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International
Journal
Of Modern Engineering Research (IJMER)

Design and Fabrication of Solenoid Engine

[1]Ram Bansal, [2]Rahul Kushwah, [2]Divya Pawar
[1]*Assistant Professor, Department of Automobile Engineering, Medi-Caps institution of science and technology*
[2]*Research Scholar, Department of Automobile Engineering, Medi-Caps institution of science and technology*
Corresponding Author: Ram Bansal

ABSTRACT
As we are moving towards the developed country, the need of fossil fuel is increasing day by day with increasing population. We need alternative to replace fossil fuel. In IC engine, the chemical energy get converted into mechanical energy, i.e., the low grade energy get converted into high grade energy.
The IC engine we use cause more pollution. So to overcome this problem, the electromagnetic force is use to run the engine. The electromagnetic engine which uses electric energy to run, can replace the use of IC engine.
As we pass current through the copper wire winding, the magnetic field generated near the copper wire. The polarity of the magnetic field can vary according to the current. The magnet attached at the piston get attracted up as the polarity of permanent magnet and this force is transferred to the connecting rod and crankshaft assembly, which transfer the reciprocating motion of piston into rotating motion of crankshaft and finally the flywheel.
The electromagnetic engine should be more compatible. The electromagnetic engine does not require extra components like cam follower, valves, fuel pump, injectors, fuel tank etc. The strength of magnetic force can be increase by varying the input voltage and current.
Key Words:- *Solenoid, electromagnetic coil, relay, battery, I R sensor, piston.*

Date of Submission:26-05-2019 Date of acceptance: 08-06-2019

I. INTRODUCTION:

In present day, we can't imagine a day without IC engines, which is one of the greatest invention of man. The IC engine which is used in automobiles to run it. We need automobile for transporting goods and to travel. As increasing population, the need of automobile is increasing. The IC engine use petrol and diesel as fuel. The need of fossil fuel is increasing which give hike in the price of fuel. This create a situation that bring up a need to switch to alternative source of fuel to produce the power similar to IC engine. The challenge is not to create an engine that operates on an alternate fuel but also have higher efficiencies. The next source of energy that strike our minds is definitely electrical energy. We can use electrical energy or hybrid which runs on both fossil fuel and electric energy. To increase the efficiency of engine the combination of different energy is used.Government has taken many a steps to reduce the vehicular emission by setting emission standards. Ho wever, 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 the cylinders of a conventional IC Engine are replaced by the permanent magnet pistons and non-ferro magnetic materials respectively which led to the invention of electromagnetic reciprocating engine by Sherman S. Blalock [2]. Multi-cylinder electro mechanical engine for the automotive that consists of the cylinders containing samarium cobalt type of magnets in pistons located at right angle to the pistons [3].Gr owth 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].

Electromagnetism:

Leland W.Gifford discussed about electromagnetically driven reciprocating engine in his invention. Reciprocating pistons are sliding mounded in a cylinder and linked to a rotatable crankshaft. Fixed magnets, preferably of the samarium cobalt alloy type are mounted in the piston to intermittently attract and repel sequentially energized electromagnets which are mounted in the cylinder walls. Capacitor discharge circuit used as a power source of electromagnet which is used for directing electrical energy to the electromagnets. A computerized control means regulates the timing of discharge of the capacitor and thus the timing of energizing the electromagnets[5].

Houtman P. Siregar et. al discussed about the materials for core of electromagnetic fuel saver are made of plain carbon steel and copper. Diameters of the wire winding, which is used in the research, are 0.25 mm and 0.35 mm. Speed of engine, and number of coils which is coiled in a winding core of the fuel saver are chosen as the testing variables. From this work is obtained that the performance of the electromagnetic fuel saver which use copper core is better than the electromagnetic fuel saver[6].

Kannan et al discussed about Yamaha R15 bike 149.8 cc cylinder is made up of DiASil (Die Cast Aluminium Silicon) which an allaluminium cylinder is made possible by an exclusive Yamaha aluminium forging technology. As it uses a 20% silicon-aluminium alloy, it has excellent heat dissipation qualities and reduces the engine weight at the same time. Therefore the user should not have to go for a costly maintenance like sleeve replacements after riding say some 20,000 kilometers. Another advantage of DiASil cylinder is that the rider gets improved fuel economy. As cylinder, piston and surrounding parts are all made of aluminium, cooling is quick and efficient[7].

The Neodymium magnets can provide the significant size and weight reduction and performance of enhancement over the sintered and, particularly, bonded ferrite permanent magnets, moreover, provides these benefits at reasonable cost. Primarily for these reasons, these magnets are now used in the wide and growing range of computer peripheral, office automation, and consumer electronic applications and now constitute the fastest growing segment of a permanent magnet market.

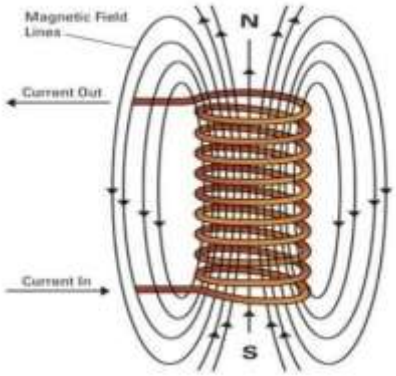

Figure 1: Solenoid

Design Of Engine Components:

(1) Cylinder: The temperature within the electromagnetic engine cylinder is very low and so no fins are needed for heat transfer. These make the cylinder easily manufacturable. The cylinder is made of stainless steel, a non-magnetic material which limits the magnetic field within the boundaries of cylinder periphery.

Figure 2: Cylinder

(2) Piston: The piston is the reciprocating part of an engine. The permanent magnet attached in the piston and the electromagnet attached in the cylinder creates a magnetic force which drive the crankshaft with the help of the connecting rod.

Figure 3: Piston

(3) Connecting rod: In a reciprocating engine, the connecting rod is used to connect the piston to crankshaft. It converts the linear motion or reciprocating motion of the piston to the rotary motion of the crankshaft.

(4) Flywheel: The flywheel is used to store the rotational energy. It regulated the engine rotation to make its operation at a steady sped. Flywheel has a significant moment of inertia and thus resist changes in rotational speed. The amount of energy stored in the flywheel is proportional to square of its rotational speed. Energy is transferred to the flywheel by applying torque to it. It is used to store rotational kinetic energy.

Figure 4: Fly Wheel

(5) Electromagnetic coil: Electromagnetic coil is formed when an insulated copper wire is curl around the core or form to create the electromagnet. There are lots of turn curl around the cylinder which all together formed a solenoid. Coils are often coated with a varnish or wrapped with insulating tape to provide additional insulation and secure them in place.

Figure 5: Electromagnetic Coil

(6) Permanent magnet (NdFeB): Most powerful 'rare-earth' permanent magnet composition is known to mankind is Neodymium-iron-boron magnet. These formation is a relatively modern, first become commercially available in 1984. NdFeB magnet has highest B & Br of any Magnet formula, and also has very high Hc. However they are very brittle and hard to machine and sensitive to corrosion.

Figure 6: Permanent Magnet

(7) Battery: Lead acid cell is the most commonly used type of battery when high value of load current is necessary. In this engine 24V lead acid battery is used. 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 frequently used in a series combination of three for a 6V battery and six for a 12V battery

Figure 7: Battery (24V)

(8) 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.

Figure 8: Relay

(9)IR sensors: IR sensors are used to detect the position of crank. According to the position of crank IR sensor sends the signals to the relay.

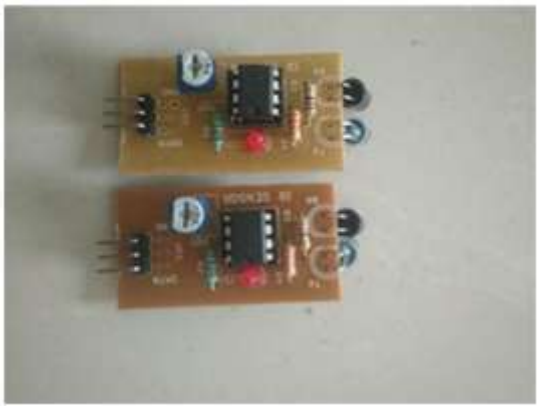

Figure 9: IR sensors

Working principle:

Solenoid engine basically working on the electromagnetic attraction. It is an electromagnetic device which moves the plunger as per the coil magnetism. Whenever electric current is supplied to conductor a surrounding magnetic field is set up at its surface and it works as electromagnet. The electromagnetic force depend upon the current flowing through coil and number of turns that wound on coil. As the current passes through coil, it works as electromagnet and the basic idea is about to run the engine on magnetic attraction and repel principle.

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 double 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 throughit resulting in the formation of North and South Pole. A standard Li ion battery of 24V was used to supply energy. When current was passed through one of the solenoid, the piston get attracted. The 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. At the time when Piston 1 is at BDC, the electromagnet is charged in such a way that it results in opposite pole to that of the Permanent Magnet 1 thus generating an attractive force on the piston. With the help of relay and IR sensors, the continuous process through piston in achieved (up and down) by also rotating the flywheel. 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 cranks 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 BDC.

Calculations:

Input voltage = 48 V
Input current = 2 A
Input Power = Voltage × Current
= 48 × 1 = 98W
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 = 2 A
K = Permeability of free space = $4\pi\times10^{-7}$
A = Cross-sectional area of electromagnet (radius r = 0.0025 m)
G = Least distance between electromagnet and permanent magnet = 0.004 m
On substitution, we get Max. Force
F_1 = 77.10 N
Force exerted by permanent magnet

Force $F_2 = (B^2A)/2\mu_0$
Where,
B = Flux density (T)
A = Cross-sectional area of magnet (radius r = 0.0025 m)
μ_0 = Permeability of free space = $4\pi\times10^{-7}$
Now flux density

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

Where,
B_r = Remanence field = 1.21 T
z = distance from a pole face = 0.004 m D = thickness of magnet = 0.0015 m
R = semi-diameter of the magnet = 0.021 m

On substitution we get flux density,
B = 0.04 T
Now substituting B in the equation of force,
F_2 = 1.25 N
Force exerted by 3 magnets: 6×1.25= 7.516N
Since, force F_1 and F_2 are repulsive,
Total force $F = F_1 + F_2$
F = 84.616 N
Torque $T = F \times r$
Where,
F = total force on piston
r = crank radius = 0.015m
Torque (T) = 1.27 N-m

Angular velocity of Fly wheel
$\omega = (2\pi N)/60$
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 = 3.98 J
Also
$E = 1/2\times I \times \omega^2$
Where,
I = moment of inertia of flywheel
ω = angular velocity

On substitution we get moment of inertia,
I = 0.01815 Kg-m^2
Moment of inertia,
$I = 1/2\times m \times r^2$
Where,
m = mass of fly wheel
r = radius of fly wheel = 0.07 m

On substitution,
We get, m =7.409 Kg
Output power

$P = (2\pi NT)/60$
Where,
N = speed = 200 rpm
T = Torque = 1.27 N-m
On substitution, we get
Output power P = 26.59W
Efficiency = (Output/Input) × 100%
= (9.2/24) × 100%
Therefore, Efficiency = 27.77%

II. 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 band 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 aluminum 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.

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Ram Bansal " Design and Fabrication of Solenoid Engine" International Journal of Modern Engineering Research (IJMER), vol. 09, no. 3, 2019, pp 41-47