DESIGN AND FABRICATION OF SINGLE CYLINDER SOLENOID ENGINE

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ABSTRACT

Solenoids are the coils of wire when connected to electric current a magnetic field is set up at its surface surrounding and this works as electromagnet which applies an electromagnetic force over a metallic element. The electromagnetic force depends upon the current flowing through the coil & number of turns that is wound around the cylinder. Solenoids help convert electrical energy into mechanical work i.e. a linear motion for the application that requires quick activity. It is an electromagnetic device which operates the piston inside a cylinder as per the coil magnetism and creates no harm or pollution into the atmosphere compared to conventional IC engines which runs on burnt fuel consumption causing dangerous pollution to the natural environment. As the current passes through the coil, the electromagnetic field is induced and the engine runs on magnetic attraction and repulsive principle. In this thesis a single cylinder solenoid engine is designed and fabricated which runs on a 230v AC supply which gives out approximately 82% of efficiency.

Keywords: *Solenoid Engine; Electromagnetic Force; Cylinder and Piston Mechanism; 3D-CAD Design Modelling; Fabrication;*

CHAPTER-1: INTRODUCTION

An Engine or motor is a machine, designed to convert one form of energy into mechanical energy. Heat engines burn fuel to create heat, which is then used to create a force. Electric motors which convert electrical energy into mechanical energy. [1]

1.1 Heat Engine: A heat engine may also serve as a prime mover-a component that transforms the flow or changes in pressure of a fluid into mechanical energy. An automobile powered by an internal combustion engine may make use of various motors and pumps, but ultimately all such devices derive their power from the engine. Another way of looking at it is that a motor receives power from an external source, and then converts it into mechanical energy, while an engine creates power from pressure (derived directly from the explosive force of combustion or other chemical reaction, or secondarily from the action of some such force on other substances such as air, water, or steam. However the use of this engine typically has a negative impact upon air quality and ambient sound levels. There has been a growing emphasis on the pollution producing features of automotive power systems. Carbon monoxide is highly toxic, and can cause poisoning, so it is important to avoid any build-up of the gas in a confined space. Catalytic converters can reduce toxic emissions, but not completely eliminate them. Also, resulting greenhouse

gas emissions, chiefly carbon dioxide, from the widespread use of engines in the modern industrialized world is contributing to the global greenhouse effect – a primary concern regarding global warming.

1.2 Electric Motor: An electric Motor Vehicle (EMV), also referred to as an electric drive vehicle, uses one or more electric motors or traction motors for propulsion. An electric vehicle may be powered through a collector system by electricity from off-vehicle sources, or may be self-contained with a battery, solar panels or a generator to convert fuel to electricity. EVs include road and rail vehicles, surface and underwater vessels, electric aircraft and electric spacecraft. An electric motor uses electrical energy to produce mechanical energy, usually through the interaction of magnetic fields and current-carrying conductors. The reverse process, producing electrical energy from mechanical energy, is accomplished by a generator or dynamo. Traction motors used on vehicles often perform both tasks. Electric motors can be run as generators and vice versa, although this is not always practical. Electric motors are being found in applications as diverse as industrial fans, blowers and pumps, machine tools, household appliances, power tools, and disk drives. They may be powered by direct current (for example a battery powered portable device or motor vehicle), or by alternating current from a central electrical distribution grid. The smallest motors may be found in electric wristwatches. Medium-size motors of highly standardized dimensions and characteristics provide convenient mechanical power for industrial uses. Electric motors may be classified by the source of electric power, by their internal construction and by their application.

1.3 Solenoid Engine: "A solenoid engine is defined as the engine that works by passing electricity through the coils which makes the pistons move back and forth due to electromagnetism."

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. Solenoids are important because they can create controlled magnetic fields and can be used as electromagnets. The term solenoid refers specifically to a magnet designed to produce a uniform magnetic field in a volume of space (where some experiment might be carried out).

In engineering, the term solenoid may also refer to a variety of transducer devices that convert energy into linear motion. The term is also used to refer to a solenoid valve, which is an integrated device containing an electromechanical solenoid which actuates either a pneumatic or hydraulic valve or a solenoid switch, which is specific type of relay that internally uses an electromechanical solenoid to operate an electric switch; for example, an automobile starter solenoid. The solenoid coil engine is like a normal internal combustion engine. Here the crankshaft is driven by the use of solenoid coils instead of burning of fuel.

1.4 Electro-magnetism:

Reciprocating pistons are sliding mounted 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.

When supplies current through coil then due to electromagnetism generates magnetic field around hat coil due to that the rod inside get repel or attract based on direction of current. To give movement from one plunger to other plunger attraction can use simple distributor rather than micro controller.

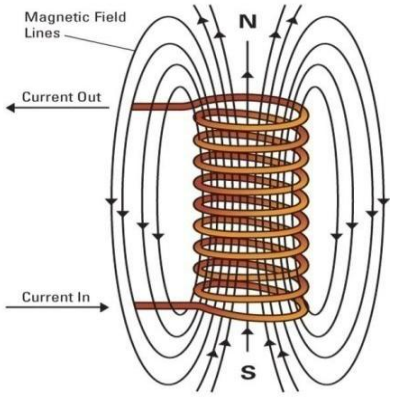

Figure 1: Solenoid Electro-mechanism

1.5 Principle Working of Solenoid Engine:

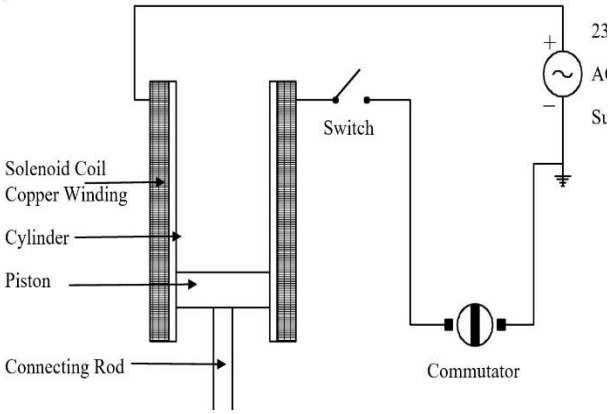

Figure 2: Schematic circuit diagram of Solenoid Engine

In Operation, as shown in the above figure 2, the circuit consist of a simple cylinder and piston arrangement of a single cylinder solenoid engine. The cylinder is coil wound around its circular external surface. Initially the piston is in BDC position. When the current is supplied from the 230v AC mains and switch is in closed position the current flows through copper coil will develop an electromagnetic field around the cylinder in the formation from South-Pole to North-Pole, resulting in the attraction of the piston in the direction of current flowing in the coil, making piston to move from BDC to TDC and the crank completes half cycle of revolution. In another half cycle the commutator which is mounted on one end of crank shaft cuts-off the current supply which breaks the induced electromagnetic field and therefore piston tends to move down from TDC to BDC due to its self-weight with gravitational force, hence the crank completes its other half of revolution. The process or cycle keeps on repeating until main power supply is switched off. The process can also be used for generating a free flowing energy by connecting a dc motor around the other end of crank with timing pulley belts arrangement. The energy generated can be stored to the batteries which can further be used for different or various applications.

1.6 Advantages:

The following are the advantages of solenoid engine:

1. The solenoid engine causes zero atmospheric pollution and help in global warming.
2. These engines can be used as an alternative to fossil fuels.
3. These engines has more efficiency with lesser torque.
4. The reaction time required for a solenoid engine is very quick.

5. It has less running cost than an internal combustion engine.
6. It takes less amount of charge from battery in every revolution of the crankshaft for few seconds.

1.7 Disadvantages:

The following are the advantages of solenoid engine:

1. It cannot produces maximum power output like a heat engine.
2. It can provide less uniform torque at cranks engine.
3. Complexity for multi-cylinder system.
4. Design is not robust in nature.

1.8 Applications:

The following are the applications of solenoid engine:

1. The core of the solenoid is used for applying mechanical force to the valves.
2. Electromagnets find application indoor locking systems as a secure closure.
3. Computer printers and fuel injector gears in cars use solenoids.
4. The can be used reciprocating systems like shaper and slotting machines.
5. Due to its low cost and maintenance these solenoid are getting employed in wide range of fields like mechatronics engineering.

CHAPTER-2: LITERATURE SURVEY

As a result of extensive literature survey we have reached the condition that a number of works has been done in the field of design, development and fabrication of various solenoid engines. Some of the important works are mentioned below:

Design & Fabrication of 4-Stroke Solenoid Engine (2019) By-Anamika Tiwari, et. al. [2]:

In present investigation they have designed a solenoid coil engine based on Induction principle which is alternate option of electric Engine in future due to its 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.

Magnetic Repulsion Piston Engine (2015) By- Danish Shaikh et. al. [3]:

Magnetism possess a magnificent opening for development. Bullet trains using the technology of magnetic levitation have proved the strong nature of electromagnetic fields. Keeping in mind the arising needs of industry, in this project we tried to design and experiment, a system called Magnetic Repulsion Piston 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 force thus developed is used to generate mechanical power. Successful development in this field can actively help in switching over internal combustion engines.

Studies on Electromagnetic Engine (2014) By- G. Bala Subramanian et. al. [4]:

Over the last century numerous changes were brought to the internal combustion engines. Numerous researches are carried out in hopes of improving the engine characteristics. Increasing the efficiency and reducing the exhaust gases have been dominant in the fields of

research. The volume and number of applications of engines have grown steadily, penetrating and conquering new markets relentlessly. The exhaust gases contain numerous pollutants that are extremely harmful though in chronic conditions. Hence, electromagnetic engines were created that uses the combined power of an electromagnet as well as a permanent magnet. These engines cause no air pollution and are a dominant force when this world faces huge crisis due to inadequate fossil fuels. While these engines have already proven their worth as alternative sourced engines, non-polluting and eco-friendly, the current challenge is to make them more efficient and cost effective.

An Electromagnetic Mechanism which works like an Engine (2013) By- Shirsendu Das et. al. [5]:

Engine is the main power source of automobiles where combustion takes place and produces heat which converts into mechanical energy. We know internal combustion engines are used in automobiles, aeroplanes etc. but the incomplete combustion produces some harmful gases, which is one main cause of air pollution. Modern science and technology has taken many positive steps for emission control. Like, using CNG and LPG's instead of petrol and diesel. Now technology brings electrical bikes, scooters and cars. The battery of electrical vehicle can charge easily like mobile. They have less running cost and 100% emission free. But they have very less load carrying capacity and not suitable for long run. So basically we have to prefer engines for more power and more running capacity. Here, introduction of a mechanism which has more load carrying capacity and running capacity than electrical vehicles and makes zero emission or pollution has been done.

Electric Vehicle with zero-fuel Electromagnetic Automobile Engine (2013) By- J. Rithula, et. al. [6]:

The main aim of the project is to design an electromagnetically reciprocating automobile engine. A four-stroke engine is used in the vehicle. The design involves the replacement of the spark plugs and valves by conductors and strong electromagnetic material. The piston is a movable permanent magnet and while an air core electromagnet is fixed at the top of the cylinder. When the electromagnet is excited by A.C. (square wave) supply, for same polarities these magnets will repel and for opposite polarities they will attract, thus causing to and fro movement of the piston. So when cylinder of the four-stroke engine experiences attraction of magnets due to which the piston moves upwards, repulsion takes place inside cylinder in which the piston moves downwards and then during the next stroke vice-versa occurs. The to and fro movement of the piston is converted into a rotary motion by the crankshaft, which in turn is coupled to the wheels which causes the wheel to rotate. So with the help of electromagnets & permanent magnets, the to and fro movement of the piston is obtained using the alternating attractive and repulsive force of the magnets, which is responsible for the movement of the vehicle. Thus we can run the electric vehicle without a motor and the energy is extracted in a clean way as it does not require fuels, reducing the air pollution.

Prototype Implementation of Electromagnetic Piston (2016) By- Ashwin Mathew Johnet.et. al. [7]:

The presented paper is an electromagnetic piston that works on the basis of magnetic attraction and repulsion.

The piston consists of an electromagnet placed between two permanent magnets of same polarity. The permanent magnets, being of same polarity, are held apart due to repulsive forces. When the electromagnet is energized, the magnets are attracted and hence move towards each other. When the excitation is removed, the electromagnet reverts to its original state, and hence the permanent magnets repel and move away from each other. When the electromagnet is energized and de-energized alternatively, the magnets move towards and away from each other, contributing to the reciprocating movement of the piston.

Solenoid Engine (2018) By- K.Sreenivas et. al. [8]:

Combustion takes place & produces heat which converts into mechanical energy. We know IC-Engines are used in Automobiles, Aero plane etc. But the incomplete combustion produces some harmful gasses, which is one main cause of air pollution. Modern Science & Technology has been taken many positive steps for emission control. Like, using CNGs & LPGs instead of petrol & diesel. Now technology brings Electrical bikes, scooters & cars. The battery of electrical vehicle can charge easily like mobile. They have less running cost & 100% emission free. But they have very less load carrying capacity & not suitable for long run. So basically we have to prefer Engines for more power & more running capacity. Here I have introduced a mechanism which has more load caring & running capacity then electrical vehicles but make zero emission or pollution

Design and Fabrication of Solenoid Engine (2019) By -Ram Bansal et. al. [9]:

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 causes 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.

Experiment Working Model of V8 Solenoid Engine

2021 By- Rahul Bhatia. et. al. [10]

Electric Vehicles are becoming an increasingly attractive alternative to the car with a combustion engine, considering the effect on the environment as well as economic factors such as the gradual increasing price of fluid fossil fuels, maintenance and others. Due to that these vehicles are widely known for their zero-emission and powered by renewable energy sources. The idea of the project is to take another alternative design of EV prime

mover to replace the existing electric motor. In general, EVs are driven and controlled by the integration of electrical, electronics and also mechanical components but the main component that moves these vehicles is the electric motor.

The electric motor works on principles of electromagnetic induction by converting electrical energy to kinetic energy. This energy conversion is the main purpose of an electric motor and this actuator are highly popularized in most EV's designs. So a solenoid will be used to replace the electric motor as a prime mover. For this, a prototype of a solenoid is designed, built, and tested. The solenoid will be used as a kicking device. As earlier studies have investigated a solenoid as a shooting mechanism. In one study the solenoid is investigated as the most suitable kicking device. The other study designed and optimized a solenoid. In this study, a prototype solenoid is designed and tested.

CHAPTER-3: METHODOLOGY

3.1 Methodology Employed:

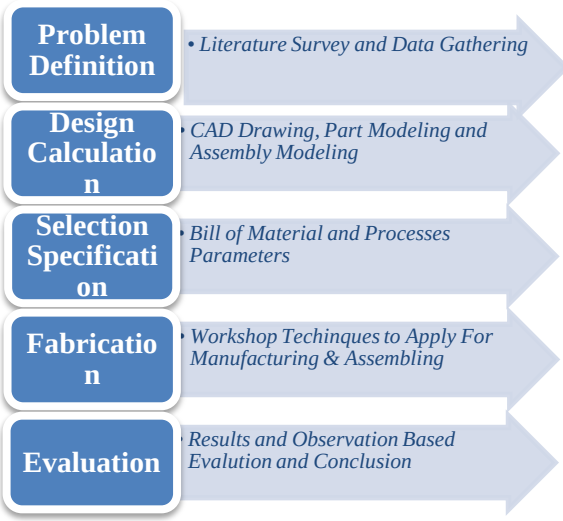

Figure 3: Methodology to be employed

3.2 Design Calculations:

Input Voltage, ***V***= 230 V AC

Input Current, ***I***= 0.7 A

Input Power, ***IP*** = ***V*** x ***I*** = 230 x 0.7 = 161 W

The maximum force exerted by electromagnet due to input power is given by

$\mathbf{F} = \frac{\mathbf{N^2 I^2 AK}}{\mathbf{2G^2}}$ *Where, N= No. of Coil Turns* = 2750

I= Current Flowing Through 28-Gauge Coil = 0.7A

A= Cross-Sectional Area of Electromagnet = 0.0005725 m^2 (d=0.027m)

K= Vacuum Permeability of Free Space = $4\pi \times 10^{-7}$ H/m

G= Least distance between piston and cylinder of electromagnet = 0.002 m

Therefore,

$\mathbf{F} = \frac{2750^2 \times 0.7^2 \times 0.00057 \times 4\pi \times 10^{-7}}{2 \times 0.002^2} = 331.7$ N

Torque transmitted due to force exerted by electromagnet and crank radius (0.019m)

T = F x **R** = 331.7 x 0.019 = 6.3 Nm

3.3 Assembly Modelling and CAD Drawings:

A ***'MAXON CINEMA 4D'*** 3D-Modelling software was employed for design and development of the project model to conceptualize and ***'Autodesk CAD'*** 2D-Drawing software was used to create actual part model and assembly drawings.

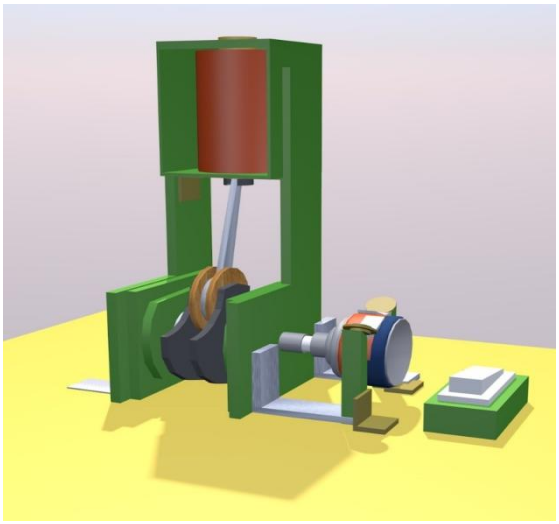

Figure 4: Isometric View of Assembly 3D-Model Representation

The actual parts of the single cylinder solenoid engine that has been fabricated and assembled corresponding to the 3D project model.

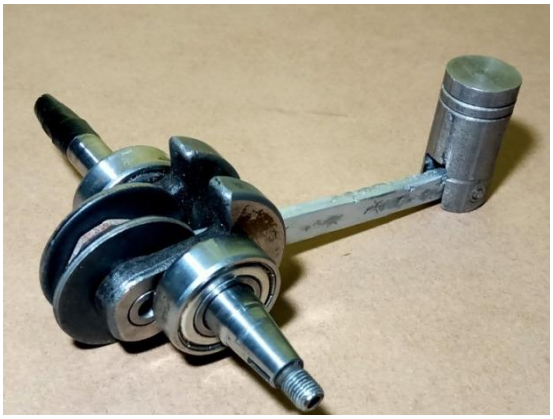

Figure 5: Comprising Piston & Pin, Connecting Rod, Crank Shaft, Bearing, Washer & Pin

Figure 6: Commutator welded with Nut

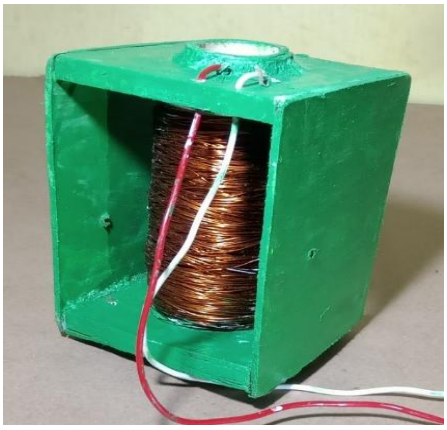

Figure 7: Cylinder with Solenoid Coil

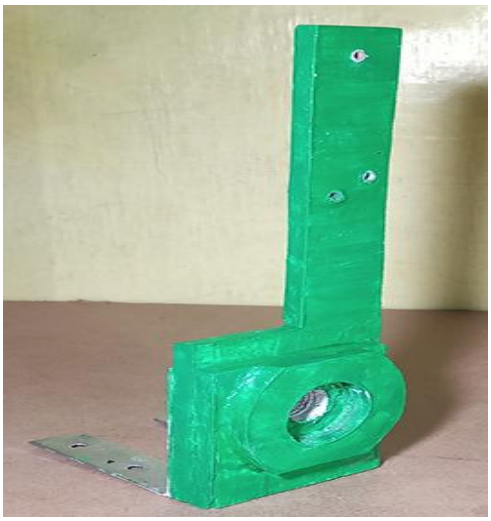

Figure 8: Supporting Column Wall

Figure 9: Supporting Base Plate

Figure 10: Assembly of Actual Fabricated Model

CHAPTER-4: OBSERVATIONS AND RESULTS

4.1 Observations:

Output Angular Speed ***N*** = 200 rpm

Output Power at Shaft End

$$OP = \frac{2\pi NT}{60} = \frac{2 \times \pi \times 200 \times 6.3}{60} = 131.9 \text{ W}$$

Efficiency of the Single Cylinder Solenoid Engine is

$$\acute{\eta} = \frac{OP}{IP} \times 100 = \frac{131.9}{161} \times 100 = 81.95\ \%$$

4.2 Results:

The following results were obtained based on design and fabrications of single cylinder solenoid engine.

Table 4.1: Observation and Results

Input IP (W)	Force F (N)	Torque T (Nm)	Angular Speed N (Rpm)	Output OP (W)	Power ή (%)
161	331.7	6.3	200	131.9	81.95

The efficiency of single cylinder solenoid engine obtained is approximately 82%.

CONCLUSIONS:

The following conclusions were drawn based on the results obtained.

- We selected this topic because we want to study a revolutionary engine that will reduce the pollution to a greater extent which has been increasing due to the harmful emissions from the conventional IC (Heat) engines.
- A single cylinder solenoid engine was designed and manufactured effectively based on selection of material specification and design considerations. To design and development of the project model, a 3D and 2D-CAD softwares were used for modelling and drawings. Basic conventional machining operations were performed for fabrication and assembling of the project model.
- The observations and results of working model concludes that for an input power of 161W, the electromagnetic force exerted on cylinder is 331.7 N which transmits a torque of 6.3 N-m and obtains the output power of 131.9 W. Therefore the efficiency of the engine is found to be approximately 82%. The result signifies the solenoid engine can give more output efficiency for the energy supplied than comparing to IC Engine or Electrical Motor Vehicles.

FUTURE SCOPE:

From the point thus far reached in this work, studies can further be extended in the following directions:

- This engine run a crankshaft using the solenoid coils and obtain power. However, the power obtained through this engine cannot be compared to the power of a conventional IC engines

because these vehicles use electromagnetic force to run the engine.

- 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 may also increase the power.
- This engine would eliminate the drawbacks of the electric motor used in electric vehicle because of its capabilities of achieving higher efficiency. The drawback observed during the working of the engine was that it produced a lot of noise and vibrations. Hence, if all the parameters were regulated more effectively then we could have attain more power in future.

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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]. Anamika Tiwari, Anurag Singh, Deepak Agarwal, Ajay Kumar Verma, "Design and Fabrication of 4-Stroke Solenoid Engine", International Research Journal of Engineering and Technology (IRJET), Volume-6, Issue-12, December 2019.

[3]. Piyush Hota, Mahima Rathore, Danish Shaikh, "Magnetic Repulsion Piston Engine", International Journal of Science and Research (IJSR), ISSN 2319-7064, Volume-4, Issue-12, December-2015.

[4]. Amarnath Jayaprakash, Balaji, G. Bala Subramanian, "Studies on Electromagnetic Engine", International Journal of Development Research (IJDR), ISSN 2230-9926, Volume-4, Issue-3, pp. 519-524, March-2014.

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

[6]. 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).

[7]. Ashwin Mathew John, Mathew George, Reenu Saji, Shamith Kaur, "Prototype Implementation of Electromagnetic Piston", International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering (IJIREEICE), ISSN 2321-2004, Volume-4, Issue-4, April 2016.

[8]. K.Sreenivas, T. Suresh, P. Sai Srinivasulu, K. Akhileswar, B. Santhi, "Solenoid Engine", International Journal of Engineering Trends & Applications (IJETA), ISSN: 2393-9516, volume-5, Issue-2; Mar-Apr 2018.

[9]. Ram Bansal, Rahul Kushwah, Divya Pawar, "Design and Fabrication of Solenoid Engine", International Journal of Modern Engineering

Research (IJMER), ISSN: 2249–6645, Volume-9, Issue-3; March 2019.

[10]. Rahul Bhatia, Vishal Jariwala, Akash Jariwala, Abhishek Alkari, Hiral Chauhan, "Experimental Working Model of V8 Solenoid Engine", International Journal of Creative Research Thoughts (IJCRT), ISSN: 2320-2882, Volume-9, Issue-4, April 2021