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Effect of Thickness and Type of Magnet against EMF Back PMSG 12S8P with FEM

Liliana[1], Z Aini[1], A Wenda[1], T D Putri[1]
[1]Electrical Engineering Departement, UIN Suska Riau Pekanbaru, Indonesia

E-mail: liliana@uin-suska.ac.id

Abstract. Synchronous Magnet Generator (PMSG) is one of the main components of wind power generation. This generator has excellent low speed applied especially for less strong winds. Electromotive Force (EMF) output is expected to be enhanced for higher PMSG efficiency. This research aims to analyze the influence of thick and magnetic types on EMF Back PMSG 12S8P. Thickness and type of magnets vary to get the highest EMF output. The thickness is variated at a value of 3 mm and 6 mm, while the magnetic material used Neodymium Iron Boron (NdFeB) and PM12 Br 1.2 Mur 1. Linkage flux value is generated with Finite ElemenMethode (FEM) using Magnet 7,5 Software for each variation. From analyze results and compared to other variations, the highest EMF value obtained from the variation in magnetic thickness 6 mm with material type PM12 Br 1.2 Myrrh 1 with EMF value reaching 21.13122 Volt.

1. Introduction

The Generator is one of the electrical machines that can turn the kinetic energy into electrical energy. We need a reliable, low speed generator with good efficiency, especially in the not-so-tight winds. The Alternator Permanent Magnet meets these qualifications. So far the generator is the most popular choice in designing a successful small windmill e.g. generator I-2 permanent magnet 18 slots 16 Pole (coggingless) with output generated 500 W with wind speed limitation of 12 m/s [1,3].

The magnitude of voltage greatly affects the power output in generators. The magnitude of the voltage depends on the speed of the rotation, the amount of wire in the coil that cuts the flux, and the magnitude of the magnetic flux raised by the magnetic field and the generator's gear [2]. The resulting flux is limited in a state of saturation (maximum condition) so as to operate at a low speed, the generator should work at a lower voltage. This can be done by changing the coil connection from parallel to a series or Delta to a star or wearing a more number of rounds of percoils [4].

Flux is produced by magnetic field from permanent magnet used. The permanent selection of magnets with the best quality is preferred to produce larger flux. The properties of permanent material magnets will directly affect the performance of the generators. Knowledge of the properties of good material is indispensable to be able to choose the right material. In recent year magnetic materials such as aluminium nickel and Cobalt (Alnico) alloys, StrosiumFerit or Barium Ferrite (Ferit), Samarium Cobalt (SmCo) are the first generation of Rare-Earth and Neodymium Iron-Boron Magnets (NdFeB) being the second generation. NdFeB is the most common Rare-Earth magnet used on current generators [4,5]. This type of magnet is known to be the best-in-class magnet. Other magnet also very

[1] liliana@UIN-suska.ac.id.

good is the type of magnet PM12; Br 1.2 Mur 1. These two permanent magnets have the highest permanent magnet characteristics, have a maximum energy product value and also have a high cohesive force [7]. The thickness of the magnet itself will also affect the flux output, the larger the magnetic dimension then the flux spread will also be wider [6].

The study aims to analyse the influence of thickness and magnetic material against the EMF back output and K_E of PMSG 12S8P. The EMF back is caused by an ever-changing electric field cut on the conductor on the dynamo or generator. The terrain that continues to change on the dynamo conductor is caused or produced by the use of EMF. The EMF back value can be derived directly from the linkage flux that is quoted as Dψ using Faraday's law that is represented in the equation below [4].

$$E(\xi) = \frac{d\psi}{dt} = \omega_m = \frac{d\psi(\xi)}{d\xi} \quad (1)$$

where, $E(\xi)$ is EMF back (V), $d\psi$ is flux change, and dt is time span (s). The output of the EMF back relies on the strength of the magnetic flux line, the number of coil on the conductor, a magnetic flux intersecting angle with the conductor, and the velocity of the conductor in cutting magnetic flux lines. EMF back or K_E constants represent the construction of the machine. If all coils that are in one phase are connected and have the total peak value of EMF back then the K_E is defined in the following equation [4]

$$K_E = \frac{e_{ph}}{\omega_m} \quad (2)$$

where K_E is Konstanta EMF back, e_{ph} is average EMF (V), and ω_m is angular speed (rad/s). The simulation was made into four model variations namely models with a thick 3mm and 6mm magnet that uses the Neodymium Iron Boron material (NdFeB) and a model with a thickness of 3mm and 6mm magnets using material PM12: Br 1.2 mur 1.0. From this simulation result will be analysed combination which has the best EMF back output result on PMSG 12S8P.

2. Methodology

2.1 Research Prosedure

The procedure to get the best EMF Back value of PMSG 12S8P is presented complete as follows:

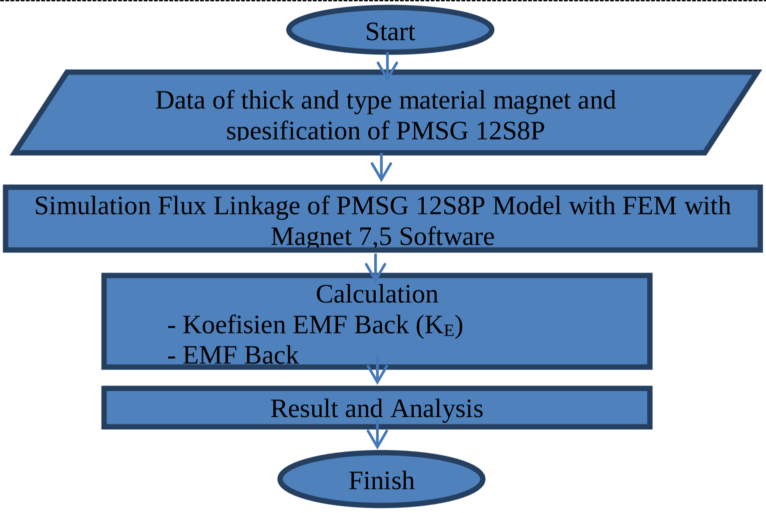

Figure 1. Research Procedure

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2.2. Description Research Procedure

2.2.1. Research Data

Magnet permanent used with two thickness variations is 3 mm and 6 mm while the permanent magnet material to be used in this simulation is Neodymium Iron Boron (NdFeB) and PM12 Br 1.2 Mur 1

Table 1. Thick and type of permanent magnet variation

Variation	Thicknees (mm)	Material
1	3 mm	odymium Iron Boron(NdFeB)
2	6 mm	odymium Iron Boron(NdFeB)
3	3 mm	PM12 Br 1.2 mur 1.0
4	6 mm	PM12 Br 1.2 mur 1.0

Specification model PMSG 12S8P was used in the studies given below

Table 2. Specification PMSG 12S8P

Spesification	Description
Number of slots	12
Dimensions	180 x 180 x 40
Number of Poles	8
Number of Coil	10
Stator Material (iron Core)	Carpenter: Silicon steel
Coil Material	Copper: 5.77e7 Siemens/meter
Rotor Material	Carpenter: Silicon steel
Airbox Material	Air
Airgap Material	Air

2.2.2. Simulation Flux Linkage with FEM using Magnet 7,5 Software

The simulation steps of PMSG 12S8P to get linkage flux values are as follows : (1) Setting the display tools FEM on Magnet Software, (2) Create geometry design PMSG 12S8P, (3) Variation of thickness and type of magnet, and (4) Testing so as to get Flux Linkage

3. Results and Discussions

3.1. Flux Linkage

From the flux linkage data graph, it is known that the modelling of this generator is a 3-phase generator consisting of a phase U, phase V and phase W. This graph is a rotor rotation graph against the output flux value generated per 360 ° or by one round of the rotor, and it can be seen that the magnitude of flux with U, V, W coil at each angle change will result in flux forming sinusoidal waves caused by the change of north and south pole magnet through the coil during rotation rotor. The data to be presented is a flux output data against a 3° rotor rotation of up to a full rotation. For flux output of each variation model will be described as follows.

From the chart (d) of the material variation model of PMSG PM12: Br 1.2 Mur 1.0 with a magnetic thickness of 6 mm above can be seen that the flux is produced when the rotor rotates 360 ° empty touching the 0.008 line and this model results in the highest flux output among the three other models (a,b, and c). This Model proves that magnetic permanent material also greatly affects the flux generated in each rotor rotation.

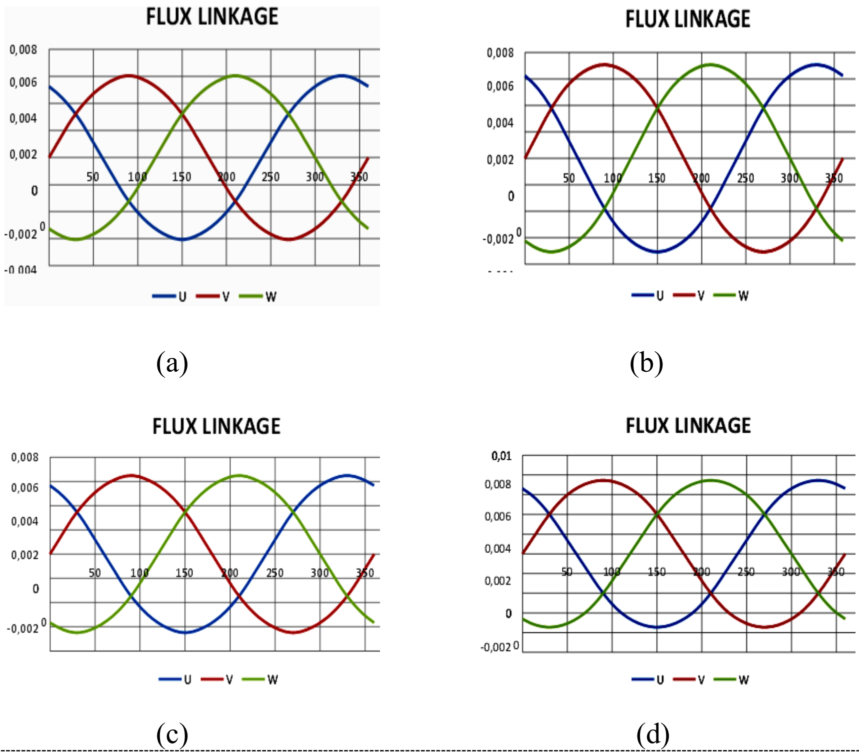
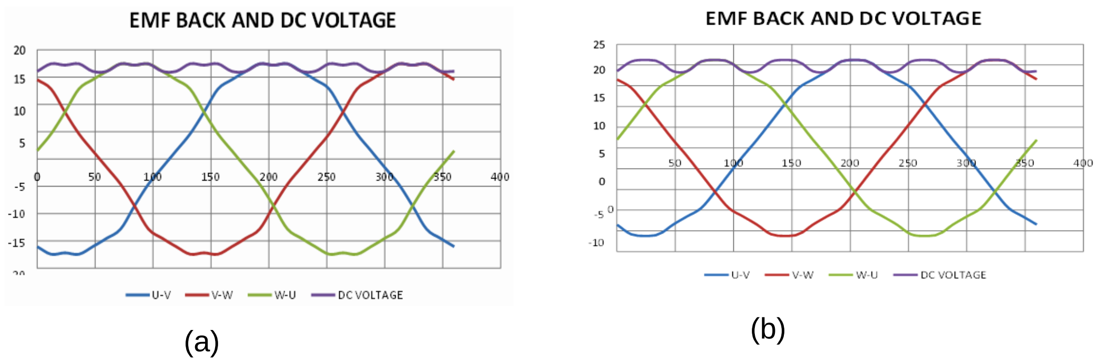


Figure 2. Graphics Flux Linkage (a)) thick 3 mm NdFeB, (b) thick 6 mm NdFeB (c) thick 3 mm, PM12 Br 1.2 Mur 1, and (d) thick 6 mm, PM12 Br 1.2 Mur 1

3.2. K_E and EMF Back Output

Once the result of the magnetic flux output is obtained, the next is calculating the EMF Back and K_E value of each phase. From the chart (d) above it can be seen that the average voltage of the modelling of these variations is at a value of 21.13122 V and the value K_E be obtained for this PMSG variation model 0.20 Vs/rad for each 360° rotor rotation. This variation model has the best average EMF Back output and K_E value among the other three models (a, b, and c). This proves that the thickness and material used on the permanent magnet will affect the resulting voltage when the rotor rotational



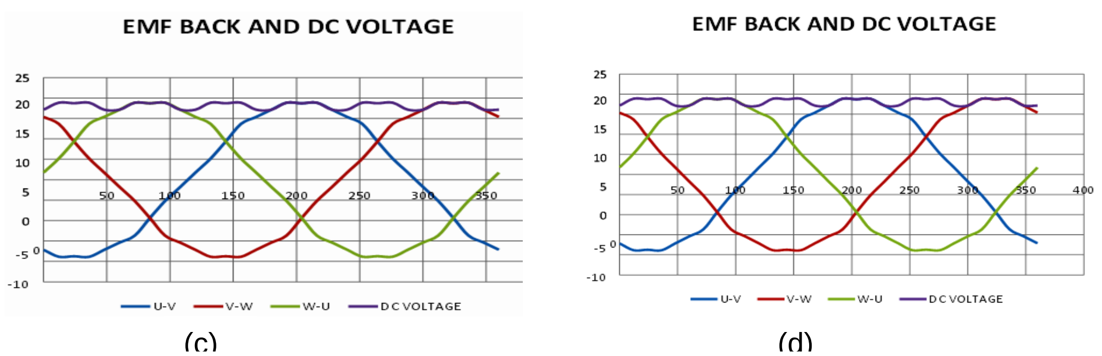


Figure 3. Graphics EMF Back and DC Voltage (a)) thick 3 mm NdFeB, (b) thick 6 mm NdFeB (c) thick 3 mm, PM12 Br 1.2 Mur 1, and (d) thick 6 mm, PM12 Br 1.2 Mur 1

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4. Conclusion

The test results for four variations resulted in the conclusion that the permanent Magnet Synchronous Generator (PMSG) 12 Slot 8 Pole with FEM using Magnet 7,5 Software was variated in the permanent material magnets using PM12 Br 1.2 Mur 1 with a thickness 6 mm magnet resulted in the output of EMF Back and value K_E the largest of other variations of PMSG 12S8P. This proves that the thickness and permanent material of the magnet greatly affects the output voltage that the generator will generate. This means that the larger the dimension or thickness of the permanent magnet will lead to a wider spread of flux resulting in a better voltage. The resulting EMF Back is heavily influenced by the value of the magnetic flux.

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References

[1] Piggot H 2000 *Windpower Workshop, Peninsula* (British: Wind Energy Association).
[2] Chapman S J 2005 *Electric Machinery Fundamentals* (New York: McGraw-Hill) 4th edition.
[3] Ummami, Muhammad Irsyadul 2018. *Desain Generator Sinkron Magnet PermanenJenis Neodymium Iron Boron Untuk PLTB Daya 500 Watt Menggunakan Perangkat Lunak Mag Net Infolytica* UniversitasMataram.
[4] Hanselmen, DC 2006. *Brushless Permanent Magnet Motor Design* (New York: McGraw-Hill).
[5] Prasetyo Y 2019 *Analisis Perbandingan Bahan Material Magnet Dalam Pemodelan Permanent Magnet Synchronous Generator (PMSG) 12 Slot 8 Kutub Dengan Menggunakan Finite Elemen Method (FEM) Software* UniversitasMuhammadiyah Surakarta.
[6] Nugroho W B, Kusuma I R, dan S Sarwitto S 2014 *Jurnal Teknik* **3**
[7] Arifianto I, Hasibuan M R2018 *Seminar Nasional Microwave Antena dan Propagasi (SMAP)* pp 43-47.