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DESIGN AND FABRICATION OF SINGLE CYLINDER SOLENOID ENGINE

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Abstract : *Combustion takes place & produces alittle explosion inside the piston cylinder, which converts into energy. We all know IC-Engines are utilized in Automobiles, Aero plane etc. But incomplete combustion generates some harmful gasses, which is main reason for pollution. Science & Technology has been taken many steps for controlling pollution. Like, using CNGs & LPGs rather than Fossil fuels.. Now technology brings Electrical bikes, scooters & cars. Battery of electrical vehicle can be charged easily like mobile. They have less running cost & 100% emission free. But they need very less load carrying capacity & they are also not suitable for long run. So basically, we must prefer Engines for more power & more running capacity. Here we have introduced a mechanism which has more load carrying and running capacity then electric vehicles but make zero emission or pollution. And Introducing Solenoid engines to the world is important as by seeing the current growing electrical automobile market obviously their will a huge demand for the Induction motors as well which in turn will make the traditional IC engine deplict. So, to see the engines in future we have to make some changes in the Tradition Engines. Solenoid engines is a step in the same direction.*

Keywords – *battery, Electric vehicles, more load carrying, Solenoid engine , Zero emission.*

I. INTRODUCTION

Engines are machines that convert a source of energy into physical work. If you need something to move around, an engine is just the thing to slap onto it. But not all engines are made the same, and different types of engines don't work the same.

Probably the most intuitive way to differentiate between them is the type of energy each engine uses for power.

- Thermal engines
    1. Internal combustion engines (IC engines)
    2. External combustion engines (EC engines)
    3. Reaction engines
- Electrical engines
- Physical engines

II. TYPES OF ENGINES

1. Thermal engines

In the broadest definition possible, these engines require a source of heat to convert into motion. Depending on how they generate said heat, these can be combustive (that burn stuff)

or non-combustive engines. They function either through direct combustion of a propellant or through the transformation of a fluid to generate work. As such, most thermal engines also see some overlap with chemical drive systems. They can be airbreathing engines (that take oxidizer such as oxygen from the atmosphere) or non-airbreathing engines (that have oxidizers chemically tied in the fuel).

2. Internal combustion engines

Internal combustion engines (IC engines) are ubiquitous today. They power cars, lawnmowers, helicopters, and so on. The biggest IC Engine can generate 109,000 HP to power a ship that moves 20,000 containers. IC engines derive energy from fuel burned inside a specialized area of the system called a combustion chamber. The process of combustion generates reaction products (exhaust) with a much greater total volume than that of the reactants combined (fuel and oxidizer). This expansion is the actual bread and butter of IC engines — this is what provides the motion. Heat is only a by-product of combustion and represents a wasted part of the fuel's energy store because it doesn't provide any physical work.

3. External combustion engines

External combustion engines **(**EC engines) keep the fuel and exhaust products separately — they burn fuel in one chamber and heat the working fluid inside the engine through a heat exchanger or the engine's wall. That grand daddy-o of the Industrial Revolution, the steam engine, falls into this category.
In some respects, EC engines function similarly to their IC counterparts — they both require heat which is obtained by burning stuff. There are, however, several differences as well.

4. Reaction engines

Reaction engines, colloquially known as jet engines, generate thrust by expelling reactionary mass. The basic principle behind a reactionary engine is Newton's Third Law — basically, if you blow something with enough force through the back end of the engine, it will push the front end forward. And jet engines are *really* good at doing that.

5. Electrical engines

There are three types of classical electrical engines: magnetic, piezoelectric, and electrostatic. The magnetic one, like the battery there, is the most commonly used of the three. It relies on the interaction between a magnetic field and electrical flow to generate work. It functions on the same principle a dynamo uses to generate electricity, but in reverse. In fact, you can generate a bit of electrical power if you hand crank an electrical-magnetic motor.

6. Physical engines

These engines rely on stored mechanical energy to function. Clockwork engines**,** pneumatic**,** and hydraulic engines are all physical drives.
They're not terribly efficient. They usually can't call upon large energy reserves either. Clockwork engines for example store elastic energy in springs and need to be wound each day. Pneumatic and hydraulic types of engines must carry hefty tubes of compressed fluids around, which generally don't last very long. For example, the *Plunger*, the world's first mechanically powered submarine built in France between 1860 and 1863, carried a reciprocating air engine supplied by 23 tanks at 12.5 bars. They took up a huge amount of space (153 cubic m / 5,403 cubic ft) and were only enough to power the craft for 5 nautical miles (9 km / 5.6 mi) at 4 knots.

III. INTERNAL COMBUSTION ENGINES V/S SOLENOID ENGINE

1. Internal Combustion Engine

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1. Induction or injection of a fuel-air mix (the carburate) into the combustion chamber.
2. Compression of the mix.
3. Ignition by a spark plug or compression — fuel goes *boom*.
4. Emission of the exhaust.

For every step, a 4-stroke piston is alternatively pushed down or back up. Ignition is the only step where work is generated in the engine, so for all other steps, each piston relies on energy from external sources (the other pistons, an electric starter, manual cranking, or the crankshaft's inertia) to move. That's why you have to pull the chord on your lawnmower, and why your car needs a working battery to start running.
Other criteria for differentiating IC engines are the type of fuel used, the number of cylinders, total displacement (internal volume of cylinders), distribution of cylinders (inline, radial, V-engines, etc.), as well as power and power-to-weight output.

2. Solenoid Engine

This project is about to design electricity operated engine construction. In this engine there is no use of fuels like diesel and petrol. So, this engine is operating on pure electricity coming from a battery source. An electromagnet is positioned on the top of the cylinder, while construction of engine is traditional. And piston is just a permanent magnet (Neodymium magnet). There is no combustion within the cylinder, so design of piston and cylinder arrangement is simpler as compared to IC Engine. So, the accuracy of dimensions is not a serious matter here. Although this engine can't produce any flue gases which are harmful to the environment, because there is no combustion of fossil fuels in this engine.

IV. METHODOLOGY

Components used in Solenoid Engine.

1. 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.

Fig. 4.1.1 Copper coil

2. Permanent magnet (NdFeB):

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

Fig. 4.1.2 Neodymium Magnets

3. 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.

Fig. 4.1.3 Solenoid Cylinder

4. 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.

Fig. 4.1.4 Piston

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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 nonmagnetic 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 through it 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 solenoids, the piston gets attracted. The electromagnet was placed over the cylinders, which were nonmagnetic. 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 was such a way that they provide a high output when the piston reaches close to BDC.

Design Calculations:

Input voltage = 48 V
Input current = 60 A
Input Power = Voltage × Current
= 48 × 60 = 2,880W

Pressure to be simulated (same as an traditional IC Engine) = 100 psi = 689476 pascals = 6.8×10^5 pascals
Diameter of the piston cylinder = 50mm = 0.05m
Area(A) on which pressure will be acting:
$A = \pi \times D^2/4 = \pi \times (0.06)^2/4 = 2.8 \times 10^{-3}$

Force(F) exerted on the piston:
$F1 = P/A = 6.8 \times 10^5 / 2.8 \times 10^{-3} = 2.4 \times 10^8$ N

Now,
We try to find out No. of Turns(N) on the solenoid cylinder.
Max. Force exerted by electromagnet on piston
F1 = (N2 I 2KA)/2G2
Where,
$F1 = 2.4 \times 10^8$ N
N = number of turns
I = Current flowing through coil = 60 A
K = Permeability of free space = $4\pi\times10^{-7}$
A = C/S area of Solenoid Cylinder (radius r = 0.0025 m)
G = The length of the gap between the solenoid and the piece of metal = 0.004 m
On substitution, we get No. of turns
N = 10,000 Turns

Now,
We calculate the Magnetic field Required/Generated
$B = \mu_0 nI = \mu_0 NI/l = 4\pi \times 10^{-7} \times 10000 \times 100 / 0.09$
B = 13.96 T

Force exerted by permanent magnet Force
$F2 = (B^2A)/2\mu0$
Where,
B = Magnetic Field (T) = 13.96 T
A = Cross-sectional area of magnet (radius r = 0.0025 m)
μ0 = Permeability of free space = 4π×10-7

$F2 = 217114 = 2.1 \times 10^5$ N

Now,
Length of copper wire required to make the solenoid windings
$L = N \times \pi \times D = 10000 \times \pi \times 0.05$
L = 1570 m

Now,
We have to find which diameter copper wire should we use for the solenoid cylinder
We have,
R = V / I = 42/60 = 0.7 ohms

$R = rho \times L / A = rho \times L / Pi(d/2)^2$

Where,
Rho is resistivity of copper wire
d is the diameter of the copper wire
After substituting the values
d = 0.006 m

Since force F1 and F2 are repulsive,
Total force F = F1 + F2
$F = 2.4 \times 10^8$ N

Torque T = F × r
Where, F = total force on piston
r = crank radius = 0.015m
Torque (T) = 3.6×10^6 N-m

Power, $P = I^2 \times R$
$P = 100^2 \times 0.7$
P = 7000 W = 7 KW
Therefore
Output power P = 7000 W

Efficiency = (Output/Input) × 100%
= (2880/7000) × 100%
Therefore, Efficiency = 41.14 %.

TABLE 4.1: Tentative Costing of Project

PARTS	COSTS
Copper Coil	₹ 134 /-
Neodymium Magnet	₹ 4000/-
Solenoid Cylinder	₹ 1000/-
Piston	₹ 200/-
Connecting Rod	₹ 300/-
Relay Module	₹ 65/-
IR Sensor	₹ 200/-
Crank Shaft	₹ 2000/-
Flywheel	₹ 2000/-
Battery	₹ 1000/-
Total	₹ 10,899 /-

V. CONCLUSION

With repeated use, 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. To Avoid this, we have to make the solenoid coils tight so that can’t get loose. 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 Solenoid Egine 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. Though providing the engine with a cooling system will be beneficial. 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.

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