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# Modeling Of Permanent Magnet Machine Using Ceiling Fan System

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***Abstract-****Induction motors are widely used in several household applications and some government agencies that introduced regulations forced in reduction of energy consumption. We designed of electrical machine using ceiling fan system to generate electrical power. The wasted kinetic energy of ceiling fan is converted into electrical energy by dc generator. Existing workofceiling fan technologies, previous researches on ceiling fan, type of flux and air gap configurations was systematically analyse in order to obtain the optimum proposed designs configuration. The permanent magnet machine configuration and axial flux configuration was selected to propose the design of an electrical machine. We have introduced the new concept of single rotor double stator that combining the motor and generator in one system. In our system, permanent magnet is rotor and the armature coil is stator.*
***Keywords -*** *Permanent Magnet Synchronous Generator (PMSG), Permanent magnets, Axial Flux.*

## I. Introduction

To design the electrical machine of a ceiling fan system purposely to generate additional electrical power.The conventional single-phase ceiling fan using an induction motor has a lower 30% efficiency. In addition, the wasted kinetic energy from the mechanical rotor rotation can be converted from mechanical energy to electrical energy. The newly introduced design concept in this study is the use of concept single rotor double stator that combining the motor and generator in one system. The energy usage for each building and household are affected by the usage of electrical appliances, such as lighting system, electronic appliances and cooling appliances which carries high electricity consumption. However, the rate of energy electricity consumption is depends on surrounding factor for instance occupant, management, environmental standard, building design and construction, mechanical and electrical equipment and climate.

To design a permanent magnet generator for domestic application.In ourproposed system, permanent magnet is rotor and the armature coil is stator.The wasted kinetic energy of ceiling fan is converted into electrical energy by axial flux generator. And we have introduced the new concept of single rotor double stator that combining the motor and generator in one system [1].

## II. Induction motor

The power consumption of each electrical appliances varies by the power rating, depends on the amount of consumed energy and the usage time of the appliances. Even though the usage time of air conditioner is lower than electrical fan, the energy consumption of air conditioner is 42% higher compared to electrical ceiling fan because of the high power rating. The ceiling fan must be high in efficiency and also energy saving. The standard electric ceiling fan using single-phase induction motor and has a low efficiency.

Generally, conventional ceiling fan is driven by a single-phase induction motor with 30% efficiency. This value of efficiency is not sufficient enough for the performance of the ceiling fan motor. To improve the efficiency of ceiling fan by wasted kinetic energy is converted into electrical energy.

### *A. Types of Induction Motor*

1. Split phase induction motor
2. Capacitor start induction motor
3. Capacitor run induction motor
4. Shaded pole induction motor

### *B. Construction and Operation*

Stator is a stationary part of induction motor. A single phase ac supply is given to the stator of single phase induction motor. The rotor is a rotating part of induction motor. The rotor is connected to the mechanical load through the shaft. The rotor in single phase induction motor is of squirrel cage rotor type.

The construction of single phase induction motor is almost similar to the squirrel cage three phase motor except that in case of asynchronous motor the stator have two windings instead of one as compare to the single stator winding in three phase induction motor.

The operation of a single phase induction motor converts electrical energy into the mechanical energy. When the current carrying conductor placed in a magnetic field then torque is setup in the conductor. Single phase induction motor is non-self-starting because alternating current have two component i.e. positive and negative component these two component produce two flux which is rotated in opposite direction hence they cancelled with each other, then the resultant flux will be zero.

Hence two winding is preferred one is starting winding other is running winding. Starting coil is connected in series with the capacitor, current flowing through the starting winding is lead, and then two flux produced in two winding, then resultant flux setup the torque in the rotor.

## III. Axial Flux

Axial Flux simply means the lines of magnetic flux that passed through the coils of wire, travel along the **"axis"** of the turning motion.An axial flux generator is different from conventional electric generator due to the different path of the magnetic flux.

In conventional generator the flux flows radially through the air gap between the rotor and the stator. The air gap increases the magnetizing current needed. For this reason, the air gap should be minimal. Very small gaps may cause mechanical problems in addition to noise and losses

### *B. Design of axialflux generator*

For all kind of electric machines the design procedure starts from the imposed rated apparent power, in our case, for a Multi-pole 3 phase generator we have:

$S_n = mqUI - - - - - - - - - - -1$

Where m=3 is the phase number and q=2 is the total number of coils per phase, U is the induced voltage in a coil and I is the coil current.

The magnetic flux through a coil is:

$$\emptyset = \emptyset_m \cos(\omega t) - - - - - - - - - - -2$$

And the induced voltage in a coil, according with the induction Law, has the expression:

$$e = -E_m Sin(\omega t) - - - - - - - - 3$$

With the amplitude:

$$E_m = N\omega\emptyset_m - - - - - - - - - - 4$$

Where "N" is the number of turns for one coil and U is the rms Value of a coil induced voltage.
The maximum value of the excitation magnetic flux is:

$$\emptyset_m = B_g \boldsymbol{A}_c = K_\sigma B_m A_m - - - - - - - - 5$$

If the ceiling fan has a rated speed of *n=250 rpm*, then for having induced voltage, frequency of approximately 50 Hz.
We must have a total of pairs of poles (one North Pole on a rotor and a south pole on another rotor)

$$A_c = ac\ bc = \frac{NI}{J_a} k_f - - - - - - - - - - 6$$

Where, Ja =10A/mm2 is the admissible current density in the coil, Kf = 0.5 is an acceptable filling factor at coil winding. ac and bc are the dimensions of the transversal cross-section of the coil.
Now the total apparent power looks like:
. $S_n = 4.44\ mqf\ K_\sigma K_f B_m A_m\ ac\ bc - -7$

From this equation can be seen that the same power can be obtain with a big magnet area am and a small cross-section area of the coil Ac = acbc or vice-versa.

From a permanent magnet supplying company, we have chosen the magnet type NdFeB.[3]

### C*. Types of axial flux generator*

Several axial-flux machine configurations can be found regarding the stator position with respect to the rotor positions and the winding arrangements giving freedoms to select the most suitable machine structure into the considered application. Possible configurations are:

i) Structure with one rotor and one stator, Fig. 1 (a).
ii) Structure, in which the stator is located between the rotors, Fig. 1(b).
iii) Structure, in which the rotor is located between the stators, Fig. 1(c).
iv) Multistage structure including several rotors and stators Fig. 3(d).[4]

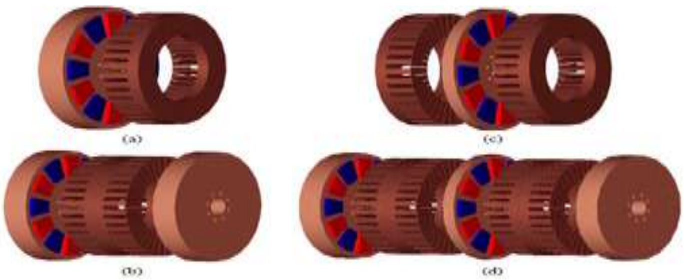

Fig 1.Types of Axial Flux Generator

### *D. **Efficiency of axial flux generator***

The motor efficiency as a function of time in a test run for which the cooling of the machine was arranged by natural convection and radiation. This cooling method, in particular, has been in the primary design criterion for the prototype generator. The efficiency is calculated according to its value is at steady state 89.6%.

## IV. 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. It is so important to learn basics of magnets before designing the machine.

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. They can provide power even during electrical network failure because of built-in permanent self-excitation.

### *A. Types of permanent magnet*

There are some types of permanent magnets they are,

1. Neodymium iron boron (NdFeB)
2. Samarium cobalt (SmCo)
3. Alnico
4. Ceramic or ferrite magnets

### *B. Characteristics of neodymium magnet*

Magnetic material can be described by the BH curve. Second quadrant of this characteristic is called demagnetization curve and is useful for magnetic calculation. The point where this characteristic cross H 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 isresidual flux density. Value of Br tells about the magnetization of material when external magnetic field (H) is removed. Based on those two components it is possible to determine demagnetization curve. This function is almost linear for neodymium magnets.

### *A. Properties of neodymium magnet*

Recently, Nd-Fe-B magnet material with reminisce a flux density of 1.52 T and a maximum energy product of 440 kJ/$m^3$ was reported.

The values are close to the practical performance limit of Nd-Fe-B magnets because the theoretical maximum energy product for Nd-1 Fe-14 B-1 crystal is 510 kJ/$m^3$. These extremely high performance grades, however, suffer from a poor thermal behaviour. The maximum operating temperature is limited to about 100°C. This is related to the strong temperature dependence of the neodymium magnetic moment.

As the temperature increases, there appears a rapid drop in the magnetization and an even faster decline in the intrinsic coercively to zero at about 250 °C.

The best Nd-Fe-B grades, capable of tolerating temperatures up to 200 °C, have remanence flux densities of about 1.2 T and have their maximum energy product of 300 kJ/$m^3$ at a 20 °C temperature. As the intrinsic coercivity ($H_c$) is also a function of the temperature, a set of *B-H* loops may be constructed with respect to the temperature and the external field strength. For the Nd-Fe-B permanent magnet material the curves are described in Figure 2.

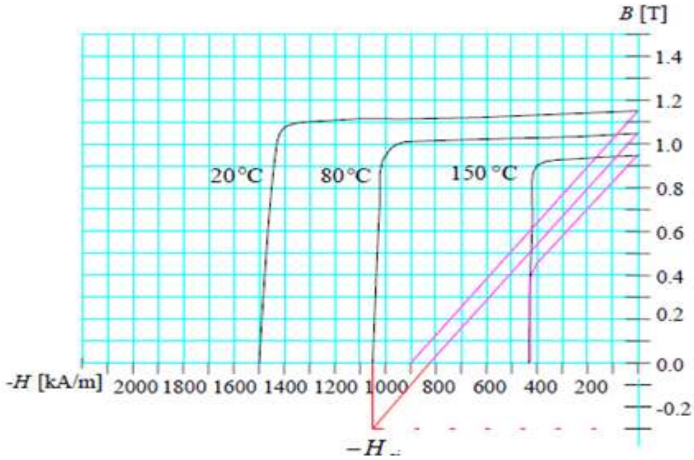


**Fig.2.** B-H curves for Nd-Fe-B Permanent Magnet

## V. Permanent Magnet Synchronous Generator (Pmsg)

This particular axial-flux machine configuration proves to be the most adequate structure for industrial applications considering low-speed high-torque. The reason for that is, firstly, fixing of the stators may be arranged reasonably easily. Secondly, an electrical machine equipped with two stators is capable of operating (with some precautions) even though one of its stators is electrically disconnected and finally, an axial loading of bearings is small due to the internal rotor configuration.

### *A. Construction of PMSG*

In general, synchronous generator consists of two parts rotor and stator. The rotor part consists of field poles and stator part consists of armature conductors. The rotation of field poles in the presence of armature conductors induces an alternating voltage which results in electrical power generation.

### *B. Operation of PMSG*

The principle of operation of synchronous generator is electromagnetic induction. If there exists a relative motion between the flux and conductors, then an emf is induced in the conductors. To understand the synchronous generator working principle, let us consider two opposite magnetic poles in between them a rectangular coil or turn is placed.

If the turn is rotated towards vertical position, then the induced current reduces to zero. For one complete revolution of rectangular turn the current in the conductor reaches to maximum & reduces to zero and then in the opposite direction it reaches to maximum & again reaches to zero. Hence, one complete revolution of rectangular turn produces one full sine wave of current induced in the conductor which can be termed as the generation of alternating current by rotating a turn inside a magnetic field.

Now, if we consider a practical synchronous generator, then field magnets rotate and the stationary armature conductors is placed between the rotors. The synchronous generator rotor mechanically coupled to each other and rotate at synchronous speed. Thus, the magnetic flux cutting produces an induced emf which causes the current flow in armature conductors. Thus, for each winding the current flows in one direction for the first half cycle and current flows in the other direction for the second half cycle with a time lag of 120 degrees (as they displaced by 120 degrees). Hence, the output power of synchronous generator can be shown as below figure.

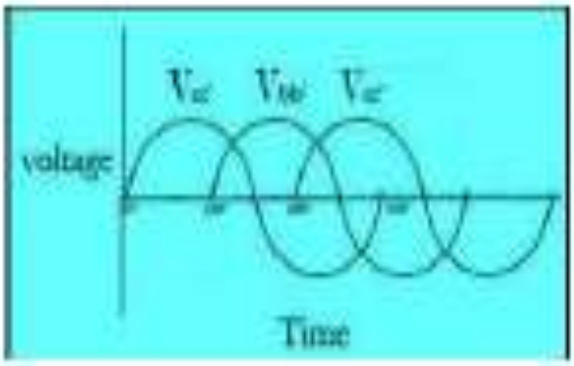


**Fig.5.1.** Output power of PMSG

### *C. Benefits 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 means low mechanical friction losses. Another advantage is its compactness.

The recent introduction of high-energy density magnets (Nd Fe B 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 length. Since no noise is associated with the mechanical contacts and the driving converter switching frequency could be above 20 kHz producing only ultrasound inaudible for human beings.

### *D. Types of PMSG*

The permanent magnet PMSG generator can be categorized according to the way the permanent magnets are mounted on the rotor and the shape of the induced emf. The permanent magnets can either be surface-mounted, interior-mounted, or buried in the rotor, and the induced emf shape in the stator can either be sinusoidal or trapezoidal.

## VI. Bridge Rectifier

A Bridge Rectifier is an Alternating Current (AC) to Direct Current (DC) converter that rectifies mains AC input to DC output. Bridge Rectifiers are widely used in power supplies that provide necessary DC voltage for the electronic components or devices. They can be constructed with four or more diodes or any other controlled solid state switches.Depending on the load current requirements, a proper bridge rectifier is selected.

### *Types of bridge rectifier*

Bridge rectifiers are classified into several types based on these factors: type of supply, controlling capability bridge circuit's configurations, etc. Bridge rectifiers are mainly classified into,

1. Single phase
2. Three phase
3. Uncontrolled
4. Controlled

## VII. Conclusion

The permanent magnet axial magnetic flux generator is a good option in the case of small power system, because the simplicity of the manufacturing technology makes it available for a grate number of small fans. This design methodology that allows the design of axial flux permanent magnet generate small power.

The proposed permanent magnet axial flux PM generator operates at low speeds and it convert waste kinetic energy into electrical energy. In our permanent magnet axial flux PM generator we are using 6 coils (2 coils per phase) and two sets of 8 permanent magnet to produce low power from the ceiling fan.

We evaluate improve the performance of the ceiling fan, type of flux and air gap configurations was systematically analysed in order to obtain the optimal result. In order to introduce regulations forced in the reduction of energy consumption.

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