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DESIGN AND DEVELOPMENT OF ELECTROMAGNETIC POWER GENERATION SYSTEM

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Abstract - The non-renewable energy sources such as petrol as being depleted day by day. The renewable energy sources are not used to its full potential due to seasonal or climate changes, therefore we need to find a power source which is available all the time and it should be within our surroundings so as to save the power wasted during transmission.Here the electricity is generated by a non- conventional method .Here we are converting mechanical energy to electrical energy. In this modernised era non-conventional energy system is essential for us. It's an eco-friendly project and the losses are minimum as compared to other energy resources.In this research the working principle is electromagnetic induction. The control mechanism carries a copper coil wound around a core. A rechargeable battery is used to store this generated voltage.
Keywords: electromagnetic induction, renewable energy source.

I. INTRODUCTION

While energy surrounds us in all aspects of life, the ability to harness it and use it for constructive ends as economically as possible is the challenge for us. Alternative energy refers to energy sources, which are not based on the burning of fossil fuels or the splitting of atoms. The renewed interest in this field of study comes from the undesirable effects of pollution both from burning fossil fuels and from nuclear waste by-products. Fortunately there are many means of harnessing energy, which have less damaging impacts on our environment. We have many alternatives such as solar power, tidal power, and hydroelectric power. But the major drawback is they occupy more space, and the energy loss during transmission is considerably high.In addition to these we have developed a new methodology of generating power and we call this alternative "Magnecity". Magnecity finds its application on roads (speed breakers, pavements), gyms, suspension systems and corridors of a building.

WORKING PRINCIPLE

This project works on the principle of electromagnetic induction. When current passes through a conductor, a magnetizing force and hence a static magnetic field is produced which can be intensified by winding the conductor over a core.

In this project, we use this principle in reverse which is also known as self-induction. Here, we keep the coil stationary and make the magnet move to and fro inside it. As the magnetic field lines are cut by the coil, an electromotive force (EMF) is developed.

This phenomenon is known as Electro-magnetic induction, and was first discovered by Michael Faraday back in 1830's.

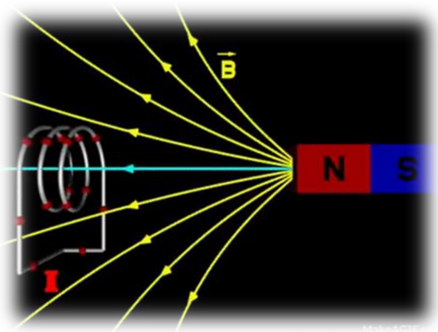

Figure 1.1 Principle of Electromagnetic Induction

II. DESIGN OF THE MODEL

The software used to design the model is CATIA V5 R20.Initially we used three wooden planks as shown in figure 3.1. The magnets are fixed to the inner surface of the top plank. There are eight pairs of nut and bolt and eight springs placed between them which are responsible for the linear motion.

The middle plate acts as a guide plate which guides the magnets into the copper coils. Holes are drilled in the guide plate whose diameter is larger than the diameter of the magnets.

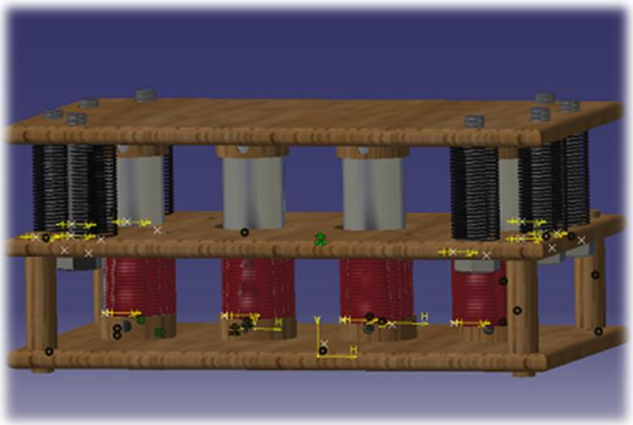

Figure 2.1 3-D design of the model

The bottom layer contains a copper coil consisting of a Bakelite core over which copper wire is wound. There is one coil for each of the magnet. There are four supports between the guide plate and bottom plate.

The fabricated model is an improvised version of the CATIA design.

Ways in which the design can be optimised:

1. The weight of the model should be minimum.
2. The dimensions of the model should be minimum.
3. To reduce the material used for making the model thereby reducing the cost of manufacturing.

III. EXPERIMENTAL EQUIPMENT AND INSTRUMENTATION

The experimental set-up is made for flat surface such as roads, corridors of a building etc. It primarily consists of two layers of wooden plates, neodymium magnets, a hollow core around which copper is wound, led lights, springs, M8 nut and bolts. The coils and magnets are geometrically similar. Figure 3.1 shows a photograph of the experimental set-up.

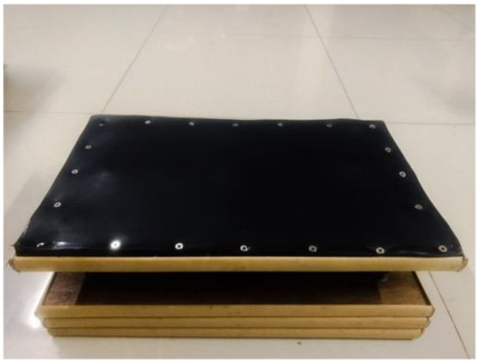

Fig. 3.1 Photograph of fabricated model

Magnet

In the present work, the use of magnets have been well studied. There are many types of magnets are available in the market. Various properties of these magnets have been taken into consideration and neodymium magnets are the considered the best (Refer Table 3.1). A neodymium magnet (also known as NdFeB, NIB or Neomagnet), the most widely used type of rare earth magnet, is a permanent magnet made from an alloy of neodymium, iron and boron to form the $Nd_2Fe_{14}B$ tetragonal crystalline structure.Neodymium magnets are the strongest type of permanent magnet commercially available. They have replaced other types of magnets in many applications in modern products that require strong permanent magnets, such as motors in cordless tools, hard disk drives and magnetic fasteners. The dimensions of the magnet are20mm in diameter and 4mm in thickness.

Material Properties

The mechanical properties of neodymium magnets are given below

Table 3.1 Typical physical properties of neodymium magnets

PROPERTY	VALUE
Coercivity (C)	0.875-1.99 MA/m
Relative permeability	1.05
Flexural strength (F_s)	250 N/mm²
Tensile strength (T_3)	75 N/mm²
Vickers hardness (V_h)	550-650 HV
Magnetic field strength (M_m)	40 BHmax or MGOe

Fig. 3.2 Neodymium magnets used in experiment

Wood

The base of the model is made of wooden plank. The geometry of the wood is rectangle. The dimensions of the plank are 435mmx265mmx15mm. Wood is considered because of its lightweight, easy availability and easy machinability. The upper plank is made of the same dimensions and the distance between them is 50mm.The linear motion between the two planks is restricted to 25mm.The neodymium magnets are fixed to the upper plank in 3 columns with each column of 5 magnets. The copper coils are fixed in the lower planks.The coils are fit into the planks to reduce the distance between the two planks so as to reduce the overall height of the model. The two planks are held together 6 pairs of nuts and bolts with springs between them. The springs help in bringing back the top plate to its initial position after the applied load is removed.

Copper coil

Copper coils play an important role in this experiment. These coils and the neodymium magnets together generate electricity. The coils are wound around a core made of non-magnetic material (Bakelite). The voltage generated is directly proportional to the number of turns in the coil. The thicker the diameter of the copper coil , more power is generated. In this experiment we use three copper coils in which two of them have similar dimensions than the other one. Since the discovery of copper in the early days it is known for its ductility and low resistivity. Due to this properties copper is used to transmit current from one place to another. The dimensions are given in table 3.2.

Table 3.2 Dimensions of copper coil

Sl no	Entity	Coil 1	Coil 2	Coil 3
1	Gauge*	33	30	33
2	Coil diameter (D)	0.180mm	0.255mm	0.180mm
3	Core diameter (D)	22mm	22mm	22mm
4	Length of core (L)	40mm	40mm	40mm
5	No of turns (n)	600	1150	600

*The conversion of gauge to mm are based on the American Wire Gauge (AWG) system.

In the above table we have two different coils with two different outputs. In order to show the output of the power generated, we are using LED's. When force is applied on the upper plank, the magnet enters these hollow copper coils and a voltage is generated. According to the gauge and the number of turns of the copper coil, the voltage drop differs.

Fig. 3.3 Copper coil

IV. EXPERIMENTAL METHODS

In order to determine the voltage and current generated by each coil, the following procedure was followed. A cathode ray oscilloscope (CRO) was used to determine the current and the voltage values. We chose to use a CRO since it is sensitive enough to detect pulses of the generated voltage. The core used in this experiment is non-magnetic. If the core is made of a metal there are chances of the magnet getting attracted to the core which will hinder the linear motion between and the magnet and the coil . Before we assemble the model we need to know the individual output of each coil and magnet pair. For a single coil 4 magnets are used. Connect the two end of the coils to the CRO and bring the magnet inside the coil .The output is shown in the CRO display. Follow the same procedure for the other 2 coils and note down the readings

When a force is applied on the plank, due to the applied force the spring compresses. There are two linear motion when the force is applied, i.e. when the force is applied and when the applied force is removed. When the force is applied, the two coils having lesser no of turns (Coil 1 and 3) powers the big led array and when the applied force is removed, the coil having more no of turns (Coil 2) powers the other led light.

The compression of the spring depends on the stiffness constant of the spring. Compression of the spring is directly proportional to the stiffness constant. The stiffness of a body is a measure of the resistance offered by an elastic body to deformation. Here we are dealing with one Degree Of Freedom (DOF).

The formula for stiffness constant is given by

$$\mathbf{k}=\frac{F}{\delta}$$

Where,

k is the stiffness constant

F is the force on the body

δis the displacement produced by the force along the same degree of freedom (for instance, the change in length of a stretched spring).

In the International System of Units, stiffness is typically measured in Newtons per meter (N/m).In this the force applied is approximately 7kg (68.67 N).The displacement of the spring is 1.5cm (15mm). By substituting these values in the above formula we get

$$\mathbf{k}=\frac{F}{\delta}$$

$$\mathbf{k}=\frac{68.67}{15}= \ \mathbf{4.578}\ N/\mathbf{mm}$$

Neodymium magnets are graded according to their maximum energy product, which relates to the magnetic flux output per unit volume. Higher values indicate stronger magnets and range from N35 up to N52. Letters following the grade indicate maximum operating temperatures, also known as Curie temperature , which range from M (100 °C) to EH (200 °C). Some of the grades of neodymium magnets are

1. N35-N52
2. N33M-N48M
3. N30H-N45H
4. N30SH-N42SH
5. N30UH-N35UH
6. N28EH-N35EH

According to the application we can choose the desired grade of neodymium magnets available in the market.

V. EXPERIMENTAL RESULTS AND DISCUSSION

Experiments conducted in the present work are summarized as follows. The comparison of voltage drop, no of turns and gauge, of each coil used in this experiment are given below

Table 4.1 Comparison of voltage drop and dimensions of coil

Sl no	Entity	Coil 1	Coil 2	Coil 3
1	Voltage (V)	1.3-1.7 V	2.5 -3.6V	1.3-1.5 V
2	Current (I)	.075-0.095 A	0.160-0.180 A	0.075-0.090 A
3	Gauge	33	30	33
4	No of turns (n)	600	1150	600

The voltage and current varies according to the change in magnetic flux

From table 6.1, we can compare the voltage generated by each coil with respect to the dimensions of the coil. The voltage generated is directly proportional to the number of turns of the coil. To achieve high outputs we need to consider the ideal number of turns and approximate gauge of copper coil.

Spring stiffness also plays an important role in this experiment. The model should be compressed to the maximum extent to get more output. As the spring stiffness increases we need more force to compress the model. To decide the stiffness constant of the spring certain factors are taken into consideration, such as average weight of person, weight of the automobile etc.

If we assume a person of 60kg weight is stepping on the model, the model should compress and come back to its original position. If we use springs having higher value of stiffness constant then we will have to apply a larger force in order to compress the spring.

VI.CONCLUSIONS

Experiments have been conducted for two different coils having same core diameter with two different gauges.In the present work we establish a relation between the voltage drop and the no of turns in a coil and the spring stiffness.

Conclusions drawn from the present work areas follow:

1. The voltage generated is highest in the coil having more no of turns coil 2 having 1150 turns followed by coil 1 and 3 having 600 turns each.
2. The higher the maximum energy product the more powerful the magnet. In this case neodymium magnet has an energy product of 40, followed by SmCo (Samarium-Cobalt) magnets having an energy product of 26.
3. The voltage drop is inversely proportional to the gauge of the coil.

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