

DESIGN AND FABRICATION OF A SOLAR POWERED SOLENOID ENGINE

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in Mechanical Engineering

By

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SCHOOL OF MECHANICAL ENGINEERING**

SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with grade "A" by NAAC

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APRIL 2021



SATHYABAMA

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of **T BHARGAV (37150193)** and **T HARISH (37150194)** who carried out the project entitled "**DESIGN AND FABRICATION OF A SOLAR POWERED SOLENOID ENGINE**" under my supervision from November 2020 to April 2021.

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Submitted for Viva voce Examination held on _____

Internal Examiner

External Examiner

DECLARATION

We, **T BHARGAV (37150193)** and **T HARISH (37150194)** hereby declare that the Project Report entitled “**DESIGN AND FABRICATION OF A SOLAR POWERED SOLENOID ENGINE**” done by us under the guidance of Mr. R. DEVARAJ, is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

1.

2.

DATE:

PLACE: CHENNAI

SIGNATURE OF THE CANDIDATES

ACKNOWLEDGEMENT

We are pleased to acknowledge my sincere thanks to Board of Management of **SATHYABAMA** for their kind encouragement in doing this project and for completing it successfully. We are grateful to them.

We convey our thanks to **Dr. S. Prakash, M.E., Ph.D., Dean, School of Mechanical Engineering** and **Dr. G. Arun Kumar, M.E., Ph.D., Head of the Department, Department of Mechanical Engineering** for providing us necessary support and details at the right time during the progressive reviews.

We would like to express our sincere and deep sense of gratitude to our Project Guide **Prof. R. DEVARAJ** for his valuable guidance, suggestions and constant encouragement paved way for the successful completion of our project work.

We wish to express our thanks to all Teaching and Non-teaching staff members of the Department of Mechanical Engineering who were helpful in many ways for the completion of the project.

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ABSTRACT

Now a days, most of the internal combustion engines use petroleum products such as diesel, gasoline. These chemicals during ignition liberates harmful gases like Carbon dioxide (CO₂), Carbon monoxide (CO), Sulphur dioxide (SO₂), Polycyclic aromatic hydrocarbons and Volatile organic compounds into the earth's atmosphere and affects largely the nature. To bring down these destructive consequences on environment the alternative source to these conventional internal combustion engines are electrical engines. The main objective of the present work is to design and fabricate a solar powered solenoid engine. This engine works on the principle of electromagnetic induction. The system also reduces the fuel cost by using renewable source of energy.

CHAPTER 1

INTRODUCTION

The advancement and production of electric vehicle is gradually increasing from the past few years and continuous research is going on in this department to raise the efficiency and to replace the existing theory. At present electric cars work with electric motors, accumulator is used to store the energy.

The main moto of this work is to design a V8 solenoid engine that follows the concept of electromagnetic induction. Solenoid is used as the replacement for the standard pistons that are being used in internal combustion engines. V8 solenoid engine consists of eight solenoids that power the engine. Here the electrical energy is converted into mechanical work. A specific firing order is given to run the engine without any excessive load. Electricity is the best alternative for the petroleum products to stop the emission. We use solar panel to charge the batteries and obtain clean source of free energy to run the engine.

The main parts used in solenoid engine construction are:

- Solenoid Coil
- Plunger
- Connecting Rod
- Crankshaft
- Spur Gear
- Bearings
- Chain Drive
- Screw and Bolt
- Flywheel
- Battery
- Solar Panel
- Relay
- Transformer
- Metal Proximity Sensor
- PCB

1.1 SOLENOID COIL

If a coil of copper wire is used as an electromagnet, it is referred as a solenoid which transforms electrical energy to mechanical energy when an electric current pass through the coil that creates a magnetic field which can be used as a source for creating linear motion. Solenoids are used in industries to control the flow of gases and liquids, automotive applications, car washing machines.



Fig.1.1 Solenoid

The advantage of using electromagnet compared to permanent magnet is that the magnetic field can be turned on when the power is supplied and this can be used as a switch making it automatic.

The electromagnetic field of an activated solenoid has positive and negative poles that attract or repel ferromagnetic material which allows the plunger to move back and forth. The solenoid that is used here has 1000 copper turns and of 25 gauge. Capacity of the solenoid is of 12V.

1.2 PLUNGER

The plunger is assembled in a long cylinder solenoid, which can be moved back and forth (push-pull). Plunger is made up of ferromagnetic material. The distance between the plunger and the solenoid is equipped with a suitable seal. Without power, the plunger extends for a part of its length outside the coil. When power is supplied magnetic field pulls the plunger into the coil. Electromagnets with fixed cores are not considered solenoids.

1.3 CONNECTING RODS

Connecting rod connects the plunger with the crankshaft.

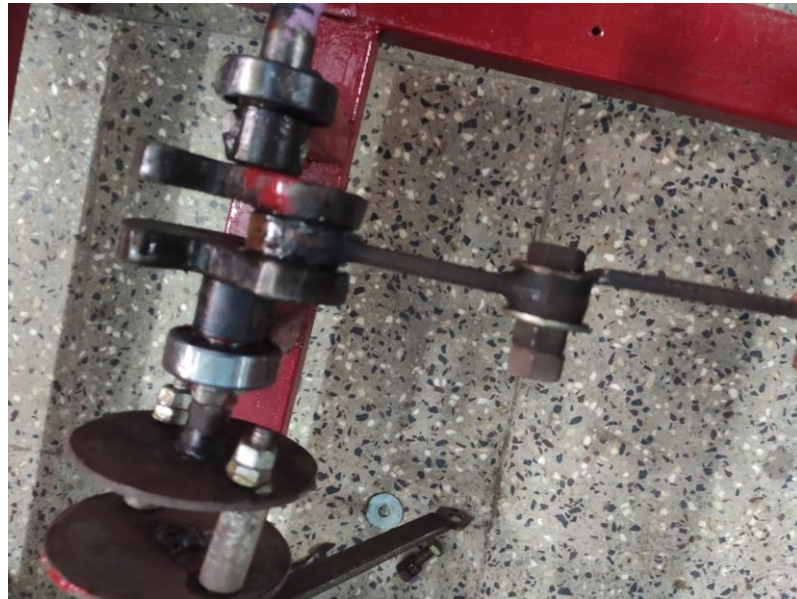


Fig.1.2 Plunger and Connecting Rod

1.4 CRANKSHAFT

A crankshaft is a shaft driven by the principle of crank mechanism, consisting of a series of cranks and crankpins to which the connecting rods are connected. It is a mechanical part able to perform a conversion from reciprocating motion to rotational motion.



Fig.1.3 Crankshaft

1.5 SPUR GEAR

Spur gears are most popular type of accuracy cylindrical gears. These gears feature a simple design of straight, parallel teeth placed around the circumference of a cylindrical body with a bore at the center fits over a shaft. In many variants, the gear is machined with a hub which thickens the gear body around the bore without changing the gear face. The central bore can also be put forward as to allow the spur gear to fit onto a spline or keyed shaft.

Spur gears are used in mechanical works to control the speed of a device or multiply torque by transmitting motion and power from one shaft to another through a series of mated gears.

The structural design and construction of a spur gear will influence its performance. For completing the work effectively and efficiently, gears need to be fabricated from quality materials and with accurate dimensions. The dimensional measurements of each feature are integral to how a specific gear function. As such, when an industry professional requires a new spur gear design or a replacement spur gear, it is imperative that they are familiar with the terms for each gear part and their respective measurements to ensure clarity and accuracy in the production or purchase.

1.6 BEARING

Bearing is a mechanical element that converts relative motion to the desired motion, and this reduces wear and tear between moving parts. The bearing design may give the free linear motion of the moving part or it can provide free rotation around a fixed axis, it can prohibit motion by controlling the vectors of normal forces that act on moving parts. Most bearings provide the required motion by reducing friction. Bearings are divided into many types according to the different operation.



Fig.1.4 Bearing

1.7 L - BRACKETS

An angle bracket is a L-shaped buckle used to join two parts at an angle 90-degree. Basically, it is made of metal but it can also be made of wood or plastic. The metallic L-brackets featured with holes to use screws. It is used to join a wooden shelf to a wall or to attach two furniture parts together. In V shaped engine construction L-brackets are used to support the pistons.

1.8 CHAIN DRIVE

Chain drive transmits mechanical power from one place to another place. It is often used to transmits power to the wheels of a vehicle, basically motorcycles and bicycles. It is used in a vehicle and machinery.

Roller chain is used to convey the power; it is known as the chain drive or transmission chain, pass by a sprocket gear, with the teeth of the gear meshes with the holes at every links of the chain. When the gear is turned, it pulls the chain and transfers mechanical force to the system.

Periodically the power output is obtained by simply rotating the chain, which is used to drag objects and lifting the weights. In some circumstances, the second gear is placed to recover the power by connecting shafts or hubs to the gear. By changing the diameter of the both input and output gears with reference to each other, we can also alter the gear ratio.

1.9 SCREW AND BOLT

Screw and Bolt are basically made of metal with helical ridge known as male thread. In machine construction, usually a circular cylindrical member with helical rib as a fastener.

Screws are known for self-tapping when the screw is turned the thread cuts into the material, it creates an internal thread that tends to pull fastened materials together and stops the pull-out. There are many screws for a variety of materials; those commonly fastened by screws include wood, sheet metal, and plastic. Bolts are related to screws which has internal thread cut known as female thread.

1.10 FLYWHEEL

A heavy rotating metal wheel which is designed to store the rotational energy which is a form of kinetic energy which is proportional to momentum of inertia and square of its rotational speed. If the rotational speed is doubled the kinetic energy is quadrupled.

Once suitably abstracted, the principle of energy storage system can be generalized as concept of an accumulator. In engine's the flywheel helps to smooth out the vibrations of energy obtained from during combustion in the cylinders. More precisely, a flywheel's stores energy when the input power is high and this stored energy can be used when the input power is low. Many reciprocating engine's uses flywheels to produce more torque at each piston.

Delivering energy at rates beyond the ability of an energy source. This is achieved by collecting energy in a flywheel over time and then releasing it quickly, at rates that exceed the abilities of the energy source. Most of the flywheels are made up of steel, cast iron and these are rotated on bearings. These flywheels revolve at limited RPM. To attain high revolving speed up to 60,000 RPM, it should be made up of carbon fiber material fixed with magnetic bearings. The flywheel used here is 900 grams.

1.11 RECHARGEABLE BATTERY

A rechargeable battery is a type of electrical battery which can be charged and discharged many times. It is made up of one or more electrochemical cells. The accumulator is a device that is used to store energy and also used to transfer it by the process of electrochemical reaction. Rechargeable batteries can be manufactured in many shapes and sizes, ranging from megawatt systems to button cells used to stabilize an electrical distribution network. There are different combinations of electrode materials and electrolytes, including lead–acid, zinc-air, NiCd, NiMH, Li-ion, LiFePO₄, Li-ion polymer.

The energy used to charge rechargeable batteries usually comes from a battery charger using AC mains electricity, although some are equipped to use a vehicle's 12-volt DC power outlet. The voltage of the source must be higher than that of the battery to force current to flow into it, but not too much higher or the battery may be damaged.

12volt rechargeable battery is used as a power source.



Fig.1.5 Rechargeable Battery

1.12 SOLAR PANEL

The photo-voltaic (PV) cell can be termed as solar panel. A framework of solar panel can be installed by placing photo-voltaic cell in a single module. Sunlight is used as a source of energy for Photo-voltaic cells and generate electricity. A group of PV modules is called a Solar Panel, and a system of panels is known as array. Arrays of a photovoltaic system supply solar electricity to run electrical appliances.

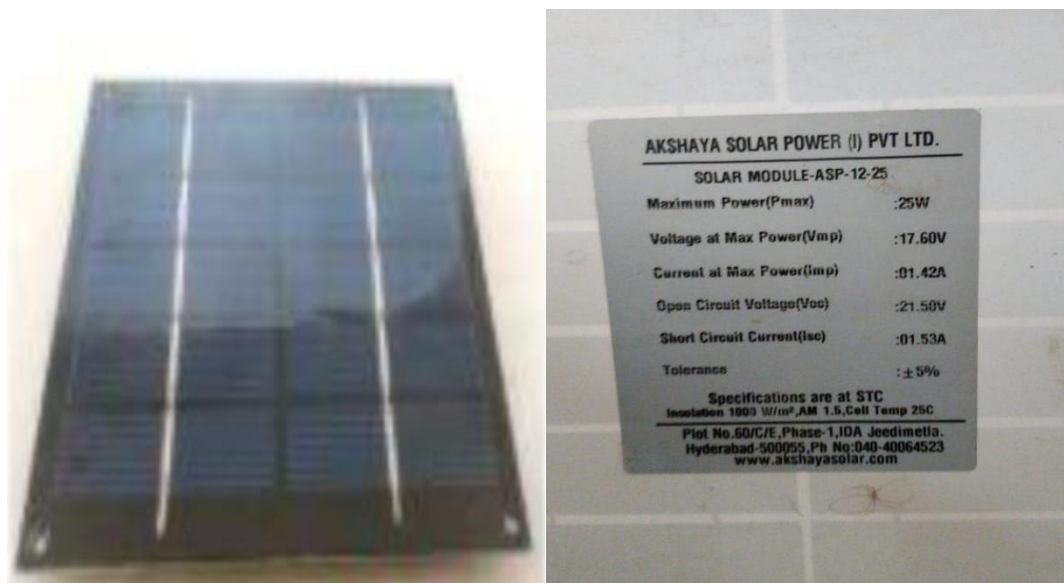


Fig.1.6 Solar Panel

Photovoltaic modules use photons which are emitted from the Sun to produce electricity through the photovoltaic effect. wafer-based crystalline silicon cells are used in most of the modules. The load carrying member of a module could be either the bottom layer or the top layer. Cells must be prevented from physical damage and water moisture. Most modules are hard, but the thin-film cells which are semi-flexible in nature are also available. A desired voltage can be obtained by connecting the cells in series, and to increase amperage they

must be connected in parallel. The module wattage can be calculated mathematically by voltage and ampere that are obtained in the module. The power output of the solar panel is different from manufacture specifications because they are obtained in laboratory conditions while operating in physical condition it depends on sunlight that exposed on panel.

- Model – ASP - 12- 25
- Panel Dimension - 555 * 340 mm
- Cell Type - Poly crystalline
- Maximum power (P_{max}) - 25W
- Voltage at minimum power (V_{amp}) - 17.6V
- Current at maximum power (I_{amp}) - 1.42A
- Open circuit voltage (V_{oc}) - 21.5V
- Short circuit current (I_{sc}) - 1.53A
- Panel efficiency - 13.2%
- Operating Temperature - 40 to 85 degree centigrade

1.13 Relay

Through the coil of the relay, an electrically powered switch, flowing current creates the magnetic field that initiates a lever to change the switch contact. In the present work, 30 amps relay switch is used.

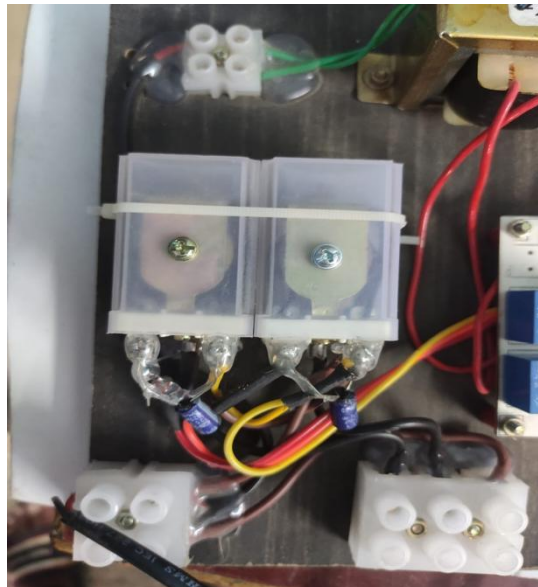


Fig.1.7 Relay

1.14 Transformer

A transformer is known as passive electrical device. The process of electromagnetic induction is used in transformer that transfers electrical energy from one circuit to another circuit. This device is used to step up or step down the voltage levels between circuits.



Fig.1.8 Transformer

1.15 Metal Proximity Sensor

This sensor works on the principle of eddy currents. Metal proximity sensor can only detect metal targets. They cannot detect non-metal targets such as plastic, wood, paper, and ceramic. Inductive proximity sensors can detect a metal object via opaque plastic, unlike photoelectric proximity sensors.

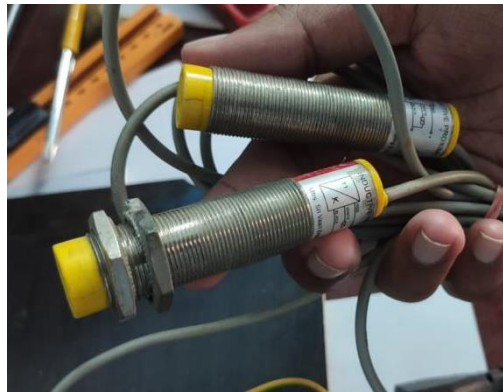


Fig.1.9 Metal Proximity Sensor

1.16 PCB board

It is used to connect all the electronic components using conductive pathways. It receives signal from the LDR sensor and controls movement of parabolic trough through the worm gear box arrangement.

For the present system, PCB board with relays and IC's is used. All the required electronic components are connected to this board by soldering.

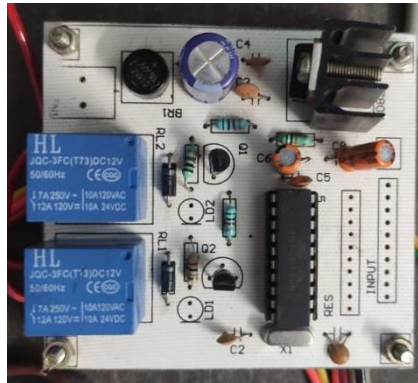


Fig.1.10 PCB Board

Advantages of PCB board:

Compact size and saving of wire.

Short circuits can be avoided.

Low cost and highly reliable.

CHAPTER 2

LITERATURE SURVEY

1.Title: Design and Fabrication of an Electromagnetic Piston Engine

Journal: International Research Journal of Modernization in Engineering Technology and Science

Author: Sanith Vaddepalli , Preetham N M, Ashish B Karanth

Year: 2020

Description

The electromagnetic piston engine is a type of reciprocating engine that operates on the electromagnetism principle, which states that like poles attract and unlike poles repel. The piston, connecting rod, cylinder, and crankshaft are all present in the engine, just as they are in a traditional engine. A neodymium magnet is fixed to the top of the piston since it is a very strong magnet. The piston attracts the solenoid from BDC to TDC as the magnet and solenoid have opposite poles. The solenoid repels and moves the piston from TDC to BDC until it switches poles and becomes the same pole as the magnet. This paper's engine is a four-cylinder V4 configuration engine. As a result of this experiment and project, this engine cannot currently be used to lift high-power loads or for significant vehicular applications. However, this engine can be improved in any way, and with continued improvement, it could soon be seen as a viable alternative to the current engine.

Conclusion

For the most part, the solenoid piston engine is based on the concept of a traditional IC engine. The solenoid replaces the engine's cylinder, and the piston is fitted with a high-power neodymium magnet. The engine works similarly to an IC engine, and it can be configured in any way that an IC engine can be configured. This engine is still in its infancy. As it stands, the engine produces low rpms and has a 20 percent lower performance than the IC engine. However, the most important thing to note is that the engine is powered by electricity and is therefore better in terms of environmental factors than traditional IC engines. The engine is inoperable. The piston is devoid of piston rings, and a solenoid replaces the traditional valves and ports in the cylinder head. The rest of the parts, such as the crankshaft, configuration, and flywheel, remain unchanged. The engine can power autonomous low-speed vehicles and has a lot of space for advancement in the future. This is one of the possible replacements for IC engines with adequate power.

2.Title: Design and Development of V8 Solenoid Engine

Journal: International Research Journal of Engineering and Technology

Author: Sarthak Raison

Year: 2020

Description

The engine is the primary source of power in a car, and the vast majority of engines today are Internal Combustion (IC) engines that run on either gasoline or diesel. When these fuels are burned in the piston, heat energy is released, which is then converted into mechanical energy. After combustion, these fuels emit toxic gases, polluting the atmosphere and having detrimental effects. Fossil fuels will be depleted in the near future, and Electric Cars are currently the perfect alternative to gasoline-powered vehicles. Electricity is a pollution-free energy source with virtually no emissions. The aim of this project is to create a solenoid engine that operates on the electromagnetism principle. This principle is applied to the conversion of electrical energy to mechanical energy.

Conclusion

The aim of the project is to make an electric vehicle that is powered by a group of solenoids function efficiently. A battery is used to provide current to the solenoid as well as to power the auxiliaries found in automobiles. The piston is based on the solenoid concept, and the power train is based on the IC engine. This idea is proposed in light of the steadily rising prices of fossil fuels and the emissions they cause. It will require a higher initial investment than traditional gasoline-powered vehicles, but it will prove to be more effective and cost less in the long run.

3.Title: Design and Fabrication of 4-Stroke Solenoid Engine

Journal: International Research Journal of Engineering and Technology

Author: Anamika Tiwari, Anurag Singh, Deepak Agarwal and Ajay Kumar Verma

Year: 2019

Description

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.

Conclusion

The four-stroke solenoid engine has been designed and fabricated 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 augment the power output. 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. It can be concluded that the test engine is simple to run the electric vehicle efficiently 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.

4.Title: Design, Analysis and Manufacturing of a V8 - Solenoid Engine

Journal: International Journal of Engineering Research and Technology

Author: Ruthwik Aki, N. V. Dharma Teja, K. S. V. Phanindra, Setty Siddhartha

Year: 2019

Description

In an automobile, the engine is the primary power source, in which fuel is burned and heat energy is emitted, which is then transformed into mechanical energy. When fuel is burned, toxic gases are emitted, resulting in air pollution. Electric vehicles are being built these days. For power generation, we prefer electromagnetic engines. We presented the design, as well as an analysis, in this paper.

Conclusion

Based on our estimates, we have a 21.44 percent efficiency, which can be improved by improving the design and choosing appropriate materials that work well under the specified conditions, i.e., making the mechanisms more fluid and therefore reducing friction and stresses. With that said, the new solenoid coils are constrained by a high drop in efficiency caused by the coils' unwanted heat generation. Even if this phenomenon is used for other applications, as in a traditional Combustion Engine, we are limited to today's technical advances to increase performance, but this model shows great promise for the future.

5.Title: Design and Fabrication of Solenoid Engine

Journal: International Journal of Modern Engineering Research.

Author: Ram Bansal, Rahul Kushwah, Divya Pawar

Year:2019

Description

As we move toward becoming a developed world, the demand for fossil fuels increases. Hence an alternative to fossil fuel is the present requirement. The internal combustion engine pollutes the environment. As a consequence, the electromagnetic field was invented to solve this problem.

Conclusion

The electromagnet's windings loosened up with repeated handling, increasing the gaps between the windings. This results in a decrease in potential energy from the power source band, which prevents successful magnetic flux generation. It's also worth noting that the permanent magnet's energy is greater than that of an electromagnet. The engine will be built with materials that have a high strength-to-weight ratio.

6.Title: Solenoid Engine

Journal: International Journal of Advance Engineering and Research Development.

Author: Fanse Mayur N, MachhiJeet Kumar B, Panchal Prashit Kumar D.

Year: 2017

Description

This paper focuses on reducing the use of large fossil fuels and increasing the use of renewable energy sources. Using a solenoid engine, it is possible to reduce emissions and save electricity in the future. The use of electromagnetic engines reduces air emissions and allows for environmentally sustainable activity. The current challenge is to make them more cost-effective by making them more powerful and comfortable. The friction of the engine in this engine is high.

Conclusion

The pentagonal engine structure is presented in this work. We may build the structure with more sectional design in the future for more power and torque output, similar to a V8 or V12 engine with more powerful power output. The use of non-renewable resources is limited as a result of this and similar systems, and potential energy can be conserved.

7.Title: Solenoid engine

Journal: Indian Journal of Research

Author: Dr. Vijay Kumar, Anurag, Ankit Kusum, Aditya Nadh Yadav

Year: 2017

Description

The purpose of this work is to design and construct an electromagnetic engine. This engine differs from internal combustion engine because of its operating principle as this engine works on electromagnetic principle instead of combustion of fossil fuels.

Conclusion

The working of a magnetic piston engine differs from other engines. This engine does not use gasoline as a result there is no pollution. Since ignition is absent, only a small amount of heat energy is generated, making it cost-effective.

8. Title: Emission less Engine by using electromagnet.

Journal: International Journal of Advance Engineering and Research.

Author: C. Sudhakar, K. Premkumar, K.Vijith, S.Balaji,

Year: 2014

Description

The purpose of this work is to build an electromagnetically reciprocating car motor. The vehicle is driven by a four-stroke mechanism. Although the plunger is a movable permanent magnet, the top of the cylinder is fixed by an air core electromagnet. The magnets repel for the same polarities and attract for the opposite polarities, allowing the piston to travel back and forth.

Conclusion

From this paper they tried to implement v-type engine that consist of two permanent and electromagnet respectively that works as per the magnetic principle, which can give better output.

9.Title: Electromagnetic Reciprocating Engine.

Journal: International Journal of Engineering Trends and Applications.

Author: Kala Butler.

Year: 2014

Description

Businesses have been searching for ways to reduce their reliance on oil. Oil supplies are depleting, and demand is rising in tandem with the price. The Electromagnetic Reciprocating Engine, which owns the patent for electromagnetic engine, will replace the Combustion Engine.

Conclusion

In a generator the electromagnetic reciprocating engine will replace the combustion engine resulting in green renewable energy. The electromagnetic reciprocating engine has a 12-year maintenance period and a low running cost. The electromagnetic reciprocating engine has the ability to replace the use of fossil fuels in transportation and power generation for homes and businesses.

10.Title: A Literature Review on Hybrid Electric Vehicles.

Journal: International Journal of Engineering Research & Technology.

Author: M. Viswanath, K. M. Arunraja, K. Lakshan Raaj.

Year: 2014

Description

In a generator the electromagnetic reciprocating engine will replace the combustion engine resulting in green renewable energy. The electromagnetic reciprocating engine has a 12-year maintenance period and a low running cost. The electromagnetic reciprocating engine has the ability to replace the use of fossil fuels in transportation and power generation for homes and businesses.

Conclusion

Hybrid-electric vehicles (HEV) combine the advantages of internal combustion engines which electric motors, and can be designed to achieve a variety of goals, including increased fuel efficiency, increased capacity, and additional auxiliary power for electronic devices and power tools. Power transmission through freewheels and chain wheels is both inexpensive and dependable. One downside is that driving on electric power is not a feasible long-distance alternative. Though in more stop-and-go traffic conditions, this hybrid power train system could be very useful.

11.Title: A Review Paper on the Study of 4-Stroke Solenoid Engine.

Journal: International Research Journal of Engineering and Technology.

Author: Anamika Tiwari, Abhishek Tiwari.

Year: 2014

Description

In this paper, we look at a solenoid engine that uses a solenoid actuator to drive the engine instead of burning gasoline, as in an internal combustion engine, and an electric motor in an electric vehicle. Essentially, this engine operates on the basis of electromagnetism. We chose to drive the engine to provide an alternative to the electric motor in an electric vehicle using the electromagnetism concept to compensate for various losses and prevent rapid battery drain. It functions similarly to a traditional gasoline engine, except the power source is now a battery, which is completely pollution-free and environmentally friendly.

Conclusion

This cutting-edge technology allows for the sustainable extraction of energy while also reducing emissions to zero, resulting in a significant reduction in pollution. It was cost-effective because the architecture is much simpler than traditional electric vehicle engines. There is no need for cooling, and many other components such as valves, cams, and ports have been removed. we can come to the conclusion that the proposed engine is an easy and effective method for operating an electric vehicle efficiently, and that if used in large-scale production, the power, speed, and efficiency can be increased to a greater extent by taking into account the recommendations stated in the future scope.

CHAPTER 3

AIM AND SCOPE OF THE PRESENT WORK

3.1 AIM OF THE PRESENT WORK

The main aim of the present work is to reduce greenhouse effect. In conventional engines petrol and diesel are used as their main fuel source and release pollutants. The objective of the work is to design and fabricate solar powered solenoid engine. That is constructed on traditional v-8 model. The basic principle used in solenoid engine is electromagnetism. The electrical energy is supplied to the solenoid which pushes the plunger to rotate the shaft. Battery is the power source for the engine. Batteries are charged using solar cells.

3.2 SCOPE OF THE PROJECT

The idea of this prototype is to use the property of an electromagnet. By changing the direction of current flowing through the solenoid we can change the polarity of the poles. The permanent magnet attached to the plunger is attracted or repelled by polarity difference. The performance of the engine can be improved by adding more permanent magnets in series, thus improving its efficiency, so that it can be used in heavy vehicles and other applications.

3.3 BACKGROUND OF SOLAR AS A SOURCE

Solar energy has always been a great source of energy due to its low cost and the unlimited existence of the sun. However, energy source that comes from natural resources are decreasing and some of them may become extinct source of energy in the future. So, we are using the most abundant source of energy as the power input to the solenoid engine.

3.4 DESIGN OF V-8 SOLENOID ENGINE

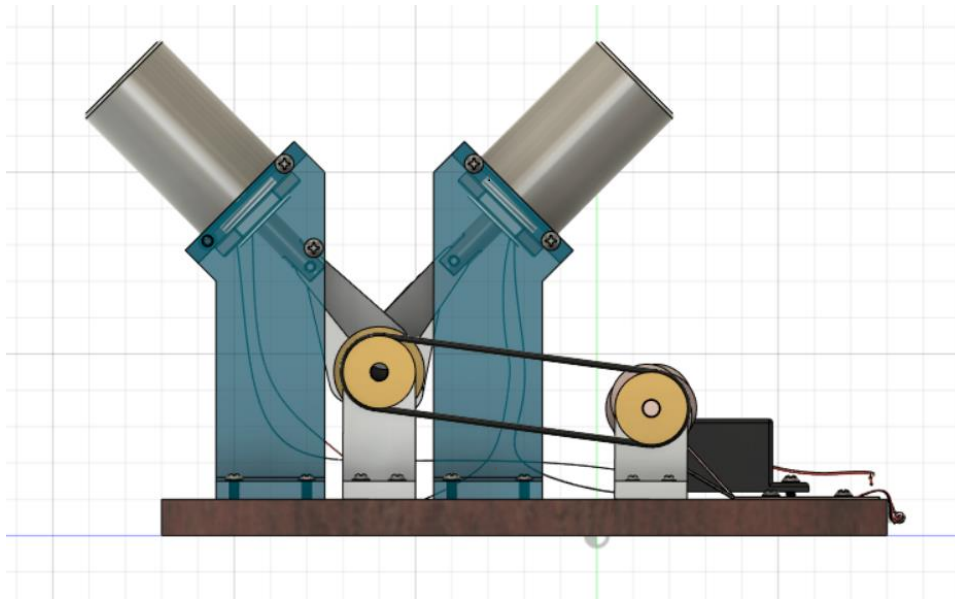


Fig.3.1 Front View of the Engine

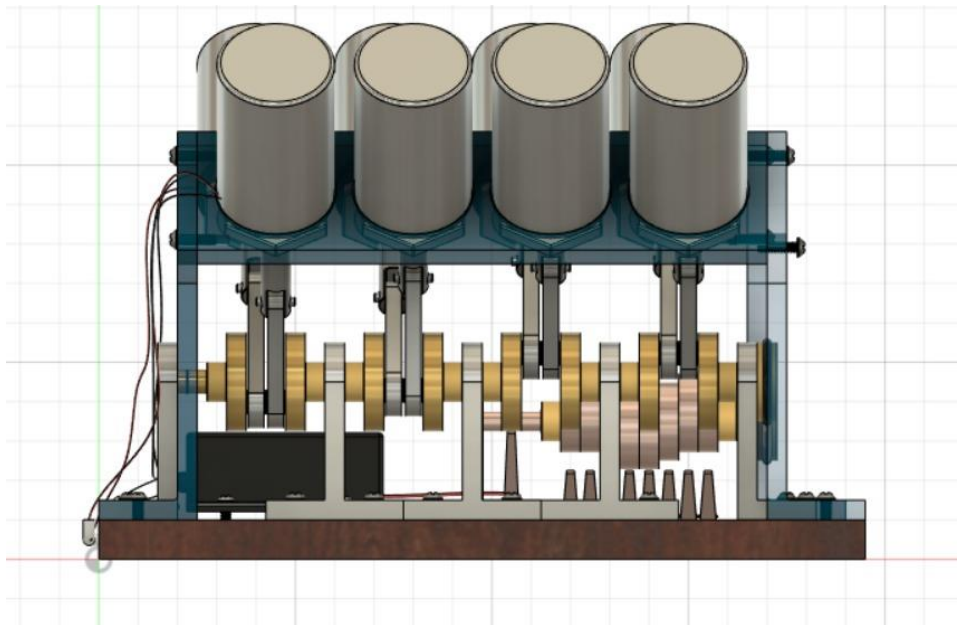


Fig.3.2 Profile view of the Engine

CHAPTER 4

FABRICATION METHODOLOGY

4.1 METHODOLOGY

- A design of the engine is made using Autodesk Fusion 360 software. The parts to be fabricated and the parts to be procured are to be identified and a market survey has to be done in order to identify the cost of these parts. The required parts have to be procured based on the design calculations.
- At first, base frame of approximately 860x460 mm is constructed.
- Crank shaft is fixed in the frame using bearing support. The crank shaft is customized as per design calculations.
- Flywheel is connected to the crankshaft and the speed of the engine is measured here.
- Crank shaft is connected to piston through link rod which leads to the movement of the crankshaft.
- Based on the requirement of input power, solenoid of 12V is constructed and coupled with crank shaft.
- An electronic based control unit is wired with solenoid and a proximity sensor is used to get the feedback.
- Now each crank is operated as per the firing order of the solenoids and the power output from the solenoid engine is obtained and the efficiency of the engine is computed.

4.2 WORKING

The electromagnetic attraction is the basis of the solenoid engine. It is an electromagnetic unit that uses coil magnetism to drive the plunger. A magnetic field is created around a conductor when an electric current is applied to it, and the conductor serves as an electromagnet. The current flowing through the coil, as well as the number of turns wound on the coil, are used to quantify the electromagnetic power. As current flows through the coil, it behaves like an electromagnet, and the motor is controlled using the magnetic attraction and repel principle. A piston reciprocates within a nonmagnetic cylinder that is open to the atmosphere in the mechanical sub-system. A connecting rod attached the piston to a crankshaft, allowing for rotary output. A magnet was placed at the top surface of the piston as part of the system. During reciprocating motion magnets travelled along with the piston. Magnets followed the piston during reciprocating motion.

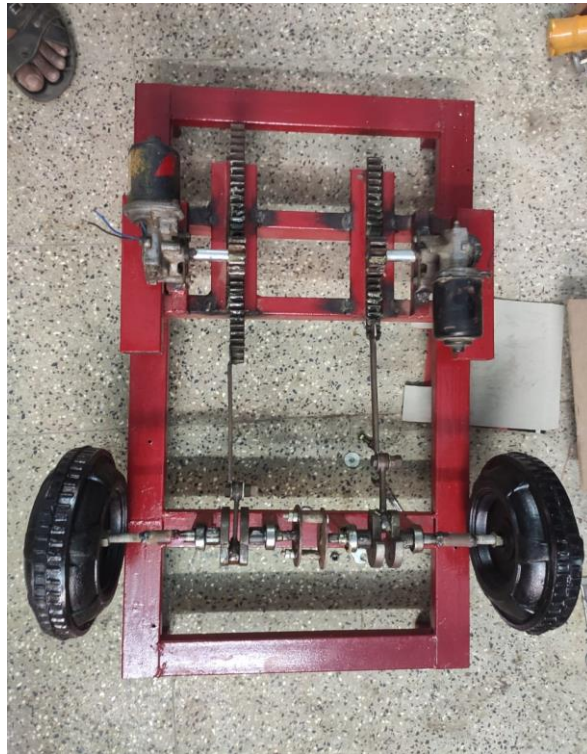


Fig.4.1 Solenoid Engine

The pole orientations of the magnets were oriented in the same direction. The north poles of both magnets would be exposed to the atmosphere if the south poles of both magnets were fixed to the piston rim. As current passes through a solenoid, it creates a dipole on both ends, resulting in the formation of the north and south poles. The energy was supplied by a normal Li-ion battery with a voltage of 12V.

The piston is attracted as current is passed through one of the solenoids. The nonmagnetic

cylinders were covered with the copper wire which acts as an electromagnet. It was fixed in place by a rigid frame made up of differential positioning arrangements. The controlling circuit is made up of two proximity sensors placed at TDC and BDC each of them senses the movement of both pistons separately. When Piston 1 is at BDC, the proximity sensor sends the signal to PCB and it actuates the relay. By using relay the solenoid is charged in such a way that the poles of the electromagnet are opposite to the Permanent Magnet 1, creates an external force on the piston. The continuous process can be achieved by rotating the flywheel with relay and metal proximity sensors. The regulating circuit was in charge of switching the direction of current in the electromagnet. When the piston approaches BDC, the sensors are positioned in such a way that they have a high performance. Solar panels are used as main power source which is connected to battery by using battery controller. This controller helps to connect the solar panel and battery.

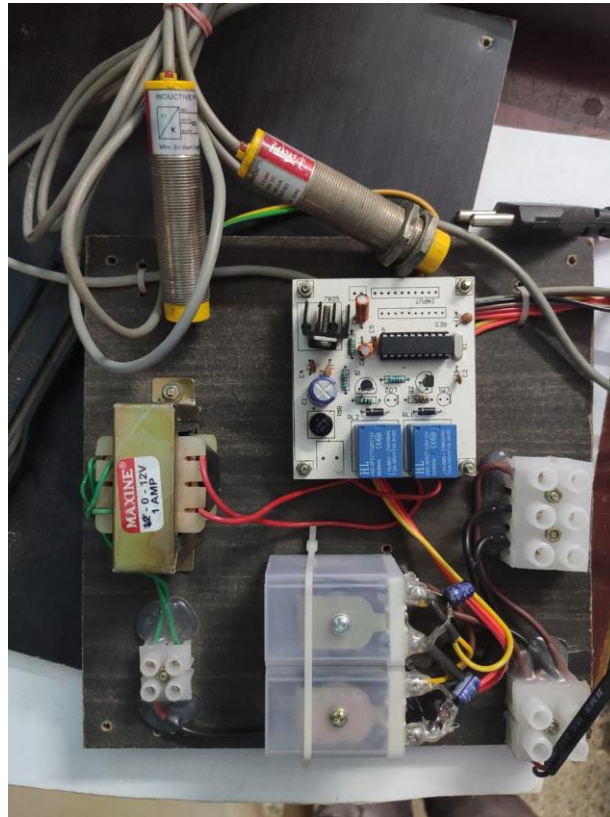


Fig.4.2 Electrical Circuit

4.3 CALCULATIONS

These calculations are done on exemplary basis

Voltage input (V_i) = 12 Volts

Current input (I_i) = 1 Amps

Power input = $V_i \times I_i = 12 \times 1 = 12$ Watts

Max. Force exerted by electromagnet on piston

$$F_1 = (N^2 \times I^2 \times K \times A) / (2 \times G^2)$$

Where, N = number of turns = 1000

I = Current through coil = 1 A

K = Permeability of free space = $4\pi \times 10^{-7}$

A = C/S area of electromagnet (radius $r = 0.0175$ m)

G = Least distance between electromagnet and permanent magnet = 0.005 m

We get,

Max. Force $F_1 = 24.127$ N

Force exerted by permanent magnet Force F_2

$$F_2 = (B^2 \times A) / 2\mu_0$$

Where, B = Flux density (T)

A = Cross-sectional area of magnet (radius $r = 0.0125$ m)

μ_0 = Permeability of free space = $4\pi \times 10^{-7}$

Now flux density $B = Br / 2 \times [(D + z) / (R^2 + (D + z)^2)^{0.5} - z / (R^2 + z^2)^{0.5}]$ Where,

Br = Remanance field = 1.21 T

Z = distance from a pole face = 0.005 m

D = thickness of magnet = 0.012 m

R = semi-diameter of the magnet = 0.0125 m

On substitution we get flux density, $B = 0.2568$ T

Now substituting B in the equation of force, $F_2 = 12.67$ N

Since, force F_1 and F_2 are repulsive,

Total force $F = F_1 + F_2$

$F = 36.8$

Torque $T = F \times r$

r = Crank radius = 0.01 m

Torque $T = 0.3685$ N-m

Mass of Fly wheel $\omega = (2 \times \pi \times N) / 60$,

where $N = \text{Speed} = 200\text{rpm}$

Therefore $\omega = 20.94 \text{ rad/s}$

Energy stored on flywheel $E = T \times \theta$

Where $T = \text{torque}$ $\theta = \text{Angle of rotation} = \pi \text{ radians}$

On substitution, the energy stored $E = 1.157 \text{ J}$

$$E = 0.5 \times I \times \omega^2$$

Where, $I = \text{Moment of inertia of flywheel}$

$\omega = \text{Angular velocity}$

On substitution we get moment of inertia, $I = 5.277 \times 10^{-7} \text{ Kg-m}^2$

Moment of inertia,

$$I = 0.5 \times m \times r^2$$

Where, $m = \text{Mass of fly wheel}$

$r = \text{Radius of fly wheel} = 0.07 \text{ m}$

$m = 2.154 \text{ Kg}$

Output power

$$P = (2 \times \pi \times N \times T / 60)$$

Where, $N = \text{Speed} = 200 \text{ rpm}$

$T = \text{Torque} = 0.3685 \text{ N-m}$

On substitution, Output power $P = 7.718 \text{ W}$

Efficiency = $(\text{Output}/\text{Input}) \times 100 = (7.718/36) \times 100\}$

Therefore,

Efficiency = 21.44

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Results and Discussion

An electromagnetic piston engine is one that operates on the magnetism principle, in which like poles attract and unlike poles repel each other. An engine with V8 configuration was designed based on this. The following findings were observed.

1. This engine has a low power input to high power output ratio. A higher load carrying capacity solenoid will provide more power to the engine but it will increase the size of the engine significantly.
2. This engine cannot handle heavy loads on its own as the load carrying capacity of the solenoid used in this engine is limited.
3. Vibration and noise of the engine can be reduced by mounting a flywheel which makes the engine to run smoothly at constant speed.
4. The load carrying capacity of this engine can be increased by gear mechanism which improves the engine speed and its performance.
5. Solenoid engines architecture is simpler and lighter as it has no valves and ports. This reduces the maintenance cost of the engine and also it minimizes the lubrication.
6. This engine can be used to power light unmanned vehicles where the speed of the engine is not important. This can be used where solar power is aplenty.
7. For solenoid coil testing, 28-gauge copper conductor with 1000 turns is taken. By varying the input current in the coil, the magnetic force can be increased and the plunger movement is observed as shown below.

Table 5.1 Coil Testing Observation for 1000 turns coil

Serial No.	Current	Movement of Plunger
1	1.2 Amp	Attraction
2	3.5 Amp	Rapid Attraction
3	6.5 Amp	Strong Attraction

8. This engine use solar energy thereby fossil fuel consumption can be greatly

reduced and hence the global warming can be minimized.

9. This work has a lot of scope for improvement in its design and performance as two solenoids, one at the top and other at the bottom of the piston can be added.

5.2 Advantages of solenoid engine

- It has less running cost than an internal combustion engine.
- It does not create pollution and can reduce global warming.
- It takes less amount of energy from the battery for every revolution of the crankshaft.

CHAPTER 6

SUMMARY AND OUTCOME OF THE PROJECT

6.1 SUMMARY

Based on the performance calculation, the efficiency is found to be 21.44%, which can be improved by improving the design and choosing appropriate materials that work well under the specified conditions, i.e., making the mechanisms easier and therefore reducing friction and stresses. The current solenoid coil has drop in efficiency due to the heat generated by the coil. The same phenomenon is observed in internal combustion engine and in order to increase the efficiency, the cooling process has to be improved.

6.2 OUTCOME OF THE PROJECT

A working model of a solenoid engine is designed and constructed which works on the principle of electromagnetism. The combination of eight electromagnetic coils and a specially built crankshaft results in emission-free operation. This device needs further improvement before it can be used for various industrial applications.

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