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INVESTIGATION INTO MAGNETIC FLUX DENSITY EFFECT ON STATOR-ROTOR ARRANGEMENT OF NEODYMIUM MAGNET IN CYLINDRICAL CONFIGURATION

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Abstract – Due to the limitations of non-renewable energy sources, various efforts have been pursued to overcome this issue. In order to find a replacement for these non-renewable resources i.e., coal, crude oil and natural gas, necessary action must be taken to explore new, potential sources of alternative energy. This latest invention seeks to highlight the possibility of creating free energy by applying the natural magnetic force of neodymium magnets in a rotational or cylindrical configuration. This paper presents the results of an ongoing study that aims to prove that the rotor can perform a complete rotation (360°), with the aid of both the rotor and stator components which will cause the neodymium magnet to produce a repelling force. A proper layout of neodymium magnet in a cylindrical configuration is believed to be able to produce a continuous motion by using the repelling force of neodymium magnet, and some initial force. In this paper, a block shape of neodymium magnet grade N42, (10mm x 10mm x4mm thickness and 20mm x 20mm x 5mm thickness), arranged cylindrically in a stator-rotor configuration, was used. This paper will reveal the results of the physical experiment on stator-rotor configuration of neodymium magnet and simulated Finite Element Analysis (FEA) on the effect of magnetic flux density of the rotor in circular motion, conducted on JMAG Designer ver.14.0 software. However, based on the physical experiment, it is found the rotor was able to rotate at only 8°, and that the primary reason for this inability was attributed to the cogging effect, as confirmed by the simulated Finite Element Analysis (FEA). In conclusion, it is obvious that the phenomenon of magnetic locking, also known as cogging or teeth locking, which happened between the rotor and the stator parts, is the major obstacle to achieving a successful continuous motion.

Keywords: *Neodymium Magnet (NdFeB), Finite Element Analysis (FEA), Magnetic Flux Density, Magnetic Locking.*

1.0 INTRODUCTION

1.1 Renewable Energy

Renewable energy, also known as alternative energy, comes from natural sources such as water, wind, sun and tides and are used in the process of generating power. This kind of energy can be used as many times as required without running out. These sources are available in abundant amounts and are considered the most efficient source of energy in terms of their cleanliness [1]. The contribution of renewable energy sources (RES) to the overall percentage of world energy demand is estimated at 14% of supply [2].

Renewable Energy Sources (RES) such as geothermal, hydropower, biomass, marine energy and wind, are the primary energy resources for domestic use. The renewables are considered to be very clean energy and are infinite. [3, 4]. Large-scale hydropower plants supply 20% of global electricity. Wind power, available in coastal areas and other potential windy districts, is seen as a promising renewable energy source [2, 3].

For the next generation of society, renewable resources will become essential. In order to avert a potential energy crisis, renewable energy is the best option for society [5]. Besides, these renewables, namely biomass, solar, geothermal, wind and fuel cells energy can be utilised to create inexhaustible and sustainable power supply. [6]. The evolution of energy, especially alternative energy has reached its climax. Hence, the need to explore and discover new sources of alternative energy is critical to meet the demand for supply.

1.2 Neodymium Magnet

By nature, magnet is a material that consist of its own specific energy. It does not require external outsource to power up itself but instead, provides its own energy to power up or generate an effect. [7]. In fact, if the same poles of two magnet bars are positioned facing each other, it will produce a repelling force as shown on figure 1. Meanwhile, the attraction force will occur when the opposite poles of two magnet bars are positioned facing each other, as seen in figure 1. The occurrence of a huge repelling force can be traced to the properties of the magnet. It is a good sign and indication whereby a huge torque might be obtained due to the strong repelling force. The strength of the magnet's repelling force depends on the grade of a magnet's properties. [8, 9, 10].

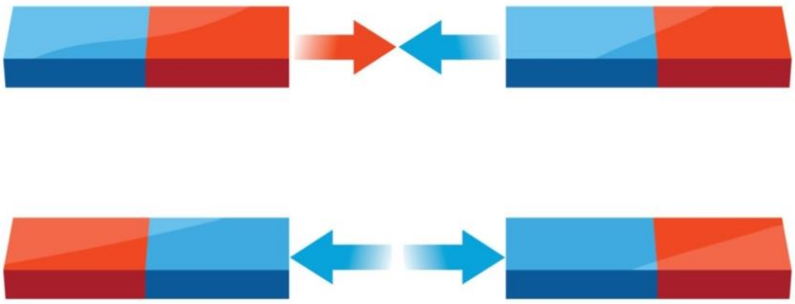

Figure 1: Repelling and attraction force of magnet poles [11].

Various types of magnets exist in this world, and one of the strongest magnets on earth is the Neodymium Magnet, also known as NdFeB or Neo magnet [12]. It is a rare earth type magnet and it is the most widely used in the world. Neodymium magnet is basically made from an alloy of neodymium, iron and boron to form the Nd2Fe14B tetragonal crystalline structure [13]. Although there are other types of rare earth magnets such as cobalt samarium, neodymium magnets are the most commonly used. In fact, neodymium magnets are capable of producing stronger magnetic fields to allow higher performance levels than other types [14]. Neodymium magnets are typically measured from grade N24 to N55 on a magnetization scale that can extend up to grade N64, which is the square measure of their magnetic theory. Depending on the shape, composition, and method of production, neodymium magnets can be categorized anywhere in this range and are capable of providing strong tensile strength and repulsion [15].

Neodymium magnets were invented and developed in the early 1980s by General Motors and Sumitomo Special Metals. Both companies found that by combining Neodymium with a small amount of iron and boron, they were able to produce strong magnets. General Motors and Sumitomo Special Metals subsequently cooperated and manufactured the world's first Neodymium Magnet, offering to the world, a more cost effective and alternative type of magnet, compared to the other rare earth magnets available in the market [14]. Named as the most powerful permanent magnet in the world, neodymium magnets are magnets made of neodymium. To illustrate the magnitude of this magnet from the perspective of its strength, the neodymium is capable of producing magnetic fields up to a scale of 1.4 degrees. It is a rare earth element with atomic number 60. Rare earth elements were first discovered in 1885 by chemist Carl Auer von Welsbach and a century later, neodymium magnet was successfully created [14].

The birth of neodymium magnets has influenced many aspects of life – our cell phones, personal computers, laptops and kitchen cabinets all come with the use of neodymium magnets. The application of these neodymium magnets is also important in the sectors of renewable energy such as the production of wind turbines and electric cars [13]. Neodymium magnets also help in terms of recycling some of the basic components of magnetic separators [13]. As a magnet with such powerful properties, its usefulness can be described as versatile. It can be manufactured for commercial and industrial purposes. For example, something as simple as a piece of magnetic jewellery that uses neodymium to maintain its originality. In addition, neodymium magnets are sent into space to help collect dust from the surface of Mars. The natural ability of these neodymium magnets also leads to their use in experimental equipment. Besides, these neodymium magnets can also be used in applications such as welding clamps, oil filters, tool mounts, clothing and more [15].

Various literatures around the world have documented the uses of neodymium magnet in motor components and electric generators for the purpose of efficiency enhancement. However, there is still inadequate effort to prove that neodymium magnet can be applied as a perpetual motion device. Neodymium magnet in stator-rotor configuration will be used to demonstrate the application of magnet as a motion device. A proper research will be conducted to investigate the magnet's potential with a purpose to develop a totally clean free energy device that is based on green technology concept.

1.3 Research Descriptions

This paper describes the investigation of physical experiment on Neodymium Magnet grade N42 stator-rotor configuration. The layout of the magnet arrangement will be explained in the next section. The main aim of this paper is to examine the possibility of producing a perpetual motion by applying the repelling force produced by the stator-rotor configuration on the Neodymium Magnet to completely rotate the magnet at 360°. The research was carried out using physical experiment, and verified by the simulated Finite Element Analysis (FEA) conducted on JMAG Designer ver.14.0 software. Results of the physical experiment and simulated FEA analysis will be shown in the next section.

2.0 METHODOLOGY

Due to its natural characteristics to power up or generate an affect, neodymium magnet grade N42 has been chosen as an official magnet in this research. This kind of magnet are believed to be capable of creating continuous motion when it is placed in the correct configuration that eliminates any magnetic locking phenomenon [16]. As shown in figure 2, a total of 19 units of block shape magnets measuring 10mm x 10mm x 4mm was used as an official size for a rotor compartment and 13 units of block shape magnets measuring 20mm x 20mm x 5mm were used for a stator compartment in this research. The magnet on stator compartment was purposely selected to be bigger than that of the magnet on rotor compartment because it is believed that magnet on stator compartment is capable to provide more magnetic repelling force towards magnet on rotor compartment in order to produce a continuous motion. Those components were arranged in cylindrical positions respectively. All magnets placed on stator and rotor compartments were arranged in a position to make them repel to each other. In fact, north poles of magnet in stator compartment were arranged to face north poles of magnet in rotor compartment. This kind of magnet arrangement is believed to have the capability to create continuous motion, as well ability to avoid magnetic locking situation. 3D printing method will be used to produce the component of rotor and stator compartment. Finite Elements Analysis (FEA) of industrial magnetic software which is known as JMAG Designer ver.14.0 was used to study the magnetic flux density characteristics and acted force on stator-rotor configuration.

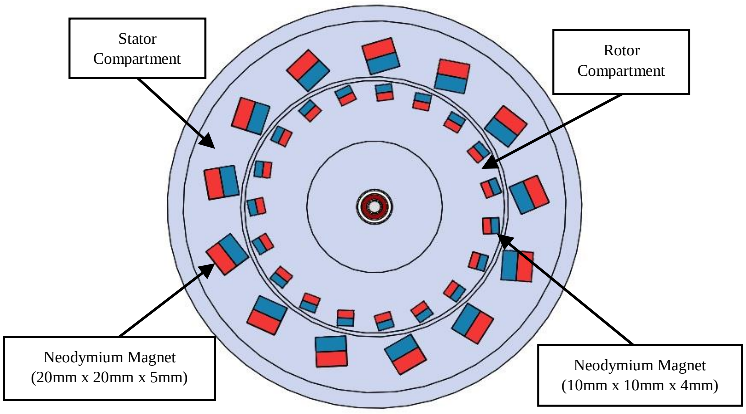

Figure 2: Neodymium magnet configuration in cylindrically arrangement in the 3D CAD format

3.0 RESULTS AND DISCUSSIONS

3.1 Preliminary study

A preliminary study has been carried out to calculate the repelling force between two same sized magnets through online calculators. Through this online calculator that was obtained from magnetic portal website, the pull forces can be determined based on a theoretical calculation of the flux density [17]. As seen in figure 3 and figure 4, magnets of two different sizes have been applied to calculate the amount of repelling forces produced by those magnets. Figure 3 shows that the 0.236 inches gap between two units of magnets sized 10mm x 10mm x 4mm will produce 0.59 lb of repelling force for each other. While Figure 4 indicates that the 0.236 inches gap between two units of magnets sized 20mm x 20mm x 5mm will result in 2.25 lb of repelling force for those magnets.

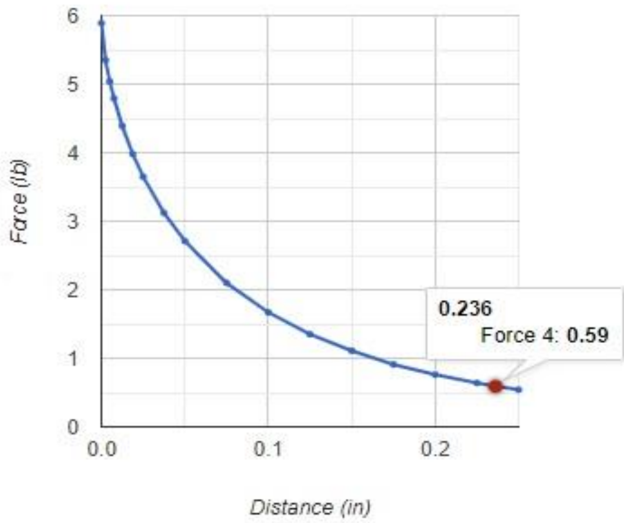

Figure 3: N42 Neodymium magnet repelling force between two units of magnets sized 10mm x 10mm x 4mm [17].

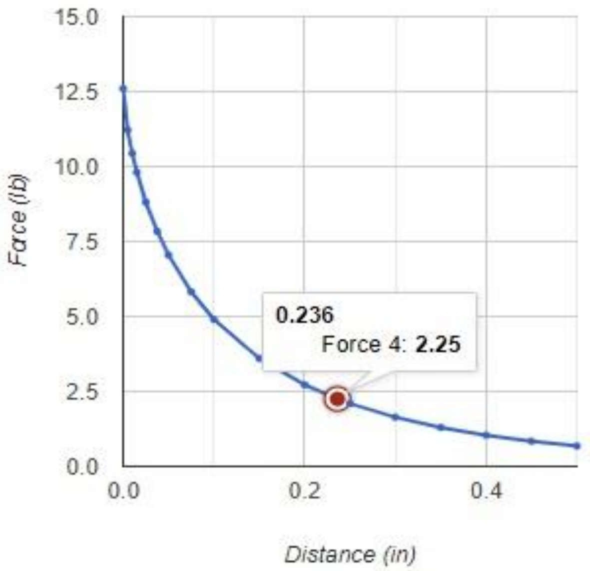

Figure 4: N42 Neodymium magnet repelling force between two units of magnets sized 20mm x 20mm x 5mm [17].

3.2 Investigation results

A concept design has been introduced to investigate the magnetic flux density effects on stator – rotor configuration. As seen in Figure 5 and Figure 6, these are the concept design which has been chosen as an official stator – rotor configuration for this research. Figure 5 shows the first arrangement of stator – rotor configuration in a 3D CAD format. The first arrangement indicates the initial position of stator – rotor configuration before any movement happened towards this configuration. Meanwhile, Figure 6 shows the second arrangement of stator – rotor configuration in a 3D CAD format. The second arrangement indicates the final position of stator - rotor configuration after the motion has happened. Both configurations use a magnet sized 10 mm x 10mm x 4mm on a rotor compartment and a magnet sized 20mm x 20mm x 5mm on a stator compartment.

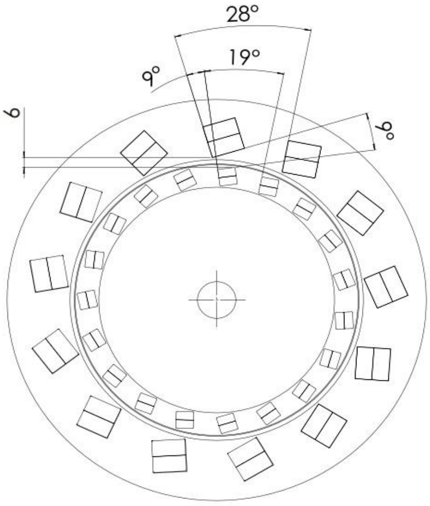

Figure 5: First arrangement of stator – rotor configuration in a 3D CAD format

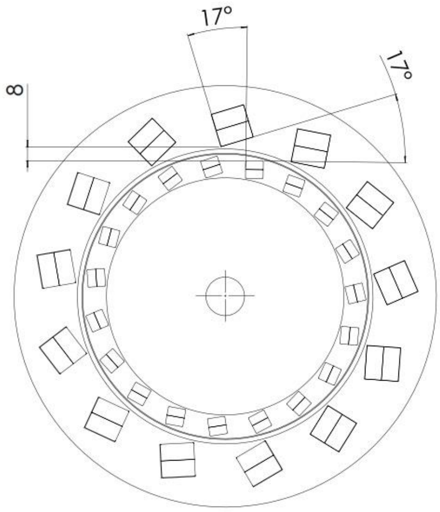

Figure 6: Second arrangement of stator – rotor configuration in a 3D CAD format

As seen in Figure 7, an actual rapid prototype has been produced to conduct an investigation towards stator – rotor configuration. In this study, the main goal is the expectation for the rotor compartment to complete full rotation (360°) by applying the repelling force of neodymium magnet generated by both the rotor and stator compartments.

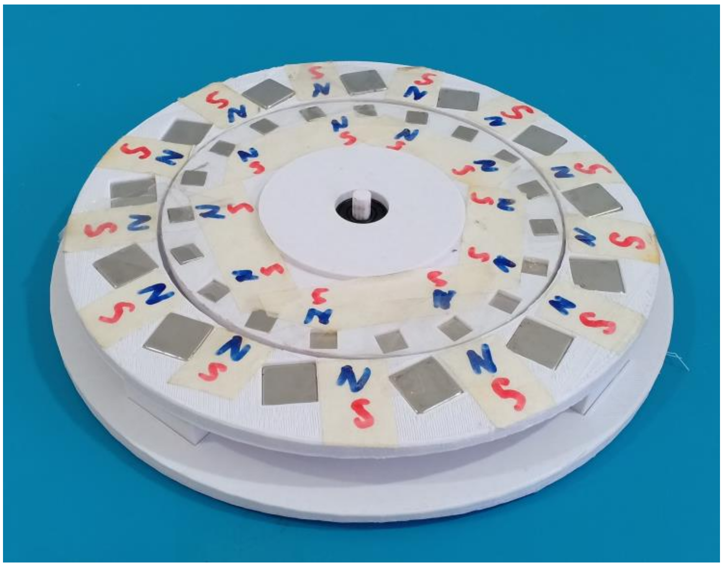

Figure 7: Rapid prototype of stator – rotor configuration

As shown in Figure 5, the first magnet on rotor compartment was positioned 9° from the first magnet on stator compartment. A comprehensive attempt has been done by implementing an initial repulsive force manually using a human hand towards rotor compartment on the first arrangement of stator – rotor configuration. The result shows, after initial repulsive force has been applied, that the rotor compartment is only capable to rotate as much as 8° (17°- 9°) as shown in Figure 6. Based on observation of the experiment, it is believed that the magnetic locking phenomenon or cogging conditions causes the force of rotor magnet to be locked in between the force of the stator magnet, resulting in the rotor compartment's ability to rotate at only 8°. Thus, the main objective of ensuring the rotor compartment can freely rotate without any intervention could not be achieved.

3.2 Magnetic Flux Density results.

As seen in Figure 8 and Figure 9, the main purpose of this analysis is to show the distribution of magnetic flux density of the arrangement of stator – rotor configuration in two circumstances. The 3D CAD format was developed using SolidWorks software and then imported into a JMAG Designer Ver. 14.0 software to perform a Finite Element of Analysis (FEA) of magnetic flux density. As shown in Figure 8 and Figure 9, it states the value of magnetic flux density contour at a maximum and minimum value and illustrates the magnetic flux density distribution under two circumstances, i.e. the first arrangement and second configuration of stator – rotor configuration. The Finite Element Analysis (FEA) software on the effect of magnetic flux density was used to verify this cogging phenomenon.

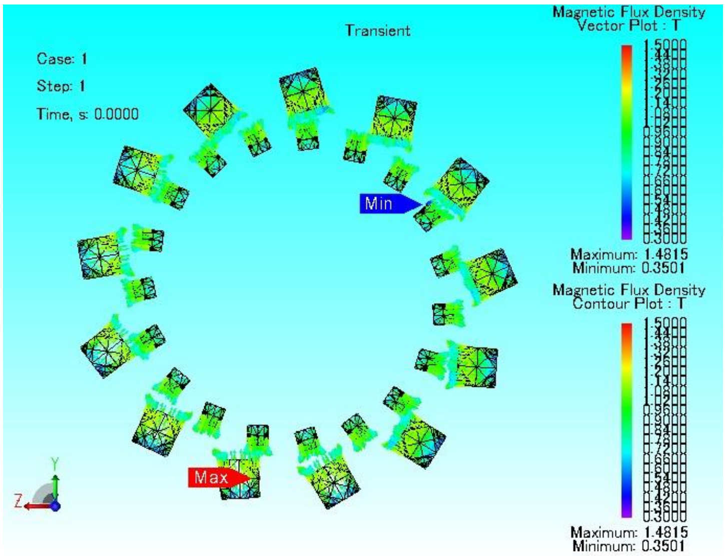

Figure 8: Distribution of magnetic flux density on first arrangement of stator – rotor configuration.

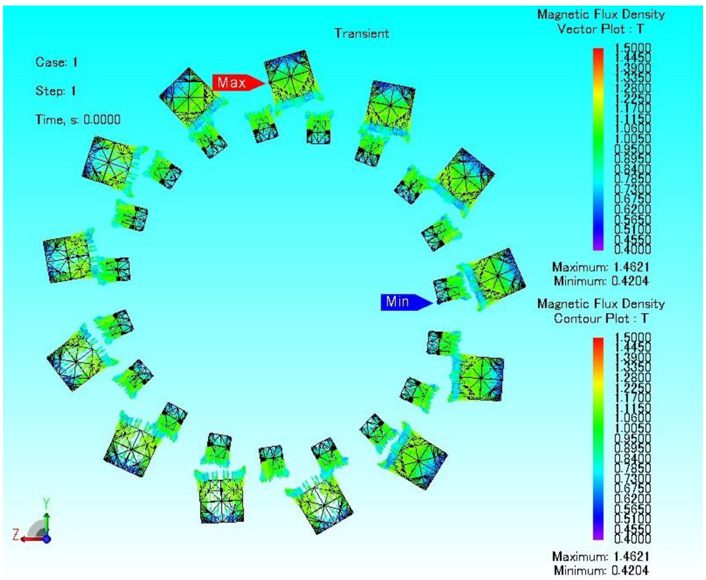

Figure 9: Distribution of magnetic flux density on second arrangement of stator – rotor configuration.

As stated in Figure 8 which is the first arrangement of stator – rotor configuration, it shows the maximum and minimum value of magnetic flux density contour as 1.4815 tesla and 0.3501 tesla respectively. Meanwhile, as stated in Figure 9 which shows the second arrangement of stator – rotor configuration, the maximum and minimum value of magnetic flux density contour are 1.4621 tesla and 0.4204 tesla respectively. As mentioned, initial position is in the first arrangement, followed by the second arrangement which happened after repulsive force is applied manually towards the first arrangement. As seen in the second arrangement, the rotation is only as much as 8° due to the "void flux" phenomenon, which means magnet on rotor compartment gets locked and stopped in its motion in between magnet on stator compartment. In fact, to explain more details about this magnetic locking phenomenon would further require a proper study on the magnetic flux density distribution, especially at the area of void flux or cogging.

4.0 CONCLUSIONS

As a conclusion, this paper presented two positions of stator – rotor configuration arrangement. Elements of performance analysis and design studies are properly described throughout this paper. Based on the investigation and observation via physical experiment of rapid prototype, the result shows that magnet on rotor compartment is only capable of minor degree of rotation (8°). This unexpected result ties back to the main objective, i.e. the rotor compartment magnet being able to rotate freely at 360° without interventions of any force, particularly from the force of stator compartment magnet which causes the motion to cease. In summary, it is found that the phenomenon of magnetic locking or cogging conditions, also known as void flux, is the major obstacle to producing a successful perpetual motion through this stator – rotor configuration. The cogging effects phenomenon is also identified as a major barrier in the creation of a successful motion device based on the natural characteristics of neodymium magnet which has forces that repel and attract. A proper further research, experiment and investigation would need to be conducted to find the right stator – rotor configuration by manipulating the design arrangement and configuration angle to avoid any cogging conditions.

CONFLICT OF INTERSEST: The authors declare no conflict of interest.

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