Design of Magnetic Reciprocating Engine

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1. Abstract - One of the most important issues which need to be addressed in the modern era is the huge dependency of vehicles on convectional sources of energy for working. The traditional I.C. Engine requires a fuel which is burned inside the engine to provide the energy required for the working of engine. The major problem with these engines is that they require non-renewable source of energy for working and also causes pollution. This led to depletion of convectional sources of energy as the automobile industry is increasing exponentially and thus causing the depletion of these resources and an ever-increasing pollution. To overcome all these issues, we propose the design of a reciprocating magnetic engine.

The magnetic engine works on the principle of magnetism i.e. it converts attractive and repulsive force into mechanical work. These engines use the combined power on an electromagnet and permanent magnet. The project considers several design aspects which ensure high efficiency, low production cost and generation of required power which are listed in the problem statements. The objective of the project is to develop a magnetic engine in which the cylinder head is an electromagnet and a permanent magnet is attached to the piston head. When an electromagnet is charged, it attracts or repels the magnet, thus pushing the piston downwards or upwards thereby rotating the crankshaft. This is how power is generated in electromagnetic engine. The recent trends show that the efficiency of electromagnetic engine lies between 12-20%. It can be achieved up to 40-45% by proper sealing the magnetic flux of the electromagnet and alignment, exact fitting the piston and cylinder and prevent the magnet flux leakage. Project will consider and work on the include working on the above points. The fabrication of the unit will be done using suitable process and test will be conducted to prove the above said features working in the model.

1.1 Introduction

With th**e** increase dependency on automobiles and around 50 million vehicles manufactured each year around the globe, it is becoming an alarming situation to switch to another source of energy. The communication and expansion which is growing manifolds each and every year leading to increase in automobiles run by fossil fuels. These IC engines could lead to depletion and exhaustion of fossil fuels and there won't be any left for future generation. This leads to creation of engines and machines which run on alternate sources of energy. The most preferred one is electricity which also provides good efficiency.

These situations lead of increased in other source of energy, one being the magnetic energy. This energy is found in thee universe as well as in the human body. This energy has certain potential and tapping into it can lead to enormous amount of success in the coming future. The recent studies have also confirmed about the same. The attraction and repulsion of the magnets which possesses humongous amount of energy can easily drive an automobile engine with reduction in cost and losses as well as increase in efficiency.

2. WORKING PRICIPLE

It works on the principle of magnetism and EMI. First we will discuss about the magnetism phenomenon and then we discuss about the EMI.

2.1 Mechanical part

As we have two NdFeb of grade 35 (N35) permanent magnet (main magnet) having same specifications, both the magnet will directly couple to motor. When the switch is in ON position the motor will come in the operation lead to rotate the magnet , while doing continuous rotation the polarity of magnet change again and again due to proper rotation. On the other side we will fixed the polarity of same NdFeb magnet but of different specification(as it is very small in size compared to main magnet) and there are five number of magnet fixed at the required location. Now the fixed magnet will comes under the magnetic field of main magnet, naturally it applied force on the fixed magnet . So as we fixed the polarity and location of smaller magnet it will perform oscillatory motion at the fixed position followed by supporting rod. This oscillatory motion rod will connected to connecting rod, and the further motion goes to crank shaft to convert the oscillatory motion into rotary and then all the transmission part will come as it is.

F= If both poles are small enough to be represented as single points then they can be considered to be point magnetic charges. Classically, the force between two magnetic poles is given by

$$F = \mu q_{m1} q_{m2/4\pi r^2}$$

where

F is force (SI unit: newton)
q_{m1} and q_{m2} are the magnitudes of magnetic poles (SI unit: ampere-meter)
μ is the permeability of the intervening medium (SI unit: tesla meter per ampere, henry per meter or newton per ampere squared)
r is the separation (SI unit: meter).

Magnetic field formula for cylindrical magnet:

B = Br /2 × [(D + z)/(R^2 + (D + z)^2) 0.5 – z/(R^2 + z^2) 0.5]

2.2 Electrical portion

As we said above it also use the principle of EMI and generating emf which play a very crucial role in it. As we know the variable magnetic flux when linked to closed coil an emf will produced in the loop according to faraday's law of EMI. The direction of induced emf will according the Lenz's law. So our rotating magnet will produced a variable magnetic field within the chamber. The variable magnetic field will directly linked to the coil having required no.of turns placed within the chamber. So an emf will induced in the coil which will further used to charge the battery connected to the motor. If the emf induced will alternating in nature, then we have to convert it into dc by using suitable rectifier and then by using suitable IC we used to charge the battery. As the coil behaves like an strong electromagnet such and it has its own magnetic field arranged in such a way that it supports the magnetism of permanent magnet connected to the motor to attract or repel the fixed magnet motion. By using all these we will made a engine which is self dependent and possessed some quality of renewable sources of energy.

Induced voltage is given by

$$\varepsilon = -N\frac{d\Phi_B}{dt}$$

Where, ε is the induced voltage, ***N*** is the total number of turns of the loop, Magnetic flux, ΦB**= B.A**, (B is the magnetic field and A is the area of the loop), ***t*** is the time.

3. DESIGN

Input voltage = 24V

Input current =3.5A

Input power = Voltage× Current

= 24×3.5 = 84W

Force exerted by permanent magnet

Force F = (B^2A)/2μ0

Where, B = Flux density (T)

A = Cross-sectional area of magnet (radius r = 0.05 m)

μ0 = Permeability of free space = 4π×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 = Remanence field = 1.21 T

z = distance from a pole face = 0.04 m

D = thickness of magnet = 0.025 m

R = semi-diameter of the magnet = 0.025 m

On substitution we get flux density, B = 0.0158 T

Now substituting B in the equation of force, F = 99.68 N

Torque T = F × r

Where F = total force on piston

r = crank radius = 0.05m

Torque T = 4.984N-m

Mass of Fly wheel

$\omega = (2\pi N)/60$,

where N = speed = 130rpm

Therefore ω = 13.08rad/s

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

Where T = torque

θ = Angle of rotation = 180 degree = π radians

On substitution we get energy stored E = 15.64 J

Also

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

Where, I = moment of inertia of flywheel

ω = angular velocity

On substitution we get moment of inertia, I =0.182 Kg-m^ 2

Moment of inertia, $I = 0.5 \times m \times r^2$

Where, m = mass of fly wheel

r = radius of fly wheel = 0.07 m

On substitution, We get m = 0.187 Kg

Output power,

$P = (2\pi NT)/60$

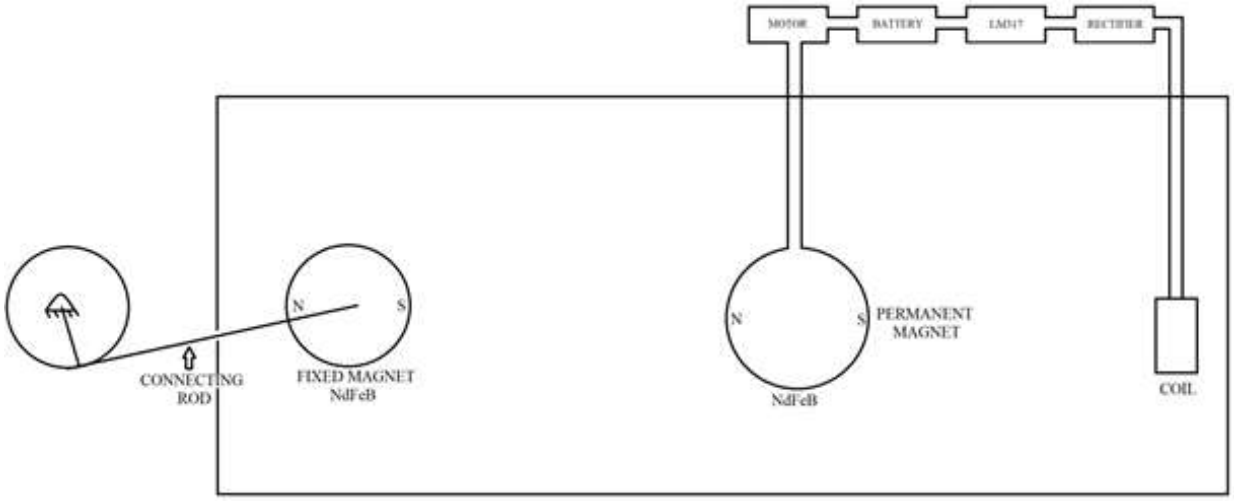
Where, N = speed = 130 rpm

T = Torque =4.984 N-m

On substitution, we get Output power P = 67.815 W

Efficiency = (Output/Input) × 100 = (67.815/84) × 100

Therefore, Efficiency = 80.732 %



Block diagram of MRE

4. STANDARD COMPONENTS

4.1 Neodymium Iron Boron Magnets

A neodymium magnet (also known as NdFeB, NIB or Neo magnet), the most widely used type of rare earth magnet, is a permanent magnet made from an alloy of neodymium, iron and boron to form the $Nd_2Fe_{14}B$ tetragonal crystalline structure. They have replaced other types of magnets in many applications in modern products that require strong permanent magnets, such as motors in cordless tools, hard disk drives and magnetic fasteners.

4.2 Cylinder

Electromagnetic engine uses only magnets for its operation. The cylinder must take care of unwanted magnetic field and other losses further cylinder material itself should not get attracted to the magnet and resist the movement of the piston. To take care of above issues, the cylinder must be only made up of non-magnetic materials such as stainless steel, titanium or similar materials of high resistivity and low electrical conductivity. The cylinder of an electromagnetic engine is a simple rectangular block with a blind hole in it. Usage of aluminum material makes the engine lighter unlike the cast-iron cylinder used in internal combustion engine.

4.3 Piston

The hollow piston casing is made up of non-magnetic stainless steel, titanium or similar materials of high resistivity and low electrical conductivity. Alternatively, piston casing can also be made up of non-metallic and non magnetic, thermal resistant materials as well or can be made by integrating both nonmagnetic and non-metallic materials. One end of the hollow case is fitted with a powerful permanent magnet made of (NdFeB), (SmCo) or similar high field strength magnetic materials. The permanent magnet acts as the core of the piston. The flat surface (which is also the pole of the magnet) of the piston that is nearer to the pole of the electromagnet is called the magnetic head of the piston or piston head. .

4.4 Connecting Rod

In a reciprocating engine, the connecting rod is used to connect the piston to the crankshaft. It converts the linear motion or oscillatory motion of the piston to the circular motion of the crankshaft. The connecting rod used in this engine is that of a power sprayer. The material of the connecting rod is cast iron. As the magnetic fields are contained inside the cylinder, the connecting rod will not be affected much.

4.5 Crank Shaft

The crankshaft transforms the linear motion of the pistons into a rotational motion that is transmitted to the load. Crankshafts are made of forged steel. The forged crankshaft is machined to produce the crankshaft bearing and connecting rod bearing surfaces. The rod bearings are eccentric, or offset, from the center of the crankshaft as illustrated in Figure above. This offset converts the reciprocating (up and down) motion of the piston into the rotary motion of the crankshaft. The amount of offset determines the stroke (distance the piston travels) of the engine.

4.6 Flywheel

Flywheel is made up of mild steel and it is used to convert reciprocating energy into rotational energy. It regulates the engine's rotation, making it operate at a steady speed. The amount of energy stored in a flywheel is proportional to the square of its rotational speed. Energy is transferred to the flywheel by applying torque to it. It is used to store the rotation kinetic energy.

4.7 Battery

Where high values of load current are necessary, the lead acid cell is the type most commonly used. The electrolyte is a dilute solution of sulfuric acid (H_2SO_4). In the application of battery power to start the engine in an auto mobile, for example, the load current to the starter motor is typically 200 to 400A One cell has a nominal output of 2.1V, but lead-acid cells are often used in a series combination of three for a 6-V battery and six for a 24-V battery.

4.8 DC Motor

A motor is an electrical machine which converts electrical energy into mechanical energy. The principle of working of a DC motor is that "whenever a current carrying conductor is placed in a magnetic field, it experiences a mechanical force". The direction of this force is given by Fleming's left hand rule and its magnitude is given by F = BIL. Where, B = magnetic flux density, I = current and L = length of the conductor within the magnetic field.

4.9 Rectifier

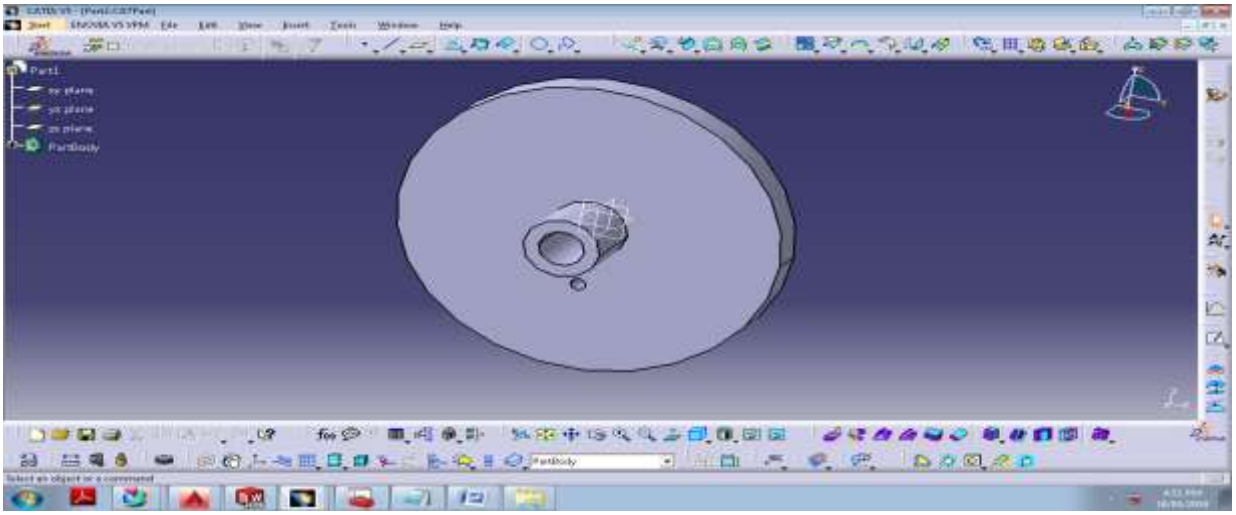
A rectifier is an electrical device that converts alternating current, which periodically reverses direction, to direct current, which flows in only one direction. The process is known as rectification, since it "straightens" the direction of current.

4.10 IC LM317

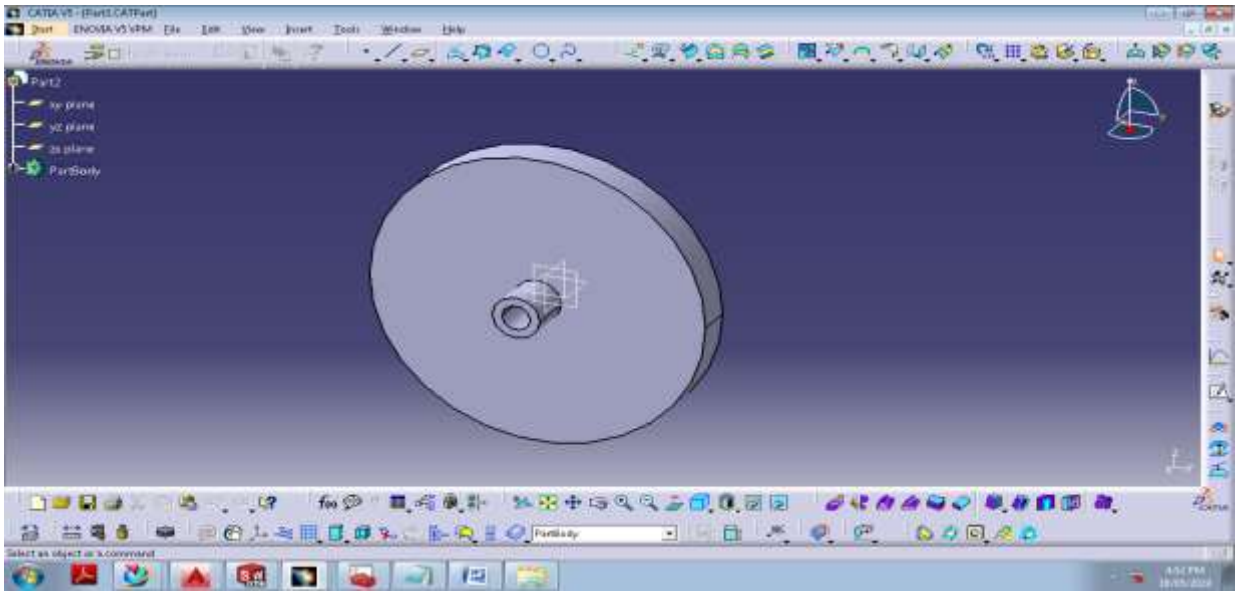
LM317 Voltage Regulator Circuit. The circuit consists of a low-side resistor and high-side resistor connected in series forming a resistive voltage divider which is a passive linear circuit used to produce an output voltage which is a fraction of its input voltage.

5. PART MODELLING BY USING CATIA

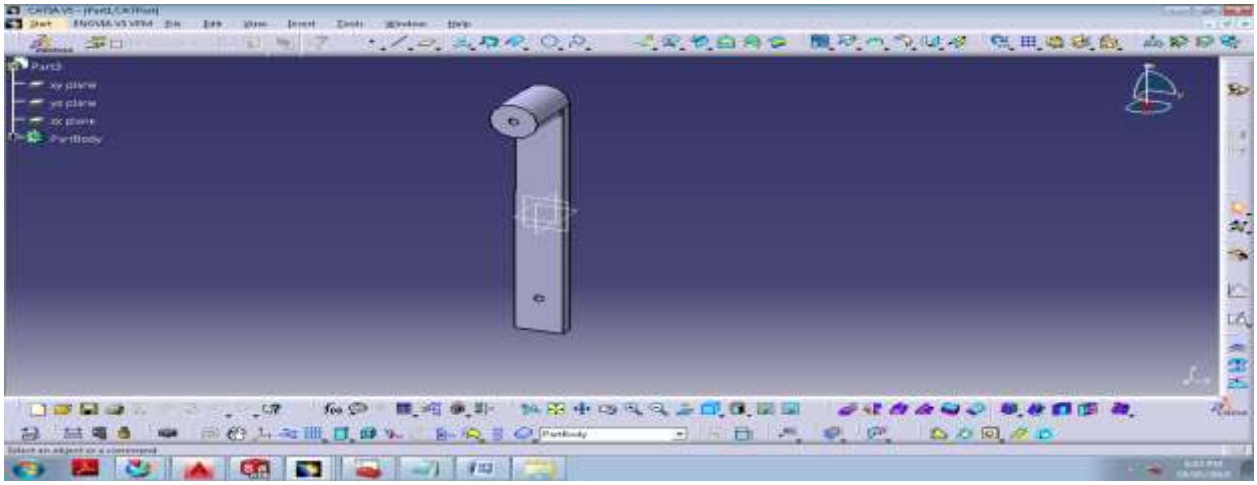
5.1 Crack shaft model



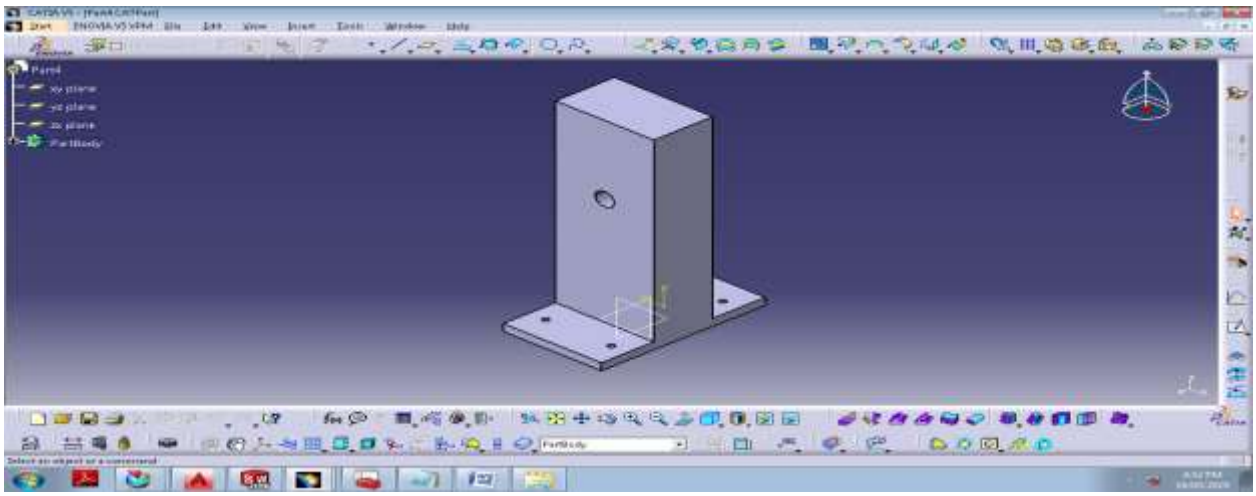
5.2 Flywheel model



5.3 Connecting rod model

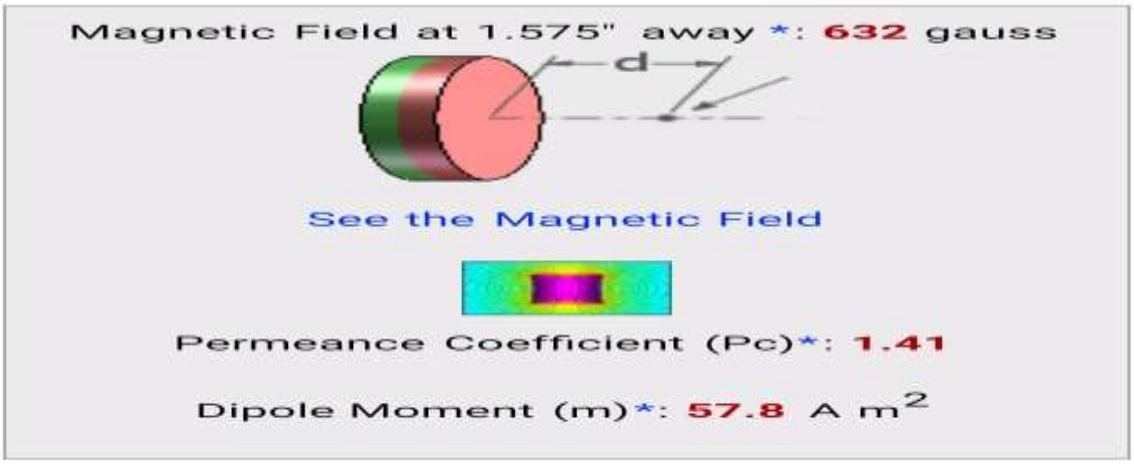


5.4 Supportable T – Frame model



6. EXPERIMENTAL ANALYSIS

The above graph shows the variation of force with distance. Force decreases as the distance is increased.



7. CONCLUSIONS

The magnetic engine has various advantages over the internal combustion engines. The main advantage is, no fuel is being used in the engine. This results in no pollution which is very desirable in the present day situation. As there is no combustion taking place inside the cylinder there is only very little heat generation. This eliminates the need for a cooling system. As magnetic energy is being used the need for air filter, fuel tank, supply system, fuel filter, fuel injector, fuel pump, valves etc. are eliminated and the design of the engine is made simple. Also by the use of materials like Aluminium, titanium etc. we can reduce the weight of the engine

The neodymium magnet is to be used as it gives maximum magnetism, the lead cell battery is used when high value of load current are required. The lead cell battery gives nominal output of 24V. The cylinder is made from non-magnetic material like aluminium so to make it lighter & prevent magnetic losses in the chamber.

The prototype is an idea which uses the property of an permanent magnet by virtue of which it changes the polarity of its poles whenever the motor is in operation of. This variation in polarity is utilized to attract or repel the permanent magnet attached to the piston.

8. REFERENCE

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