

Construction And Investigation Of Electromagnetic Engine

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Abstract

Increasing fuel prices and pollution are the major demerits of Internal Combustion (IC) engines. Also presently the demand for fuel has increased and in the nearby future, shortage of fossil fuels is being expected due to the ever growing consumption. So need of alternative energy has become necessary. The main object of this paper is construction of Electromagnet Engine (prototype) and study at various current inputs principle of magnetism. The working principle of the engine is the magnetic force principle, i.e. magnetic repulsion between the same poles of two different magnets. When similar poles of two different magnets come in contact with each other they repel each other. This phenomenon of repulsion is used in this engine to create motion.

This is an engine in which reciprocating movement of piston is created by the magnetic forces. Here the cylinder head is an electromagnet and piston is a permanent magnet. The movement of piston from Top Dead Centre (TDC) to Bottom Dead Centre (BDC) by the repulsion between cylinder head and piston and its movement from BDC to TDC takes place due to force of attraction between cylinder head and piston. The working principle of electromagnetic engine is based on magnetic attraction and repulsion phenomenon i.e. Magnetic repulsion between same pole and attraction between different pole. This principle moves piston TDC to BDC and vice versa. .

Keywords: Electromagnet, TDC-Top Dead center, BDC-Bottom Dead Center.

1. INTRODUCTION

The internal combustion engines that which are using in present day automobiles have an efficiency of around 35 to 40%. This is due to loss of heat energy through various parts of engine combustion chamber and engine are. Heat lost to cylinder walls. Heat taken away by lubricating oil, Heat absorbed by piston, Heat absorbed by cylinder head and. Heat taken away by the flue gases. Mechanical efficiency is the percentage of energy that the engine puts out after subtracting mechanical losses such as friction, compared to what the engine would put out with no power loss. Most engines are about 94% mechanically efficient.

So need to alternate these Internal Combustion (IC) engines by electromagnetic engine

The electronic circuit typically consists of a 555 timer integrated circuit along with some other electronic components which are required for switching. As it is difficult to change the current passing through one circuit, so there is a need to employ two independent circuits which are connected to the electromagnet by their respective transistor switches to the electromagnet coil.

For the sensing of the **Top Dead Centre** (TDC) and **Bottom Dead Centre** (BDC), two Inductive proximity sensors are being employed. One sensor will sense the

TDC and the other will sense the BDC. These two sensor signals are independent of each other.

2. LITERATURE SURVEY

In the late 1820s and early 1830s two of the world's leading scientists; Michael Faraday and Joseph Henry were conducting a series of experiments utilizing the newly discovered phenomenon of electromagnetism. This work led to a number of scientists endeavoring to develop practical electric motors. The early electromagnetic engines can be broadly divided into two groups. The first to appear were the reciprocating engines. One problem that faced the experimenters was converting the linear motion of an electromagnet into a rotary motion. Contemporary steam engines solved this problem by the use of connecting rods and cranks and initially it seemed logical to follow suit. These reciprocating electromagnetic engines are a fascinating example of one of technologies dead ends.

Victor Konev [1] explains about the most common electromagnetic drives. A Sumit Dhangar et al [2] describe the construction and design of a V-type magnetic piston engine, which operate with the help of electromagnetic force. This mechanism is entirely different from normal IC engine mechanism. It works with electromagnetic effect and repulsion of magnetic force instead of fossil fuels. It consists of, two permanent magnet and two electro magnet

J. Rithula et al [3] reviewed about the electromagnetically reciprocating automobile engine. A four-stroke engine is used in the vehicle. The design involves the replacement of the spark plugs and valves by conductors and strong electromagnetic material. Amarnath Jayaprakash et al [4] review report on magnetic damping properties, residual magnetism and the effect of heat on neodymium magnets. A prototype is designed where relay switches are replaced with position sensors. A. F.

Abdelaziz et al [5] gives about the electromagnetic field distribution inside a jet engine is studied through full wave analysis. Results are statistically analyzed by comparisons to the models used for the reverberation chamber with a mechanical mode stirrer.

3. ELECTROMAGNETIC ENGINE

This is an engine in which reciprocating movement of piston is created by the magnetic forces. Here the cylinder head is an electromagnet and piston is a permanent magnet. The movement of piston from Top Dead Centre (TDC) to Bottom Dead Centre (BDC) by the repulsion between cylinder head and piston and its movement from BDC to TDC takes place due to force of attraction between cylinder head and piston. As the piston is a permanent magnet, the poles cannot be changed periodically so the only chance to change is reversing the current direction in the electromagnet periodically i.e., let us assume that the piston has North Pole at the top. So, when the piston arrives at the TDC, the current in the electromagnet flows in such a way that the cylinder head inside the chamber acts as North Pole. Assume that permanent magnet is aligned such that it has a north pole at its top. So, there will be repulsion between piston and cylinder head. Due to this force, the piston moves down rotating the crank shaft. And when the piston reaches the BDC, the current direction in the coil of electromagnet is reversed so the previous north pole of electromagnet now becomes South Pole. At this point there will be force of attraction between cylinder head and piston so the piston moves from BDC to TDC. This change of current direction is done by sensing the position of TDC and BDC and employing appropriate electronic circuit to send the current in a required direction periodically

3.1 ELEMENTS OF ELECTROMAGNETIC ENGINE

The following are the parts of electromagnetic engine:

- Cylinder block
- Cylinder head
- Piston with permanent magnetic head
- Electromagnet
- Crank
- Connecting rod
- Shaft
- Inductive proximity sensors
- Circular disc with tooth
- Electronic circuit

➤ Specifications of electromagnet:

- Part No : BDE-2016-12
- Diameter : 2 inches
- Length : 1.625 inches
- Required voltage : 12 volts
- Minimum power required: 5.2 Watt
- Pull : 220 lbs.
- Weight : 1 lb.

➤ Specifications:

- Supply voltage : 10-30 VDC
- Ripple on supply : 10% max
- No load current : less than 10 mA
- Maximum load current : 100 mA/300 mA (for M12 and above)
- Hysteresis : 15% max
- Operating temperature : -25°C to 70°C
- Output transistor : PNP
- Output logic : NO or NC
- Repeat accuracy : less than 0.02 mm
- Temperature drift : 5% typical
- Switch on effect : incorporated
- Reverse polarity protection: provided
- Short circuit protection : provided
- Status indication : provided through LED
- Type : Flush mounted
- Sensing distance : 8 mm (for mild steel material sensing)

3.2 Timer 555IC

The 555 timer IC is an integrated circuit (chip) used in a variety of timer, pulse generation, and oscillator applications. The 555 can be used to provide time delays, as an oscillator, and as a flip-flop element. Derivatives provide up to four timing circuits in one package. Introduced in 1972 by Signetics, the 555 is still in widespread use, low price, and good stability



Fig 3.1: Electromagnet

3.1.1 INDUCTIVE PROXIMITY SENSORS

Inductive proximity sensors can be used for position sensing, speed measurement, counting & in conditions such as oily, dusty, corrosive environment.

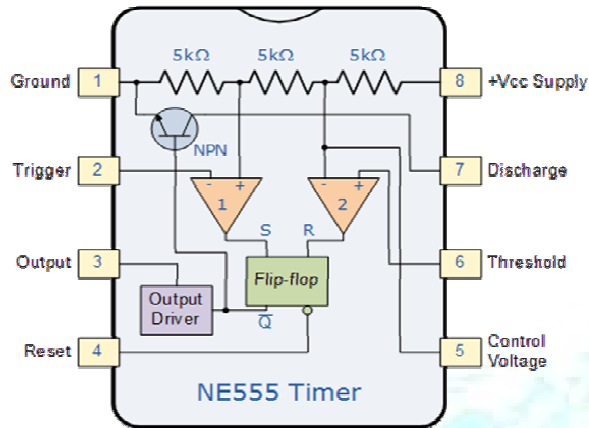


Fig 3.2: NE 555 Timer

3.3 CONSTRUCTION PROCEDURE

- Select an old engine (50 cc) make a slot in the cylinder head from the top and having an internal collar exactly at the end of cylinder head so that it can support the electromagnet. Make sure that the collar is made of aluminium so that it and its associated parts will not be affected by the magnetic field. Make a provision in the cylinder head for the terminals of the electromagnet.
- Cut the piston top portion and make a seating position for the permanent magnet (Neodymium Boron). Make sure that it should not affect the stroke length and the movement of connecting rod and piston pin.
- The permanent magnet is bonded to the piston by using **ARALDITE**. Araldite is a synthetic epoxy resin adhesive for bonding metals, glass, porcelain, and other materials. Araldite sets by the interaction of a resin with a hardener. Heat is not necessary although warming will reduce the curing time and improve the strength of the bond.
- Extend the shaft of the engine and fit a disc to it (metal or non-metal) but should contain a single

mild steel tooth at its circumference so that it can be sensed by the proximity sensors.

- Circumferentially to this disc, arrange a proximity sensor such that it senses the position just a degree before the Top Dead Centre.
- Similarly and Exactly opposite to this sensor, place another sensor so that it senses the position a degree before Bottom Dead Centre.
- The two sensors are then connected to two independent monostable circuits.
- Build the circuit as per the circuit diagram but make sure of the capacitors as per the requirement.
- Make sure that all the connections are made perfectly without failure (short circuited).

4. RESULTS AND DISCUSSION

The electromagnetic engine which works on the principle of magnetism was successfully designed and fabricated. Experimental analysis was successfully performed on the prototype. The results obtained from the experiment are as follows.

4.1 SPEED VS TIME DELAY

As the speed is getting increased, the frequency of pulses sent by the position sensor increases. So, then the later time delay will accommodate more than a pulse. So, the time delay has to decrease with increase the speed. It is good to have the electromagnet in active condition up to 43.2% of the time between two pulses.

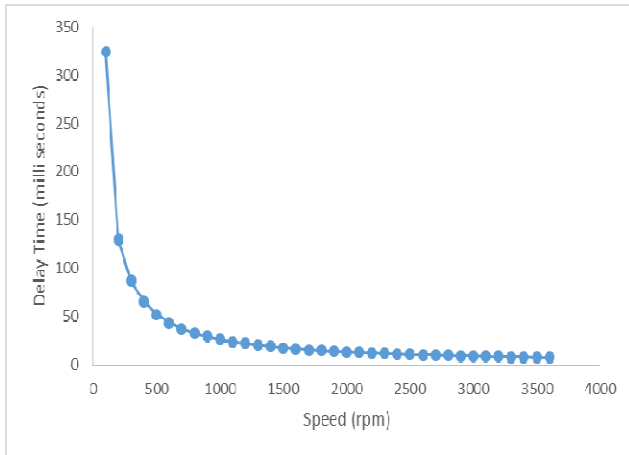


Figure 4.1: Showing time delay vs Speed

Figure 4.1 shows Delay time is on Y-axis and speed is on X-axis. So, as per the graph obtained the time delay has to be increasing with decreasing speed

The speed as given by

$$\text{Speed} = \frac{30902.643}{\text{Time delay}^{1.0232349}}$$

So, speed is inversely proportional to 1.0232349th power of time delay.

4.2 INPUT CURRENT AND MAGNETIC FLUX DENSITY

As the piston is reciprocating, the field not only varies with current and also with the distance between the electromagnet. So, to calculate the **off axis field** shown in figure in 4.2, the individual fields of electromagnet and permanent magnet are to be calculated first and according to the position of those two magnets, the fields at respective distances will be added.

Firstly observe how the field of electromagnet is getting varied with the current and distance outside the core. It varies according to the relation as shown below.

At points far from a magnet, solenoid, current loop or Helmholtz coil, you can approximate the field by

modelling the coil (or magnet) as a magnetic dipole moment. The error of this technique is less than roughly 2% at distances greater than 5 times the largest dimension of the coil (or magnet), and it approaches 0% as the distance approaches infinity.

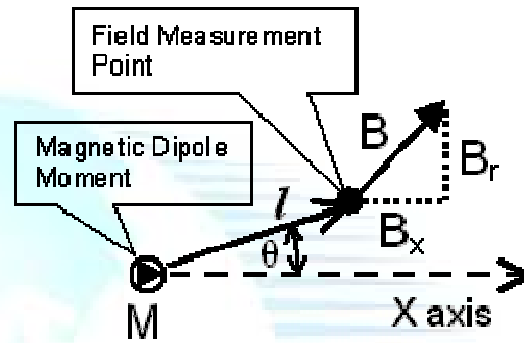


Figure 4.2: Off Axis Field

B is the magnetic field, in tesla, at any point in space that isn't at the origin. It is equal to the sum of two field components,

B_x – The magnetic field component which is aligned with the x axis and

B_r –The magnetic field component which is in a radial direction.

x- The distance, on axis, from the dipole to the field measurement point, in meters.

l - The distance from the dipole to the field measurement point, in meters.

θ- Angle between the dipole axis, and the position vector of the field measurement point.

$$B_x = \frac{\mu_0 M}{4\pi} \left[\frac{3(\cos \theta)^2 - 1}{l^3} \right]$$

$$B_r = \frac{\mu_0 M}{4\pi} \left[\frac{3 \cos \theta \sin \theta}{l^3} \right]$$

As dealing with the reciprocating motion, there is no need to consider the radial component of magnetic field. And also as it is going along the axis, the value of θ is also zero.

M- Magnetic moment of electromagnet

$$M = \frac{NIA}{L}$$

μ_0 - Permeability of air = $4\pi * 10^{-7} N/A^2$

N- Number of turns in the coil of electromagnet= 2000 turns

I- Current passing through the coil of electromagnet

A- Cross-sectional area of core

L- Length of core

After substituting all these values the above axial component of magnetic field, we get

$$B = 5597.74 \frac{I}{x^3} \text{ gauss}$$

So at various current inputs, the field of electromagnet varies along the stroke as graphs are shown from figure 4.3 to 4.8.

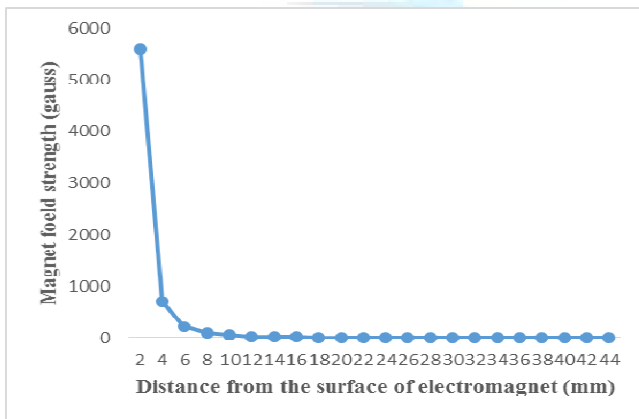


Figure 4.3: Magnetic field along the stroke at I= 8A

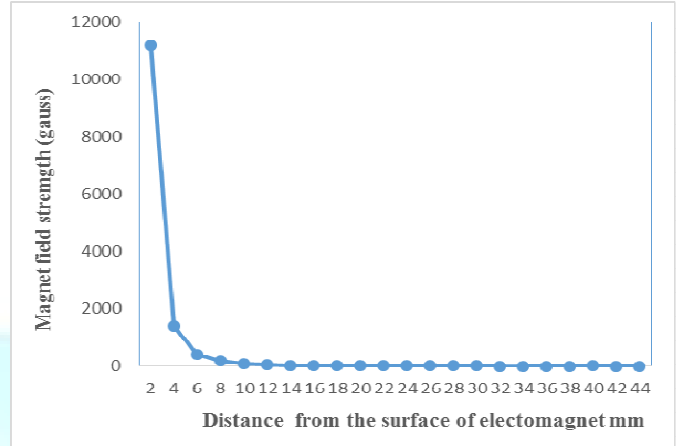


Figure 4.4: Magnetic field along the stroke at I= 16A

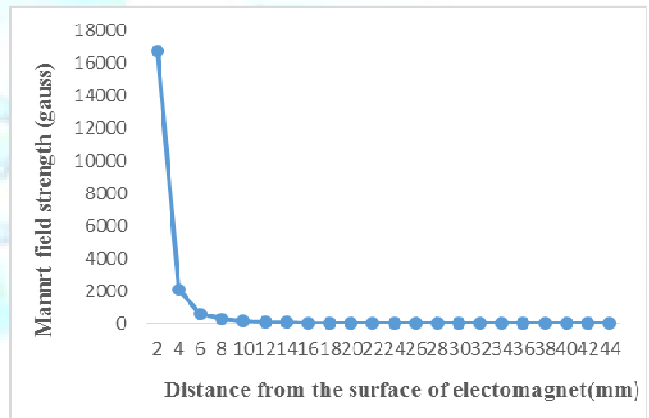


Figure 4.5: Magnetic field along stroke at I = 24A

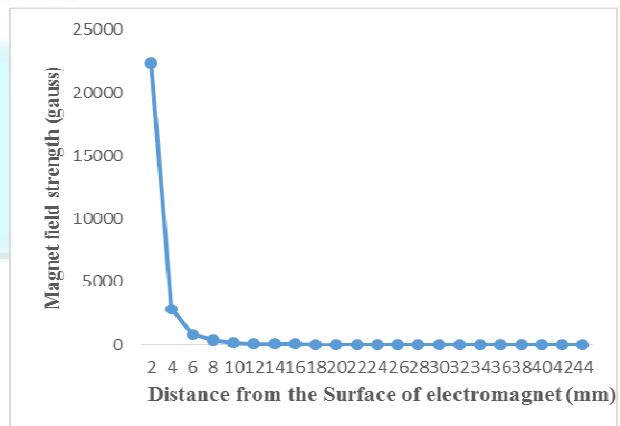


Figure 4.6: Magnetic field along the stroke at I = 32A

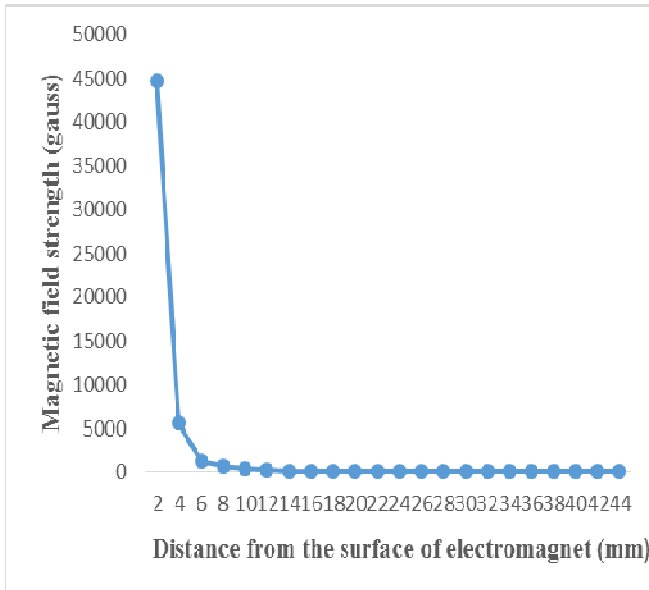


Figure 4.7: Magnetic field along stroke at I = 64A

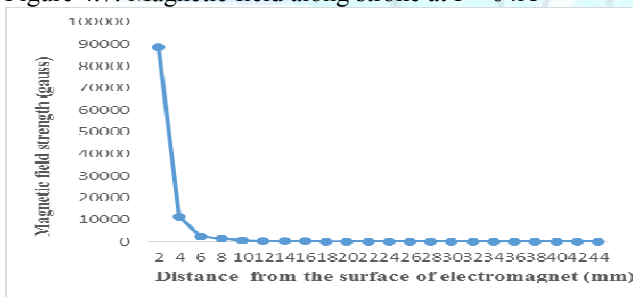


Figure 4.8: Magnetic field along the stroke at I = 128A

Here the distance along the stroke is plotted on X- axis and magnetic field strength is taken along Y-axis. So, from the graph it can be extracted that the field strength increases with increase in the current (ampere A) in the coil of electromagnet. For the design engine (50 cc) a minimum of 64 A, 12 V is desired values.

The field strength of permanent magnet will increase with the decreasing distance along the stroke shown in figure 4.9.

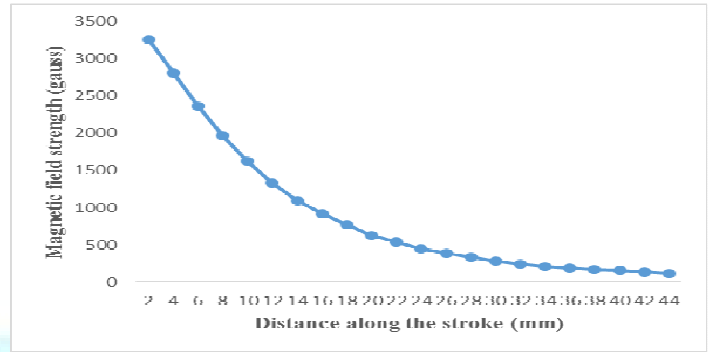


Figure 4.9: Magnetic field along the stroke for permanent magnet.

B-Field strength in gauss

x- Distance in mm

$$B = -4.9552332 \times 10^{-9} \times x^6 + 0.00072994649 \times x^5 - 0.040635342 \times x^4 + 0.98327766 \times x^3 - 4.971.63 \times x^2 - 224.19406 \times x + 3722.0638$$

This is obtained as a 6th degree polynomial equation after being interpolated. The field variation with distance for permanent magnet is different from electromagnet. To calculate field density for a particular distance between electromagnet and permanent magnet, use electromagnet field strength value at a distance equal to the distance of the surface of permanent magnet and use permanent magnet field strength value at the same distance. If we add those two we will get the net field strength value.

The below figure 4.10 shows the variation of field for permanent magnet

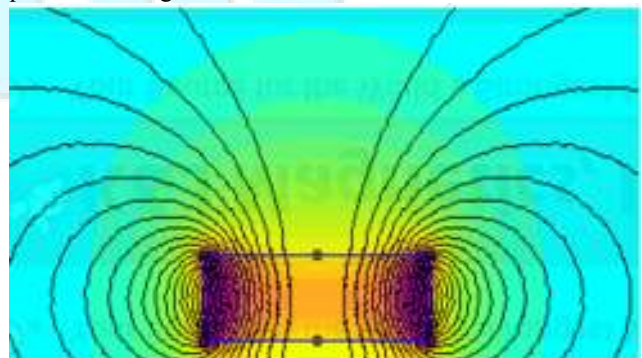


Fig 4.10: Field of Permanent Magnetic.

The violet colour field is the high strength field and the blue colour field is the low strength field. But along the axis, the yellow colour field is the high strength field and blue is the low strength field

4.3 FORCE BETWEEN MAGNETS VS DISTANCE BETWEEN MAGNETS

The force produced by the electromagnet is different from the force between electromagnet and permanent magnet, it is given by

$$F = \frac{\mu_0 m_1 m_2}{4\pi x^2}$$

μ_0 – Permeability of free space

m_1 – Pole moment of electromagnet

m_2 – Pole moment of permanent magnet

x – Distance between two magnets

$$\mu_0 = 4\pi * 10^{-7} \text{ N/A}^2$$

$$m_1 = \frac{NIA}{L}$$

N- Number of turns in the electromagnetic coil

I – Current through the electromagnetic coil

A – Cross sectional area of the electromagnet core

L- Length of electromagnet core

$$m_2 = \frac{B_0 C}{\mu_0}$$

C- Cross-sectional area of permanent magnet

B_0 – Magnetic flux density very close to the magnet

μ_0 – Permeability of free space

$$\therefore m_2 = \frac{0.36669 * \pi * (15 * 10^{-3})^2}{4\pi * 10^{-7}} = 206.263125 \text{ A - m}$$

$$\therefore F = \frac{4\pi * 10^{-7} * 2000 * 1 * \pi * (14 * 10^{-2})^2 * 206.263125}{10 * 10^{-3} * 4\pi * x^2 * 10^{-6}} = 2540.139 \frac{1}{x^2} \text{ N}$$

Now the variation of magnetic force at various currents along the stroke graphs are plotted below

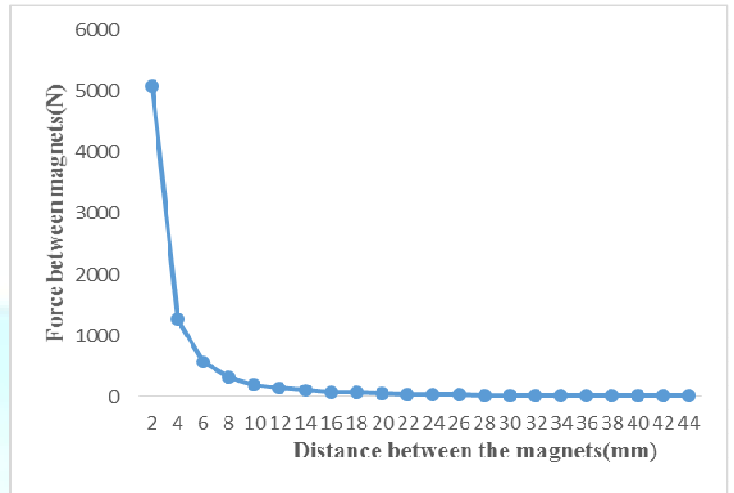


Figure 4.11: Force between magnets at various gaps at I = 8A

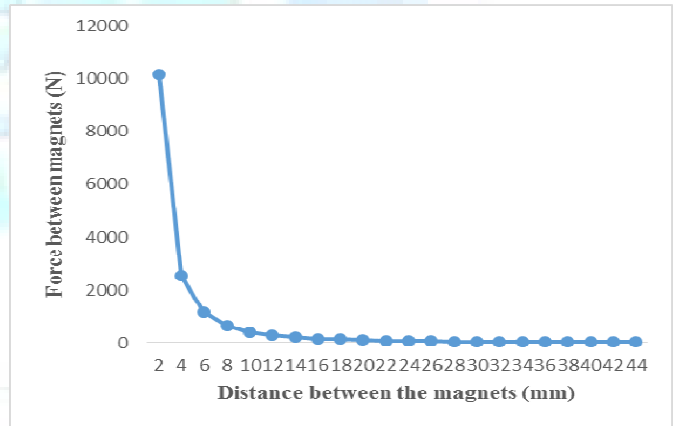


Figure 4.12: Force between magnets at various gaps at I = 16A

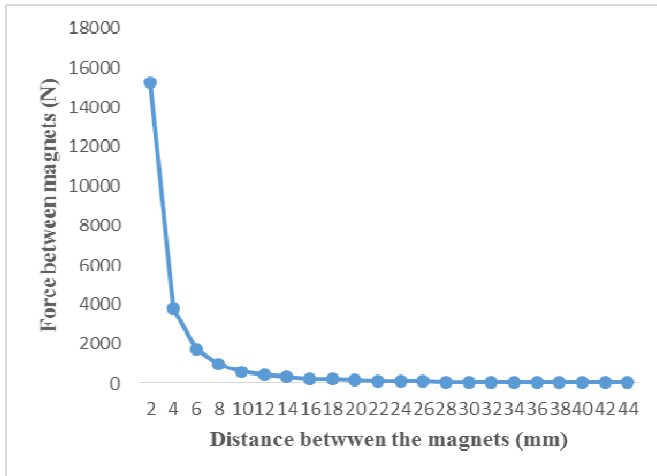


Figure 4.12: Force between magnets at various gaps at I = 24A

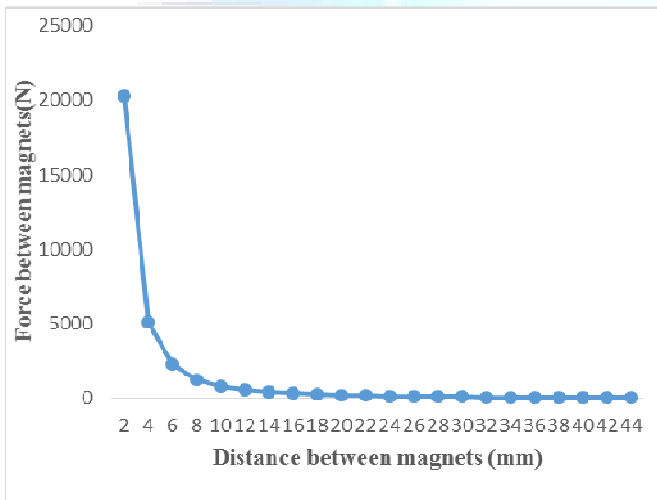


Figure 4.13: Force between magnets at various gaps at I = 32A

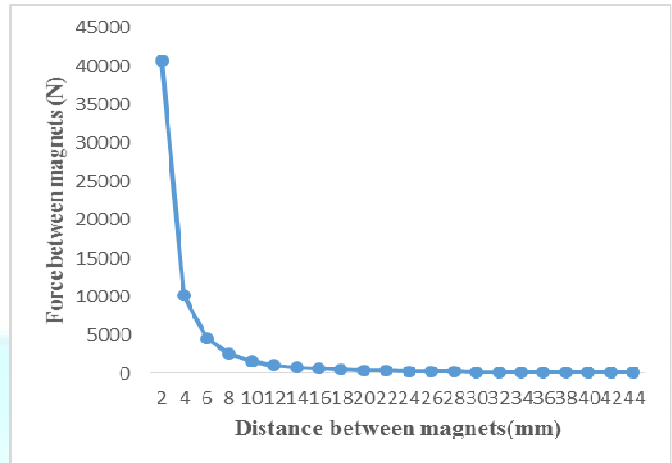


Figure 4.14: Force between magnets at various gaps at I = 64A

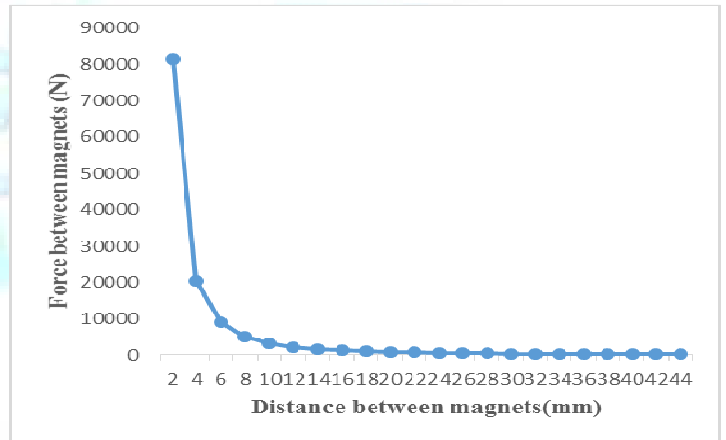


Figure 4.15: Force between magnets at various gaps at I = 128A

From the above graphs 4.11 to 4.15 shows that, the distance between the magnets is taken along X- axis and force between magnets is taken along Y- axis. It can be observed that there is a drastic change of force for every millimeter and it goes on decreasing with the increase in the distance between magnets.

5. CONCLUSIONS

The electromagnetic engine has various advantages. The main advantage is, no fuel is being used in the engine. This results into no pollution which is very need in the present day situation. As there is no any type of combustion taking

place inside the cylinder there is only very little heat generation by the coils. This eliminates the need for a cooling system and desirable for any automobile. As magnetic energy is being used the need for air filter, fuel tank, supply system, fuel filter, fuel injector, fuel pump, valves etc. are neglected and the design of the engine is made simple. Also by the use of materials like Aluminum, titanium etc. we can reduce the weight of the electromagnetic engine

The electromagnetic engine (prototype engine) which works on the principle of magnetism was successfully design and constructed.

- It uses electricity as its input. No fuel is consumed, which was the primary goal.
- The prototype creates no pollution and is eco-friendly.
- The prototype is a two stroke engine.
- Only the repulsive force between the magnet and electromagnet is used for power generation.
- Acceleration is done by controlling the timer which controls the relay
- It can be obtained the time delay has to be increasing with decreasing speed
- The field strength of permanent magnet will increase with the decreasing distance along the stroke.
- It can be extracted that the field strength increases with increase in the current (Ampere A) in the coil of electromagnet.
- It can be observed that there is a drastic change of force for every millimeter and it goes on decreasing with the increase in the distance between magnets.

6. SCOPE OF FEATURE WORK

Extended work need to be done regarding the load which it can bear and how much current need to be supplied to maintain the same speed at different loads. The following results need to be found.

- Current Vs Speed at different loads.
- Speed Vs efficiency at different loads.
- Input Vs efficiency
- Output Vs efficiency
- Torque Vs Speed

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