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MANUFACTURING OF AXIAL FLUX PERMANENT MAGNET GENERATOR

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ABSTRACT
An axial flux permanent magnet machine, designed to operate as a generator in a small-scale wind-power applications. This paper is about manufacturing of one of type of such machines. The procedure of manufacturing of Single Stator single rotor Axial Flux permanent Magnet Generator (AFPMG) is shown here. This procedure and idea will be helpful to any student to manufacture their own generator. This paper also gives the idea of material requirement and selection.

INDEX TERMS – Flux, Ndfeb magnets, Iron, Generator etc.

I. INTRODUCTION

Non- conventional energy sources such as solar, wind, tidal etc.are clean and cheap and their significance is also increasing now a days. Presently approximately 200 GW energy from the wind is available in the world. It may also increase above 1000 GW into upcoming years; it means demand of wind energy is increasing day by day [1]. To achieve electrical energy from wind energy generators are required. The conversion efficiency of generators should be well enough to get good wind energy power generation system. The mechanical input to the generators is provided by wind turbines which must be taller to achieve as maximum wind as possible. These turbines require more complex and flexible towers along with lighter weight and smaller sized nacelles for better stability and improved performance. One of the basic wind generator is consider for manufacturing in this paper.

II. AFPM CONFIGURATION

There are so many types of Axial Flux (AF) permanent magnet generator configuration such as single rotor single stator, double rotor single stator (TORUS), Single rotor double stator (AFIR) and multi rotor multi stator. Manufacturing of basic type of generator is described along with material selection here. This type of generator has single stator and single rotor, placed on a same shaft with adjustable air gap between them. To prepare the stator of proposed generator, coils are assembled together. It consists total 6 coils, 2 coils per phase. There are 76 turns of enamelled copper wire per coil. To eliminate the iron losses and to prevent the winding from core warm ups, the stator is keep coreless. The generator rotor is disc type. The N-S-N-S arranged neodymium magnets (NdFeB) are mounted on rotor steel disc. The larges faces of magnets are their poles. To complete the magnetic path of back poles of magnet steel disc is used.

III. BASIC OPERATING PRINCIPLE OF SELECTED GENERATOR

Faraday's law of electromagnetic induction states that, "Rate of change of the magnetic flux passing through coil, will induce a voltage in that coil". The movement of flux in the coil should be rapid to produce high voltage in every turn of each coil. Voltage produced by the coil is depends upon the no. of coil turns, flux & rpm. At low speed the coil will produce low voltage. When turbine reaches a certain cut-in speed, the voltage is become a nearly enough to charge a battery. To charge the battery the speed of wind turbine should be above cut in speed. The strength of the wind and the size of the blades decide the electrical output of the turbine. The mechanical energy produced by the blades is converted into electrical energy by the generator.

IV. MATERIAL AND TOOL SELECTION

The materials and tools required for manufacturing of generator should be easily available and of low costs. Stator & rotor moulds are ideal for low cost application. These materials can be easily found anywhere in Maharashtra for exp. In any enterprises and wood workshops. in Shalimar Engineers, pune Stainless steel disks are available. Proton Metal crafts Private Limited, Pune provides Bearing hub required for rotation of generator. The neodymium magnets (NdFeB) are available JR Strong Magnet Pvt. Ltd,Pune.In Gayatree Polymers Private Limited, Pune. We get Polyster resin which is a material that can provide support for the stator coils which lay in the air and protection from corrosion for the magnets.

V. CONSTRUCTION OF PROPOSED GENERATOR

The manufacturing of proposed generator is very simple. The N-S-N-S arranged neodymium magnets (NdFeB) are mounted on rotor steel disc. The larges faces of magnets are their poles. To complete the magnetic path of back poles of magnet steel disc is used as shown in Fig 1. [2].

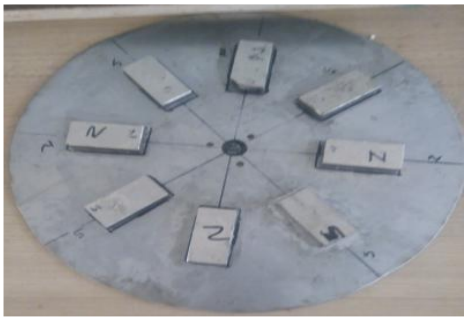

Fig.1. Rotor disk

To prepare the stator of proposed generator, coils are assembled together. It consists total 6 coils, 2 coils per phase. There are 76 turns of enameled copper wire per coil as shown in Fig 2.

Fig.2.Assembly of coils

The assembled coils are placed in a mould for casting purpose in polyester or vinyl ester resin as shown in Fig.3.

Fig.3.Stator cast in epoxy resin

For effective distribution of flux in each coil, the stator and rotor are mounted on shaft in such a way that they face each other.

VI. MANUFACTURING AND INSTALLATION OF PROPOSED GENERATOR

1) Tools Used:

In most cases there are various options depending upon cost and what skill you may have [3].

Table 1) Tools

Sr.No	Purpose	Tools Used
1	Safety	Hand gloves
		small square shape wooden parts
2	All purpose	screwdrivers
		spanner set
		cutter
		center punch
		Drill machine
		Hammer
3	For Marking & Measuring	Compass
		Pro-circle
		Black marker
		Pencil
		roller
		scale
4	Electrical	Multimeter
		Tachometer
		soldring gun
		Extention board
		coil winder
5	Mechanical	Nut bolts
		MS flat Patti (215mm x 25.4mm x 5mm)(for stator)
		MS flat Patti (160mm x 25.4mm x 5mm)(for base)
		Bush(bearing adapter)
		Washers
		MS Shaft
		Bearings
6	Resin Preparation	Araldite epoxy resin (1 kg)
		Araldite Hardener (800 g)
		spoons, two small use-n-throw tea cups and sticks for mixing resin & hardner

2) Material Collection:

a. Stator:

1) Enamelled copper wire of gauge 1.42mm is brought from Aanand Electricals,solapur.(Total copper wire weight 1.45 kg)

2) Then prepare coil winder for wounding the coil in college workshop.

3) Then brought cotton tape for protection and having good mechanical strength of coil.

4) Then brought Metal for soldering purpose.

5) Then brought three rectangular plywood pieces namely lead, base & surround of size (340mm x 355mm x 11mm),(340mm x 355mm x 11mm) & (340mm x 355mm x 18mm) for preparing stator mould.

6) Then ordered Araldite epoxy resin and hardener for casting the assembly of stator coils.

7) Then prepare the MS flat Patti (215mm x 25.4mm x 5mm) in college workshop to place or support the stator on shaft

b. Rotor:

1) Purchase Stainless Steel (SS) disc then done the cutting of SS disc in required size.

2) After that purchase 8 rectangular pieces of NdFeB magnet from permag tradelink, wakdewadi,pune.

3) Then purchase Araldite glue and fevi quick for sticking the magnets on SS rotor disc.

c. Other:

1) Purchase two bearings, one for base and another for stator. Base bearing is of 6000 no. (Size) and rotor bearing is of 6001 no. (Size) from Aanand Electricals,solapur.

2) Then brought ceiling fan shaft from Aanand Electricals,solapur.

3) Manufacturing Process:

Following is the step by step procedure for manufacturing of AFPM generator:

1) First get Auto-CAD drawing of theoretically designed stator and rotor.

2) Then decided to fabricate stator initially, for that made the 6 coils of enameled copper wire as shown in Fig.4.Each coil is wounded by cotton tape for achieving tightness and good mechanical strength.

Fig.4.Copper Coils

3) Then connected the 6 coils in series star connection as shown in Fig.5.

Fig.5.Star Connection

4) After that testing of star connection or continuity is done with the help of lamp as shown in Fig.6.

Fig.6.Testing of Connections

5) Then took the SS rotor disc which was cut as per required size and start to divide the disc in 450 as shown in Fig.7. And also mark the space for placing magnets.

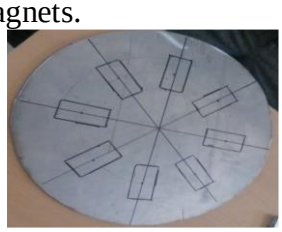

Fig.7. Rotor Disk Marking

6) Now started to place the magnets one by one on SS disc with the help of Araldite glue and fevi quick as shown in Fig 8.After all magnets glued the rotor disc is look as shown in Fig.9.

Fig.8.Placement of Magnet

Fig.9. Magnet Rotor Disk

7) Fixed the star connected assembly of coils on the plywood piece for testing the generator output and at the same time taken the marking on MS flat patti for drilling purpose as shown in Fig.10.

Fig.10. Marking on MS flat patti

8) Started to make holes in two MS flat pattis, for fixing the stator and rotor on the shaft with the help of drill machine in the workshop as shown in Fig 11.

Fig 11. Drilling of MS flat patti

9) Took the SS magnet disc and fix the bush at the back side and in the center of the disc for smooth rotation of disc as shown in Fig 12.

Fig 12. Rotor disc with bush

10) Then fix the base MS flat patti at the bottom bearing which is fixed with the shaft, then place the rotor disc on the shaft as shown in Fig.13.

Fig.13. Placing Rotor on shaft

11) Done the testing of Generator output as shown in Fig 14.

Fig 14. Testing of Generator output

12) Took the surround of plywood and cut it with the diameter which is quite greater than stator disc outer diameter. After that surround is put on base piece [4]. Then assembly of star connected coils is placed into the hole in surround which is covered by news paper. After that araldite epoxy resin and hardener is mix in cup and pour on the assembly of coils placed into the surround until all coils are completely emerged into the resin as shown in Fig. 15.

Fig.15. Stator coils casted in epoxy resin

4) Installation:

Once the stator and rotor disc are ready, next step is to assemble or install them on shaft .In this case the shaft of ceiling fan, two bearings, two MS flat patti and nuts-bolts are used to assemble stator and rotor disc .Installation procedure is explained below:

1) Kept the above casting for one complete day to get it dry. After that make the holes in the casting to fix it to the MS flat patti as shown in Fig 16 a) and b).


Fig 16 a) Drilling of casted stator b) fixing MS flat Patti

2) One bearing of 6000 no. is fixed at the base of the shaft and another bearing of 6001 no. is fixed at the top of rotor disc as shown in Fig 17. Then placed stator disc on the shaft as shown in Fig 18. And balanced mechanical distance between stator and rotor disc is maintained to 5mm. as shown in Fig 19.

Fig.17. Fixing rotor

Fig.18. Fixing Stator

Fig 19. Adjustment of gap between stator and rotor

3) For making stator disc stationary, it is fixed to the base plywood rectangular piece as shown in Fig 20. The three terminals R, Y, B and a neutral is brought out from the casted stator disc for testing and connection purpose. The rectangular plywood piece is fixed at the bottom of assembly for balancing the generator. The rubber black bush is fixed to the base plywood piece.

Fig 20. Rectangular Piece base

V. CONCLUSION

The all possible parameters of single stator single rotor AFPM generator are designed with required assumptions and with the help of mathematical equations in this paper.

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