ORIGINAL RESEARCH PAPER
Volume - 10 | Issue - 03 | March - 2021 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

MAGNETIC LEVITATION AS ENERGY HARVESTER

Engineering

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ABSTRACT

Magnetic levitation as energy harvester has been widely studied since past few years. It can be used to implement a low-cost and maintenance-free energy harvester. For self-powering a broad range of technologies for long periods of time, levitation-based harvesting systems able to operate autonomously. In this paper, a theoretical study is presented of a harvester configuration that utilizes the motion of a levitated hard-magnetic element to generate electrical power. The levitation used minimizes the loss caused due to wear and tear of mechanical part thus increasing the life of the system.

KEYWORDS

I. INTRODUCTION:

Motion-driven electromagnetic energy harvesting systems have been used to come up with self-powering for a wide range of technologies such as mobile electronics, remote sensors and actuators, biomedical implants and wearable devices etc. These harvesters are usually complex and their use is often unfeasible due to dimensional constraints. Besides, the tuning mechanisms must be subject to constraints thus, practical applications require geometric optimization. Consequently, for design optimization prior to fabrication, as well as to fulfill demanding adaptability requirements, modeling of the energy transduction is essential. Because of the highly non-linear behavior of most harvesters, such modeling is problematic.

Magnetic levitation has been used to implement low-cost and maintenance-free electromagnetic energy harvesters, with the ability to operate autonomously with stable performance for long periods of time. Their simple design is effective in many applications involving heavy-handed dimensional constraints. However, according to the excitation's characteristics, the intelligent control algorithms used to control the position of their components can be developed.

Many general models for the implementation of the energy harvester have been proposed. Because of their complexity and the requirement of precise calculation and design procedures, only a few have been studied and are brought under continuous experimentation. The result of which are not quite pleasant but are desirable as the experimentation is still under process.

II. Principles Used

A. Magnetism:

Magnetic field can be defined as a region surrounding a magnet where another magnet or moving charge will feel a force of attraction or force of repulsion. As we know that magnets having two poles named as North Pole and South Pole. When the two magnets are brought towards each other with opposite poles facing, they will attract each other. When the two magnets are brought towards each other with like poles facing, they will repel each other.

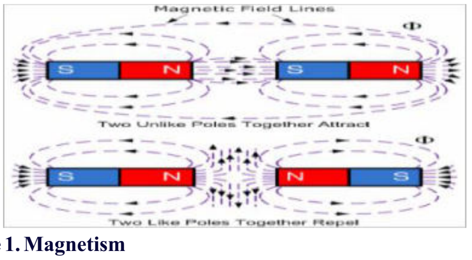

Figure 1. Magnetism

B. Magnetic Levitation (Maglev):

Magnetic levitation (Maglev) is a method by which an object is suspended with no support other than magnetic fields. Magnetic force is used to counter-act the effects of the gravitational acceleration and any other acceleration.

Materials in a magnetic field will become magnetized. Most materials such as plastic, wood and water are diamagnetic, which means that they are repelled by magnetic fields. This repulsive force, however, is very weak compared with the attractive force a ferromagnetic material such as iron will experience due to a magnetic field. As shown in Fig. 1, if the repulsive force on a diamagnetic object due to a magnetic field is exactly equal to the weight of the object, then the object may be levitated in air. This type of levitation requires very large, typically 17 T magnetic fields. Producing such large fields requires using superconductive magnets. Thus, maglev relies on superconductors in practical applications.

Superconductors are strongly diamagnetic, which means it repelled by magnetic field. Other diamagnetic materials are also commonly placed and can also be levitated in a magnetic field if it is strong enough than the gravity.

Magnetic Levitation can be done using:

1. Using a magnet and a diamagnet:

Diamagnetic materials mean the materials create an induced magnetic field in a direction opposite to an externally applied magnetic field and are beat back by the applied magnetic field. From the re-alignment of electron parts, Diamagnetic properties will be arising under the influence of external magnetic field.Diamagnetic materials are bismuth, gold, silver, graphite etc.

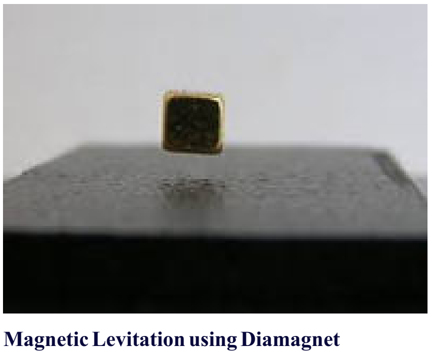

Figure 2. Magnetic Levitation using Diamagnet

2. Using two magnets:

Here levitation occurs due to the property of repulsion of magnets. Both the magnets are placed such that their like poles are always facing each other.

Figure 3. Magnetic Levitation using Two magnets

3. Using a diamagnet and an electromagnet:

Here a diamagnetic material is suspended in air using an electromagnet. The height, at which the levitating body can be changed by changing the control system circuit.

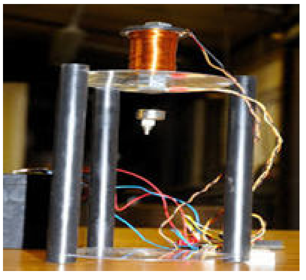

Figure 4. Magnetic Levitation using Diamagnet and Electromagnet

C. Mutual Inductance:

Mutual Inductance between the two coils is defined as the property of the coil due to which it opposes the change of current in the other coil, or you can say in the neighboring coil. Mutually Induced emf can be defined when the current in the neighboring coil is changing, the flux sets up in the coil and because of this changing flux emf is induced in the coil and this phenomenon is known as Mutual Inductance.

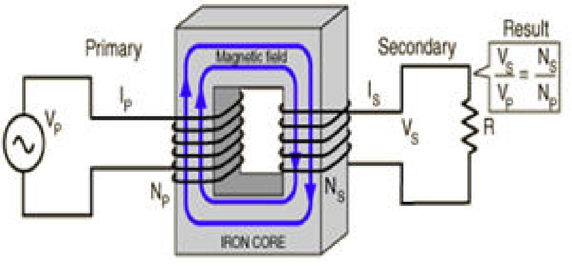

Figure 5. Mutual Inductance

III. Types of magnetic energy harvesters:

A. Magnetic energy harvester using rotational motion of levitating magnet:

Levitated magnet is rotated using an extra ring of magnets placed around the levitating magnet. Additional magnets are placed at either side of levitating magnet. These magnets are placed such that they are isolated from each other. This setup provides a continuous generation of energy for unless the ring is placed surrounding the levitating magnet. The magnet in the ring is placed at an angle of 45 degree to the horizontal axis of the ring.

Figure 6. Magnetic Energy Harvester

B. Magnetic energy harvester using vibration motion of levitating magnet:

The levitating magnet is placed in between the two fix magnets. The repulsion from both the magnets produces oscillation. These oscillations again change the magnetic flux linked with the coil thus producing current in the coil.

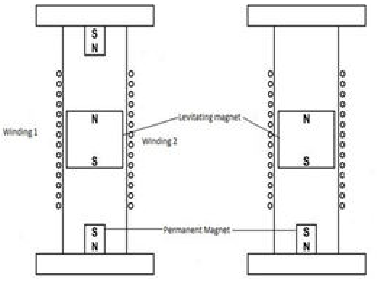

Figure 7. Magnetic Energy Harvester

IV. Advantages:

A. Magnetic Fields

Intensity of magnetic field effect of Maglev is extremely low (below everyday household device). Hair dryer, toaster, or sewing machine produces stronger magnetic fields

B. Energy Consumption

The energy consumption of Magnetic Levitation as energy harvester is null or zero as it itself is the source of power generation.

C. Noise Levels

As there are no moving parts, the noise produced is almost negligible as compared to other power generating devices.

D. Operation Costs

Virtually no wear. Main cause of mechanical wear is friction. In Magnetic Levitation it does not requires contact, and hence no possibility of friction. Thus, the operating cost again is negligible. Magnetic Levitation can be used as a power bank to store charge.

V. Disadvantages:

Only diamagnetic substances can be used as they can be levitated and also that the main aim to produce free energy. Power generated is less as it is used only to charge phones and other such electronic equipment. Copper coil needs to be placed at a distance of 1mm from the magnet so that majority of flux change can be sensed by the coil

VI. Applications:

Maglev has been successfully implemented for many applications in research and industry. Levitating trains and levitating displays are two examples of electromagnetic levitation. The need for fast and reliable transportation is increasing throughout the world, particularly in developing nations. In many countries high-speed rail has been solution for it. Trains are fast, comfortable, and energy efficient. Conventional railroads, however, operate at speeds below 300 km while maglev vehicles are designed for operating speeds of up to 500 km. A maglev train is a train-like vehicle that is suspended in the air above the track and propelled forward using the repulsive and attractive forces of magnetism.

A major advantage of maglev systems is their ability to operate in almost all-weather conditions; they are prepared for icy conditions because they do not require overhead power lines that are subject to freezing on conventional railroads. The epoch-making technology would change the train control system from conventional manual control to ground-based control. The United States is lagging behind European countries in high-speed rail research and development. In 1986, the U.S. government stopped all funding toward maglev technology. Meanwhile, in Germany and Japan, magnetic levitation is being implemented to solve public transportation problems. Germany is the furthest into their development efforts and the closest to beginning construction of a commercial maglev route. In 1991, the German government approved a maglev route for public transportation that will run from Hamburg to Berlin.

While America appears to be many years from the first maglev demonstration, this practical form of high-speed transportation will soon be a reality in Germany and Japan. Japan and Germany have invested billions of dollars into the research and development of their maglev systems. In the United States, communities from Florida to California are considering building maglev systems. However, the full potential of application has not yet been realized, and the introduction of maglev systems has been slow to occur. Cost and complexity may be among the reasons.

VII. Future Scope:

Magnetic Levitation can be used in applications of high-power requirement. It can be used in applications such as speed transportation. Magnetic Levitation can be used as a source for launching rockets. The future application of magnetic levitation could optimize business systems and conventional operating models. Perhaps the most obvious impact would be on modes of personal and commercial transportation. Infrastructures within and between countries would have to change to facilitate the technology.

The Magnetic Levitation Technology has been taken to consideration in order to create cities at a level far above the earth. This technology has been proposed by a Chinese architect named Wei Zhao. The concept was named as Heaven and Earth.

Figure 8. Heaven and Earth

Automated moving vehicles can be manufactured with advance technologies and varied possible ways for speedy transportation with speeds around 300km/hr.

Figure 9. Automated Moving Vehicles

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