Effect of Geometry Generator Variation Design 12 Slot 8 Pole on Power Efficiency Design

by Jaka Windarta

EFFECT OF GEOMETRY GENERATOR VARIATION DESIGN 12 SLOT 8 POLE ON POWER EFFICIENCY DESIGNED

Jaka Windarta[1,2], Sudjadi[1], Karnoto[1], Tejo Sukmadi[1], Imam Santoso[1] and Anjar Desmiarti[1]

[1] *Department of Electrical Engineering Diponegoro University*

[2] *Master Program of Energy-School of Postgraduate Studies Diponegoro University*

ABSTRACT

The development of generator technology continues to improve from year to year. The scope of such improvement varies from the shape, design, size, the usage of material, and even regarding to the efficiency of the generator output power. However, the improvement of generator technology development could not be separated from the role of the software to design such electric machinery. So before doing the design and implementation of the manufacture of electric machines, especially generators, it is important to know the specifications of materials which are needed in the design of the generator. Regarding to that, the initialization of each constituent part of the generator—for example, in the pre-design process of a 12-slot 8-pole generator—is a must.

Keywords: Output Power, Input Power, Efficiency

INTRODUCTION

The development of generator technology continues to improve from year to year. The scope of such improvement varies from the shape, design, size, the usage of material, and even regarding to the efficiency of the generator output power. However, the improvement of generator technology development could not be separated from the role of the software to design such electric machinery. So before doing the design and implementation of the manufacture of electric machines, especially generators, it is important to know the specifications of materials which are needed in the design of the generator. Therefore, it is expected that further research could be able to provide such information regarding the materials needed to build the generator. Many prior researches and studies used Trial and Error methods, especially here in Indonesia. The method in other words means to directly work on the building process of the generator that has been designed mathematically. This is because of some things that has been putted into consideration, for example, regarding the geometric design which is used. Then came an idea to design a generator using the help of software, such as Magnet, to create a simulation of the generator. When performing the manufacture or design of the generator, one must determine the ideal efficiency value of the generator so as to be able to reach the desired target value. In designing a generator using electromagnetic software, such as Infolytica, there are many aspects that need to be considered, either before or during the design process. It's because many parameters use equations which needs to be calculated when designing the generator [1]-[4]. The width of the air gap is one of the parameters that uses equation because the air gap will later affect the output and performance of the generator.

MODELING, SIMULATION

A. *Pre Design 12 Slot 8 Pole Generator*

The design drawing is the stage to draw the geometric shapes of the stator, rotor, slot , air gap width, and determining the appropriate magnet layout so that it will produce a good sinusoidal signal. Design drawings can be done directly using software such as Magnet

Infolityca, as well as CAD software, such as Solid work, Inventor and AutoCAD, Figure 1 shows a generator design made using Infolityca software.

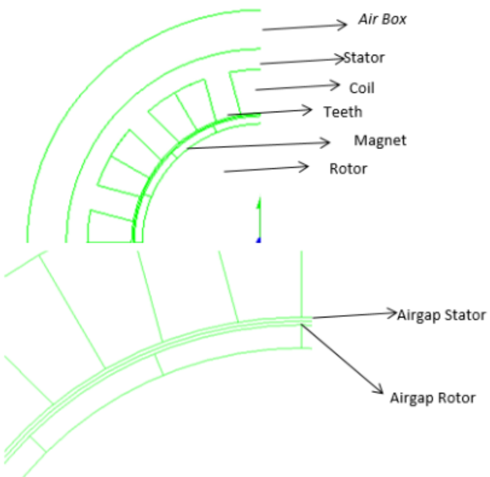


Figure 1 Design ¼ Model Generator

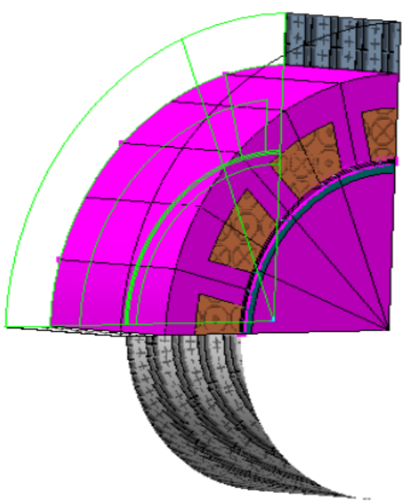


Figure 2 Design 3D ¼ Model Generator

Table 1 Initialization on each part

Part	Material
Airbox	AIR
Stator	Carpenter: Silicon steel
Coil	Copper:5.77e7 Siemens/meter
Teeth	Carpenter: Silicon steel
Magnet	PM12: Br 1.2 mur 1.0
Rotor	Carpenter: Silicon steel
Airgap Rotor	AIR
Airgap Stator	AIR

1. *Generator Testing Variation*

As for the initialization of material for each part, the value of the diameter of each part is very influential to the generated output value. In this experiment, we used three variations of value (mm) in the rotor, stator, teeth, and magnet.

a) Variations of Stator Geometry

Table 2 Size of each variation in the stator section

Part	Size (mm)		
	Variation 1	Variation 2	Variation 3
Air box	90	90	90
Stator	65	75	85
Coil	67	67	67
Teeth	10	10	10
Magnet	49	49	49
Rotor	46	46	46
Air gap Rotor	49.5	49.5	49.5
Air gap Stator	50	50	50

b) Variations of Teeth Geometry

Table 3 The size of each of the foreign variations in the teeth section

Part	Size (mm)		
	Variation 1	Variation 2	Variation 3
Air box	90	90	90
Stator	75	75	75
Coil	67	67	67
Teeth	7	10	13
Magnet	49	49	49
Rotor	46	46	46
Air gap Rotor	49.5	49.5	49.5
Air gap Stator	50	50	50

c) Magnetic Geometry Variations

Table 4 Size of each variation on the magnet

Part	Size (mm)		
	Variation 1	Variation 2	Variation 3
Air box	90	90	90
Stator	74	75	76
Coil	66	67	68
Teeth	10	10	10
Magnet	48	49	50
Rotor	46	46	46
Air gap Rotor	48.5	49.5	50.5
Air gap Stator	49	50	51

d) Variations of Rotor Geometry

Table 5 Size of each variation in the rotor section

Part	Size (mm)		
	Variation 1	**Variation 2**	**Variation 3**
Air box	90	90	90
Stator	65	75	85
Coil	67	67	67
Teeth	10	10	10
Magnet	49	49	49
Rotor	46	46	46
Air gap Rotor	49.5	49.5	49.5
Air gap Stator	50	50	50

B. Model Simulation

In performing the simulation, to determine the angle value of the rotor movement, two methods of calculation are performed respectively. First, by determining the mechanical angle value (degree/ms) as in the mechanical equation, then continued by determining the electrical angle value (degree/ms), shown as follows

$$\theta mechanic = \frac{360}{Multiplicity\ from\ slot\ and\ pole\ generator}$$

$$\theta electric = \frac{Pole}{2} \times \theta mechanic$$

From the above equation, it can be seen that when the magnitude of the mechanical movement for 12 Slot 8 Pole Generator is 15 degrees/ms, the electric movement is equal to 60 degrees/ms on 360 degree model. In the stop motion parameter, the stop time value of 0.015 s are being used because the design process of 12 slot 8 pole generator uses ¼ model. To determine the value of the sampling movement, however, it can be calculated using the following equation.

$$t_\theta = \frac{\theta mechanic}{\sum sampling\ data}$$

From the above equation using samples in total of 100 data, we obtained the step value of 0.00015 degrees/s. Before doing the simulation by then rotating the rotor, there are some steps that need to be done so that the rotor can rotate automatically. First of all, we need to enter the value of the rotor movement which starts from 0s and ends at 0.015s where the movement of the rotor occurs along 90 degrees, as shown in Figure 3

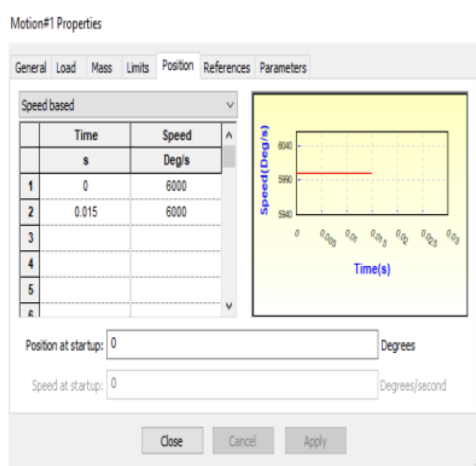


Figure 3 Insertion of speed based motion values

Next, we need to enter the transient value with the initial value 0s, and ends at 0.015s where every 0.00015s of rotor movement is being sampled until the movement to 90 degrees so that 100 data could be obtained, the process of transients are shown in Figure 4 .

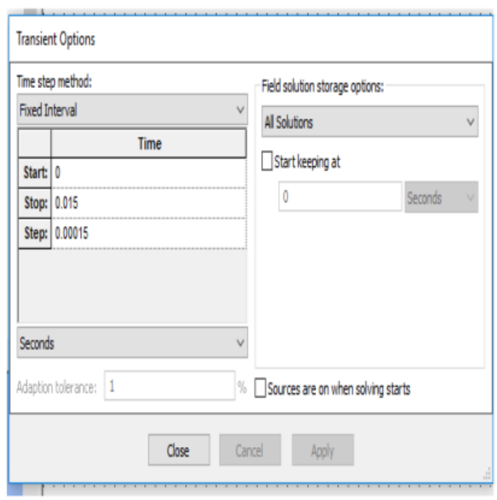


Figure 4 Transient options value entry

Meanwhile, regarding the solve options parameter that needs to be set is the value of the Polynomial order to be used. Figure 5 shows the solve options setting screen.

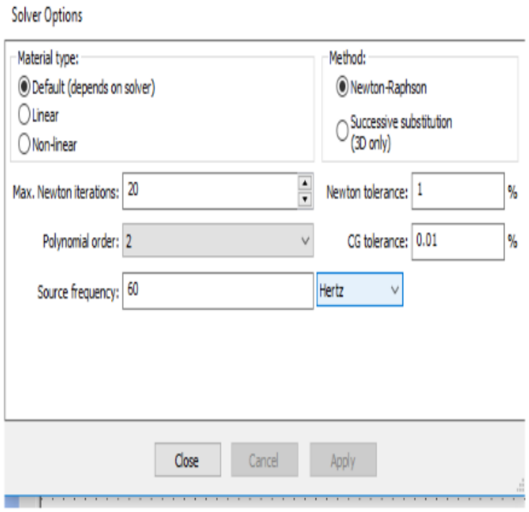


Figure 5: Polynomial order settings

The next process is the manufacture of rectifier circuit as shown in figure 6. It is the step to make the circuit which is located in the generator coil, because every generator test using the Infolytica Magnet Software uses different circuits, both for a loaded generator and a generator without load. Figure 6 shows a circuit which got 100 ohm load, using 50 loops where the junction voltage value for each generator is 0.7 V as shown by the Infolytica Magnet Software.

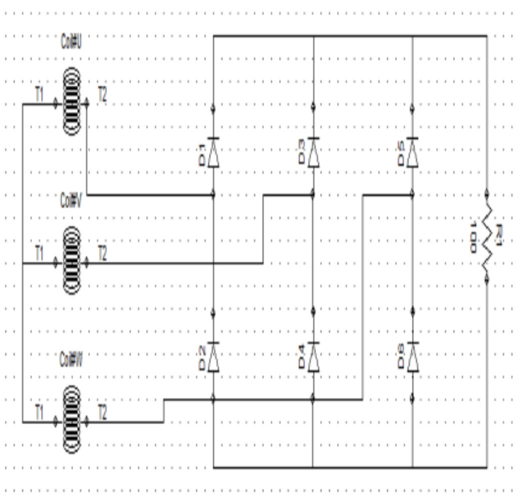


Figure 6 Rectifier Circuit

RESULT AND ANALYSIS

Results of Simulation and Data Processing

The generator works by changing the inputs of rotational speed (radians per second) and torque (Newton meter), producing outputs of voltage (Volt) and current (Ampere). The generator rotates with input through a shaft derived from the turbine. Input from the turbine in the form of turbine rotational speed, as well as the torque provided. That can be referred to as mechanical power.

$$P_M = \omega * \tau$$

$$\omega = [\frac{deg}{sec}]*[\frac{2\pi}{360}]$$

Where

P_M : *Mechanical Power (Watt)*

ω : *Angular Velocity (rad / s)*

τ : *Torque (Newton meter)*

The Output Generator is the Current and Voltage of the resulting Flux and the installed load, which is referred to as electric power.

$$P_E = V * I$$

Where

P_E : *Electric Power (Watt)*

V : *Voltage (V)*

I : *Current (Ampere)*

The input power for the generator is mechanical power and its output power is electric power, therefore to perform efficiency calculation can use the following equation.

$$Efisiensi\ (\%) = \frac{Power\ Electric\ Rate}{Power\ Mechanic\ Rate} \times 100\ \%$$

A. *Analysis From The Result*

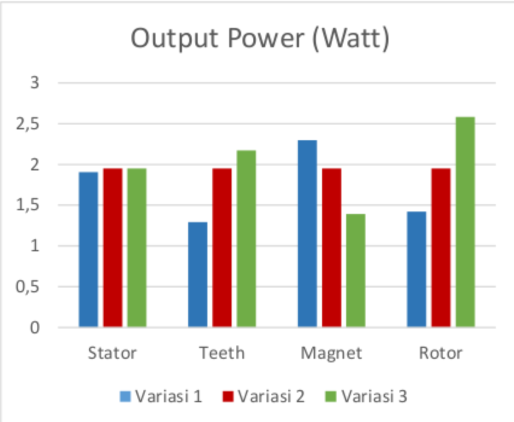
a) Power Output Generator

The calculation of the output power of the data in the simulation shows the results in Table 6.

Table 6 Comparison Results of output power of each part

	Stator	Teeth	Magnet	Rotor
Variation 1	1.9040	1.2931	2.2962	1.4203
Variation 2	1.9489	1.9489	1.9489	1.9489
Variation 3	1.9496	2.1701	1.3926	2.5809

From Table 6 we get a comparison graph of output power in each variation of geometry as in Graph 1.



Graph 1 Comparison Graph of the output power of each part of the geometry variation

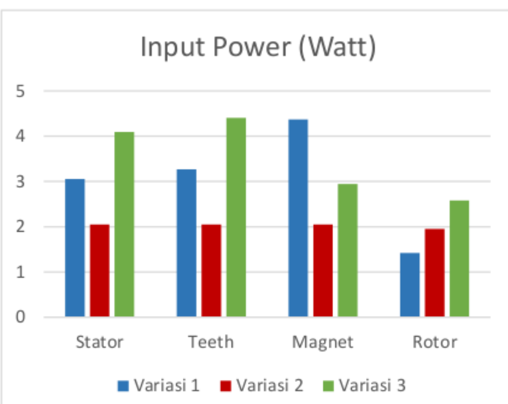
b) Power Input Generator

The calculation of the input power of the data in the simulation shows the results in Table 7.

Table 7 Comparison Results of input power of each part

	Stator	Teeth	Magnet	Rotor
Variation 1	3.0525	3.2660	4.3696	1.4203
Variation 2	2.0478	2.0478	2.0478	1.9489
Variation 3	4.0951	4.4045	2.9442	2.5809

From Table 7 we get a comparison graph of input power in each variation of geometry as in Graph 2.



Graph 2 Comparison Graph of the input power of each part of the geometry variation

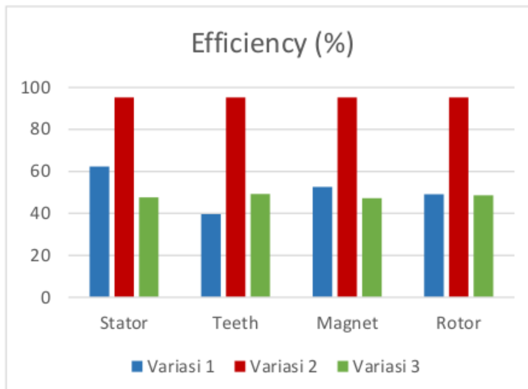
c) Generator Efficiency

The calculation of the efficiency of the simulated data in the simulation shows the results in Table 8.

Table 8 Comparison Results of efficiency value of each section

	Stator	Teeth	Magnet	Rotor
Variation 1	62.3761	39.5935	52.5512	49.176
Variation 2	95.1723	95.1723	95.1723	95.172
Variation 3	47.6089	49.27	47.3006	48.631

From Table 8 we can see the comparison of efficiency values for each geometry variation as shown in Figure 8.



Graph 3 Comparison Graph of efficiency values of each part of geometric variation

CONCLUSIONS

From the practical in the software infolityca can be concluded as follows:

1. In the pre design process generator 12 slot 8 pole, each constituent part of the generator must be initialized.
2. The diameter value in the generator greatly affects the resulting output value.
3. In the first variation the highest efficiency value is in the stator which is 62.3761 %
4. In the second variation an efficiency value is 95.1723 %

   In the third variation the highest efficiency value is in the teeth section which is 49.27 %

REFERENCES

[1] Kenjo, T and S. Nagamori. 1985. Permanent-Magnet and Brushless DC Motor. Tokyo: Sogo Electronis Publishing Company.

[2] Hendershot, James R., and Timothy John Eastham Miller. 1994. Design of Brushless Permanent Magnet Motors. UK: Magna Physics Pub.,.

[3] Fitzgerald, AE, Kingsley, C., Umans, SD, & James, B.2003. Electric Machinery. Vol. 5. New York: McGraw-Hill.

[4] Chapman, Stephen.2005 Electric Machinery Fundamentals. Tata McGraw-Hill Education,.

[5] Chapman, Stephen J., 2002. Electric Machinery and Power System Fundamentals. New York: McGraw-Hill.

Effect of Geometry Generator Variation Design 12 Slot 8 Pole on Power Efficiency Design

ORIGINALITY REPORT

7%	4%	4%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.semanticscholar.org Internet Source	4%
2	A T A Salim, N Romandoni, A Aminudin, D W S Wardana, E Sudibyo. "Effect of materials character on the design of the 12 slot 8 pole generators on power efficiency", Journal of Physics: Conference Series, 2019 Publication	1%
3	Liliana, Zulfatri Aini, Alex Wenda, Tahlil Darmiayu Putri. "Effect of Thickness and Type of Magnet against EMF Back PMSG 12S8P with FEM", IOP Conference Series: Materials Science and Engineering, 2020 Publication	1%
4	RB Sularto, Suryono, Monica Puspa Dewi, Kagirenza Alexis Fidele. "Denial of Service (DOS) Attack Identification As A Means To Be A Capable Guardian", E3S Web of Conferences, 2020 Publication	1%

Exclude quotes	On	Exclude matches	Off
Exclude bibliography	On		

Effect of Geometry Generator Variation Design 12 Slot 8 Pole on Power Efficiency Design

GRADEMARK REPORT

FINAL GRADE

/0

GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6