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Effect of Dimension and Shape of Magnet on the Performance AC Generator with Translation Motion

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Abstract. The development of power plants using the renewable energy sources is very rapid. Renewable energy sources used solar energy, wind energy, ocean wave energy and other energy. All of these renewable energy sources require a processing device or a change of motion system to become electrical energy. One processing device is a generator which have work principle of converting motion (mechanical) energy into electrical energy with rotary shaft, blade and other motion components. Generator consists of several types of rotation motion and linear motion (translational). The generator have components such as rotor, stator and anchor. In the rotor and stator having magnet and winding coil as an electric generating part of the electric motion force. Working principle of AC generator with linear motion (translation) also apply the principle of Faraday that is using magnetic induction which change iron magnet to produce magnetic flux. Magnetic flux is captured by the stator to be converted into electrical energy. Linear motion generators consist of linear induction machine, wound synchronous machine field, and permanent magnet synchronous [1]. Performance of synchronous generator of translation motion is influenced by magnet type, magnetic shape, coil winding, magnetic and coil spacing and others. In this paper focus on the neodymium magnet with varying shapes, number of coil windings and gap of magnetic distances. This generator work by using pneumatic mechanism (PLTGL) for power plants system. Result testing of performance AC generator translation motion obtained that maximum voltage, current and power are 63 Volt for diameter winding coil 0.15 mm, number of winding coil 13000 and distance of magnet 20 mm. For effect shape of magnet, maximum voltage happen on rectangle magnet 30x20x5 mm with 4.64 Volt. Voltage and power on effect of diameter winding coil is 14.63 V and 17.82 W at the diameter winding coil 0.7 and number of winding coil is 1260 with the distance of magnet 25 mm.

1. Introduction
The development of power plants from renewable energy sources is currently needed. The availability of fossil and petroleum power generation resources from petroleum depletion, the scarcity of petroleum availability and uncertain price fluctuations causes the demand for the development of power plants with renewable energy sources is higher. This demand is fulfilled with the utilization of wind energy sources, solar energy, ocean wave energy and other energy. The power plant with energy source requires several components so that the existing potential can be utilized properly. The components are shafts, generators, inverters, batteries, drive components or heat receivers. The axis serves to continue the rotation of the driving components such as blades, piston and other components to the generator. In the generator, the rotating motion of the shaft is converted into electrical energy through the induction force

that occurs inside the generator. Induction force occurs because on the inside of the generator there is a rotor and stator that interaction moves to produce an electric motion force.
Induced motion in the generator can occur linear and rotation. Motion generator linear contains magnetic element. The linear motion generator works by translating and using magnetic induction to produce the magnetic flux processed by the stator to produce electrical energy. Linear motion generators consist of linear induction machines, field-wound synchronous machines, and permanent magnet synchronous [1]. Linear induction machine is a kind of conventional generator that simple and widely used by industries. The generator induction machine has a larger air resistance than the rotary induction and has reactance to the low excitation coil. This causes the generator to require greater excitation current than the rotating rotor design. Field-wound synchronous machine is a high-speed rotary generator that is rarely used in industry. Field-wound synchronous machines have a disadvantages that is small power and requires a large spin to generate electricity. The advantage is the excitation current can be controlled and the resulting voltage is stable. Permanent magnetic synchronous is a generator that can be used for power generation. The magnitude of the output produced by Permanent magnet synchronous depends on the magnet. The principle of permanent magnetism works using Lorentz force and its performance is influenced by the direction of flux and the translational movement [1].
Magnets are used in permanent magnet generator is made of a magnetic material such as neodymium (NdFeB), Samarium-Cobalt magnets, ceramic magnets, plastic magnets and alnico magnet [2]. Magnets on the generator can create their own magnetic field, where the magnetic field is an area that has a magnetic force (flux). Magnetic flux [3] flows from the North Pole into the South Pole and never intersecting. The magnetic field is getting stronger with a dense magnetic flux. The movement that occurs in the magnetic flux generated and the amount will cause an electromotive force (EMF). The amount of voltage coming out of the generator depending on the magnetic field strength, number of windings coil, the addition of the iron core and motion generator (speed). The strength of the magnetic field depends on the type of magnet in the generator.
Application of generators can be seen in hydroelectric power plants, wind power plants, ocean wave power plants, diesel power plants, and etc [4-12]. The principle works of generator can move in rotation and translation. For generator with rotational motion is often found in hydroelectric power plants, diesel turbine and wind turbine. Micro hydro power plants also use generators with rotational work system [1]. For the kinetic energy of ocean waves can be seen on the piston mechanism that has been done in previous studies [4-6].
The previous study used generator for sea wave power plant is a DC generator which utilizes rotational move pneumatic motion and has been able to generate electrical energy (able to turn the incandescent and LED) [4-6]. The weakness that occurred in previous research is that the resulting voltage is not maximal, less stable and also rotational motion requires the initial trigger for pneumatic motion can run well. To overcome this problem is done by replacement rotation motion system into translational motion. In this paper focused on the manufacture and experimental testing of performance generators with a translational motion system using neodymium magnets. Neodymium magnet shape, number of winding coil, dimension of winding coil and gap of the magnet are used as a reference to being investigated. The resulting generator is an AC generator.
These generators are used for fishing in the sea to replenish the batteries [7] and the electrical energy needs while at sea. By doing experimental testing of performance AC generator with translational motion is obtained a better voltage and power supply. Experimental testing was done by varying the number of windings coil and distance of magnetic. From experimental results obtained maximum voltage, current and power for AC generators.

2. Methods

AC generator with the translational motion mechanism is made of PVC tubing. AC generator has a rotor and stator components. The rotor as moving parts on the generator which contains shaft as a piston and winding coil. The stator having magnet component is mounted on the generator tube wall. The magnet used is neodymium magnet (NdFeB) with variations of round shape, trapezium and rectangle magnet

2.1. Stage of Testing

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Experimental testing of AC generator with the translational motion mechanism can be seen in Figure 1.

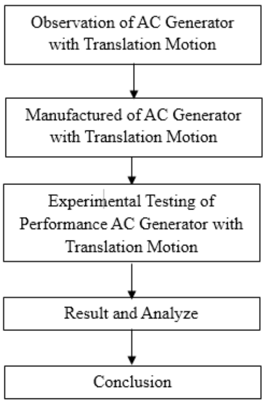

Figure 1. Stages of Experimental Test Performance of AC Generator

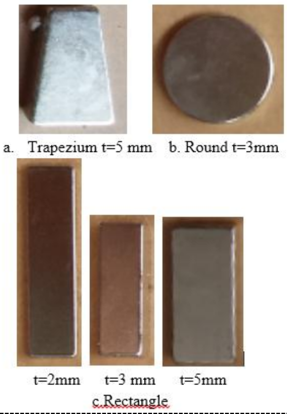

Figure 2. Dimension and Shape of Magnet for AC Generator

Figure 3. AC Generator with Translation Motion

Figure 4. Koker

Figure 5. Diameter Coil of Winding 0.7 mm

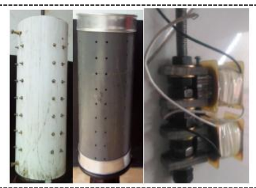

Figure 6. AC Generator Translational Motion Mechanism

2.2. Tools and Materials

Tools and materials are used in the AC generator have mechanical and electrical components. Mechanical components include: PVC tube d = 8 in a house with a generator mounting length of 600 mm; piston shaft 12 mm with a length of 1000 mm; rectangle coil with size 45 mm x 45 mm and t = 4 mm; and hexagon-shaped coil holder containers with t = 4 mm. Electrical components include: neodymium magnet rectangle, trapezium-shaped magnet with a thickness of 5 mm and round-shaped magnet with a thickness of 3 mm; winding coil with size 0.5-0.7 mm with the number of winding coil 920 to 13000. The shape and dimensions of the magnet can be seen in Figure 2.

For dimensional measurements, the test data is done by using a caliper, multimeter, tachometer, and other measuring equipment. The shape of the mechanical component of AC generator with translation motion can be seen in Figure 3 which consists of piston tube, piston, koker (see Fig.4) and buoy. Electrical component can be seen in Figure 5 includes a magnet and windings coil (diameter).

3. Results

The design of generator can be seen in Figure 6 and the experimental testing were conducted using one side of the tube with the variation number of windings coil and distance of magnetic between 10-25 mm. Shape of magnets used in AC generator are rectangle, trapezoid and round. The results of performance

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testing of AC generator with translation motion using various shape of neodymium magnets, the number of coil windings 920 and 0.7 mm diameter of coil windings can be seen in Table 1. Table 1 shows that the rectangle-shaped magnet neodymium with the dimension 30x20x5 mm having maximum a voltage is 4.64 V, the lower value of voltage on shape of rectangle magnet happen with the dimension 40x10x2 mm. From experimental testing by using various shape of magnet neodymium show that voltage by the rectangle-shaped magnet is higher than the round shape and the trapezium shape of magnet. In other hand, magnetic dimensions such as length, width and magnetic thickness will be improve the performance of generators such as voltage, current and power.

Table 1. Performance of Generator with Variation Shape of Magnet

Dia Coil (mm)	Shape of Magnet	Size of Magnet/ LxWxt (mm)	Number of Coil	Number of Pole (P)	Distance of magnet (mm)	Voltage (V)	Current (A)	Power (W)
0.7	Rectangle	30x10x5	920	5	20	1.40	0.241	0.337
0.7	Rectangle	30x20x5	920	5	20	4.64	0.725	3.364
0.7	Rectangle	40x10x2	920	5	20	0.58	0.108	0.062
0.7	Round (dxt)	2.5x3	920	5	20	1.85	0.228	0.421
0.7	Trapezium	5	920	5	20	3.44	0.535	1.841

Table 2. Performance of Generator with Shape of Rectangle Magnet with Number of Coil

Dia. Coil (mm)	Number of Winding Coil	Number of Pole (P)	Distance of magnet (mm)	Voltage. (V)	Current. (A)	Power (W)
0.7	460	5	20	2.23	0.627	0.925
0.7	920	5	20	4.64	0.725	3.364
0.7	1380	5	20	4.00	0.506	2.024

Table 3. Performance of Generator with Shape of Rectangle Magnet with Number of Coil

Dia. Coil (mm)	Number of Winding Coil	Number of Pole (P)	Distance of magnet (mm)	Voltage. (V)	Current. (A)	Power (W)
0.12	13000	5	15	53	0.024	1.251
0.12	13000	5	20	57	0.028	1.590
0.15	13000	5	20	63	0.039	2.470
0.18	9600	5	20	59	0.070	4.124
0.20	6000	5	20	34	0.092	3.135

Based on the number of windings coil with the diameter 0.7 mm is obtained that performance of power generator is 3.364 W, voltage 4.64 V and current 0.725 A on the amount of number of winding coil 920 as shown in Table 2. Table 2 shows that an increase in the number of windings will increase the voltage and current is generated. On the difference in coil diameter, the number of winding coil decreases due to the ability of the koker with dimensions 45x45x4 mm can accommodate a certain number of windings as indicated by Table 3. As shown in Table 3, for winding coil diameter 0.2 mm the koker is able to accommodate 6000 windings coil and for the diameter 0.12 mm the number of windings coil is 13000. The resulting voltage for diameter winding coil 0.12 mm with the number of coil 13000 is 53 V, current 0.024 A and power 1.25 W at magnetic distance 15 mm. The addition of magnetic distances to 20 mm will increase the voltage, current and power as shown in Table 3. For the diameter winding coil 15 mm, the koker is still capable having a number of coil 13000 where the resulting voltage is 63 V, the current is 0.039 A and power 2.47 W. This phenomenon shows that the power increases with increasing winding coil diameter and distance of magnet. The addition of the winding coil diameter will increase the current and power but the voltage decreases as the number of coil becomes small. To increase the power generator can be done by increasing the current value by enlarging the diameter of winding coil, the number of winding coil and the installation of the generator on a parallel basis.

Results of experimental testing of AC generator for variation diameter of coil 0.55 mm and 0.7 mm, a distance of magnet 15-25 mm using a rectangle magnet with dimensions 40x18x5 (mm) and 40x21x10 (mm) can be seen in Table 4. Table 4 shows that for diameter coil 0.55 mm with a magnet dimensions 40x18x5 (mm) provides a lower voltage, current and power value than the magnetic dimension

40x21x10 (mm). The effect of distance of magnet shows the increase of the greatest voltage value and it's found that in 20 mm. The same phenomenon occurred in coil diameter 0.7 mm but the highest voltage happen at distance of magnetic 25 mm.

Table 4. Performance of Generator with Shape Rectangle of Magnet

Dia. Coil (mm)	Number of Winding Coil	Number of Pole (P)	Core distance anchor (mm)	Distance of magnet (mm)	Voltage. (V)	Current. (A)	Freq. (Hz)	Power (W)
Dimension of Magnet 40x18x5 (mm)								
0.55	2000	5	30	15	3.914	0.351	7.62	1.374
	2000	5	30	20	3.894	0.313	10.07	1.219
	2000	5	30	25	1.517	0.275	7.61	0.417
Dimension of Magnet 40x21x10 (mm)								
0.55	2000	5	30	15	9.19	0.739	13.78	6.791
	2000	5	30	20	14.27	0.666	19.29	9.504
	2000	5	30	25	12.78	0.666	10.44	8.511
Dimension of Magnet 40x18x5 (mm)								
0.7	1260	5	30	15	3.21	0.322	9.86	1.034
	1260	5	30	20	2.886	0.508	7.4	1.466
	1260	5	30	25	3.459	0.589	7.47	2.037
Dimension of Magnet 40x21x10 (mm)								
0.7	1260	5	30	15	8.15	0.878	28.2	7.1557
	1260	5	30	20	10.67	1.3	11.54	13.871
	1260	5	30	25	14.63	1.218	14.63	17.819

4. Conclusions

From the experimental testing of performance AC generator with translation motion we get conclusion is:

1. Variations shape of magnet neodymium trapezium, round and rectangle has maximal value for voltage, current and power generated at 20 mm of gap magnetic distances.
2. The maximum voltage and power obtained by AC generator with translation motion using the shape of rectangle magnet (46x21x10mm) is 14.63 V and 17,82W.
3. From effect diameter of winding coil show that the number of winding coil is very large to influence performance of AC generator such increasing diameter and number of winding coil made voltage, current and power of AC generator become increase.

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