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Generating a Greater Magnetic Force Using a Single Winding Transformer as a Solenoid

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***Abstract*-- This paper puts forth an effective way of increasing the magnetic force developed by a solenoid coil using a single winding transformer with its core and E-shaped stampings. A solenoid coil is a device which consists of copper wire wound on a core or bobbin. It produces a magnetic field when electric current is passed through the coil. A varying magnetic force using a solenoid coil can be generated using a different value of electric current.**

Keywords- **Solenoid, coil, Transformer, Stampings, magnetic force.**

1. Introduction

. A solenoid coil using a cylindrical bobbin is widely used nowadays. Using such coils, less force is generated which is suitable to certain low force applications. But if larger amount of force is required then above-mentioned solenoid coils have limited usage and uneconomical considering current carrying capacity, size of the wire, voltage supplied and cost of the setup.

In this paper a distinctive method of making a solenoid coil has been developed. As stated above this solenoid coil consists of a Transformer with a single winding, stampings and a non-ferromagnetic core.

2. Literature Review

- Principle of Electro-magnetism: -

The principle of electromagnetism states that when current is passed through a coil of electrically conducting wire, magnetic flux is generated. When a metal is kept in the core of the coil, these lines of flux are cut by the coil and a force is generated. (Kumar, 2019)

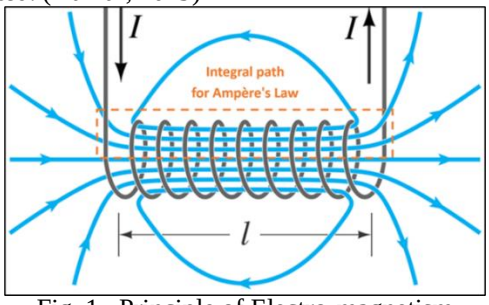

Fig. 1– Principle of Electro-magnetism

From "An Introduction to Solenoids" by Kumar, 2019, CircuitDigest (https://circuitdigest.com/article/what-is-solenoid-its-working-principle-and-types)

- Solenoid: -

A certain length of wire wound around a core is called a solenoid. The solenoid has two parts- stationary part known as core and a moveable part known as armature (Electric Solenoid Valves, 2021). A typical Solenoid coil and its parts are shown in Figure 2. In the solenoid mentioned in this paper, the stationary core is the bobbin with wire wound around it and the moving core is the I-shaped stampings.

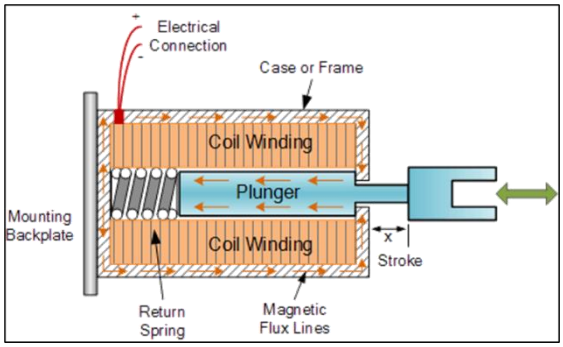

Fig. 2- Simple Solenoid

Note: From The working principle of the Linear Solenoid, by Zanty Electronics, n.d., (http://www.zantysolenoid.com/the-working-principle-of-the-linear-solenoid_n35)

There are mainly 5 types of solenoids as mentioned by (Kumar, 2019):-

1. AC- Laminated Solenoid
2. DC- C Frame Solenoid
3. DC- D Frame Solenoid
4. Linear Solenoid
5. Rotary Solenoid

Of these, the type of solenoid used in this experiment is Linear Solenoid.

- Materials and components: -

1. Plastic Bobbin
2. E- Shaped Transformer Stampings
3. Copper Wire
4. I- Shaped Transformer Stampings

1. Plastic Bobbin: -

It is a non-conductive and non-magnetic rectangular shaped plastic bobbin. It has enlarged section to facilitate winding of copper wire and restrict the wire from untwisting. It is made up of 35mm*48mm plastic material as shown in Fig 3 with hollow cavity in the middle for inserting the E-shaped through it.

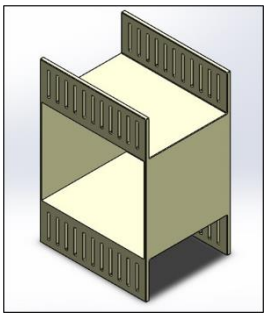

Fig.3- Plastic Bobbin

2. E-shaped Transformer Stampings: -

The E-shaped stampings from the transformer are used in this solenoid. It serves the purpose of generating magnetic field when current is passed through the copper winding. The copper winding is placed on the central arm of the stamping. Several number of stampings can be used as per requirement of the strength of the magnetic field. Fig 4 shows the E-shaped stampings.

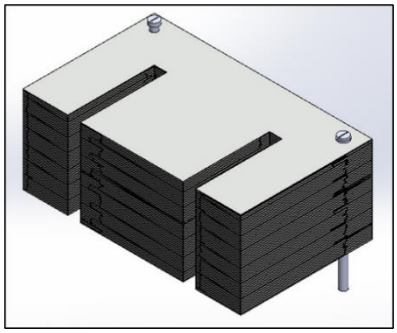

Fig.4- E-shaped Stampings

3. Copper wire: -

Copper wire is best suited for electrical applications because of its low electrical resistance. A copper wire is available in various sizes based on the diameter. According to application, a preferred size copper wire can be wound on plastic core to form a winding. Copper wire is available wound around a plastic bobbing as shown in figure 5. The size of the wire is mentioned in gauges and higher the gauge number, smaller the diameter of the wire.

Fig.5- Copper WireNote: From “Enamelled copper wire” by Masfarne Europa, n.d., (https://www.masfarne.com/enamelled-copper-wire-p-31-en)

4. I-shaped stampings: -

I-shaped stampings are used in the solenoid coil. They act as a movable arm and are pivoted at one end. The other end is free to move. This stamping is attracted to the E-shaped stamping when sufficient amount of magnetic force is generated. The number of I-shaped stampings should be equal to the number of E-shaped stampings for effective operation.

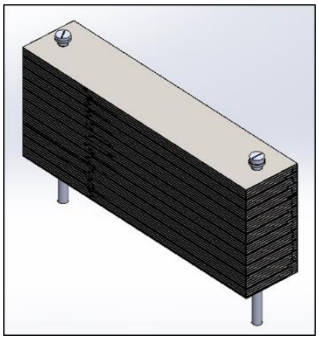

Fig.6- I-shaped Stampings

• Working Principle: -

The solenoid coil works on the principle electromagnetism i.e., when an electric current is passed through a conductor, magnetic field is generated (Kumar, 2019). This field pulls the plunger attached to the coil inwards towards the body of the solenoid coil. This principle is used in the solenoid coil mentioned above. The current is passed through the copper wire wound around a non-conducting core. This results in generation of magnetic field in the E-shaped stampings resulting in the I-shaped stampings getting attracted towards the E-shaped stampings. The solenoid coil used for the experiment has been shown in figure 7.

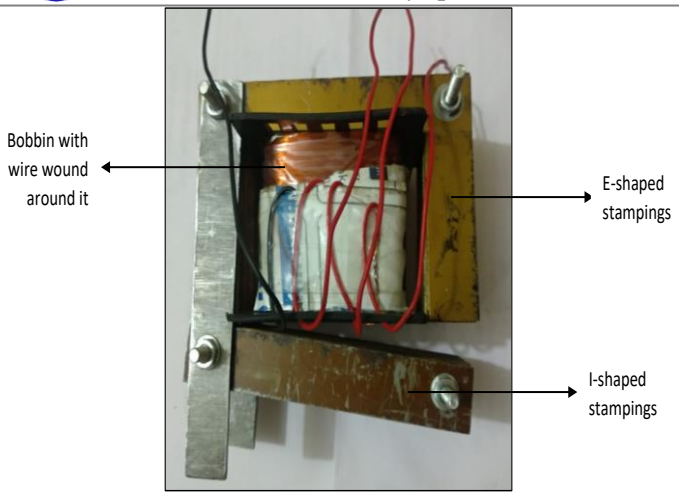

Figure 7- Solenoid Coil

The solenoid coil mentioned above was designed and tested using various sizes of the copper wire wound in the core. The results are tabulated in the table below: -

Table 1: - Experimental Results

Sr. No.	Wire Diameter	No. of turns	Magnetic field (µT)
1	28 Gauge/0.321mm	6000	49.06
2	30 Gauge/0.255mm	6000	58.4
3	32 Gauge/0.202mm	6000	66.46
4	34 Gauge/0.160mm	6000	72.76
5	36 Gauge/0.127mm	6000	77.32
6	38 Gauge/0.101mm	6000	80.49

Formula for calculating the electromagnetic force has been mentioned below (Production solution, 2019). Using the above setup, an electromagnetic force as high as 9.472kN can be obtained from the solenoid.

$$F = (N \times I)^2 \times K \times A / (2 \times G^2)$$

Where,

N= number of turns in solenoid

I= current in amperes

K= 4*3.14159*10^-7 (constant)

G= gap between the coil and piece of metal

A= cross-section area of the coil in m2

- Experimental Results and Comparison: -

From the formula above, it can be seen that the electromagnetic force generated can be varied by changing the number of turns of the wire, current in amperes, and area of cross-section of the coil.

The results in the above table 1 have been calculated using the calculator on Omni Calculators Website (Panfil, 2021).

- Conclusion: -

From the above research it can be seen that using a single winding transformer a higher amount of force can be generated which can be useful in many industrial applications as used for controlling of an elevator in case of its free fall mentioned in a research paper published in International Journal of Advance Research, Ideas and Innovation in Technology (IJARIIT) (Keskar & Khadilkar, 2019).

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