IOSR Journal of Engineering (IOSR JEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
PP 20-24

Implementation of Water Pump Based Single Phase Pmsg for Domestic Application

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Abstract : *Induction motors are widely used in several areas for domestic and also industrial purposes, due to its simple structure and low manufacturing cost. Nowadays due to increased population the demand is increasing and the electrical power couldn't be supplied efficiently. Hence in order to overcome those problems faced by the mankind we have introduced a new concept in water pump to convert the wasted kinetic energy into electrical energy with help of Axial Magnetic Flux [1] Permanent Magnet Synchronous Generator where coil is stator and permanent magnet as rotor. In the case of wind turbine generating power [2], where the input is not constant, it has high initial cost and it is not affordable to everyone. To rectify these problems we have implemented the proposed concept with some modification where input is constant and it has less initial cost which makes our system applicable in residential and industrial areas.*

Keywords – *Axial Flux, Permanent magnet, Permanent magnet synchronous generator (PMSG).*

I. INTRODUCTION

Nowadays, water pump has been requisite and plays a vital role in all domestic and industrial areas and used frequently in day to day life. The kinetic energy is getting wasted from the water pump. The wasted kinetic energy can be usefully converted into electrical energy which is essential in the technologically developed society which also reduces the demand in the consumer side. The major advantage of the proposed system is that the speed of the single phase 1/2 HP water pump is 1450 rpm whereas in existing system the speed of wind turbine is 400 rpm. Thereby the output will increase due to high speed of water pump. So that generation of electricity for domestic application is made possible easily. The basic component of our project are Water pump, Permanent magnet, Armature coil and converter. The water pump is the major source of our project. The mechanical energy of the pump shaft is converted into electrical energy by means of the Permanent Magnet Synchronous Generator. The generator is made up of stator which is the armature coil and the rotor is permanent magnet. The stator is made up of 6 coils and each coil consist of 400 turns. The rotor contains 8 pairs of poles. We have also introduced double rotor. Axial flux Permanent Magnet (AFPM) machine size and shape are important feature in applications where space is limited, so compatibility is crucial. They are more efficient because field excitation loss are eliminated and hence rotor losses are reduced. The permanent magnet used in our project is Neodymium Iron Boron Nd-Fe-B where the effective air-gap length is typically same on both axis. The voltage induced is a function of the number of turns of the coil, where the voltage can be increased with increased number of turns. In our system we have combined pump and generator into single system.

II. INDUCTION MOTOR

Single phase induction motor is an AC motor were electrical energy is converted into mechanical energy to perform certain task. In our system the water pump is used to lift the water. The single phase induction motor requires only one power phase for their proper operation. They are used in low power applications, domestic and industrial use. Simple construction, cheap cost, better reliability, eases to repair and better maintenance are some of its advantages. Additionally the water pump can be made more efficient when the wasted kinetic energy is converted to electrical energy for the usage of domestic applications.

III. Block Diagram

The block diagram presents about the design of axial magnetic flux permanent synchronous generator far domestic application. The wasted kinetic energy of the water pump is used to provide mechanical energy.

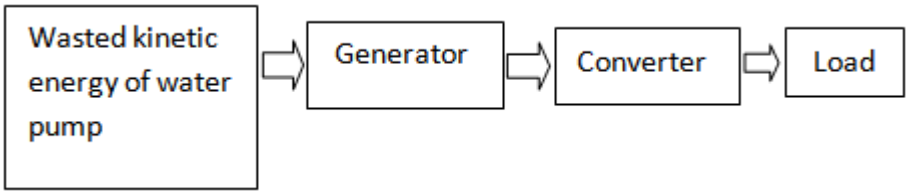

Fig.1. Block diagram of proposed system

The mechanical energy is converted to electrical energy by connecting the generator to the shaft of the water pump. The generator which is made up of permanent magnet and armature coil, which helps to produce electrical power. In addition a converter is used to step up the output voltage produced by the generator.

IV. Design And Analysis Of Output Voltage Of Generator

The output voltage of generator is the function of rpm. According to faraday's law of electromagnetic induction the voltage is induced in a wire depends upon the rate of change of magnetic flux linking a coil.

So the average output voltage = ϕ*Nphase*RPS

Where,

Total flux ϕt= (a)*(Bmg)

- The flux density depends upon the magnets which are used. The magnets selected **(NdFeB)** has the remanent flux **(Br)** density of **1.52T.**
- Total area of the magnet **(A)**

=area of one magnet*no.of poles

$$= \pi r^2 * 8$$

Where,

r =12.5mm

Therefore, A=0.00049*8

A= 0.00392 m^2

Total magnetic flux at the surface of magnet (Bmg)

=Br/2

=1.52/2

Bmg = 0.76 T

Now,

Total flux, ϕt =A*Bmg

= 0.0039*0.76

= 0.00297 Wb / m^2

Total no. of turns (Nphase) = Total no. of turns/coil * total no. of coil per phase.

=400*1

=400 turns

And,

RPS = Rpm/60

=1450/60

=24 rps

So,

The average output voltage (Vavg)

= ϕt*Rps*Nphase

= 0.00297*400*24

=29v

Peak voltage = Vavg * 1.57

=29*1.57

=46v

RMS Voltage = 0.707*peak voltage

= 33v

V. Axial Flux

Axial flux is defined as the lines of magnetic flux that passes through the coil of wire, travel along the axis of turning motion. The determination of air gap length depends upon the gap magnetic flux density and the processing of machine structure. If air gap length is too short, it will cause serious eccentric force at high speed. Wider air gap length, however will reduce the gap magnetic flux density and lower efficiency. The optimal ratio between magnet thickness and the air gap is usually selected in the range of 4-6 mm [3]. Usually generator designer determines magnet thickness in accordance with this search range.

VI. Permanent Magnet

In electric generators magnets function as transducers, transforming mechanical energy to electrical energy without any permanent loss of their own energy. That means the better magnet the better transducer and finally the better whole device. That is why, it is so important to learn basics of magnets before designing the magnets. Nowadays, Neodymium Iron Boron (NdFeB) magnets are widely known as the best one. This modern magnetic material is easily available on the market in different grades and shapes to design high efficiency electric machines. Permanent magnet electric generators are needed in renewable energy sources.

6.1. Types Of Permanent Magnets

These are several types of permanent magnets used in electrical machines they are,

- Samarium cobalt (Smco)
- Neodymium iron boron (NdFeB)
- Alnico
- Ceramic or Ferrite magnets

6.2 Characteristics Of Neodymium Magnet

Magnetic material can be described by the BH curve. Second quadrant of this characteristics is called demagnetization curve and is useful for magnetic calculation. The point where this characteristic cross horizontal axis is called Coercivity (Hc) which is a value of external magnetic field required to reduce magnetization of this material to zero.

Second important parameter is Remanence (Br) which is residual flux density. Value of Br tells about the magnetization of material when external magnetic field (H) is removed. Based on two components it is possible to determine demagnetization.

VII. Coils

Voltage induced is a function of the number of turns per coil, and the number of phases produced is based on the type of winding and magnet ring configuration. These two considerations were kept in mind when deciding on the coil configuration of the stator. The coils are connected in order to produce single phase supply. This also reduces the current in each coil, which will in turn reduces the heat losses.

VIII. Permanent Magnet Synchronuous Generator (Pmsg)

This project concentrates about axial flux machines of one stator and double rotor configuration. This axial-flux configuration proves to be the most adequate structure for the considered low-speed high-torque industrial applications. The reason for that is, fixing of the stator may be arranged reasonably and easily. Secondly, an electrical machine equipped with two rotor is capable of operating even though one of its stators is electrically disconnected and finally, an axial loading of bearings is small due to the internal rotor configuration.

8.1 Construction Of Pmsg

Basically, the permanent magnet synchronous generator consist of two parts stator and rotor. The rotor parts consist of field poles and the stator parts consist of armature conductors. The rotor of field poles in the presence of armature conductors induces an alternating voltage which results in electrical power generation.

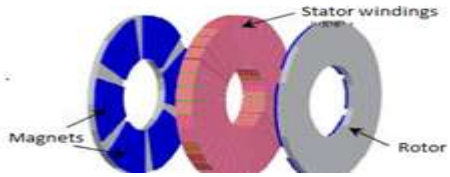

Fig.2. Construction of axial flux PMSG

8.2 Advantages Of Pmsg

The PMSG generator offers many advantages. The PMSG machine is the most efficient of all electric machines since it has a movable magnetic source inside itself. Use of permanent magnets for the excitation consumes no extra electrical power. Therefore, copper loss of the exciter does not exist and the absence of mechanical commutator and brushes or slip rings which in turn means low friction losses. Another advantage is its compactness.

The recent introduction of high-energy density magnets (rare-earth magnets) has allowed the achievement of extremely high flux densities in the PMSG generator, therefore rotor winding is not required. These in turn allow the generator to be of small, light, and rugged structure. As there is no current circulation in the rotor to create a magnetic field, the rotor of a PMSG generator does not heat up. The only heat production is on the stator, which is easier to cool down than the rotor because it is on the periphery of the generator and the static.

The absence of brushes, mechanical commutators and slip rings suppresses the need for the associated regular maintenance and suppresses the risk of failure in these elements. They have very long lasting winding insulation, bearing and magnet life.

XI. Hardware Kit

The hardware kit of our project is shown below.

Fig.3. Hardware kit

The output of the generator can be increased and regulated by a power electronic converter. The final output from the converter can be used to drive domestic appliances.

X. Conclusion

Thus the permanent magnet axial flux generator is a good option in the case of small power system, because the simplicity of manufacturing technology makes it available for a great number of pumps. This design methodology allows the design of axial flux permanent magnet generator to generate small powers.

The proposed permanent magnet axial flux PM generator operates at high speed and convert wasted kinetic energy into electrical energy. In our permanent magnet axial flux generator, we are using sixteen magnet and six coils. We are obtaining a output voltage of 25V from the PMSG and are in a process to increase the output voltage by using converter.

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