A THEORETICAL EXPERIMENTAL OF ENERGY CONSERVATION USING THE CONCEPT OF MAGNETIC ENERGY

Choong Chee Guan[1], Chiang Yoke Yen[1], Robert@Kerk Swee Tian[2] & Saw Chun Lin[1]

[1]Politeknik Ungku Omar
dr.choong@puo.edu.my
yenchiang@puo.edu.my
sawchunlin@puo.edu.my
[2]Kolej Komuniti Kota Marudu
robert_kerk@yahoo.co.uk

ABSTRACT

A conceptual learning process of continuous movement using magnetic energy is a theoretical experimental carried out by applying a series of laws regarding conservation of energy and concept of magnetism. To be exact, this experiment will be studied using some Neodymium magnets, which is the main component in this study. In this conceptual study, magnetic energy will be transformed into kinetic energy with some mechanisms. The function of neodymium magnet is to provide the system with magnetic energy which then will be transformed into kinetic energy. The magnetic energy will be fed into the system to create a circular movements, this circular is a continuous movement unless it is disturbed. To improve the efficiency of the project, the Neodymium magnet is placed at an optimum angle toward the other magnet at the base of the prototype. With the exposure to this experiment, a student can understand how magnetism affects kinematics and thus affecting how much output electricity.

Keywords: conservation of energy, magnetism, neodymium magnets, continuous movement.

1. Introduction

A conceptual study of continuous movement using magnetic energy is a theoretical experiment study under magnetism and energy conversation law. The experimental study will be started off when the self-made permanent magnet motor is activated, and all the magnets are in good position facing poles to poles to the magnets on the other flat disk, which allows the magnets to effectively repel each other transforming magnetic energy to kinetic energy (Yeo, 2013). With the design and the concept used, it does not need any extra power supply when it is working, since the kinetic energy to activate the generator is converted by magnetic energy. Next, the direction of repelling forces produced by the magnets are based on the nature of the magnet: North pole repels with the North Pole, South Pole repels South Pole, and North pole attracts South Pole and vice versa.

Nonetheless, in regards of the concern of the safety of the theoretical study, the whole of the experiment is covered by magnet shield which can prevent the contact of magnetic field inside the project to outsiders. The machine will stop spinning when the pulley of self-made permanent magnet motor is pushed, and the magnet shield will block the magnetic field between bottom and upper magnets.

The aim of this conceptual study is to critically access the combination of magnetism and angular momentum. The idea is to use the simplest practical to carry out a theoretical experiment to explain about the theory of magnetism and angular momentum. Three objectives that have to be made in order to achieve the aim:

i) To study the continuous movement of an object by using magnetic energy;
ii) To enhance student's knowledge on energy law conversion;
iii) To enhance student's understanding by conducting practical experiments using the designed apparatuses.

The used of magnetic energy is increased days by days. Although many applications are using magnetism concept, but this concept is still continued deeply research. Thus, conceptual study of continuous movement using magnetic energy is designed because it can simply carry out the basic concept of magnetism. First and foremost, students in this generation only can get the knowledge in theory. Sometimes, theory is not that perfect, and some students are difficult to remember the whole concept in theory. By involve in the theoretical experimental study on continuous movement using magnetic energy, students can easily catch up the basic concept of magnetism in practical. Since the students are doing the practical by guided with lab sheet, the procedures and safety precautions will become very helpful to students.

2. Methodology

Conceptual study of continuous movement using magnetic energy is inspired by the concept of repulsive force from magnets (Stefan, 2002). By using the suitable placing of permanent magnet, repulsive force is from and this magnetic energy will convert into kinetic energy which is unlimited.

First of all, Mu-metal shield that cover the stator part of magnet is being open. Secondly, the magnet on both stator and rotor part will repel each other to produce a kinetic energy, this kinetic energy will make the shaft to be rotated and this shaft is directly connect to plate 1. Both of the plate 1 and plate 2 are install with permanent magnet on them, the rotated plate 1 will drive plate 2 to be rotated. The plate 2 will rotate unlimitedly until the stator part of magnet is being cover back by the Mu-metal shield.

2.1. Force between two magnets

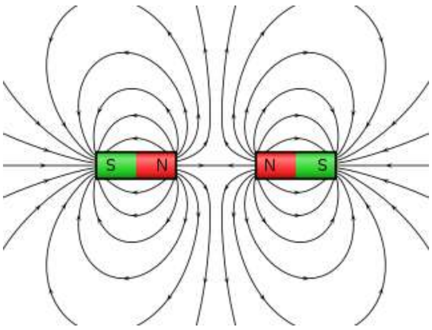

Figure 1. Two repelling magnets

The force between two identical cylindrical magnet bar (**Figure 1**) are placed end to end is approximately:

$$F = \left[\frac{B_0^2 A^2 (L^2 + R^2)}{\pi \mu_0 L^2}\right]\left[\frac{1}{x^2} + \frac{1}{(x+2L)^2} - \frac{2}{(x+L)^2}\right] \quad (1)$$

where;

B_0 = the flux density very close to each pole, in T
A = the area of each pole, in m^2
L = the length of each magnet, in m
R = the radius of each magnet, in m
x = the separation between the two magnets, in m

$$B_0 = \frac{\mu_0}{2} M \quad (2)$$

The formula above relates the flux density at the pole to the magnetization of the magnet.

2.2. Torque

Torque, moment, or moment of force (see the terminology below) is the tendency of a force to rotate an object around an axis, fulcrum, or pivot. Just as a force is a push or a pull, a torque can be thought of as a twist to an object. Mathematically, torque is defined as the cross product of the vector by which the force's application point is offset relative to the fixed suspension point (distance vector) and the force vector, which tends to produce rotational motion (Fink and Beaty, 2013).

$$\tau = r * F \quad (3)$$

where;
τ = Torque, in Nm
r = The distance between midpoint and the force apply, in m
F = Force, in N

The torques can be added and subtracted. If more than one torque acts on an object, the torques are combined to determine the net torque. If the torques tend to make an object spin in the same direction (clockwise or counter-clockwise), they are added together. If the torques tend to make the object spin in opposite directions, the torques are subtracted (see **Figure 2**).

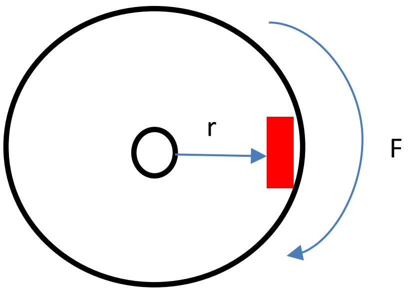

Figure 2. The element of calculated Torque

2.3. Rotational Dynamics

When an object moves in a straight line then the motion is considered as translational but when the same object moves along an axis in a circular path then it is known as Rotational Motion as shown in **Figure 3**. Consider a wheel rolling without slipping in a straight line. The forward displacement of the wheel is equal to the linear displacement of a point fixed on the rim. As we know that in linear motion, an object is moved till it feels any external force. This force changes the motion of objects. But when an object is moving about a fixed axis in a circular or curved path then, it can also feel the force better known as Torque. It is easier to open a door by pushing on the edge farthest from the hinges than by pushing in the middle. Thus, the torque is a force which is studied under rotational dynamic.

In rotational motion, the object is not treated as a particle but is treated in translational motion. The rotational dynamics starts with the study of Torque that causes angular accelerations of objects.

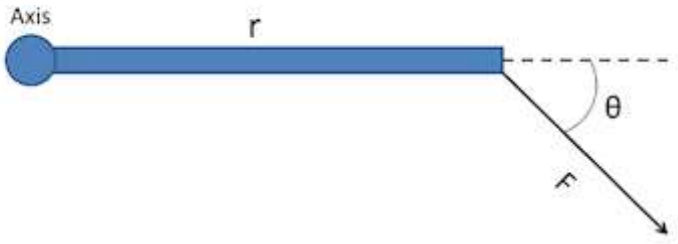

Figure 3. Rotational Dynamics calculation draft

$$T = F * r * \sin\theta \quad (4)$$

where;

T = torque
F = linear force
r = distance measured from the axis of rotation to where the linear force is applied
θ = the angle between F and r

2.4. Angular Acceleration

The angular displacement can be defined as the change in the angular position of the particle or object. Angular displacement is denoted by θ. For a particle moving in a circle of radius, *r* and assuming that it has moved an arc length of *s*, the angular position theta is given by,

$$\theta = \frac{s}{r}$$

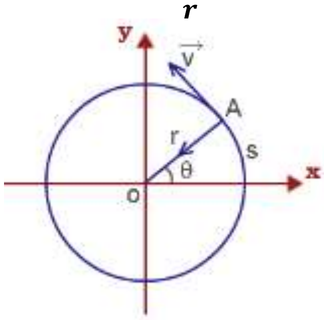

Figure 4. The element of calculated Angular Acceleration 1

Unit: radians

1 radian = $\frac{180}{\pi}$

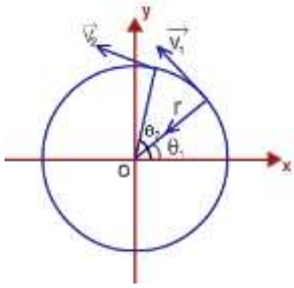

Figure 5. The element of calculated Angular Acceleration 2

$\Delta\theta = \theta2 - \theta1$
$\theta2$ = Final angular position
$\theta1$ = Initial angular position
Angular Velocity and Angular Acceleration
The rate of change of angular displacement is called Angular velocity. The rate at which angular velocity changes with time is called Angular acceleration.

Unit: radian per second

$$\overline{\omega} = \frac{\Delta\Theta}{\Delta t}$$

$$\omega = 2\pi f \tag{5}$$

where;

ω = angular velocity

$$\bar{A} = \frac{\Delta\omega}{\Delta t} \tag{6}$$

Also, a = rα = translational acceleration

2.5. Faraday's Law

Faraday's law of induction is a basic law of electromagnetism predicting how a magnetic field will interact with an electric circuit to produce an electromotive force (EMF) - a phenomenon called electromagnetic induction. It is the fundamental operating principle of transformers, inductors, and many types of electrical motors, generators and solenoids (Houston and Kennelly, 1902).

2.6. Design and Prototype

First of all, Mu-Metal shield that cover the stator part of magnet is being open. Secondly, the magnet on both stator and rotor part will repel each other to produce a kinetic energy, this kinetic energy will make the shaft to be rotated and this shaft is directly connect to plate 1 (refer to **Figure 6 - 9**). Both of the plate 1 and plate 2 are install with permanent magnet on them, the rotated plate 1 will drive plate 2 to be rotated. The plate 2 will rotate unlimitedly until the stator part of magnet is being cover back by the Mu-Metal shield.

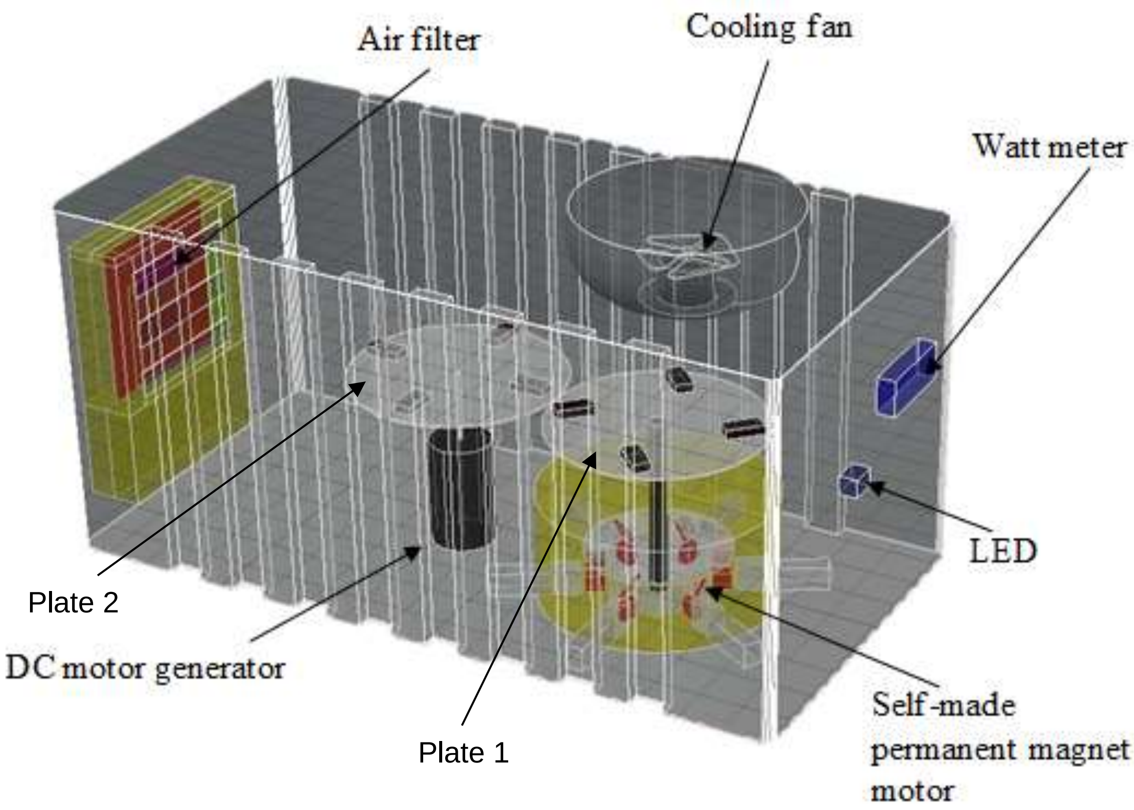

Figure 6. Proposed design of prototype

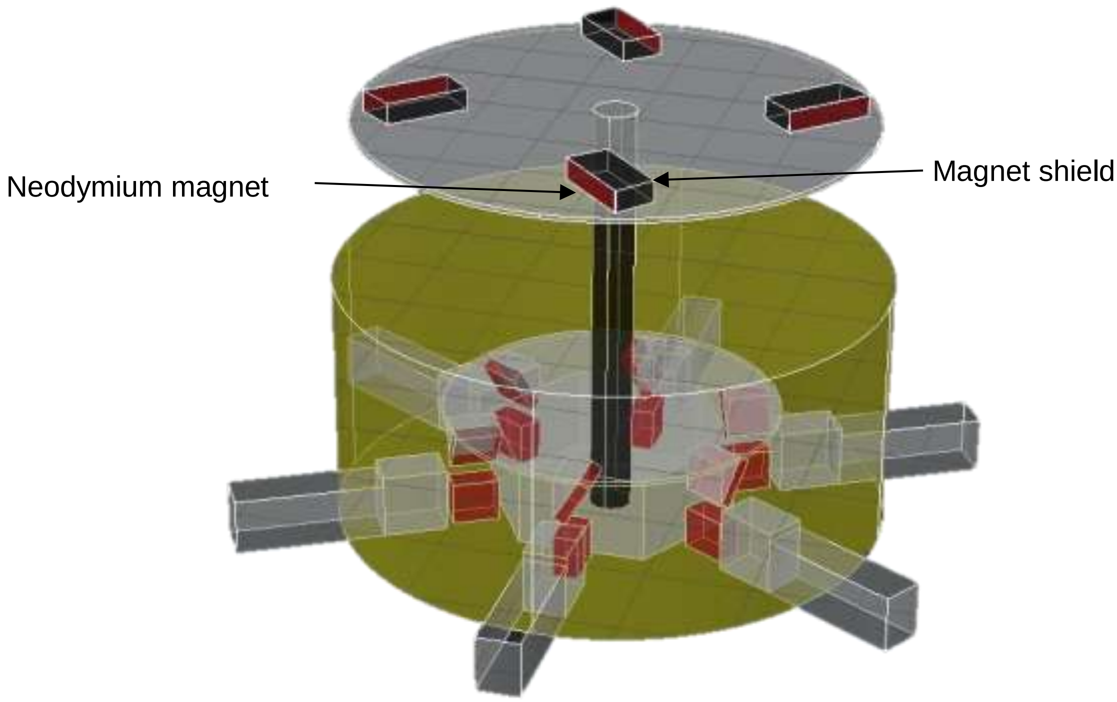

Figure 7. Design of self-made permanent magnet motor

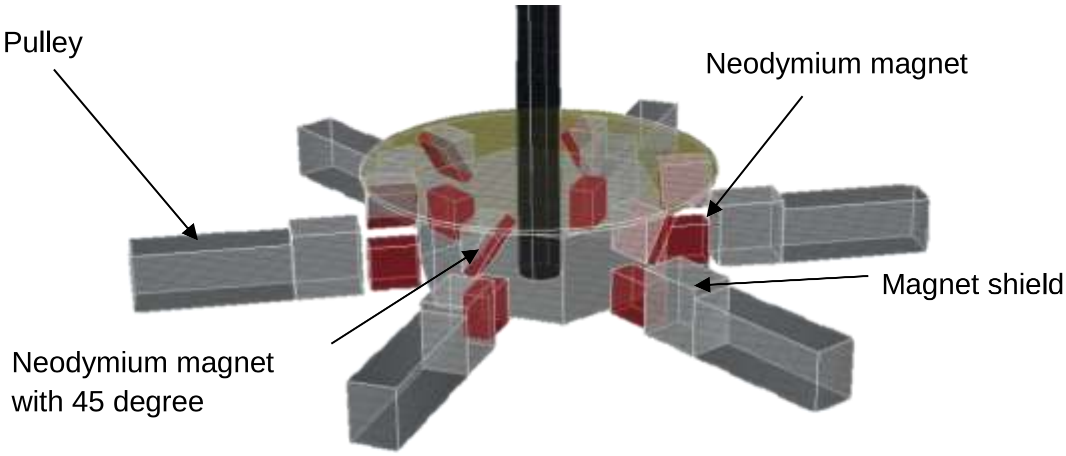

Figure 8. Zoom in the design of self-made permanent magnet motor

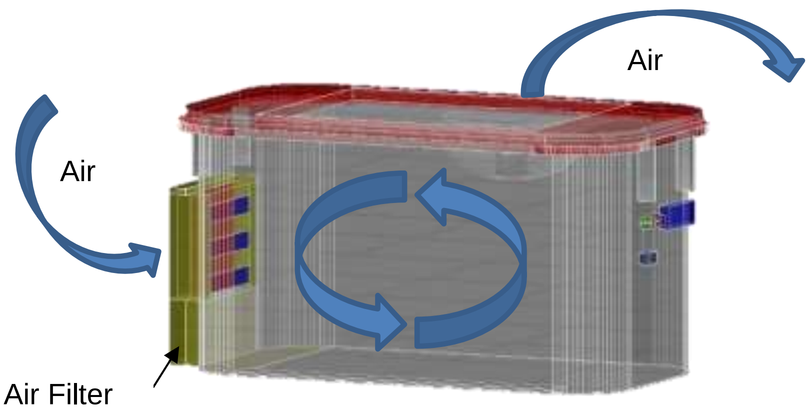

Figure 9. Cooling system of project

When the pulley is pulled, the shield will remove and the bottom magnets will contact to the magnetic field of the upper magnets. To stop the contact between both magnets, push the pulley and the shield will block the contact of magnetic field.

3. Expected Results

The process flow of the theoretical experimental of energy conversation using the concept of magnetic energy is shown in **Figure 10-11**.

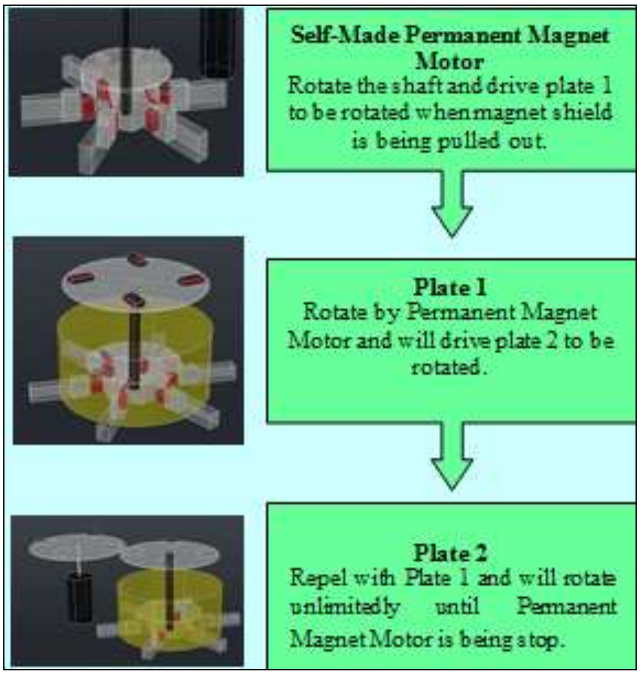

Figure 10. Process flow of experimental study

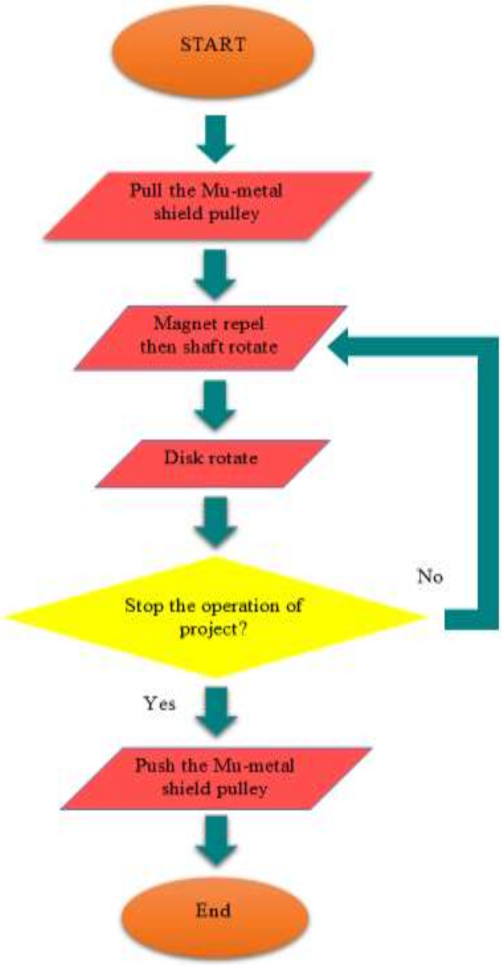

Figure 11. Flowchart of experimental study

From the prepared labsheet of the experiment, students are expected to be able to calculate the speed of spinning disk (rpm) versus the number of Neodymium magnets used. With the idea of a conceptual study of continuous movement using magnetic energy, a continuous moving concept will be presented in self-made permanent magnet motor. This experiment could also be potentially become a practical study in secondary school, since it is easy to use. In the experiment, students can manually control the number of used of magnets to apply in the experiment, the Mu-Metal can either push inside (to block the contact of magnetic field between two magnets) or pull outside (to unblock the contact of magnetic field between two magnets). Ideally, the more the used of magnets, the faster the disk spin, which means the higher the strength between magnets. Thus, the conceptual study of continuous movement using magnetic energy is a type of project which can present continuous movement, it uses the magnetic energy to become the energy source instead of extra energy. It is flexible in size design.

The concept of the experiment is not something new, and some may have tried to do it. The purpose of this experiment is to realise the functionallity of a magnet into electrical energy production. By doing this experiment, a student will be able to learn the correlation between rotational energy, magnetic energy and the result --- electrical energy. The calculation would rather be a simple and easy as a lot of assumption is made. With the exposure to this experiment, a student can understand how magnetism affects kinematics and thus affecting how much output electricity.

4. Discussion

The strength of the magnetic field is directly proportional to the number of magnets because the larger the number of magnets the stronger the strength of the magnetic field. The pulley in this experiment is covered by Mu-Metal. Mu-Metal is a permalloy which is an alloy of nickel, iron and molybdenum. It is a soft magnetic alloy with exceptionally high magnetic permeability. The alloy has a low coercivity, near zero magnetostriction, and significant anisotropic magnetoresistance. With these characteristics, it will become a very useful magnetic shield to block the magnetic field between two magnets and caused the movement stop down.

5. Conclusion

The concept of the experiment is not something new but some may have tried to do it. The purpose of this theoretical experimental study is to realize the functionality of a magnet into electrical energy production. By doing this study, a student will be able to learn the correlation between rotational energy, magnetic energy and the result - electrical energy. The calculation would rather be a simple and easy as a lot of assumption is made. With the exposure to this experiment, a student can understand how magnetism affects kinematics and thus affecting how much output electricity.

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