the free energy difference is delivered to the external circuit as electrical energy.

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vii. **Motion Detector**

A motion detector is a device that detects moving objects, significantly individuals. Such a device is often integrated as a element of a system that automatically performs a task or alerts the user of motion in that area. They form a vital component of security, automatic lighting management, home management, energy efficiency and other useful systems.

viii. **Light sensor**

Light sensor, also called as photo sensors, are sensors of light or other electromagnetic radiation. A photo detector has a p–n junction that converts photons into current. The absorbed photons build electron–hole pairs in the depletion region. Photodiodes and photo transistors are the examples of photo detectors.

ix. Pic16 Controller

PIC16 microcontrollers are very fast and easy to execute a program compared with other microcontrollers. PIC Microcontroller architecture is based on Harvard architecture. PIC microcontrollers are very popular because of their ease of programming, wide availability, easy interfacing with other peripherals, low cost, large user base and serial programming capability.

V. AUTOCAD DESIGN OF PERMANENT MAGNET SYNCHRONOUS GENERATOR

Based on the dimension values in the table I. The CAD diagram of the axial flow permanent magnet generator is designed and is shown in the figure. 5. There are two rotors and a stator which are coupled through neodymium permanent magnets the magnetic field of the rotor is provided by these Permanent Magnets. The rotating parts, rotors are supported to bearing which is a device that is used to enable rotational or linear movement, while reducing friction and handling stress. This bearing is connected to shaft, a shaft is a rotating machine element usually circular in cross section, which is used to transmit power from one part to another or from a machine which produces power to a machine which absorbs power. The various members such as pulleys and gears are mounted on it. The material used for ordinary shafts is steel. When high strength is required, an alloy steel such as nickel, nickel-chromium or chromium-vanadium steel is used. Blades are coupled to this shaft, when the blade rotates experiencing the wind force hence the shaft also rotates where this mechanical input given to the generator gives electrical output.

TABLE- 1. AFPMSM design parameters

S.No	Parameter	Dimensions
1	*Number of poles*	*12 poles*
2	*Number of turns per coil*	*23 turns*
3	*Rotor diameter*	*150 mm*
4	*Stator diameter*	*180 mm*
5	*Air gap between two poles*	*14.2 mm*
6	*Air gap between shaft and coil*	*3.8 mm*
7	*Air gap between coil & yoke*	*4.2 mm*
8	*Coil dimension(L*W)*	*47*34 mm*
9	*Thickness of Coil*	*5 mm*
10	*Thickness of Magnet*	*5 mm*
11	*Size of Magnet(L*W*T)*	*25*12*5 mm*
12	*Total height of generator*	*17 mm*
13	*Shaft diameter*	*70 mm*

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The above Table.1. Shows the design specifications considered for designing an axial flow Permanent Magnet Generator. The Neodymium type permanent magnets are used where the magnetic field is generated by the internal structure of the material itself. For a three phase supply 12 magnets and 9 coils are used. Also, by using these dimensions CAD design is being made and is shown in the Fig.3.

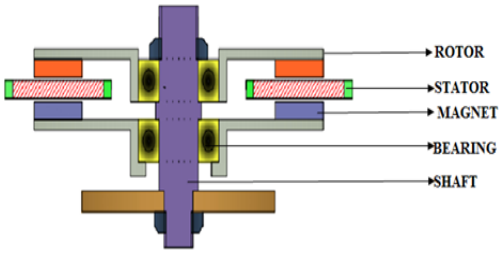

Fig.3. CAD Design Of Axial Flow PMSM Generator

VI.GENERATOR DESIGN

a. Neodymium Magnet

There are several types of permanent magnets available but the Neodymium magnet has been a key technological development that allows practical and efficient alternators to be built. The high strength of Neodymium is part of reason which makes computer hard drives so compact. Now the material is available commercially for all style of functions. Many sizes are now available for the perfect use in the DIY alternators. Below Fig. 4, shows some of the common sizes of magnets available. In our generator square type neodymium magnets are used as it has higher field of attraction than circular type magnets.

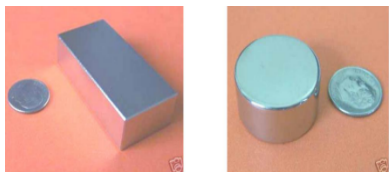

Fig.4. Neodymium Magnets.

Magnetic field is the technical term for the lines of force which are often drawn to picturized the magnetic field around the magnet. The magnetic field intensity is measured in either Tesla or Gauss. The symbol “B” represents the field intensity. The intensity, B, gets stronger as you catch up with to the magnet, since the lines get closer together. The magnets we prefer have poles on the faces with the most surface area. For example magnets shown in the above Fig. 6. is flat in one direction the poles are on the broadest faces. Some kinds of magnets are longer on the polarized axis. An axial flux alternator is efficient and lighter when the magnets are needed to be sufficiently big for the work, and no bigger.

b. Magnetic Field

A few illustrations can improve the understanding of how magnetic fields are manipulated. When magnets are attracted to metallic objects, the attraction is often witnessed by a distortion of the field lines. The lines are drawn to that object, in the same way that the object itself is drawn to the magnet. As the magnet gets nearer to the plate, field lines pass through the plate and get stronger. When the plate is in contact with the magnet, the field lines will become more concentrated in the plate. They concentrate themselves within the plate, and if the plate is thick enough, only few lines emerge out from the other side. Through the neodymium magnet itself, the magnetic strength doesn’t alter much. In a sense, holding a magnet beside the plate of iron is like holding a ball above the ground. The ball falls due to gravity, and it attains rest at a lower potential energy. Same with the piece of iron; once it is in contact with the magnet, the potential energy is lower. The magnetic field of the magnets is manipulated in this manner. The next illustration is to show when

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two magnets are close together. If similar poles are closer, then the lines diverge, and the effect is felt as repulsion. If their opposite poles are close together, then the lines converge and it is attraction. As they get closer, more lines get closer together, making the field more intense.

The field is manipulated to our advantage, when making permanent magnet alternators. By concentrating the magnetic flux between two opposite magnet poles, capturing the flux in iron plates that would otherwise be wasted, we direct as much energy as we can through the gap between the faces. This set of rotors features round magnets. This is common in the case of smaller axial-flux alternators, but as they get larger, it is often more practical to use rectangular magnets, which are available in larger sizes, and the wire coils will be more compact. It is necessary that the rotors be made of steel or iron, so that the magnetic flux is conducted by them.

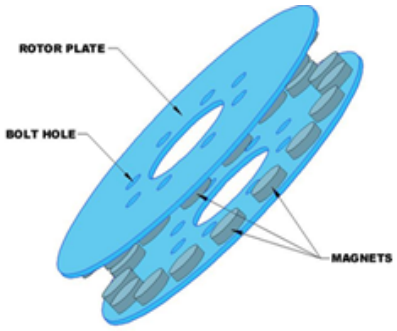

Fig.5. Rotor Diagram.

The magnets are organized in a N-S-N-S pattern around the circumference of the rotors. Opposite poles face each other. If you trace the lines of flux, they travel from one magnet face then straight to the magnet face of opposite side, then travel through the steel rotor plate to the consecutive magnet, and back across the gap. Coils of wire in this gap capture the magnetic energy in those field lines.

The path of magnetic flux ought be additional clear with the diagram above. The flux lines are concentrated by confining it between the plates. The flux also alternates between North and South. A compass inside this gap, as the rotors flip would flip back and forth frantically. A compass outside the plates is weak affected, because the fields have been confined.

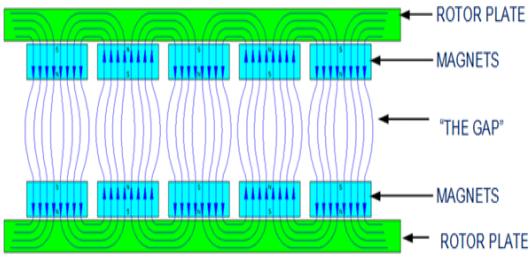

Fig.6. Magnetic Flux Between Two Rotor Plates

c. Stator Designing Part

If regular jacketed wire was used to wind coils, a lot of space could be wasted in plastic jackets. A solution was found a long time ago, and wire is bought which is coated in thin non-conductive enamel. When coils of enameled wire are wound, each loop is isolated from the other, and there exists maximum compactness. Connecting the coils of wire introduces an important question in the design. Single Phase alternators are simple to hook up all coils are wired in series with each other, and they all work together to make one giant pulse at the same time. While this is simple, the windmill experiences quite abrupt “bump” for each pulse. It will hinder windmill performance and cause damaging

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vibration. It is also more complicated to overcome the inefficiency problem which is additional difficult when rectifying that voltage to put DC into a battery, however it can be done. The more elegant solution is to wire up the coils for 3-phase operation. At any given point, only one third of the alternator is at peak power, the other two are either dropping or rising to their next peak. Vibration is reduced not only by having peak currents which is 1/3 as intense, but also by having them 3 times more often. When rectifying the 3-phase power so that a DC battery can be charged and also the current is much smoother. The cost of extra rectifiers should not be considered an obstacle. They will last for a longer time period if properly selected.

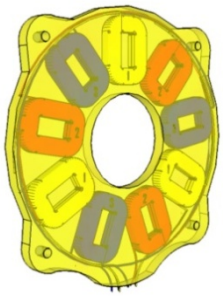

Fig.7. Stator Winding

d. **Magnet And Coil Matching**

In our Generator 12 poles, 9 coils with 23 turns each are used. When the coils of wire are cast together into one plate, they are supported as a unit called a “stator” (it remains “static” while the rotor rotates). Builders practically arrange the coils in a star-shaped pattern in a flat mould. Into the mould they pour polyester or epoxy resin. Then they close the mould and. when it is cured, the stator comes out as one big disk with the coils encapsulated inside. All of the interior electrical connections were made in advance. Either they select one particular 3-phase connection arrangement or they have enough wires coming out to allow some external connection changes.

In an alternator producing 3-phase power, one group of coils is at peak current while the others are not. Therefore, the magnets align with just only one phase at a time. Instead of finding out how this is done from scratch, here’s the trick. For every coil of wire in the 3-phase stator coil, there are 1.33 magnets. The selection of coils and magnets based on phase supply is shown in the below Table. 2.

Table. 2. Magnet and Coil Matching

COILS	MAGNETS	COILS PER PHASE
6	8	2
9	12	3
12	16	4
15	20	5
18	24	6

VII.CONCLUSION

The generator designed for Enlil turbine is Permanent Magnet Generator as the name indicates that this is useful for a longer period of life than using other magnets. This axial flow generator requires no starting torque when compared with other generators, hence smooth operation will be maintained during overall operation and the speed and efficiency will be high. This is very compact in size hence it is easy to couple with blades of the turbine. Thus the mechanical energy from these blades gets converted in generator unit as electrical energy. The energy generated may be transported to places or it can be used for maintenance of roadways. This technology can revolutionize the roads. In this paper we have

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discussed only the design of axial flow PMSM generator which is used in Enlil turbine for producing electricity and the whole arrangement will be discussed in future.

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