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Green Energy Based Maglev Train and Power Harvesting

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Abstract: ***Magnetic Levitation is a technology that has been experimented intensely over the past couple of decades. An advanced technology also abbreviated as Maglev; defines the term "Levitation" which addresses vehicle propulsion with magnets rather than with wheels, axles and bearings. This system provides the advantage of negligible wear and tear of mechanical parts, making the system more effective and reliable. The implementation of a large-scale transportation system using magnetic levitation not only has huge social aspect but can be economical respect to maintenance. Maglev trains are much smoother and quiet as compared to wheel trains; moreover their non-reliance on friction means that acceleration and deceleration can surpass that of wheeled transports, and they are unaffected by weather, providing the research aspect to this paper to not only have a green energy powered propulsion model but also to emboss energy harvesting in the system via electro motive force a term existing as "Back EMF" in coils or electromagnetic motors.***

Keywords: Propulsion, Lateral Guidance, Magnetic Levitation, Cryomagnets.

1. INTRODUCTION

There are many forces in the world that we don't know because they are not visible to the naked eye. These forces work on different principles that are gravity, electricity, and magnetism. Magnetism is the reason that the world spins and thus creates gravity. The magnetism is created by the processes within the core of the earth. The earth's iron-ore core has a natural spinning motion which creates a natural magnetic force that is held constant over the earth. This creates magnetic forces that turn the earth into a large bar magnet. The creation of North and South poles on the earth are due to this field [1].

This project is a study of the real-world feasibility of maglev trains as a transportation system. As many countries move to make themselves "greener," one of the biggest questions is, "How can we be more efficient?" Because transportation uses up such a large amount of energy, this is one of the first places to turn when looking for ways to be more environmentally friendly. Maglev trains could very well be the transportation of the future, as they have virtually no friction, making them incredibly efficient and silent. There are several types of maglev trains: those made from permanent magnets, those made from electromagnets, and those made from superconductors [1].

2. BASICS OF MAGNETIC LEVITATION

If you've ever handled magnets, you know that opposite poles attract and like poles repel each other. Electromagnets are similar to other magnets in that they attract metal magnets in that they attract metal objects, but the magnetic pull objects, but the magnetic pull is temporary.

There are two basic principles in dealing with the concept of magnetic levitation. *The first law* that is applied is commonly known as Faraday's Law. This law states that if there is a change in the magnetic field on a coil of wire, there is seen a change in voltage. [4]

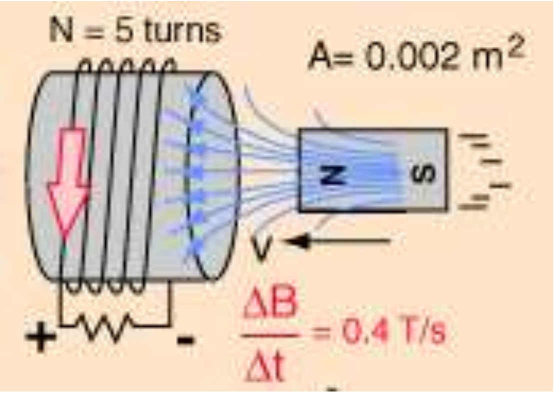

Fig 1: Induced Current from Change in Magnetic Field

The direction of the forces created by Faraday's Law was given by Lenz's law. It states that when an emf is generated by a change in magnetic flux according to Faraday's Law, the polarity of the induced emf is such, that it produces a current that's magnetic field opposes the change which produces it as shown in figure 2[2].

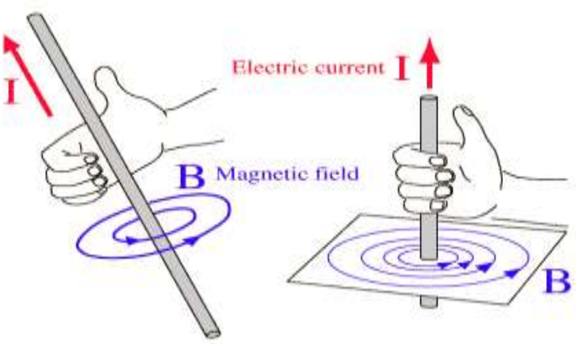

Fig 2: Electric & Magnet Fields.

- If the magnetic flux Φ linking coil increases, the direction of current in the coil will be such that it will oppose the increase in flux and hence the induced current will produce its flux in a direction as shown below (using right-hand thumb rule).
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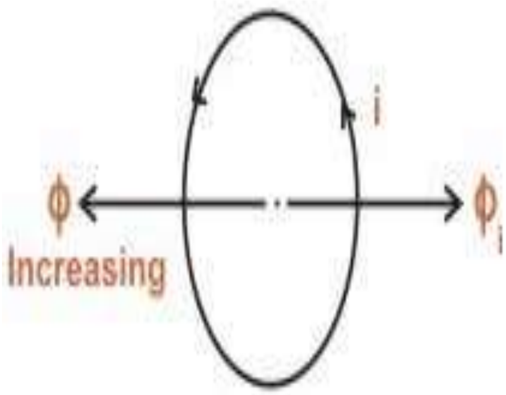

Fig3: Right-hand thumb rule

- If magnetic flux Φ linking a coil is decreasing, the flux produced by the current in the coil is such, that it will aid the main flux and hence the direction of current is as shown below,

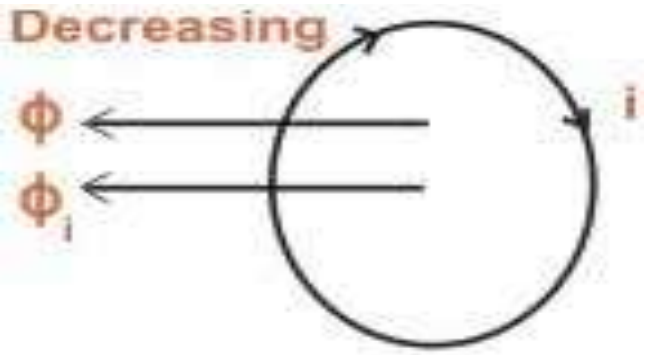

Fig4: Magnetic Flux

The application that this has on magnetic levitation is that this will allow the direction of the magnetic field to be predictable and thus a set up can be created for a specific purpose to maximize the force that is created. This has direct application to the rail gun which will be described later.

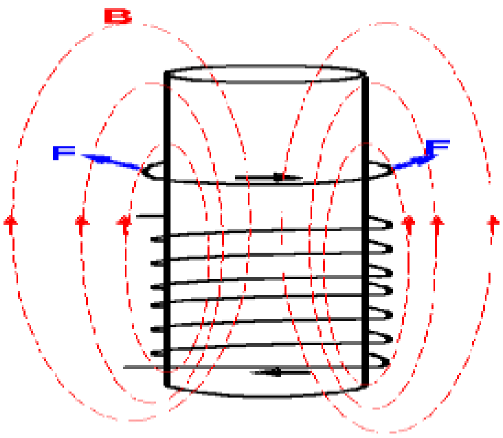

Fig 5: Perpendicular Force from Induce Current

From figure 5 above, it is illustrated that there is a coiled wire around the cylinder. Inside that coiled wire is a current that is traveling from left to right. The resulting magnetic force from that current is shown to be perpendicular to the current and is traveling from bottom to top.

Types of Magnetic Levitation

Although the concepts of magnetic levitation are, all the same, the way that those concepts are brought about can vary. These options are controlled and changed depending on the type of application that is necessary.

1) Permanent Magnets

The first type of levitation is the implementation through permanent magnets. These magnets are made of a material that creates a north and a south pole on them.

2) Electromagnetic Magnets

The basic idea behind an electromagnet is extremely simple. By running an electric current through a wire, you can create a magnetic field. When this wire is coiled around a magnetic material (i.e. metal), a current is passed through this wire. In doing this, the electric current will magnetize the metallic core. This can be seen in Figure 6.

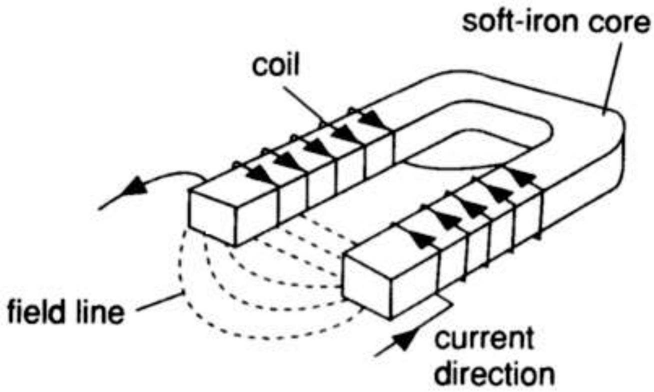

Fig6: Electromagnet

By using this simple principle, you can create all sorts of things including motors, solenoids, heads for hard disks, speakers, and so on. An electromagnet is one that uses the same type of principles as the permanent magnet but only on a temporary scale. This means that only when the current is flowing is there going to be an induced magnet. This type of magnet is an improvement to the permanent magnet because it allows somebody to select when and for how long the magnetic field lasts. It also gives a person control over how strong the magnet will be depending on the amount of current that is passed through the wire.

3) Superconductive Magnets
The ideas presented behind superconductive magnets are the same principles that are at work in an MRI. Superconductive magnets are the most common of all the magnets and are sometimes called Cryomagnetic. The idea behind the superconducting magnets is that there is a material which presents no electrical resistivity to electrical current. Once a current has been fed into the coils of this material, it will indefinitely flow without requiring the input of any additional current. The way that a material is able to have such a low resistivity to current is that it is brought to very low temperatures. The temperatures that are commonly found in superconducting magnets are around -258oC. This is done by immersing the coils that are holding the current into liquid Helium; this also helps in maintaining a homogeneous magnetic field over time. The advantage to the superconducting magnet is that they don't require constant power from a source to keep up the value of the current in the coils [3].

LITERATURE REVIEW

CATHERINE PAVLOV

Getting something to levitate is relatively easy and has been done many times. Once a superconductor is lowered to its critical temperature, the point at which the material becomes superconducting, it exhibits the Meissner Effect, in which the superconductor excludes magnetic fields, causing it to "float" above magnets. While the levitation of a superconductor is easily shown, using superconductors for transportation is somewhat trickier, as they must stay cooler longer and need some horizontal propulsion system. Another setback in the real-world feasibility of superconductor maglev trains is the cost of superconductors, which are currently very expensive. While one can't predict the future, it is very likely the cost of superconductors will eventually go down, as more is learned about them and their seemingly magical properties. [3]

High-speed rail systems have already been implemented all over the world, from France to Japan. Maglev trains have not yet become a common public phenomenon, mainly because thus far their advantages over normal high-speed rail are often not enough to justify building trains and tracks from scratch. [5] If more research is done into the top speed and efficiency of maglev trains, there is the possibility of their more widespread application in real-world use. Information from this type of research could also be applied to normal high-speed trains. Aerodynamic design from both maglev and high-speed trains could even be applied to slower moving trains, such as subways, to help increase the efficiency of transportation systems that are not ready for total reform.

U. S. INITIATIVES

The U. S. government has allocated $55 million for pre-construction planning activities of maglev systems. Funds will be awarded to five selected project groups. Application deadline is December 31, 1998

Principle of magnetic levitation

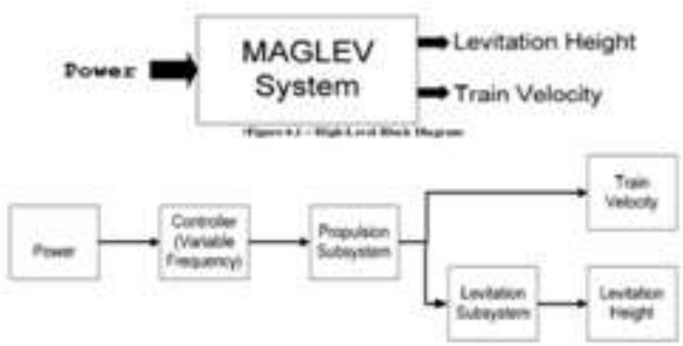

Fig7: Block Diagram

Maglev is a system in which the vehicle runs levitated from the guideway (corresponding to the rail tracks of conventional railways) by using electromagnetic forces between coils on the ground. The following is a general explanation of the principle of Maglev. There are many different moderations of the technology used in levitating train cars for transportation, but the following in the first example. This example can be seen in Figure A, B below. In the first figure is where the principle of magnetic levitation is employed. In the picture, you can see the figure 'A' of levitation coils that are installed on the side walls of the guideway. Also from the figure, you can see that there are superconducting magnets attached to the vehicle itself. As the vehicle is moving at a high rate of speed, there is an electric current that passes through the coils only at the instant that the vehicle is passing the coils. Once this happens, this turns the coils into electromagnets temporarily.

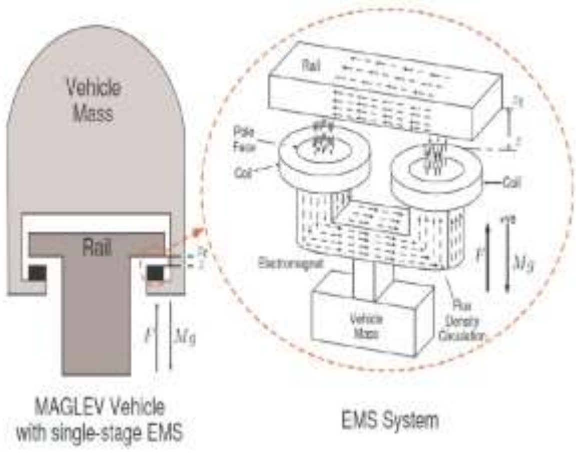

Fig 8: Principle of Magnetic Levitation

Once the electromagnets are turned on, the interaction between the coils on the guideway and the magnets on the vehicle allow the vehicle to stay levitated above the track for a few centimeters. As can be seen from the figure 8, on the side of the vehicle there is a magnetic force acting to push the vehicle up from the bottom, and at the same time, there is a force pulling it up from the top part of the coil. This process is responsible for the levitating aspect for the track.

The main task to complete for the system is to levitate the vehicle; otherwise, the technology is not a breakthrough at all. But on the other hand, there are a couple more important things to remember. With magnetic forces, there is an unstable force that needs to be contained to act efficiently. So with this known, care must be taken to make sure that the vehicle does not slide from side to side. This is done by the principle of Lateral guidance. This is illustrated in Figure 9 below.

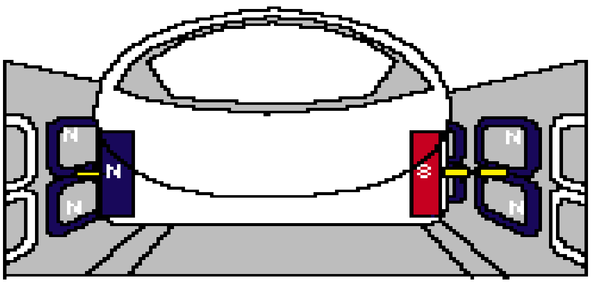

Fig9: Principle of Lateral Guidance.

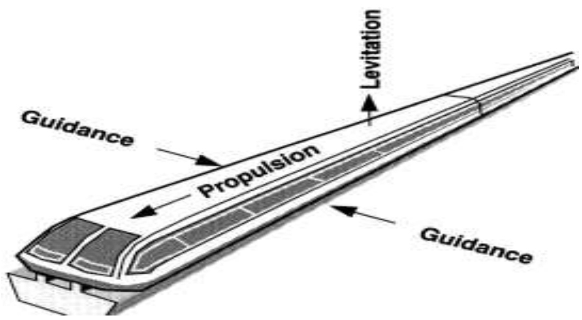

Fig 10: primary function of maglev

The magnitude of the magnetic force is best represented by Equation 1 below and the magnetic field is calculated by equation 2.

$$B = \frac{\mu 0\ I}{2\pi r} \quad (1)$$

Where:

B = Magnetic Field Strength (Tesla)
r = Radial distance
I = Current through the Rails and Conducting Object (Amps)

$$L = \frac{\mu N^2 A}{l} \quad (2)$$

When the current moves through the conducting object over Length L in the presence of a magnetic field B, a force is created. That force can be calculated from Equation 3 below.

$$F = I.L.B \ (3)$$

Where:
F = Force on Conducting Object (Newton)
I = Current Through the Rails (Amp)
L = Length of the Rail Separation (Meters)
B = Magnetic Field Strength (Tesla)

The direction of the force depends on the direction of the current through the projectile and the magnetic field since the force is truly a vector with direction dictated by the cross product of the vector quantities I and B. Figure 10 shows that the direction of the force is orientated down the rails, away from the power source. Utilizing this concept our maglev train can be best understood as shown in figure 11 below:

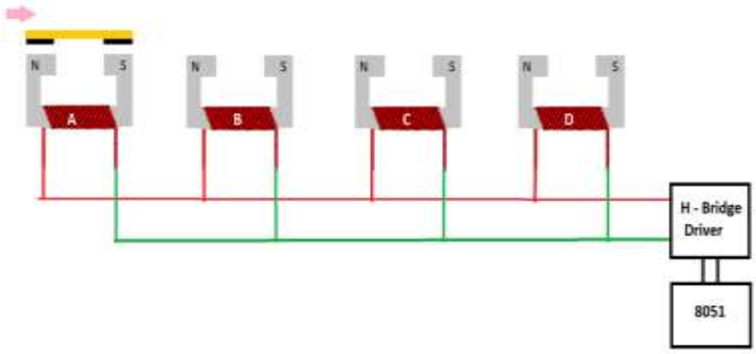

Figure 11: Maglev Block Diagram for our work

Discussion and Innovation

The levitation of the train is basically controlled by the current which produces a magnetic flux in the coil. The more the amount of current we apply, greater is the levitation that will control the gap between the coil and the magnet (train). If we are using a 12v battery of 2amp, and 27 gauge copper wire, we can calculate magnetic flux density (B) [eq1] and the inductance of solenoid (L) [eq2]. From these parameters, we can calculate force [eq3], which is being applied to the magnet to push it in the forward direction as shown by pick arrow in figure 11. The h bridge driver is utilized for excitation of coils like stepper motor driving. This H-Bridge is driven with the help of a microcontroller 8051 so that the speed of magnetic pole switching of the core can be controlled.

During this switching on and off duration, the amount of current plays a crucial role which is directly proportional to the weight of the propelling vehicle. More the weight more is the required current. The current that flows in the coils causes levitation; when we cut off the power supply, due to the frictions part the magnets are bound to descent because of current dissipation. The power dissipation due to the back EMF in form of peaks can be harvested and the green power supply can be recharged during each switching cycle from coil A to B to C or D as shown in figure 11. This innovative idea requires our focus and is the main research element of our project which is under test.

CONCLUSION

The idea of a force that one cannot see requires a little faith to understand. To ride on a train that is defying gravity will take a little bit more faith. Magnetic levitation is a technology that is still being newly developed. There is no telling what the future holds for these types of applications. The current applications that range from the toys to military equipment are important in the development of new and more efficient ideas. Development of these new ideas will provide a push into commercializing superconductors for electric power generation, transmission, and storage. This energy storage is the latest in technology from magnetic technology. This has come about from the demand and need for a reliable power system for day-to-day operation. This system utilizes large superconducting coils for power in times of outages or power sags.

Whether these types of technologies will later be used as common as the household light switch, it is too early to tell. There is a lot of work that needs to be done in the research and a lot of money needs to be devoted to the cause. Although with careful education and research this clean, plentiful, and friendly way of producing force could prove to be a valuable asset to many developing technologies.

This project focused mainly on the propulsion system, an area not typically focused on, at least in small-scale demonstrations. Many model maglev trains don't address propulsion at all or use mechanical systems to accelerate the train. The goal of this project is to create an effective, no-contact propulsion system that has the capability to be reversed, for stopping and multidirectional movement.

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