Analysis of Magnetic Pattern Distribution in a Mini-Permanent Magnetic Power Plant to Produce Optimal Electricity

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Abstract. The use of electrical energy is becoming increasingly important in Indonesia, but the energy used is still dominated by fossil fuels by 87.64 percent. As a result, research is required to develop new energy sources. One of the renewable energies, the presence of a permanent magnet power plant, converts magnetic attraction and repulsion into rotary motion on a shaft to rotate a generator to produce electricity. The mini-permanent magnet power plant is expected to be capable of supplying household-scale electricity. This paper aims to obtain the optimal pattern of magnet location using the basic concept of V-Gate to achieve the highest rotational speed and thus produce a large amount of electric power. The experimental method used in this study entails creating a V-Gate magnetic pattern with a variable magnitude of angle and a base distance to rotational speed. According to the test results, the best angle is 5 degrees, and the best base distance is 24 mm. According to the measurements, the mechanical power generated is 20,50 Watts.

Keywords: Magnetic pattern, Magnet permanent, Mini power plant, Optimization, Electric power.

1 Introduction

According to the data on the study of energy supply and utilization published by the Ministry of Energy and Mineral Resources on April 23, 2018, the government targets the amount of energy that must be provided in 2025 at 400 million TOE (tone of oil equivalent). 400 TOE will be obtained from various energy sources, with 25% coming from petroleum, 22% from natural gas, 30% from coal, and 23% from new renewable energy [1]. According to this data, the use of fossil fuels continues to dominate total energy use in Indonesia, which can have a negative impact on the environment, one of which is global warming, which is already being felt. As a result, research into alternative energy sources, such as magnetic power plants, is essential. Magnetic power plants are expected to be an environmentally friendly energy source for energy-efficient homes in Indonesia in the future, particularly on small islands or in areas with limited access to downtown areas.

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The principle of operation of a magnetic power plant is that by utilizing the attractive and repulsive forces on permanent magnets, the magnetic force can be converted into rotary motion on the shaft if assembled with the proper mechanism, resulting in a magnetic-powered motor that will be used to rotate an electric generator [2]–[4]. Permanent magnets are classified into three types: ferrite magnets, neodymium magnets, and samarium cobalt magnets [5], [6]. Ferrite magnets are a type of permanent magnet that is created by combining an oxide base with a metal [3], [7]. The samarium-cobalt magnet is a powerful permanent magnet made of a samarium-cobalt alloy [8]. Neodymium magnets are a type of rare earth permanent magnet because they are made up of two atoms, the rare earth element neodymium (Nd), 14 atoms of iron (Fe), and one atom of barium (B) to form the molecular formula 2Fe14B 4B [9]. The magnetic properties of 2Fe14B4B are superior to other permanent magnets such as samarium cobalt and ferrite because these magnets have high product energy, allowing neodymium magnets to have small sizes, dimensions, and volumes in their application [9]. Table 1 shown the information of already explained comparison of magnetic characteristics.

Table 1. Comparison of magnetic characteristics [10]

Materials	**Density (g/cm^3)**	**B_R (T)**	**H_{cJ} (kA/m)**	**H_{cB} (kA/m)**	**B_{hmax} (kJ/m^3)**
Sr Ferrite	4.81	0.388	229.2	224.8	28.68
$Nd_2Fe_{14}B$	7.43	1.212	976.9	868.2	265.05
$SmCO_5$	8.36	0.882	1598.1	584.9	128.37
Sm_2CO_{17}	8.48	1.082	>1600	839.8	227.17

Numerous experiments have been carried out to produce prototypes of magnetic power plants or motors that are powered by permanent magnets [11]–[13]. One example of this is Johnson's Permanent Magnet Motorcycle, which was one of these motors. A samarium cobalt magnet is the type of magnetic material that is utilized. The configuration of the Jhonson magnetic arrangement seeks to maintain the magnetic flux of this motor in a balanced state, which will result in continuous spinning (see Fig. 1) [14]. Both the magnetic motor and the magnetic regulator are housed inside of a mu-metal cylinder. The magnetic motor is attached to a nonmagnetic shaft. Mu-metal is an excellent conductor for the flow of magnetic flux [14]. The Bowman Magnetic Motor is an additional instance of a motor that is powered by magnetic forces. This motor is powered by magnetism, and it has three shafts that are installed on two plate holders [8]. One of the shafts uses a huge wheel, while the other two shafts use small wheels with mounted gears that are used to regulate the rotation of the three wheels (see Fig. 2). This motor is powered by a permanent magnet and uses a static actuator magnet that is placed in the opposite direction of the magnet on the wheel. This static actuator magnet is utilized to deliver thrust to the magnet that is attached to the larger wheel. Following the rotation of the wheel, the belt drive power transfer system will use this rotation to transfer power to the generator, which will result in the production of electrical energy [8].

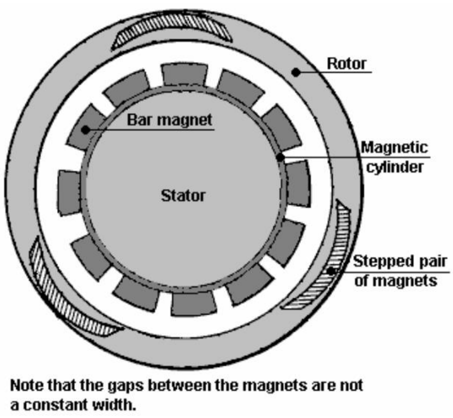

Fig. 1. Johnson's permanent magnet motorcycle [14]

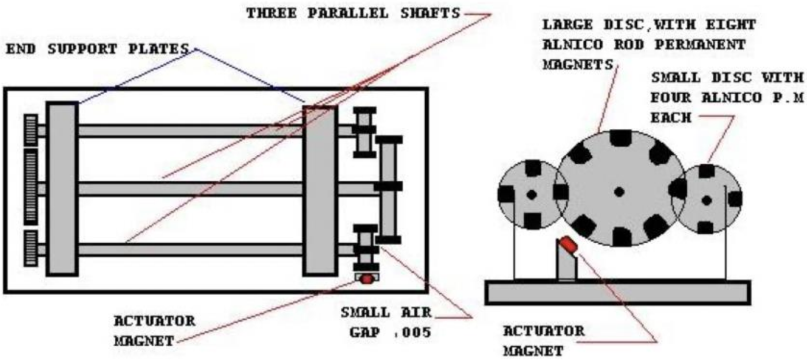

Fig. 2. Bowman magnetic motor [8]

During this time, research being carried out by Liklikwatil et al. resulted in the creation of a model of a magnetic power plant. In this generator system, to rotate the generator by employing the repulsive force between the nozzle or the driving magnet and the magnet linked to the turbine wheel while the turbine wheel is installed on the generator shaft [15]. This is done while the generator shaft remains stationary. According to the findings of his investigation, this energy-free permanent magnet turbine can rotate with a dynamic nozzle, but it is not capable of rotating continuously when the nozzle is maintained in its current position [15]. Sumarno did research that was quite like this one, and he did it by utilizing a motor and a dynamo, both of which had a disc put on them [16]. After that, a neodymium magnet, which was supposed to be the tool's primary source of propulsion, was attached to the center of the disc. A permanent magnet that has a N-S-N-S configuration, which means that it is arranged in the shape of a circle with the poles mounted opposite one another. This configuration is supposed to subject the coil to forces that are both attracted and repulsive such that electromagnetic repulsion can take place; however, this idea has not been validated by experimentation in the real world [16].

The V-Gate concept is a magnetic arrangement idea that has demonstrated capability of converting magnetic repulsion into rotary motion. This ability has been experimentally demonstrated. Whereas, this idea has its own characteristics, such as permanent magnets being arranged to form a pattern resembling the letter V on a tube that acts as a rotor, and then stator magnets with opposite poles being installed in the middle of the V pattern in the tube that acts as a rotor. In other words, this idea has its own characteristics. This idea can rotate the rotor, but not in a continuous fashion; rather, it can complete only one cycle of rotation. This is because there is a force that acts in a repelling manner at the conclusion of the cycle. Iskhaq carried out research in which the V-Gate concept was applied to the testing of a motor that was powered by permanent magnets. The test is executed in one of two ways, either manually or automatically [17]. Both methods are carried out. Testing that is done manually involves applying an additional external force to move the stator. Automatic testing, on the other hand, refers to testing that is performed without the need of any external force; hence, it is intended that the teaching aids can function automatically. The data from the manual test obtained the greatest magnetic field strength of 199.99 mT and a rotation speed of 60 rpm, whereas the data from the automatic study obtained a rotation speed of 38 rpm [17]. This information was collected from the study that was previously mentioned.

Prior researchers have implemented the V-Gate principle into a magnetic power plant. A DC motor is connected to a stator in the shape of a spiral with a V-Gate magnetic arrangement, and a repulsion-oriented rotor magnet is mounted on the shaft. Use a magnet in the stator to repel. This repulsion causes the rotor to revolve but limits its freedom of movement due to the V-Gate connection's inherent resistance to rotation. Therefore, it is operated by a DC motor with the aid of a proximity sensor when it passes through the V-Gate connection [13]. The V-Gate arrangement differs from that of earlier studies in that it is placed on the rotor at an acute angle in cases when the rotor is tubular (see Fig. 3). The stator is constructed with a mechanism that allows it to rotate in both directions (see Fig. 4).

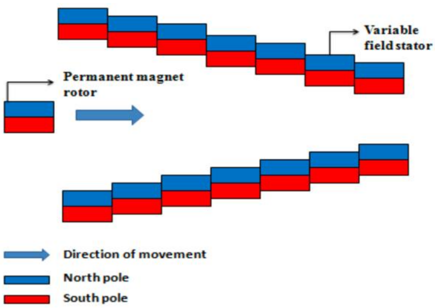

Fig. 3. V-Gate pattern [13]

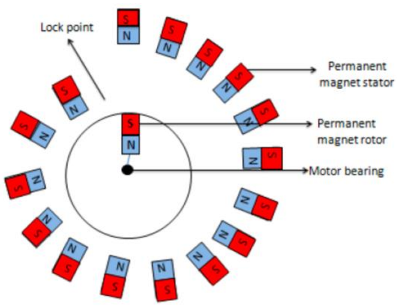

Fig. 4. Spiral rotor pattern [13]

Pulling it away from the rotor with the help of a DC motor and a proximity sensor when the stator reaches the lock point. With this mechanism, we anticipate increased power generation in addition to improved torque and rotational efficiency.

The study's objectives are to optimize the magnet's pattern angel and distance, to achieve high torque and rotation, to calculate the system's electrical output, and to determine the most efficient means of putting that output to use in the producing system.

2 Experimental Method

Fig. 5 illustrates the components and installation of a testing magnetic power plant. The technique is utilized to test variations and patterns of the V-angles Gate's and base distances as a function of rotation speed. A tachometer, proximity sensor, door lock motor, battery, PVC pipe, cardboard, slot type, and rotor mount frame are some of the tools and materials that were used in this test of a permanent magnet-powered motor. The variables that were tested were the relationship between the angle and the distance of the base of the V-Gate with the rotational speed.

On the surface of the rotor (**1**) is a pattern made up of neodymium magnets of grade N52 measuring 20 millimeters by 10 millimeters apiece. These magnets are arranged in a V-Gate pattern that is inclined at a certain degree all the way around the rotor where they are positioned. Initially, an experiment needs to be done to establish the ideal angle to employ, and then the rpm should be set to its greatest achievable value. Magnets for Stators (**2**) were installed at 30 millimeters, and the rotor magnet was put in place with the stator magnet positioned such that it faced the center of the V-pattern arrangement on the rotor magnet. The neodymium grade N52 magnet that is used in the stator is thirty millimeters long and five millimeters wide. These measurements describe the magnet's size. Because, once the lock point has been reached, the stator magnet needs to be kept at a distance from the rotor magnet to ensure that the rotor can continue to rotate continuously, it is imperative that the stator magnet be mobile.

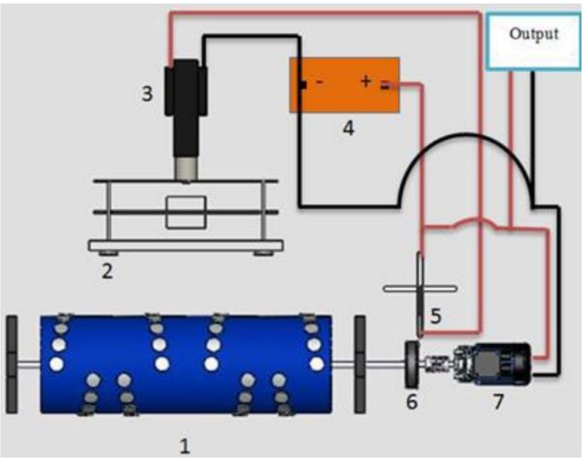

Fig. 5. Installation of a testing magnetic power plant

Motor (3) that allows the stator magnets to be retracted. This towing motor is one that employs the use of a DC motor. To run an electric current through a DC motor, the current would separate the stator from the rotor as it went through the lock point. Following the passage of the electric current through the lock point, the spring that is attached to the stator lever will cause the stator to be pushed back in the direction of the rotor [18], [19]. When an electric current is first started flowing to the stator pulley motor, it is initially drawn from the battery (4), which is the principal source of energy that is used. When the rotor has reached its maximum speed, the battery is then used to store the electric current and keep it stable. This happens after the battery has been charged. The quantity of power that is given to the DC motor can be controlled by the proximity sensors (5), which identify how close an object is by monitoring the moment that the lock point travels through the stator magnet. These proximity sensors can also tell how far away an object is. The fundamental concept is to provide the rotor with a cross section and then ensure that the cross section revolves in tandem with the rotor. This will allow the cross section to move through the sensor as it rotates with the rotor. To transfer power from the rotor shaft to the generator shaft, pulleys (6) are an essential component of the operation. To produce electricity, the pulley ratio must be adjusted so that it is compatible with the demands placed on the generator by its rotation. The generator (7) is responsible for transforming the mechanical energy that is obtained from the rotor into the usable form of electrical energy. Consumption intake and output will both benefit from the availability of this electrical energy that will be given.

3 Result and Discussion

The grade N52 neodymium magnet that is mounted on the rotor has dimensions of 20 millimeters by 10 millimeters and has a thickness of 2 millimeters. It creates a magnetic field with a strength that can be measured to be 5411.28 Gauss. The neodymium magnet that is grade N52 and has dimensions of 30 millimeters by 5 millimeters is what is mounted on the stator. It produces a magnetic field that has a strength that is equal to 1913.18 Gauss. One advantage of neodymium magnets is that they are more cost-effective than other types of magnets. This is one of the many benefits of neodymium magnets. This magnet, on the other hand, has the drawback that it cannot be used in environments with high temperatures because it can only function at temperatures up to 200 degrees Celsius. This limitation prevents it from being utilized in environments with high temperatures. Because of this, its potential applications are restricted. Magnets made of neodymium exhibit these qualities to the naked eye.

Following the completion of the identifying procedure, the experimental apparatus was evaluated to determine both how well it functioned and how it functioned. Testing the effect of a large V-Gate angle on the rotor magnet arrangement was the first step in the process. This was necessary because the large angle influenced the repulsive force that the stator exerted on the rotor. As a result of the fact that the force of repulsion is proportional to the right angle, the righter angles you achieve, the righter angles you achieve. Because of this, the force of repulsion that is exerted between the stator magnet and the rotor will become more focused, which will enable the rotor to rotate in the most efficient manner possible. This test step is the same as testing the angle, with the exception that the distance between the V-Gate bases can change. Prior to this step, it is necessary to determine how large the V-Gate angle is and how far apart the V-Gate bases are.

The following ranges of distance were used during this test: 12 millimeters, 16 millimeters, 20 millimeters, 24 millimeters, 28 millimeters, and 32 millimeters. Because the speed of rotation of the rotor is faster at 16 mm than at 12 mm, this difference in distance is used. As a result of this disparity, the base distance needs to be adjusted up to 24 millimeters. The rotational speed of the rotor starts to slow down once more when the distance is increased to 28 mm. When measured at 32 mm, the speed is also found to be reduced. The conclusion that a base distance of 24 mm generates the greatest magnetic force, which in turn results in the greatest possible rotor rotation, is one that is open to debate.

After all the tests were finished, the appropriate angle and distance for the V-base gates were calculated. After that, remove each magnet that is currently attached to the rotor. After that, holes are drilled in the rotor that are calibrated to the diameter of the magnet that will be installed to create a holder for a permanent magnet on the rotor. This is done to ensure that the magnet will fit properly. Following that, a fresh dot of power glue is utilized so that the magnet can be reattached to the rotor. The instrument can be put into operation once all the components of the generator system have been correctly installed, and the electrical voltage that is produced by the generator can be measured once it has been brought up to the appropriate level.

A rotation of 141 rpm is produced by an angle of 5 degrees, as shown in Fig. 6a. Because the repulsion that occurs between the stator magnet and the rotor at this angle is more directed toward encouraging the rotor to rotate, it is possible to obtain a greater torque at this angle. The following step is to determine the maximum rotational speed of the rotor by determining the distance between the V-base Gate and the rotor. When the base distance is increased to 24 mm, the rotation speed goes up to 146 revolutions per minute (see Fig. 6b). Because the magnetic repulsion will be more directed to push the rotor if the angle and distance of the base are arranged correctly, the rotor will be able to rotate faster with greater torque, which will result in the production of more power. The selection of the angle and distance of the base has a significant impact on the torque on the rotation of the rotor.

It has been determined that there is a mechanical power of 7.524 Watts on the rotor. Only a miniature generator that generates 5.52 Watts of electricity can be powered by this amount of energy. In this generating system, the power consumption for the 8.24-watt operation is as follows: The power that is produced by this generating system is obviously going to be negative. Because of this, it is necessary to ascertain whether the quantity, kind, and dimensions of the magnets have been modified so that they correspond to the amount of energy that the generating system itself consumes. The calculations show that the stator pulling motor has a mechanical power output of 4.39 Watts, but the amount of mechanical power that is required to pull the stator is only 1.05 Watts. As a direct consequence of this, the stator pulling motor can pull four stators, each of which is comprised of two stator magnets. According to the results of the calculations, the efficiency of this generator could be enhanced by bringing the total number of stator magnets up to eight. Therefore, based on the calculation of the mechanical power generated by 29.936 Watts, the power can generate 25.44 Watts of electricity when it is used to generate electricity with a generator that has an efficiency of 85%. With this amount of power, it can produce electrical energy for consumption by the system, and the excess electrical energy produced can be utilized for lighting needs on a household scale.

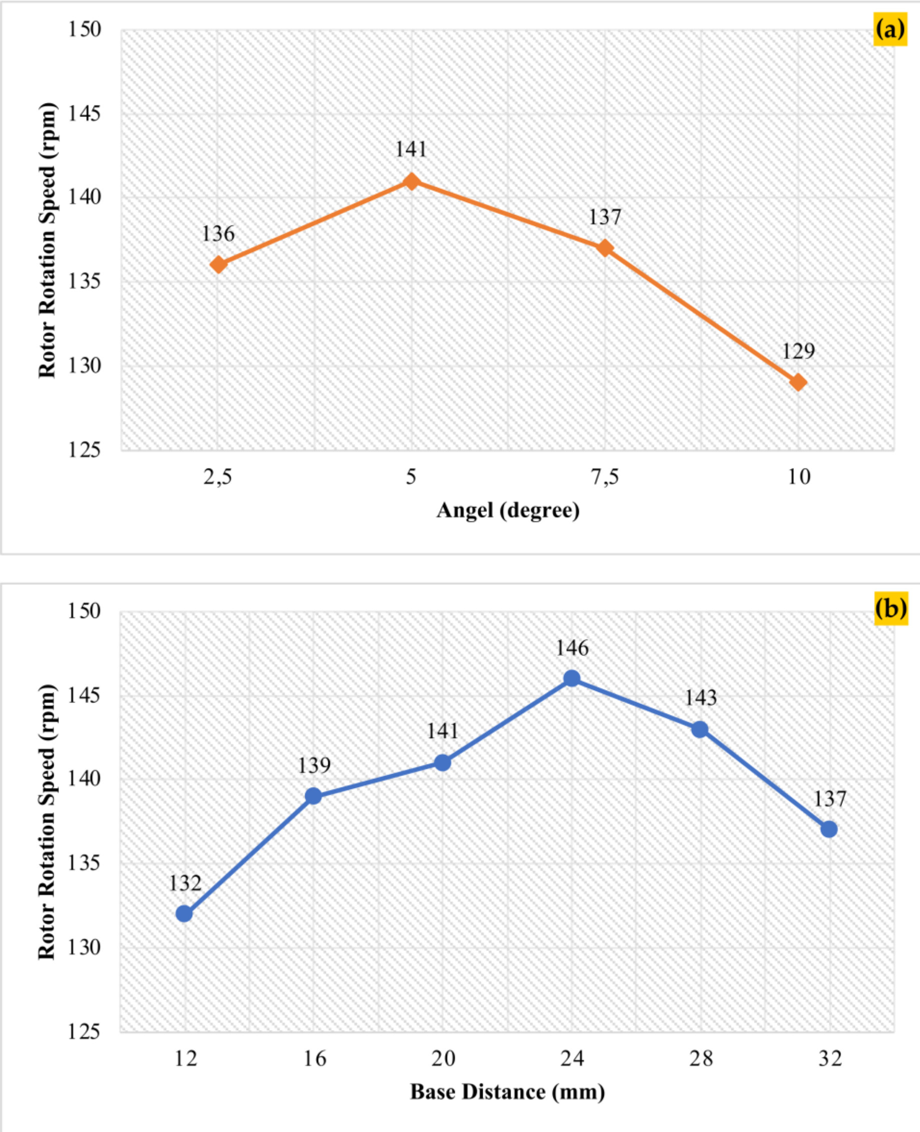

Fig. 6. Graph of rotor rotation speed test results; (a). Angle; (b). Base distance

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4 Conclusion

The findings of the experiment indicate that the optimal configuration for the placement of magnets on the rotor is one that has a V-Gate angle of five degrees and a base distance of twenty-four millimeters. This configuration yields the best results. Directly in the middle of the magnet arrangement pattern for the rotor is where the magnets on the stator are arranged in such a way that they face each other directly. Because of the way the magnetic configuration is set up, it can generate a rotor spin of 146 revolutions per minute. According to the calculations, the value of the mechanical power was 7.52 Watts, and the electrical power that was required to turn on the generator system was 8.24 Watts; as a result, 15.76 Watts of power were required to drive the system. According to the results of the tests, the power demand can be satisfied with the 20,50 Watts of electricity that were generated.

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