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Air Core Generator

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Abstract— *Generator is a device which basically converts mechanical energy into electrical energy and used for various electrical application. Normally in conventional generator we are using iron as core which has a lot of disadvantages like core losses, heavy construction due to the use of iron, also magnetic saturation of iron takes place due to which there is requirement of replacing iron thereby increasing the cost. So in our project we are replacing iron with air as core so the above mentioned disadvantages are eliminated there by increasing the efficiency and reducing the cost. In this project we are providing mechanical energy with a help of wind turbine which rotates the rotor. As the stator is placed between the rotor there is relative motion between the stator and the rotor and according to faraday law of electromagnetic induction an EMF is induced which produces current and this current is taken as output and used for various electrical application.*

Keywords— Air core, EMF, MMF, Magnets, Stator, Rotor.

I. INTRODUCTION

An engineer always focuses towards challenges of bringing the idea and concepts into reality therefore sophisticated machine and modern technique have to be developed and implemented for economical manufacturing of product and at same time no compromise is done with quality and accuracy. We the group of young engineers found that there is impending need to make more ways to make non-conventional energy attain popular acclaim. It is also very essential to preserve the conventional source of energy and explore viable alternatives like sustainable energy (the energy that we are already utilizing but for some safety of uses, we are wasting it, that can be reutilize) solar, wind, and biomass energy can enhance sustainable growth. Here we have put our efforts to generate energy i.e. electricity by coreless generator. This system is more efficient then existing traditional iron core generator as it is design to give good output even at low input. Normally the traditional core generator faces problems such as core loses which comprises of eddy current and hysteresis losses, and also the copper used in both stator and rotor causes loss equal to square of current times resistance of wire, due to the presence the slip ring suffer frictional losses. Coreless generator is design to reduce all the above drawbacks of tradition core generator their by providing good out at low input.

II. AIM OF THE PROJECT

In conventional generator we are using iron as core which has a lot of disadvantages like core losses, heavy construction due to the use of iron, also magnetic saturation of iron takes place due to which there is requirement of replacing iron thereby increasing the cost. So in our project we are replacing iron with air as core so the above mentioned disadvantages are eliminated there by increasing the efficiency and reducing the cost. In this project, we are providing mechanical energy with a help of wind turbine, which rotates the rotor. As the stator is placed between the rotor there is relative motion between the stator and the rotor and according to faraday law of electromagnetic induction an EMF is induced which produces current and this current is taken as output and used for various electrical application.

III. GENERATION OF EMF BY FARADAY'S LAW

Electric generators are devices that convert mechanical energy into electrical energy. The operating principal of these generators can be found in Faraday's law which, states that an electrical potential difference is generated between the ends of conductor that

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moves perpendicularly through a magnetic field. In this experiment, Faraday takes a magnet and a coil and connects a galvanometer across the coil. At starting, the magnet is steady, so there is no deflection in the galvanometer i.e. needle of galvanometer is at the zero position. When the magnet is moved towards the coil, the needle of galvanometer shows deflection in one direction. When the magnet is steady, at that position, the needle of galvanometer returns back to original position. Now when the magnet is moved away from the coil, again there is some deflection in the needle but in opposite direction and again when the magnet becomes steady, at that point with respect to coil, the needle of the galvanometer returns back to the zero position.

Similarly, if magnet is held steady and the coil is moved away and towards the magnet, the galvanometer shows deflection in similar manner. It is also seen that, faster the change in the magnetic field, the greater will be the induced EMF or voltage in the coil. More specifically, that the electromotive force (EMF) that is induced in any closed circuit is equal to the rate of change of the magnetic flux through the circuit.

Consider a magnet approaching towards a coil. Here we consider two instants at time T_1 and time T_2.

Flux linkage with the coil at time, $T_1 = N\Phi_1$ Wb Flux

Linkage with the coil at time, $T_2 = N\Phi_2$ Wb

Change in flux linkage = $N(\Phi_2 - \Phi_1)$

Let this change in flux linkage be, $\Phi = \Phi_2 - \Phi_1$

So, the Change in flux linkage = $N\Phi$

Now the rate of change of flux linkage = $N\Phi / t$

Take derivative on right hand side we will get

The rate of change of flux linkage = $Nd\Phi/dt$

But according to Faraday's law of electromagnetic induction, the rate of change of flux linkage is equal to induced EMF.

$$E = N\frac{d\phi}{dt} \text{.....1}$$

Lenz's law states that when an EMF is generated by a change in magnetic field according to Faraday's Law, the polarity of the induced EMF is such, that it produces an current that's magnetic field opposes the change which produces it. The negative symbol used in Faraday's law of electromagnetic induction, indicates that the induced EMF and the change in magnetic flux have opposite signs. Considering Lenz's Law.

$$E = -N\frac{d\phi}{dt} \text{.....2}$$

IV. REASON FOR OPPOSING, CAUSE OF CURRENTS ACCORDING TO LENZ'S LAW

Lenz's law follow the law of conservation of energy and if the direction of the magnetic field that creates the current and the magnetic flux of the current in a conductor are in same direction, then these two magnetic fields would added up and produce the current of twice of the magnitude and this would in turns to create more magnetic field, which will cause more current and this process continuing on and on leads to violation of the law of conservation of energy. If the induced current creates a magnetic field which is equal and opposite to the direction of magnetic flux that creates it, then only it can resist the change in the magnetic field in the area, which is in accordance to the Newton's third law of motion

V. PROPOSED SYSTEM

Traditional core generator suffers numerous inherent inefficiency such as the core in both the rotors and the stators have losses equal to square of current times resistance of wire, slip rings suffers friction losses and are a source of wear and breakdowns,

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leakage fluxes causes stray load losses, and occurs in both stator and rotors in traditional system. The iron in both stator and rotor suffers from eddy current losses which result from change in electric field introducing a parasitic perpendicular reactionary electromagnetic effect. Thus we have design a generator which overcome above all the losses which does not have any laminations, brushes and slip rings thus reducing frictional losses, weight of generator and its cost. This generator is specially design to operate at low speed.

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VI. BLOCK DIAGRAM

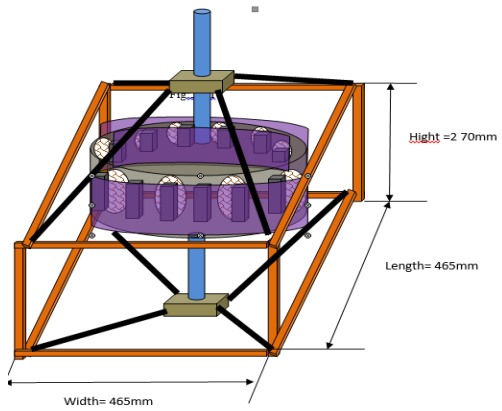

FIGURE 1: Block diagram

VII. PARTS OF GENERATOR

FIGURE 2: Rotor

7.1 Rotor

The rotor of the RFPM generator consists of two cylindrical steel yokes located concentrically one inside the other. The reason for both an inner and an outer yoke is the double row of permanent magnet (PM) material necessary to maintain the required magnetic flux density in the air-gap located between them. The large effective air-gap present in an air-cored generator possesses a much lower permeability than an iron-cored generator does. To maintain the same flux density levels in the air-gap more PM material is needed. The two steel cylindrical rotors provide a rigid steel construction, which maintains the air-gap length as well as supplies a return path for the PM's magnetic flux. Unlike in iron-cored generators, in an RFPM air-cored machine the flux distribution inside the steel rotor yokes remains static during operation. For this reason the iron losses in the rotors become negligible.

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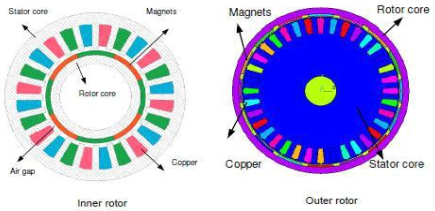

FIGURE 3: Inner and outer rotor configurations

7.2 Permanent Magnet

The RFPM generator yokes have circumferential arrays of alternating polarity permanent Magnets. The magnets are equally spaced on each yoke's periphery.

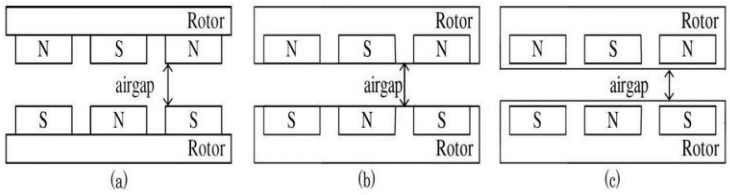

FIGURE 4: (a) Surface mounted, (b) partially embedded and (c) and fully embedded.

Inner and outer magnets are placed opposite to each other to form pole pairs. A pole pair is magnetized in the same direction. The permanent magnets can be placed in one of three ways. They are fully embedded, partially embedded or surface-mounted. These three configurations are depicted in Fig. 4. A major advantage of the surface-mounted magnets is that the steel yokes do not have to possess machined slots as in the case of embedded magnets. The absence of slots allows machining costs to drop, which makes the generator more economical. Another advantage is that the surface mounted magnets act as a fan which creates a natural wind cooling effect inside the machine. The rated operating speed of the direct drive RFPM generators are relatively low and centrifugal forces present on the magnets are small. This means that the magnets can be glued onto the yokes. If the speed of such a machine increases other means of fastening, like through magnet screws, should be considered .The RFPM generator discussed in this study makes use of the surface-mounted topology. This is primarily due to the large air-gap present in air-cored machines, which causes high amounts of magnet leakage flux to occur if the magnets are embedded within the steel. This leakage flux occurs between the magnets and iron yoke and is discussed later in the chapter. Both surfaces on which the magnets are placed are arc shaped due to the circular yokes. This means that the shape of each magnet also needs to be curved and to be radially magnetized.

7.3 Coils

la= active length
le= end winding length Therefore, total length is 2la+le
In an alternator producing 3-phase power, so one group of Coils is at peak current while the others are not. Therefore the magnets align with only one phase at a time. Here the alternative to this. For every coil of wire in the 3-phase stator, there are 1.33 magnets.

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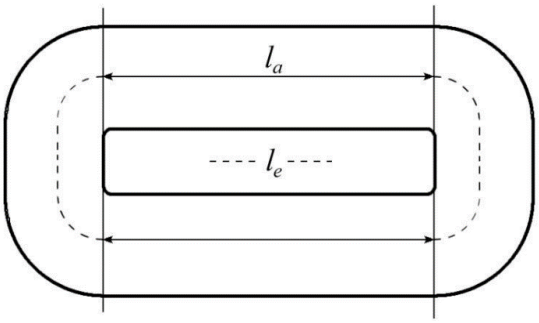

FIGURE 4: Coil profile in the air core generator

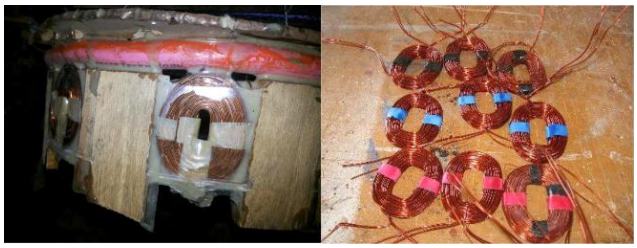

FIGURE 5: Actual coils

No, don't go slicing a magnet in half. The total minimum number of coils in a 3-phase alternator is 3 coils. One for each phase. You would therefore need 4magnets. Actually, that would be fairly clunky. Here are some typical combinations. Anything with more than 24 magnets is getting complex, and the first-time builder should beware. Similarly, varying the ratio of magnets and coils begs will create a problem, unless you know how to avoid the pitfalls of making single-phase alternators (but you wouldn't be a newbie).

FIGURE 6: Coil housing

If regular insulated wire was used to wind coils, a lot of space would be wasted in plastic. A solution was found a long time ago and wire can be bought that is coated in a thin non-conductive insulating material. When coils of enameled wire are wound each loop is isolated from the other, and the maximum compactness occurs. Connecting the coils of wire when used first time creates an important question in the design of the Permanent Magnet Alternator. Single phase alternators are simple to hook up – all coils are wired to each other in series, and they all work together to make one larger pulse at a time. 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 rotation). Usually arrangement of the coils in a star-shaped pattern in a flat mould. Into the mould they pour a polyester or epoxy resin. Then they

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close the mould, and when it has cured, the stator comes out as one big disk with the coils enclosed inside. All of the internal electrical connections were made in advance. Either they selected one particular 3-phase connection, or they have enough wires coming out to allow some external connection changes.

7.4 Windings

Recent studies on RFPM machine winding layouts have found the benefit of incorporating concentrated windings in these machines. The main reasons for considering this winding topology is the potential reduction in manufacturing cost, while simultaneously producing the same amount of torque as that of an overlapping winding in three phase. Using concentrated coils allows for a simpler coil construction which could ultimately lead to automated manufacturing of the stator and smaller end-turn lengths of the coils implying less copper being used. Overlapping windings are also very difficult to realize in these machines (three phase) because of their double-sided rotor topology.

VIII. CONSTRUCTION

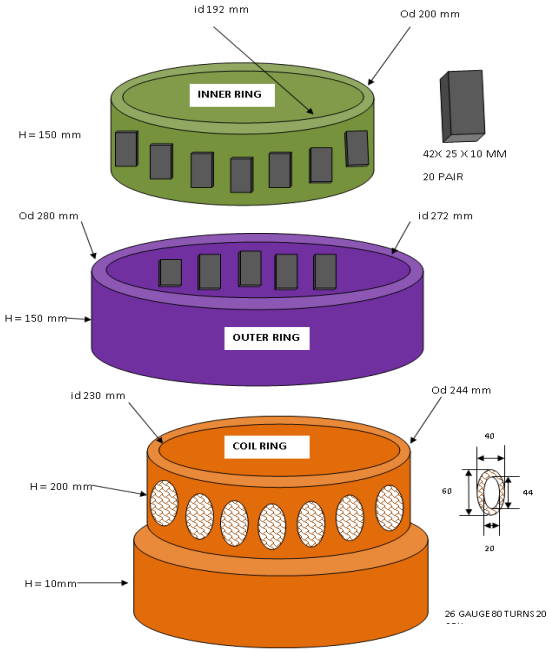

FIGURE 7: Construction

8.1 The construction can be explained through the above parts of the generator:

There is an inner and outer rotor between which lies the stator. The stator is moulded and in the mould are affixed coil of the concentrated winding type since the generator will be working in low rpm condition (considering the velocity of the wind), number of poles has to be high. The selection of the poles for this machine is therefore 20 on each rotor

8.2 Generation of EMF in the coil:

The current is induced in the active length of coil by faraday's law of electromagnetic induction. The coil consist of multiple number of turns. Alternate poles N and S are produced along the rotor magnets. When the coil passes through a single set of poles a positive cycle EMF is induced in it and further when it passes through another set of pole a negative cycle is induced in it. Hence, for a completion of one cycle of e EMF, 4 poles are required

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IX. WORKING PRINCIPLE

The inner and the outer rotor are attached to the same shaft. The project will be a hand generator, so a handle will be the prime mover. The prime mover rotates the inner and the outer rotor. Alternating poles in double rows are present on the rotor and the stator is in between the rotor. As a result of the resulting motion between the conductors and the magnetic field an EMF is generated in the winding according to the faraday's laws. The terminals from each coil in the generator can be brought out either to form a series or a parallel connection. Hence the EMF produced by the generator is the resultant of the series or the parallel connection as per the required voltage. The waveform of the flux density is sinusoidal in nature.

X. CONCLUSION

We have proposed air core generator which is portable and less in weight which serves many advantages in comparison with conventional generator, due to absence of stator the losses related to it is vanished, it also saves the raw material required for stator core thus reducing the cost, natural cooling is achieved due to absence of stator which saves the additional cost required for its cooling system. It also serves good efficiency when low input is provided.

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