DESIGN AND FABRICATION OF ELECTROMAGANTIC ENGINE

Syed Suhel[1], Chetan Baseganni[2], Naveen Dinakar[3]
[1,2.3] Students, Mechanical engineering, K.L.E.I.T., Hubballi, Karnataka, India ,

Abstract

Demand is growing for the need of alternative fuels for transportation. Electricity with its versatile applications is being utilized to switch from conventional combustion vehicles to electric vehicles. The scenario of travelling is changing rapidly with metros, electric rails, electric aero planes (solar), etc. Basically it indicates that electrical energy is being used almost everywhere to drive our life. But the current machines we use today are low in efficiency. Hence we require products with more power but also with higher efficiency. Magnetism possesses a magnificent opening for development. Bullet trains using the technology of magnetic levitation have proved the strong nature of electromagnetic fields. So as to serve the arising needs of the industry, an attempt has been made to design and fabricate, a system called Electromagnetic Engine, which makes use of magnetic force to drive a load. The working principle is based on attraction and repulsion between a permanent magnet and an electromagnet. The forces thus developed are used to generate mechanical power. Further enhancement in this field can be an alternative to switch over IC Engines

Index Terms: Electricity, Efficiency, Magnetic levitations, Magnetism, Mechanical power.

I. INTRODUCTION

Fast but unplanned urban development with economic growth has led to more dependency on automobiles in India over the last two decade which has resulted in increased of traffic and pollution. Government has taken many a steps to reduce the vehicular emission by setting emission standards. However, evolution of scientific methods for emission inventory is crucial. Therefore, analysis is done on the emissions from various vehicles by using IVE model .The quality of air in developing countries like India has reached a horrifyingly low level. Modal analysis to estimate a vehicular emission to showcase the temporal emission of vehicles [1]. Pistons and cylinders of a conventional IC Engine were replaced by permanent magnet pistons and non-ferromagnetic material respectively which led to the invention of electromagnetic reciprocating engine by Sherman S. Blalock [2]. Multicylinder electromechanical engine for automotive which consists of cylinders containing *samarium cobalt type of magnets in pistons located at right angle to the pistons* [3].Development in this field has led to the invention of Maps Engines which are incorporated with various equipment and machineries whose application are in fields such as aircraft engine, ship engine, locomotive engine and lawn mower [4].

In this paper an attempt has been to Design and Fabricate Electromagnetic Engine *using NdFeB rare earth magnets, Arduino, Relay and Infrared Sensors*. NdFeB rare earth magnet are used since they possess good Adhesive force per volume, Standard tolerances, good coercive field strength **.**The Aurdino board used here is Aurdino Nano as it met the project requirements. Infrared sensors are used to locate the various positions of the piston during operation which sends signals to the aurdino board which controls the flow of current to the solenoid. It is found that there is a need to design and fabricate a magnetic engines having a higher load carrying capacity. Earlier designed models generated power in a very low torque range which cannot be used for many applications. The trial setup had sporadic motion and was not powerful enough to drive a load. The top speed achieved was 250 r.p.m. Thus a target was setup to build up a prototype of the MRPE having a load capacity satisfactorily enough to be used in application. *We aimed to design the engine to run up to 1000 r.p.m. with constant torque characteristic*.

II. EXPERIMENTATION

Electromagnetic engine consists of Electro Magnet, Permanent magnets, V – Engine, Battery, Transformer, Relay, Sensors.

Fig 1: Electro magnet

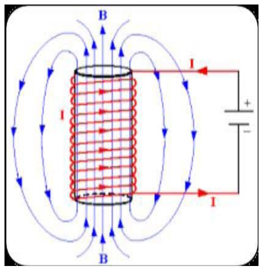


Fig 2: Magnetic field in solenoid

Electromagnetic force is one of the four fundamental interactions of nature. Electromagnetism is the physical interaction between electrically charged particles. An electromagnet is a type of magnet which possesses the ability to magnetize and demagnetize as and when required. This control is established by an electric current. When there is flow of current, magnetism is expressed, when there is no flow of current magnetism is vanished. This magnetic flux is responsible for exerting the magnetic force the strength of the magnetic field depends upon and is directly proportional to the number of coils, the strength of the current, and the magnetic permeability of the core material.

Fig 3: Permanent magnets.

Fig 4: V Engine

Engines which are of multi cylinder are made in different configurations like inline, opposed type, V oriented, W oriented etc. But, we went ahead to work with twin V-type compressor head as it was feasible and satisfied our requirement.

2.1 Battery

Table I: Battery Specifications

Types of battery	Lithium ion battery
No. of cells req.	12*2
Battery life (cycles life)	300-500 cycles
Weight	6 kg
Shelf life	2 year
Voltage	12v
Size	14 litres /1kWhr
Energy density	60-110 Wh/L
cost	3500
Overcharging tolerance	moderate

2.2 Relay

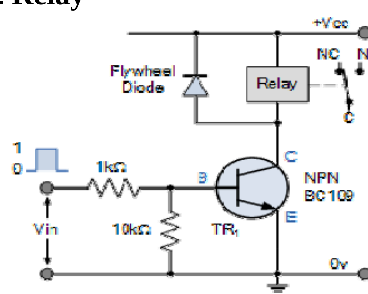


Fig 5: Relay

Relay takes a relatively small amount of power to operate, to control motors, heaters, lamps or AC circuits which themselves can draw a lot more electrical power relay can be used. To switch relatively high currents or voltages both “ON” and “OFF”, some form of relay switch circuit is required to control it, Electrical relays can be used to allow low power electronic or computer type circuits.

2.3 Infrared sensors

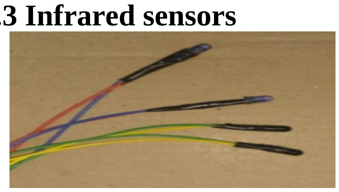


Fig 6: Infrared sensors

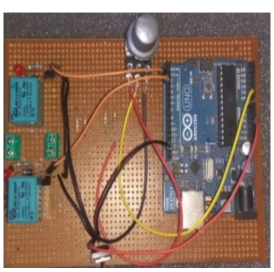
We chose to use the optical method to sense the position of the piston. These sensors are fast, and can be used without any complicacies. To simplify further we used the emitter and detector separately. At one end was the infrared emitter, and diametrically opposite was the detector located. Whenever there was a break in the path of light, a high signal used to pass from the circuit.

2.4 Engine Components

Fig 7: V cylinder engine

Fig 8: piston and connecting rod Fig 9: Crankshaft

Fig 10: Electromagnetic Bar



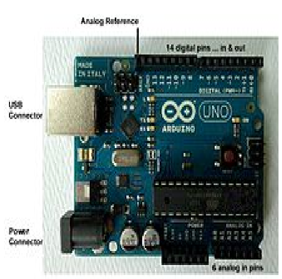


Fig 11: Arduino Fig 12: Uno R2

2.5 Software

As seen by the Arduino IDE programmer, consist of only two functions:

- *setup()*: This function is called once when a sketch starts after power-up or reset. It is used to initialize variables, input and output pin modes, and other libraries needed in the sketch.

loop(): After *setup()* has been called, function *loop()* is executed repeatedly in the main program. It controls the board until the board is powered off or is reset.

Arduino boards basically contain LED and a load resistor connected between pin 13 and ground. A typical program for a beginning Arduino programmer blinks an LED repeatedly.

```
#define LED_PIN 13                  // Pin number attached to LED.

void setup() {
pinMode(LED_PIN, OUTPUT);       // Configure pin 13 to be a digital output.
}

void loop() {
digitalWrite(LED_PIN, HIGH);    // Turn on the LED.
delay(1000);                    // Wait 1 second (1000 milliseconds).
digitalWrite(LED_PIN, LOW);     // Turn off the LED.
delay(1000);                    // Wait 1 second.
}
```

Fig 13: Arduino program

This program uses the functions *pinMode()*, *digitalWrite()*,and *delay()*, which are provided by the internal libraries included in the IDE environment. The program is usually loaded in the Arduino by the manufacturer.

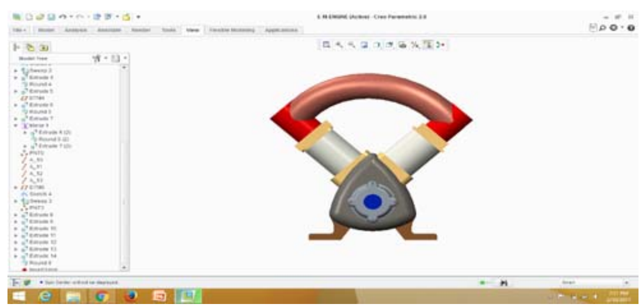


Fig 14: CADD Model

III. EXPERIMENTAL SETUP

Fig 15: Experimental setup

3.1 WORKING

The mechanical sub-system consists of a piston, which reciprocated within a cylinder made of a non-magnetic material and open to the atmosphere. Further the piston was connected to a connecting rod which in turn was connected to a crankshaft, offering rotary output. The standard engine used was of V-type twin cylinder configuration which consists of connecting rods, linked to a common crank shaft

The system consists of a permanent neodymium iron-boron magnet which was adhered to the top surface of piston. During reciprocating motion magnets travelled along with the piston. The magnets were fixed in such a way that the pole orientation was in the same direction. For e.g. if the south poles of both the magnets were fixed to piston surface then the north poles were exposed to the atmosphere.

A solenoid is an electromagnet which creates a dipole at the two end faces when the current is passed through it resulting in the formation of North and South Pole. Soft iron core present in the solenoid was bent to a particular angle to accommodate it over the engine. The two flanges placed at the end of the bent core facilitate complete interaction between magnetic fields. A standard Li ion battery of 24V was used to supply energy. When current was passed through the solenoid, one flange acted as the North Pole. This electromagnet was placed over the cylinders, which were non-magnetic. It was held sturdy with the help of a rigid frame consisting of differential positioning arrangements. The electromagnet was positioned such placed that there was no gap between its flange and permanent magnet when it was at its TDC (Top Dead Centre).

At the time when Piston 1 is at TDC, the flange of electromagnet is charged in such a way that it results in opposite pole to that of the Permanent Magnet 1 thus generating a repulsive force on the piston. Simultaneously the other flange of the electromagnet is charged oppositely, which attracts the Permanent Magnet 2, which is between TDC and BDC (Bottom Dead Centre). The generated attractive force was induced because of exposure of the Permanent Magnet 2 to the electromagnet that had the opposite pole. Due to attraction, when Piston 2 reaches TDC, it gets repelled. This results in change in direction of current which in turn results in change in nature of poles on the flanges. Due to this, same poles on permanent magnet 2 were created which are repelled in turn, while piston 1 is attracted from the other side.

During high signal from Piston 1, there was a positive current flow in the solenoid, and when there was high signal from Piston 2, current flow was negative. At all other situations the electromagnet remained unchanged.

The switching of the direction of current in the electromagnet was controlled by the controlling circuit. The controlling circuit consists a pair of Infrared emitter detector sets (IRED), which sensed the position of both the pistons individually. Whenever the link of the emitter and detector is interrupted, high value signals are generated. At all other positions of the piston the signal is low. The positioning of sensors were such a way that they provide a high output when the piston reaches close to TDC. The output signals from the op-amps were channelized to H-bridge network

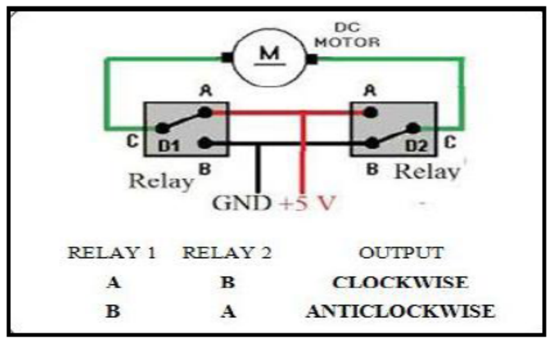


Fig 16: H Bridge Network

IV. RESULTS AND DISCUSSION

4.1 Calculation for design of Electromagnet

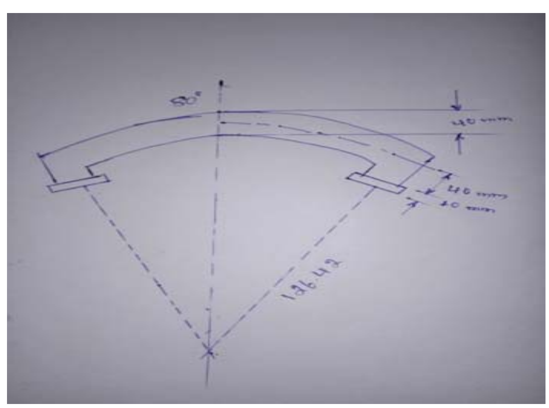


Fig 17: Dimensions of Iron Bar

Total diameter of wire d = 0.977 mm

The desired current density for a solenoid is 2.5 A/mm^2 to 3 A/mm^2

Hence, the current flowing should be between 1.6425 Amperes and 1.971 Amperes
At a potential difference V =24 V
Resistance of wire will range from
R=V/I=14.61187Ω to 12.1765 Ω (1)
Initial diameter of armature coil D1= 50 + 1 = 51 mm

As the layers increase the diameter also increased in steps of 2mm, hence the diameters of coil after successive layers would be 53mm, 55mm, 57mm, and 59mm.
In all introducing 5 layers
Length of each layer in each turn = π D
L1' = 160.22 mm
L2' = 166.5 mm
L3' = 172.79 mm
L4' = 179.07 mm
L5' = 185.38 mm
The number of turns in the 1st layer over a length of 300mm
N1 = 300
As we went on winding the number of turn decreased in each layer. Therefore, approximately number of turns in 2nd layer N2 = 280 similarly,
N3 = 260
N4 = 240
N5 = 220
Hence N = 1300 turns
Total length of wire in 1st Layer
L1 = 48.066 m
L2 = 46.62 m
L3 = 44.93 m
L4 = 42.91 m
L5 = 40.78 m
Overall length of wire L = 223.4 m
Area of cross-section of wire a = $0.657 * 10^{-6}$ m^2
Resistivity of copper c = 0.01724 -6 Ωm
Hence resistance R = 5.86 Ω
Current I =V/R = 4.094 A
Total Ampere turns $\bar{A}$ = 5322 A.T
Force exerted by permanent magnet
F1 = 1530.55 N F2 = 92.9 N

4.2 Calculation of force of Electromagnet

Input voltage = 24 V
Input current = 4 A
Input Power = Voltage × Current = 24 × 4 = 96W.
Force exerted by electromagnet on piston
$F1 = (NI2*K*A)/2G^2$ (2)
Where, N = number of turns = 1300
I = Current flowing through coil = 4 A
K = Permeability of free space = $4\pi\times10^{-7}$
A = Cross-sectional area of electromagnet (r = 0.0275 m)
G = Least distance between electromagnet and permanent magnet = 0.005 m
On substitution, we get
Maximum Force F1 = 1530.55 N
The Neodymium Magnets (NdFeB) rare earth magnet used had diameter of 50mm and thickness of 12.5mm. The strength of the magnet as indicated by manufacturer is 3000 gauss.
Ultimate Tensile Strength = 500psi
Density = 8.4 g/cc
Curie temperature = 310°C
Maximum service temperature = 150°C

V. CONCLUSION

With repeated handling, the windings of the electromagnet got loosened up which increases the gaps between the windings. This causes a drop in the potential energy from the power source and prevents the effective generation of magnetic flux. It is also noticed that the energy of the permanent magnet is higher than that of electromagnet. The design of the engine is to be done with materials having low density. This sector needs accurate manufacturing and utmost care. The MRPE has various advantages over an internal combustion engine. The most important advantage is that it is environmentally friendly. It does not use any fossil fuels, does not deplete natural resources, and does not pollute, no heat generation within the system. Though the electromagnet heats up with continuous operation, but the temperatures are very low as compared to IC engines. It rules out the need of a cooling system, a fuel injector, valves, etc. The operating noise levels are low. Proper development of this engine with materials like aluminium can reduce the weight significantly, and increase the efficiency. The important significance is that its development can decrease the dependence on depleting resources, which is a very important requirement today. With further research and development it can be proved to be a boon in the Automobile sector.

REFERENCES

[1] K.S. Nesamani, "Estimation of Automobile Emissions and Control Strategies in India," Institute of Transportation Studies. Science of Total Environment, ScienceDirect, University of California, 2009 DOI:10.1016/j.scitotenv.2010.01.026

[2] Sherman S. Blalock, Electro-magnetic reciprocating engine; US 4317058 A https://www.google.ch/patents/US4317058

[3] Leland W. Gifford; Reciprocating Electromagnetic engine; US 5457349 A http://www.google.com/patents/US5457349

[4] Radhakrishna Shesha Iyengar Togare; Magnetic Piston Engine; 2010: US 7667356 B2 http://www.google.ch/peatents/US7667356

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

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