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 aim of the project is the zero point fuel consumption. 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.

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1. INTRODUCTION

With the diminishing fossil fuel resources and unabated increase in energy costs and environmental concerns, engines using alternate energy sources such as bio-fuel, solar power, wind power, electric power, stored power, etc. are being developed around the world. However, such engines have many limitations. Production of bio-fuel takes enormous resources and they still pollute the environment. They do not meet the ever increasing energy demand as well. Similarly, the solar power is not efficient. Added to all, the initial capital and subsequent maintenance costs for machines that use alternate energy sources are very high. Hence, in the absence of a viable alternative, until now, switching to new technology by changing from traditional Internal Combustion engines has been a challenge.

Magnetism is the basic principle of working for an electromagnetic engine. The general property of magnet i.e. attraction and repulsion forces is converted into mechanical work. A magnet has two poles. A north pole and a south pole. When like poles are brought near each other they repel and attract when like poles are brought together. This principle is being used in the electromagnetic engine.

In this engine, the cylinder head is an electromagnet and a permanent magnet is attached to the piston head.When the electromagnet is charged, it attracts or repels the magnet, thus pushing then piston downwards or upwards thereby rotating the crankshaft. This is how power is generated in the electromagnetic engine. It utilizes only repulsive force that allows the field to dissipate completely, and have no restrictive effects on the rising piston. The electromagnetic engine should ideally perform exactly the same as the internal combustion engine. The power of the engine is controlled by the strength of the field and the strength of the field is controlled by the amount of windings and the current that is being passed through it. If the current is increased the power generated by the engine also increases accordingly. The current that is used to charge the electromagnet is taken from a DC source like a lead acid battery.

The main advantages of electromagnetic engine are that it is pollution free. Also it is easy to design an electromagnetic engine because there are no complicated parts. Since the engine doesn't have combustion, valves, water cooling system, fuel pump, fuel lines, air and fuel filters and inlet and exhaust manifolds etc. can be eliminated from the engine. The main challenge faced in designing an electromagnetic engine is that it has to be as efficient as an internal combustion engine.

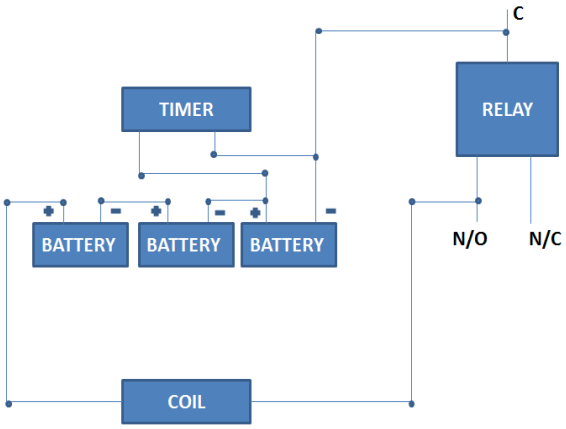
2. WORKING PRINCIPLE

The working of the electromagnetic engine is based on the principle of magnetism. A magnet has two poles a north pole and a south pole. Magnetism is a class of physical phenomenon that includes forces exerted by magnets on other magnets. By principle of magnetism, when like poles of a magnet is brought together they repel away from each other. When unlike poles are brought near each other they attract. This is same for the case of an electromagnet and a permanent magnet too. So the idea is to modify the piston head and cylinder head into magnets so that force can be generated between them.

This working of the electromagnetic engine is based on attraction & repulsive force of the magnet. The engine greatly resembles the working of a two-stroke engine. To start, let us begin from the situation, when piston is located in the lower position. The coil is connected through the battery, the copper coil is energized to produced the magnetic field the piston in side of the large power Neodymium Iron Boron magnets, the piston moved upper and lower the fly wheel connected through the piston link the copper coil energized the piston move upward and copper coil is de-energized the piston move to downward. With the help of relay and control unit. The continuous process through piston is move to (up and down) with also rotated the fly wheel. The

arrangement has shown in the figure no.3.10. Electromagnetic engines working are based on the principle of interaction between the magnetic field

Permanent magnet is fixed in the piston and iron material is connected to copper coil. So that the iron material is converted into electromagnet when the power supply is given to it. When piston is located in the lower position, the coil is connected through the battery. The copper coil is energized to produce the magnetic field. When the copper coil energized the piston move upward and copper coil is de-energized the piston move to downward, with the help of relay and control unit. The continuous process through piston is move to (up and down) with also rotated the fly wheel.



3. DESIGN

Input voltage = 36 V
Input current = 1 A
Input Power = Voltage × Current
= 36 × 1 = 36W

Max. Force exerted by electromagnet on piston

$$F_1 = (N^2I^2KA)/2G^2$$

Where, N = number of turns = 1000
I = Current flowing through coil = 1 A
K = Permeability of free space = $4\pi\times10^{-7}$
A = Cross-sectional area of electromagnet (radius r = 0.0175 m)
G = Least distance between electromagnet and permanent magnet = 0.005 m

On substitution, we get Max. Force F_1 = 24.18 N

Force exerted by permanent magnet

$$\text{Force } F_2 = (B^2A)/2\mu_0$$

Where, B = Flux density (T)
A = Cross-sectional area of magnet (radius r = 0.0125 m)
μ_0 = Permeability of free space = $4\pi\times10^{-7}$
Now flux density

$$B = B_r/2 \times [(D + z)/(R^2 + (D + z)^2)^{0.5} - z/(R^2 + z^2)^{0.5}]$$

Where, Br = Remanence field = 1.21 T
z = distance from a pole face = 0.005 m
D = thickness of magnet = 0.012 m
R = semi-diameter of the magnet = 0.0125 m

On substitution we get flux density, B = 0.2547 T

Now substituting B in the equation of force, F_2 = 12.67 N
Since, force F_1 and F_2 are repulsive,

$$\text{Total force } F = F_1 + F_2$$

F = 36.85 N

$$\text{Torque } T = F \times r$$

Where F = total force on piston
r = crank radius = 0.01m
Torque T = 0.3685 N-m

Mass of Fly wheel

$$\omega = (2\pi N)/60, \text{ where N = speed = 200rpm}$$

Therefore ω = 20.94 rad/s

Energy stored on flywheel

$$E = T \times \theta$$

Where T = torque
θ = Angle of rotation = $180^o = \pi$ radians

On substitution we get energy stored E = 1.157 J

Also

$$E = 0.5 \times I \times \omega^2$$

Where, I = moment of inertia of flywheel
ω = angular velocity
On substitution we get moment of inertia,
I = 5.277×10^{-7} Kg-m^2

Moment of inertia,

$$I = 0.5 \times m \times r^2$$

Where, m = mass of fly wheel
r = radius of fly wheel = 0.07 m

On substitution,

We get m = 2.154 Kg

Output power

$$P = (2\pi NT)/60$$

Where, N = speed = 200 rpm
T = Torque = 0.3685 N-m
On substitution, we get

Output power P = 7.718 W

Efficiency = (Output/Input) × 100
= (7.718/36) × 100

Therefore, Efficiency = 21.44 %

4. COMPONENT DESIGN

4.1 Cylinder

Electromagnetic engine uses only magnets for its operation. The cylinder must take care of unwanted magnetic field and other losses further cylinder material Itself should not get attracted to the magnet and resist the movement of the piston. To take care of above issues, the cylinder must be only made up of non-magnetic materials such as stainless steel, titanium or similar materials of high resistivity and low electrical conductivity. The cylinder of an electromagnetic engine is a simple rectangular block with a blind hole in it. The temperature within the electromagnetic engine cylinder is very low and so no fins are needed for heat transfer. This makes the cylinder easily manufacturable. Also the cylinder is made of aluminum, a non-magnetic material which limits the magnetic field within the boundaries of cylinder periphery. Usage of aluminium material makes the engine lighter unlike the cast-iron cylinder used in internal combustion engine.

4.2 Piston

The hollow piston casing is made up of non-magnetic stainless steel, titanium or similar materials of high resistivity and low electrical conductivity. Alternatively, piston casing can also be made up of non-metallic, thermal resistant materials as well or can be made by integrating both non-magnetic and non-metallic materials. One end of the hollow case is fitted with a powerful permanent magnet made of neodymium-iron-boron (NdFeB), samarium-cobalt (SmCo) or similar high field strength magnetic materials. The permanent magnet acts as the core of the piston. The flat surface (which is also the pole of the magnet) of the piston that is nearer to the pole od the electromagnet is called the magnetic head of the piston or piston head. The flat surface of the piston head may be completely exposed or it may be covered by a thin layer of non-magnetic material of sufficient thickness. The other end of the piston case connects to the piston rod that connects to the crankshaft. The crankshaft and the piston rod convert the linear reciprocating movement of the piston to the circular movement.

4.3 Connecting Rod

In a reciprocating engine, the connecting rod is used to connect the piston to the crankshaft. It converts the linear motion or reciprocating motion of the piston to the circular motion of the crankshaft. The connecting rod used in this engine is that of a power sprayer. The material of the connecting rod is cast iron. As the magnetic fields are contained inside the cylinder, the connecting rod will not be affected much. The connecting rod is same as that of an Internal Combustion engine. No modification is required.

4.4 Flywheel

Flywheel is made up of mild steel and it is used to convert reciprocating energy into rotational energy. It regulates the engine's rotation, making it operate at a steady speed. Flywheels have a significant moment of inertia and thus resist changes it rotational speed. The amount of energy stored in a flywheel is proportional to the square of its rotational speed. Energy is transferred to the flywheel by applying torque to it. It is used to store the rotation kinetic energy.

4.5 Electromagnet

An electromagnetic coil is formed when an insulated solid copper wire is wound around a core or form to create an inductor or electromagnet. When electricity is passed through a coil, it generates a magnetic field. One loop of wire is usually referred to as a turn or a winding, and a coil consists of one or more turns. For use in an electronic circuit, electrical connection terminals called taps are often connected to a coil. Coils are often coated with varnish or wrapped with insulating tape to provide additional insulation and secure them in place. A completed coil assembly with one or more set of coils and taps is often called the windings.

4.6 Relay

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and most have double throw (changeover) switch contacts.
Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits; the link is magnetic and mechanical.

4.7 Timer 555IC

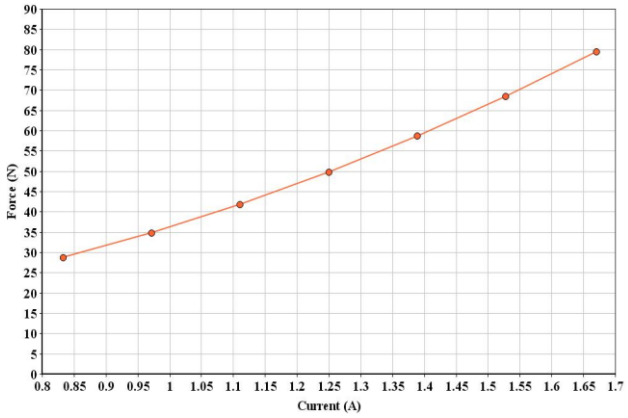
The 555 timer IC is an integrated circuit (chip) used in a variety of timer, pulse generation, and oscillator applications. The 555 can be used to provide time delays, as an oscillator, and as a flip-flop element. Derivatives provide up to four timing circuits in one package. Introduced in 1972 by Signetics,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

4.8 Battery

Where high values of load current are necessary, the lead-acid cell is the type most commonly used. The electrolyte is a dilute solution of sulfuric acid (H_2SO_4). In the application of battery power to start the engine in an auto mobile, for example, the load current to the starter motor is typically 200 to 400A One cell has a nominal output of 2.1V, but lead-acid cells are often used in a series combination of three for a 6-V battery and six for a 12-V battery.

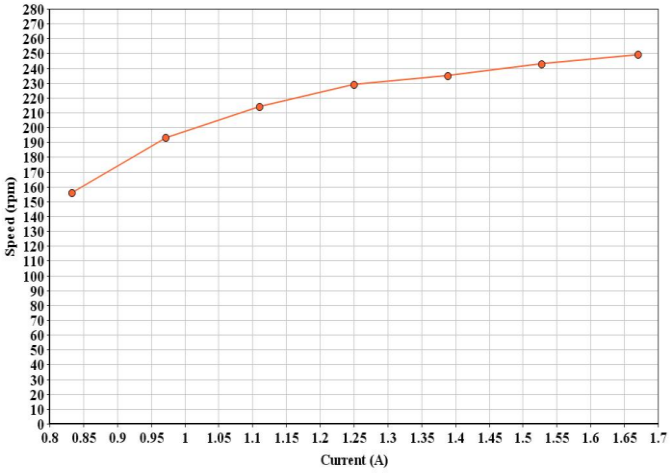
5. EXPERIMENTAL ANALYSIS

To analyze the electromagnetic engine an experimental analysis was conducted. The input parameter which was varied to obtain different readings was voltage (V). The variation of voltage was done with the help of a small transformer.



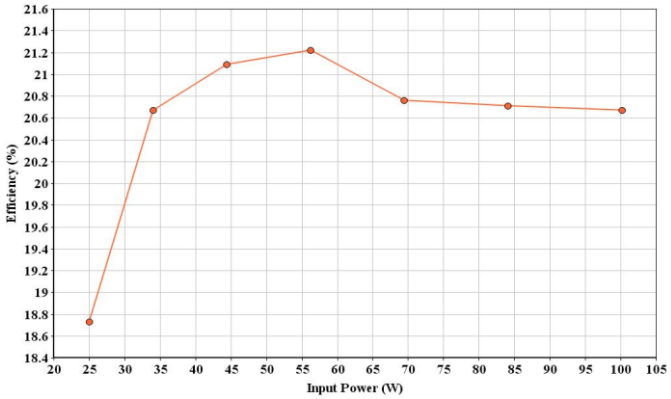
Variation of force with current (Experimental)

The above graph shows the variation of force with current. Force increases as the current is increased.



Variation of speed with current (Experimental)

The variation of speed with respect to current The speed increases as the current is increased.



Variation of efficiency with input power (Experimental)

Fig. shows the variation of efficiency with respect to input power. Efficiency, initially increases, reaches a maximum value and then decreases.

6. RESULTS AND DISCUSSION

The prototype of an 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.

- Prototype of an engine which works on the principle of magnetism was successfully manufactured.
- 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.
- Maximum efficiency obtained was 21.22% at 229 rpm for an input current of 1.2A.
- Maximum output power obtained was 20.7W at 249 rpm for an input current of 1.7 A

The efficiency and power output of the engine was less than what was expected. The reason for less power and efficiency are

- The windings of the electromagnet are not perfect. The windings are not machine wound. It was wound with hands on a lathe. So windings are not tight and there is air gap. The field generated will not be as strong as expected.
- The windings are not laminated. It will result in copper losses and hysteresis losses.
- The use of relay limits the flow of current as it offers a resistance. So with less current flow, the field generated by the electromagnet will be less and results in less force.
- The fabrication work and the design are not perfect. There might be some misalignments and it might cause a drop in output.

7. CONCLUSIONS

The electromagnetic engine has various advantages over the internal combustion engines. The main advantage is, no fuel is being used in the engine. This results in no pollution which is very desirable in the present day situation. As there is no combustion taking place inside the cylinder there is only very little heat generation. This eliminates the need for a cooling system. As magnetic energy is being used the need for air filter, fuel tank, supply system, fuel filter, fuel injector, fuel pump, valves etc. are eliminated 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 engine. Also existing transmission systems can be used in the electromagnetic engine. Less noise is produce during working.

The disadvantage of the electromagnetic engine is its high initial cost. The electromagnet and permanent magnet can be very costly. Also the power of the permanent magnet will decrease during time and the permanent magnet has to be replaced during regular intervals. The engine is not as flexible as the internal combustion engine. The power source is battery. The number of batteries will vary according to the requirement. In high power engines, the number of batteries will increase which may increase the total weight of vehicle and consume a lot of space. Also the batteries needs to be charged regularly which is difficult and time consuming. So the engine is not dependable

The prototype is an idea which uses the property of an electromagnet by virtue of which it changes the polarity of its poles whenever the direction of current is changed. This variation in polarity is utilized to attract or repel the permanent magnet attached to the piston. The usage of relay and timer will limit the output of the engine. By using an ECU in the engine instead, power can be obtained on each stroke which will result in an increased output. Also, by inserting more permanent magnets in series on the piston will enhance the output of the engine.

By slight modification in design and by the use of better hands the engine can be modified to generate more power, thereby increasing its efficiency, so that it can be used in commercial vehicles and other applications

REFERENCES

[1] K.S. Nesamani; Institute of Transportation Studies, University of California; '*Estimation of Automobile Emissions and Control Strategies in India*' (2009)

[2] Sherman S. Blalock; *Electro-magnetic reciprocating engine*; US 4317058 A

[3] Leland W. Gifford; *Reciprocating electromagnetic engine*; US 5457349 A

[4] Radhakrishna Shesha Iyengar Togare; *Magnetic Pistons Engine*; 2010;US 7,667,356 B2

[5] V. Ganesan; Tata McGraw-Hill Education; *Internal Combustion Engines*

[6] S.S. Rattan; Tata McGraw-Hill Education; *Theory of Machines*

[7] http://en.wikipedia.org/wiki/Magnet (accessed on 18 - 02 - 2014)

[8] http://en.wikipedia.org/wiki/Electromagnet (accessed on 18 - 02 - 2014)

[9] www.supermagnete.de/eng/faq/How-do-you-calculate-the-magnetic-flux-density (accessed on 18 - 02 - 2014)

[10] http://en.wikipedia.org/wiki/Neodymium_magnet (accessed on 18 - 02 - 2014)