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THE PERFORMANCE OF MAGNETIC COIL USING MAGLEV CONCEPT

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Abstract

Maglev (magnetic levitation) prototype concept using a magnetic coil was used to create electromagnetism force around the coil. A small scale model for magnetic levitation using a copper coil was constructed. The weight carried by a battery inside the copper coil and distance per time taken was determined to complete the one-meter distance and one cycle. The result show as the number of magnet increase from the number of the magnet of 2 to 10 and the time taken was also increased due to the increase in weight. The N52 magnet grade increases by almost 40% compared to magnet grade N32. It shows that the higher the magnet grade used, the less time achieved and have better movement in the one-meter distance. When the magnet weight increase from 13.98gram (6 number of the magnet) to 23.30 gram (8 number of the magnet), the time also decreases by 35%. The high magnetic force by magnetic levitation increase when the number of magnet increase but it does not affect the maximum weight of magnet applied. Then, the copper coil was set in one cycle in 42 cm to 46 cm with a 2cm increment. The time is taken increase by 36% as the diameter increased due to the distance between each coil separate too far. The flux cannot cut perfectly at the copper coil which also reduces the efficiency of magnetic levitation.

Keyword. Copper coil, magnet levitation, magnet grade, magnetic coil

1. INTRODUCTION

Magnetic fields mostly came from a force created by permanent magnets like ferrous materials such as iron, cobalt, or nickel which acting by attracting or repel with other magnet material [1]. The term maglev also was known as magnetic levitation refers not only to the moving vehicle but the track or trail way system as well. It is specially designed for magnetic levitation and propulsion. This technology nowadays was implemented because it has the lowest overlap compare to wheeled train technology [2]. Magnetic levitation is frictionless and can overcome the limitation between rail and wheel that produce heat due to contact. This technology move-in smooth movement, quiet and better as the use of a small percentage of energy consumption that mostly wasted to overcome drag created by wheel and rail [3][4][5]. There are two types of magnetic levitation concept which are electromagnetic levitation (EML) and electrodynamics levitation. This electromagnetic will produce an attraction between electromagnets and the levitation object using attractive force in the copper coil that had been magnetized. Meanwhile, electrodynamics levitation will create a repulsive force between superconductive magnets of the levitated object and the surface of the copper coil which had been magnetized [6]. The electrodynamics of a

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magnetic levitation coil is studied without the use of Maxwell's thin-plate approximation. All results are obtained from exact solutions of the Maxwell equations in which the displacement current is neglected [7]. Meanwhile, an analytical calculation of the magnetic field produced by a deflection coil in the shape of an infinitely long cone is presented by [8]. The results are compared with the corresponding results obtained from an infinitely long cylindrical model of the coil. This new concept had been discovered to handling something big and heavy by using magnetic levitation or maglev.

In this project, a small neodymium magnet, AAA battery and copper coil were used as magnetic levitation. A battery will be attached with numbers of neodymium magnet at the south pole and north pole equally as a moving prototype. Then copper coil will be used as a railway in a linear and rounded shape due to its ferrous material and become magnetized. The weight and velocity have been carried out by copper coil to complete in the 1-meter distance and one cycle. The movement of the magnetic coil was determined until it reaches maximum weight.

2. METHODOLOGY

There are several components used to construct the magnetic copper coil. The most important part was the magnet used and its strength, battery to generate electricity and copper coil. The stopwatch was used to measure the time taken to complete one distance or one cycle. The completion of the process begins with designed in CATIA software part by part until the assemble process, the factor that effecting magnetic strength, the construction of copper coil magnetic levitation and finally, the preparation for testing of copper coil magnetic levitation.

2.1Component to construct a magnetic copper coil

2.1.1. Neodymium magnet

The levitation system was constructed by having a magnet shaped like a round disc. This magnet must be as small in size as the diameter of the battery. The number of a magnet attached on both opposite pole of the battery will determine as weight. Magnet grade used in this project is N52, which is the strongest magnet, high coercivity which is high resistance from being demagnetized and also high remanence (strength of magnetic field). This project could not use a normal magnet as it does not have the same strength as a neodymium magnet. Neodymium magnet was made from an alloy of neodymium, iron and boron.

2.1.2. Battery

In this project, a triple-A battery was used to generate small electricity toward the neodymium magnet due to the small-scale magnetic copper coil diameter size.

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2.1.3. Copper coil

Copper was the material that can flow current and been magnetized. It is a good conductor of heat and electricity. This metal was partly soft, high electrical and thermal conductivity, and high among pure metal at room temperature. The copper was a suitable element to flow current to generate a magnetic field.

2.1.4. Base

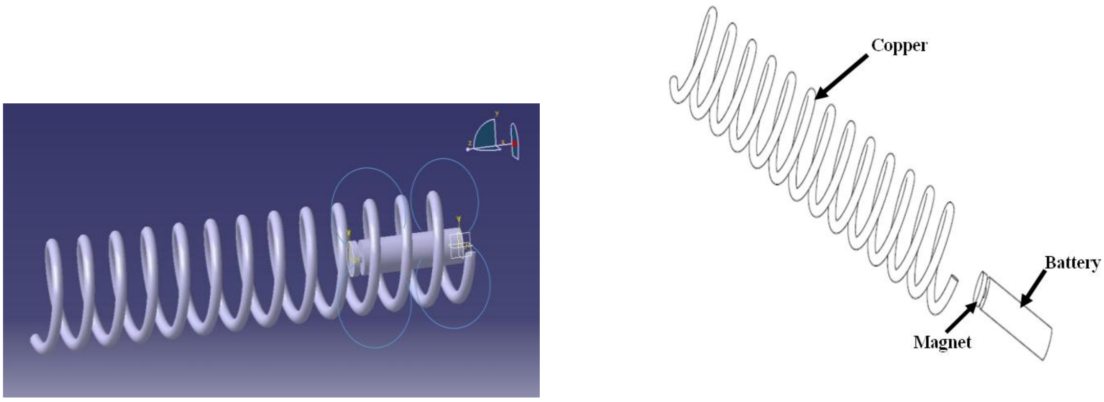
The magnetic coil was tested on a plain plywood board. It is a bad conductor of electricity and magnetism which will prevent losses of magnetism on it.

2.1.5. Stopwatch

The time was taken for the prototype to complete in one-meter distance or one cycle. A typical mechanical analog stopwatch was used.

2.2. Design construction

The design of the magnetic coil was constructed in CATIA V5R19 software. The components were assembled and drafted as shown in Figure 1. The components of the magnetic coil consist of a triple-A battery, copper coil and magnet. Figure 1 (a) shown a completed diagram of maglev using a magnetic coil. On the inside of the coil there is a single triple-A battery and was attached both poles with neodymium magnet. The magnetic field generated by the prototype was cut by the copper coil causing it to move forward at a certain speed. The assembly drafting was also shown in Figure 1(b).



(a) (b)

Figure 1: (a) Illustration of the maglev prototype using magnetic copper coil, (b) The assembly drafting of magnetic copper coil

2.3. Factors affecting magnetic field strength in a copper coil

The number of turns in the electromagnet's coil will affect the strength produces of the magnetic field. The more coils turn per length of the core, the greater the

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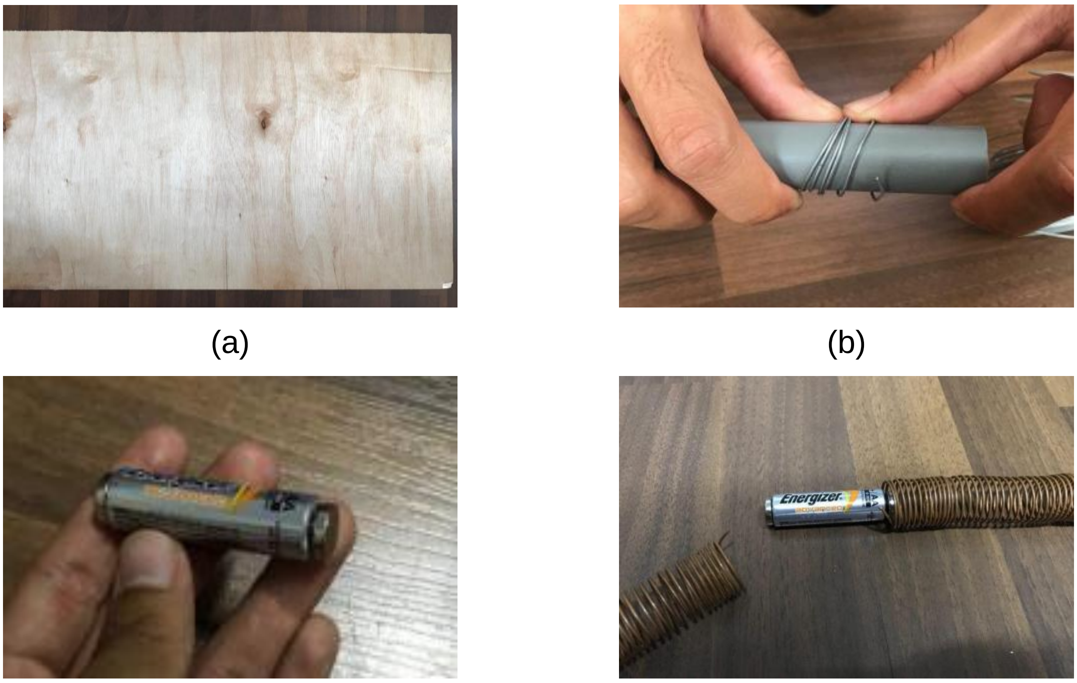
magnetic field strength will be produced among the battery. There are about 800 numbers of turns of copper coil in this project.

2.4. Magnetic coil construction

The prototype was constructed by built its main components to ensure levitation can be achieved. Firstly, the plywood was used as a rail for testing as shown in Figure 2(a)). For the copper coil, due to the limitation of pure copper coil in the local market, a normal copper coil was used and soaked into sodium hydroxide, NaOH, to remove the coating at the outer layer of the copper coil. This is to ensure only pure copper coil was used. Then, the copper was wrapped on the plastic pipe with a diameter of 20mm as shown in Figure 2(b). Figure 2(c) shows magnet attachment for both sides of the pole. The weights were based on the number of a magnet attached for both sides of the pole. Finally, Figure 2(d) shows the assembly of the magnetic levitation prepared for testing.



(a) (b) (c) (d)

Figure 2: (a) Plywood as a base, (b) Copper coil wrapped on a pipe, (c) Magnet was attached at the end of both pole, (d) The complete assembly of battery, magnet and a copper coil.

2.5. Diagram of the magnetic coil for experimental testing

Figure 3 and Figure 4 show the diagram and prototype of the magnetic copper coil construction for several experimental testing. There are two types of testing

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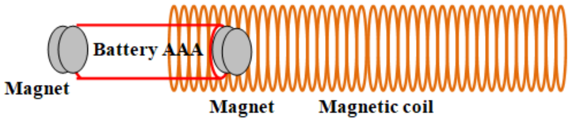
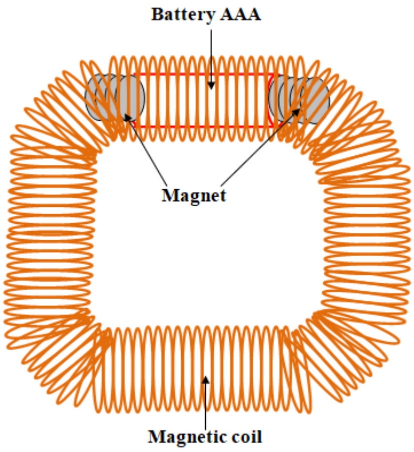
performed in this project. First, the weight, the number of a magnet attached at the both of battery pole and the grade of the magnet was investigated over time at a 1-meter distance as shown in Figure 3. Second, the experiment was testing for the magnetic copper coil in diameter distance over time taken per cycle (refer Figure 4).



(a) (b)

Figure 3: The magnetic coil for weight and time testing in linear distance illustrated in (a) schematic diagram (b) prototype



(a) (b)

Figure 4: The diagram of the magnetic coil for weight and time testing in diameter distance illustrated in (a) schematic diagram, (b) prototype

3. RESULT AND DISCUSSION

There are two experiments conducted and the result was recorded and analyzed. For the first experiment, the readings were compared between the numbers of the magnet, grade of the magnet, weight of magnet in one-meter distance per time taken. The second experiment is based on the diameter of the copper coil per time

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taken. The efficiency of the copper coil was determined based on magnet weight and time is taken.

3.1. Number of magnet per time taken

Figure 5 shows a sequence of time taken when the number of magnets applied to the prototype. The time increased when the number of magnets increased. It shows that when the number of magnets increased, the magnetic force also increases but the prototype cannot withstand the weight as it's too heavy to move. For this experiment, the number of magnets used until 10 magnets as it is efficient for the magnet to move. The result shows that when the number of magnet doubles up from the origins, the time taken will be longer almost 2 seconds from the previous. Moreover, if the number of magnets still increased, the prototype will not move or takes more time to arrive finish line due to an increase in the weight.

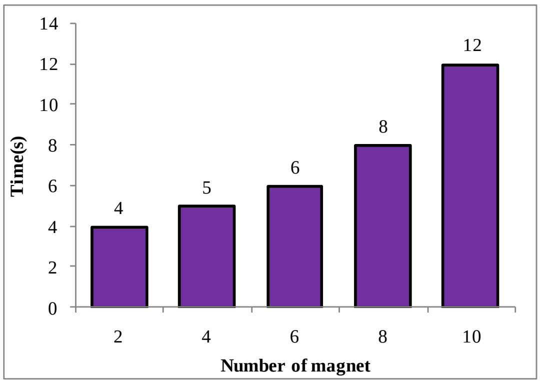

Figure 5: Number of magnet versus time taken

3.2. *Grade of magnet per time taken*

Figure 6 shows the different grades of magnet used such as N32, N48 and N52 with 2 numbers of a magnet attached to the prototype per time taken. The results show that time taken decreasing as the grade of magnet increased. The time taken was short as the grade of magnet increase. The higher grade of magnet supplied a high magnetic force with the help of a battery which acts as a power supply that generates a speed of prototypes to move forwards faster. It shows that magnet grade N32 decrease 2.54 second approximately 9.98% from N48 and 5.46 second (31.27%) from N48 to N52. It shows that when the higher grade of magnet used, the less time to achieve and better in moving in the one-meter distance.

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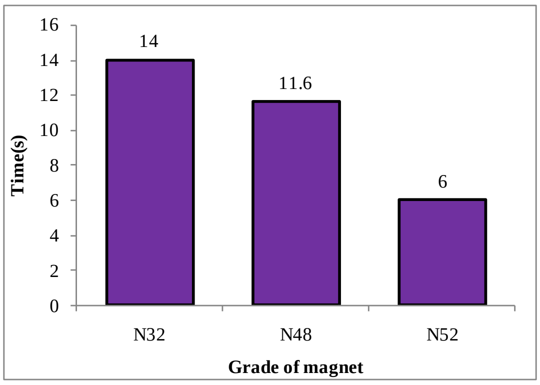

Figure 6: Grade of magnet versus time taken

3.3. Weight of magnet per time taken

The time was taken when the weight of the magnet increased the number of the magnet from 6, 8 and 10 as shown in Figure 7. The weight of the magnet start with 6 number of the magnet which weighting 13.98 gram, 8 number of magnet weighing 18.64 gram and lastly 10 number of magnet weighing 23.30 gram. From the experiments, the 13.98 gram magnet takes 4.28 seconds while the 18.64 gram magnet takes 3.22 seconds with a difference of 1.06 second approximately 14.13% decreased. However, between 18.64 grams and 23.30gram, there about 1.15 seconds which corresponds to 21.7% differences. This magnet obtains a high magnetic force of magnetic levitation as the number of magnet increases and did not affect by the maximum weight of magnet applied. It shows that, when the weight increases, it will reduce the time taken to become shorter.

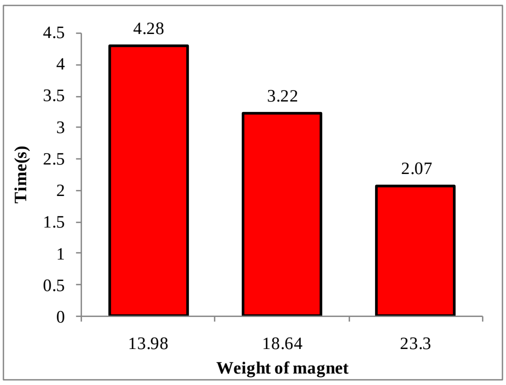

Figure 7: Weight of magnet versus time taken

3.4. The diameter of copper coil per time taken

The complete one cycle the magnet with grade N32 was tested and the time was recorded as shown in Figure 8. The copper coil diameter was set from 42cm to 46cm

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with a 2cm increment. The time is taken to increase by 36% as the diameter increase. This reduces the efficiency of magnetic levitation as it cannot cut the flux perfectly at the copper coil. It shows that this prototype traveled slower as the distance between each coil separate too far.

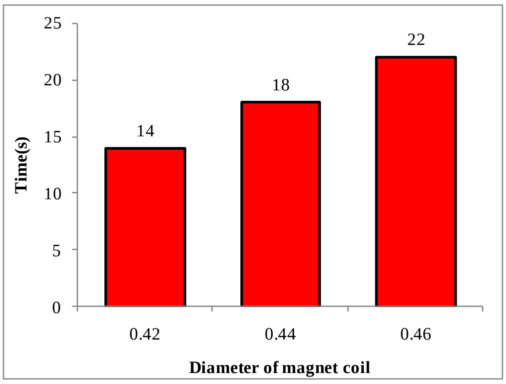

Figure 8: Diameter of copper coil versus time taken

4. CONCLUSION

The investigations of the magnetic levitation from the copper coil in terms of movement show the object being levitated from the base. The first experiment shows the number of magnets increased directly proportional to the time taken. The time taken becomes longer and increased as the number of magnets increased due to the weight from the magnet affect the speed of the prototype. The second experiment was based on the grade of magnet and time taken. The time becomes shorter as the magnet grade increased from N32 to N52 by almost 40%. The third experiment shows that the time becomes shorter as the weight of the magnet increased and the magnetic force of magnetic levitation also increased. Thus, the speed the weight tested did not reach its maximum ability and still can move in high speed from 13.98 gram (6 number of the magnet) to 23.30gram (10 number of the magnet). Finally, the diameter of the copper coil per time taken to finish in one cycle was determined. The initial diameter coil was 42cm but stretching with 2cm increased into 44cm and 46cm. As the diameter increased, the time taken in the completion of one cycle becomes longer due to the interval between each coil increased. The ability of the prototype to cut magnetic flux during moving becomes inhibited causing speed to become slower. It also concludes that these magnetic levitation gives a positive in improving workload during a short period, produce better force and energy, generating forces to move the mechanism and also avoid friction of movement. The weight, the number of copper turns, the diameter of the copper coil and the extent of one cycle will be investigated in further studies.

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