Design and Fabrication of 4-Stroke Solenoid Engine

Anamika Tiwari[1], Anurag Singh[2], Deepak Agarwal[3] and Ajay Kumar Verma[4]

[1]M. Tech student, Mechanical Engineering, IET Dr. Rammanohar Lohia Avadh University, Ayodhya, India
[2,3]Assistant Professor, Mechanical Engineering, IET Dr. Rammanohar Lohia Avadh University, Ayodhya, India
[4]Assistant Professor, Mechanical Engineering, SRMGPC, Lucknow, India

---***---

Abstract:- *In present investigation we have designed a solenoid coil engine based on Induction principle which is alternate option of electric Engine in future due to it high load carrying capacity and low cost as compared to electric engine. Through this work new advanced automobile cum electrical technology is implemented to regenerate a new advance electric engine without using a motor and it is possible to totally remove the motor from car which we name as high torque coil engine. It works like a normal fuel engine but now power source is battery with is totally pollution free and eco-friendly.*

Keywords: Solenoid actuator, Copper clad board, Crankshaft, Bearing, Solenoid armature.

1 .INTRODUCTION

 By Literature survey of [1, 2, 3&4] we develop the idea of an engine in which the reciprocating motion of the armature of the solenoid is transmitted to the crankshaft which converts into rotary motion of it, through a metal strip which acts as a connecting rod. When the power is turn ON, the coil is energized and hence pulls the armature in the middle of the coil and as the coil gets un-energized the armature returns back to its position with a hammering stroke. A single solenoid is responsible for 90 degree rotation of the crankshaft, hence to complete the cycle of 360 degree four solenoids are being used and actuator of this solenoid at different time is done using a copper clad PCB board. The copper clad PCB board is divided in four slots and on each slot one of the wire from each solenoid is soldered. There is a metal wire which is mounted on the crankshaft and one of the ends of this wire is made rounded and is in contact with the copper clad PCB board. This wire completes the circuit and actuates the solenoid. The power obtained at the crankshaft is transmitted to a gearbox of speed reduction ratio 1:4 through sprockets mounted on the ends of the crankshaft and gearbox. The number of teeth on the sprocket mounted on the end of the crankshaft is 16 and that of the sprocket on the gearbox is 28. The sprockets are connected through timing chain of length 560mm and approximately 84 grooves. From the gearbox the power is transmitted to the wheel axle using chain and sprocket as shown in fig.1.
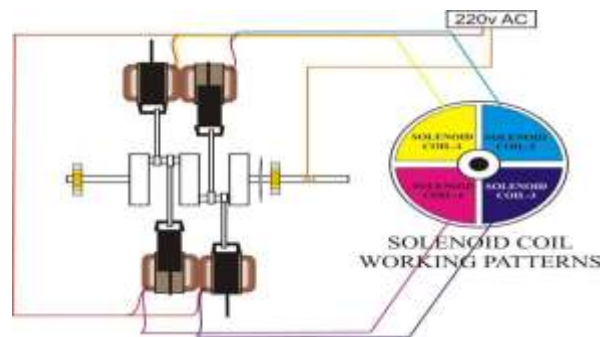

Fig. 1. Working of the solenoid armature

Fabrication setup:

Table.1. Material procured

S.N.	Materials	Specification
1.	Mild Steel circular Disc (for crankshaft)	Diameter- 62 mm Thickness- 13 mm
2.	Stainless steel rod (for crankpin)	Diameter- 8 mm Length- 250 mm

3.	Solenoid Actuators	S.A. 2602 (220 V A.C.) Rated Pull- 19.6 N
4.	Ball Bearing	Bearing number- 608 External Diameter-22mm
5.	Chain	Length- 560 mm
6.	Sprocket	No. of teeth- 28
7.	Sprocket	No. of teeth- 16
8.	Mild Steel metal strips	
9.	Gearbox	Reduction Ratio= 1:4
10.	Plywood	
11.	Wire	
12.	Nut and Bolt	
13.	Copper board (PCB)	6"x6"
14.	Electrode (S.S)	Diameter= 2.5 mm

2 .FABRICATION OF COMPONENT

2.1 Crankshaft

For the fabrication of the crankshaft circular disc of mild steel with diameter 62 mm and thickness 13 mm is chosen, this circular disc acts similar to the counter-weight of an internal combustion engine crankshaft. The factors for choosing the material for counter-weight is light weight as compared to other metals, easy availability and are cheap and best suited for welding.

The crank-pin journals or the connecting-rod journals are of stainless steel with diameter of 8 mm and length is of 35 mm of each crank pin and the main journal bearings are of length 65 mm. In the fabrication process three holes of 8 mm diameter were drilled one at the centre of the disc and other two at 15 mm from the centre as the stroke length is 15 mm as shown in fig.2. Then a stainless steel rod of total length 250 mm was cut into two pieces of length 35 mm and two pieces with length 65 mm as shown in fig.3.using metal cutting saw. The material stainless steel has been taken because it is harder and less malleable than mild steel and we needed a harder and less malleable material for the journal so as to bear the hammering stroke produced by the solenoid actuator. Thereafter, the journals were inserted in the drilled holes accordingly into the counter-weights and then welding using electric arc welding with stainless steel electrode of diameter 2.5 mm, so as to ensure there is no relative motion between the journal and the counter weight during work as shown in fig.4.
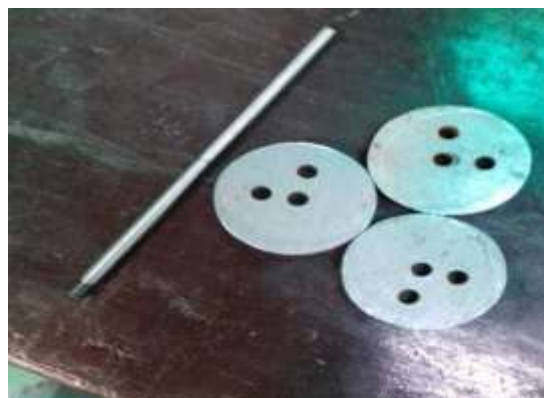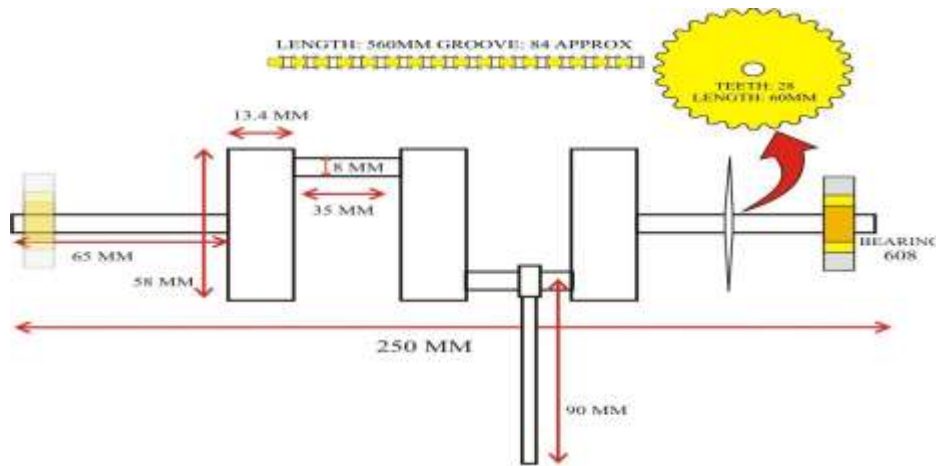

Fig.2. Journal and Drilled Counter Weight

Fig.3. Schematic Diagram of the fabricated Crankshaft

Fig.4. Final fabricated Crankshaft

2.2 Copper Clad PCB Board

This board is used to actuate the solenoids at different time. A 6" x 6" board was cut into 4" x 4" as shown in fig.5.and then four slots were made into it using a chisel and hole of 8 mm diameter was drilled into it. This board is fixed to a wooden block of the size 4" x 4".

Fig.5. Copper Clad PCB Board

2.3 Bearing Stand

The bearing used is ball bearing with number 608 that is its internal diameter is 8 mm. It is used to support the crankshaft at ends on the frame. The bearing is supported on a mild steel metal strip using electric arc welding as shown in fig.6. Firstly, bearings were inserted in a nut of internal diameter 22 mm by removing the threads of the nut for safety of the bearings as these were to be welded on the strip. Then the welding was done by placing the nut with bearing at the centre of the strip.

Fig.6. Final Welded Bearing to Metal Strip

2.3 Solenoid Actuator

A solenoid is a coil wound into a tightly packed helix. The term solenoid basically refers to a long, thin loop of wire often wrapped around a metallic core which produces a magnetic field when an electric current is passed through it.

Electro-mechanical solenoids consist of an electromagnetically inductive coil, wound around a movable steel or iron slug (termed the armature). The force applied to the armature is proportional to the change in inductance of the coil with respect to the change in position of the armature, and the current flowing through the coil (see Faraday's law of induction). The force applied to the armature will always tend to move the armature in the direction that increases the coil's inductance.

Table2. Specification of Solenoid Actuator

Parameters	Values
Rated Voltage	220V A.C.
Start Current	2 A
Holding Current	0.2 A
Rated Pull	19.6 N
Rated Stroke	15 mm
Rated Operating Frequency	1200

The solenoid with specification in table 2.acts like a piston which transmits its reciprocating motion to the crankshaft and thus the crankshaft rotates. A particular solenoid produces a rotation of about 90º and thus here 4 solenoid actuators are being used so that a complete cycle of 360º is completed. The solenoids are connected to the crankshaft through a mild steel strip.

When electric current is passed through the solenoid the coil gets energized, the resulting magnetic field pulls the armature to the middle of the coil with a force of 19.6 N, hence producing a hammering stroke which pushes the armature back to its original position.

2.4 Gearbox

The power from the crankshaft is transmitted through chain and sprocket to the gearbox with speed reduction ratio of 1:4 and then by increasing the speed it's transmitted to the wheel axle through a chain and sprocket. At both the ends of the gearbox, sprockets are mounted and these are welded using electric arc welding and one sprocket is welded to the wheel axle as shown in fig.7.
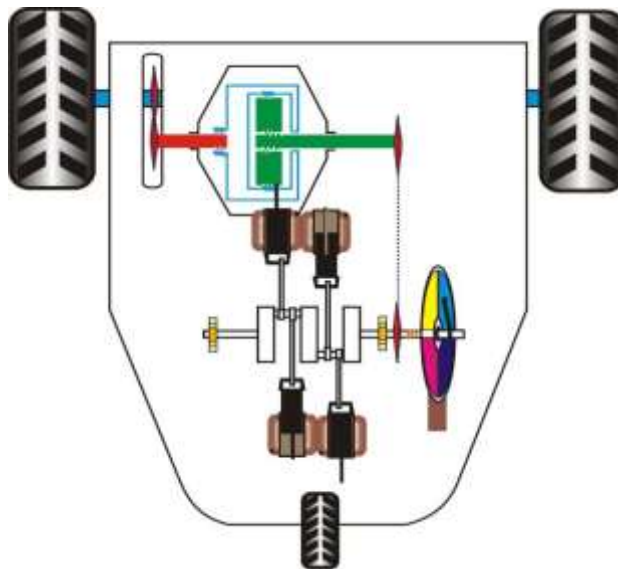
Fig.7. Gearbox with Sprocket

2.5 Actual Setup

Fig.9. Schematic Diagram of the Engine

Fig.10. Final Setup of 4-Stroke Solenoid Engine

3. Result

Speed obtained at the crankshaft, NC= 612 rpm

Speed at the wheel, NW= 2448, using the gear-reduction ratio of 1:4

We know from the specification of the solenoid that piston effort,

FP= 19.6 N

FC= FP x cos $\emptyset$

l= length of connecting rod (mm) = (90+10) mm

 Where, 10mm is the length of solenoid

Crank radius (r) =15 mm

$$n = l/r$$

n=6.66

For maximum velocity of the piston,

$$\frac{dvp}{d\theta} = 0$$

$$\cos\theta + \frac{2\cos 2\theta}{2n} = 0$$

$$n\cos\theta + 2\cos^2\theta - 1 = 0$$

$$2\cos^2\theta + 6.66\cos\theta - 1 = 0$$

$$\cos\theta = 0.1439$$

$$\theta = 81.7264$$

$$\emptyset = 8.5373$$

FC= 19.6 x cos(8.5373)

=19.6 N

 Torque, T= FC x r

T= 0.294 N-m

Power obtained from this formula,

P $= \frac{2\pi NT}{60}$

Power obtained at the crankshaft,

PC= 2 x 3.14 x 612 x 0.294 x 0.016666

=18.84 W

Power obtained at the wheel,

PW= 2 x 3.14 x 2448 x 0.294 x 0.01666

=75.329 W

4. Conclusions

The four-stroke solenoid engine has been designed as shown in fig.9.and fabricated as shown in fig.10. We have measured the speed at the wheel and at the crankshaft using tachometer successfully. The project was mainly concerned with fabricating a revolutionary engine that runs with the help of solenoid coil. Basically, it's advancement to the electric vehicles where electric motor is used to run the engine but in our project we have used solenoid coils in order to increase the battery life and eliminate the losses of the electric motor so as to enhance the power of the vehicle.

This innovative technology allows extraction of energy in a clean way and reduces the emission to zero level due to which pollution is minimized to a large extent. It has been cost effective as the design is much simpler than the conventional engines of electric vehicle. No cooling is required and many other parts such as valves, cam, ports etc. were eliminated.

We can conclude that the proposed engine is a simple and excellent technique to run the electric vehicle in a highly efficient manner and if used at a large scale production by considering the recommendations mentioned in the future scope the power, speed and efficiency can be enhanced to a greater extent.

5. Future Scope

The power obtained through the model cannot be compared to the power of an electric vehicle because these vehicles use electric motor to run the engine. But the power of the solenoid engine can be reached to the extent of the power obtained through the electric motor if the number of turns in the solenoid coil are increased, doing this would increase the force applied on the piston, hence increasing the power and apart from it studying the effect of other parameters and improving them would also increase the power. This engine would eliminate the drawbacks of the electric motor used in electric vehicle.

6. Advantages

- It has less running cost than an internal combustion engine.

- It does not create pollution and can help in checking global warming.

- It takes less amount of charge from battery in every revolution of the crankshaft for few seconds.

References

[1]. S. Mounty, A. Mirzaian, F.Gustin, A. Berthon, D. Depernet, C.Espanet, "High Torque Density Low Speed Permanent Magnet Machine", International Electric Machine and Drives Conference (IEMDC), 2011, pp. 448-453.

[2]. J.Rithula, J. Jeyashruthi, and Y. Anandhi, "Electric Vehicle with Zero-fuel Electromagnetic Automobile Engine", International Journal of Engineering Research and Technology (IJERT), ISSN 0974-3154,Volume-6, pp. 483-486, November 4 (2013).

[3]. Shirsendu Das, "An Electromagnetic Mechanism which works like an Engine", International Journal of Engineering Trends and Technology (IJETT), Volume-4, Issue 6, June 2013.

[4]. Abil Joseph Eapen, Aby Eshow Varughese, Arun T.P., Athul T.N., "Electromagnetic Engine", International Journal of Research in Engineering and Technology (IJRET), eISSN:2319- 1163, pISSN: 2321-7308, Volume-03, Issue 6, June 2014.