DESIGN AND ANALYSIS OF V6 SOLENOID ENGINE

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Abstract - *In an Automobile, Engine is the main power source of energy where Combustion, also known as burning, is the basic chemical process of releasing energy from a fuel and air mixture. The engine then converts the energy from the combustion to work. Various emissions from this process arises due to which environment is affected in a tremendous way, due to this reason now a day's electric vehicles came into existence. In this paper I succeeded in introducing an alternative way of reducing Air Pollution with an electromagnetic engine for generating power.*

Key Words: Solenoid, V6, Engine, Electromagnetic, Power, Ansys

1. INTRODUCTION

In 21st Century most of the engines that are being used are petroleum based engines which convert chemical energy into mechanical energy. These engines are for the most part either oil or diesel engines, are conventional engines, which release Pollutants like CO,HC,SO2,PM when converting the chemical energy to mechanical energy and these emissions which are emitted are highly undesirable as they cause a lot of pollution which leads to global warming and adversely affects the Environment and the fuel which are used are non-renewable sources of energy as they are derived from pre-historic fossils and won't be available once they are fully used. Their sources are limited and they are depleting at a faster rate. In order to tackle this problem, I have designed and fabricated a V-6 solenoid engine, this engine works on principle of electromagnetism. As the name indicates this has 6 solenoids or "pistons" which power the engine. In a solenoid engine the electrical energy is converted into mechanical energy, which does not result in the emission of harmful gases that is there in the case of a petrol or diesel engine.

1.1 Working Principle

The solenoid consists of a coil of wire with an iron plunger that is allowed to move through the center of the coil. Above figure shows the solenoid in the un energized state.

A solenoid is a very simple component that includes a coil of wire that is covered around a core made out of a metal. When a current is applied to the solenoid, it has the effect of assembling a consistent magnetic field. Electricity changes to magnetism then it changes to electricity and, therefore, these two forces are united into one.

1.2 Working of Solenoid Engine

The basic construction of a solenoid is where a long wire is helically wrapped around a hollow pipe repeatedly. This repeated helical wrapping of the wire causes an electromagnetic field to be produced inside of the pipe when electricity is passed through the wire. So when current is passed through the wire it produces a electromagnetic flux, which attracts any metal put inside the pipe towards it, and once the electrical supply stopped then the electromagnetic flux is no longer present which drops the metal into its original position, and again when electrical supply is given then the metal rises again. TO and Fro motion of the Metal is used to generate the mechanical energy of the engin e, such as the energy generation of the modern enginewhich is generated by the to and fro motion of the pistons inside th e cylinder.. The firing order of the pistons is 1–4–2–5–3–6.

1.3 List of Parts

A Solenoid Engine consists of various parts and are mentioned below

- Crankshaft
- Shaft
- Spur Gears
- Pistons
- Screws and Nuts
- L Brackets
- Flywheel

Table -1: Materials Used

PART	MATERIAL USED
Crankshaft	Forged Steel, Cast steel
Shaft	Cast steel
Spur Gears	Cast Iron, Steel forge, Fiber
Pistons	Cast Iron, Aluminum Alloy
Screw and Nuts	Carbon steel
L Brackets	Aluminum
Flywheel	Cast iron

2. DESIGN

The structural design of this solenoid engine is inspired from the traditional V-6 engine, but with a few modifications. This engine comprises of 3 “pistons” on each side like a traditional V-6 engine but unlike the traditional one the pistons are parallel to each other. This was done to improve the thermal efficiency of the engine and to help cooling of the solenoid pistons as it does not have any external cooling mechanism.

2.1 Crankshaft

A crankshaft is a shaft driven by a crank mechanism, consisting of a series of cranks and crankpins to which the connecting rods of an engine are attached. It is a mechanical part able to perform a conversion between reciprocating motion and rotational motion. In a reciprocating engine, it translates reciprocating motion of the piston into rotational motion, whereas in a reciprocating compressor, it converts the rotational motion into reciprocating motion. In order to do the conversion between two motions, the crankshaft has "crank throws" or "crankpins, additional bearing surfaces whose axis is offset from that of the crank, to which the "big ends" of the connecting rods from each cylinder attach.

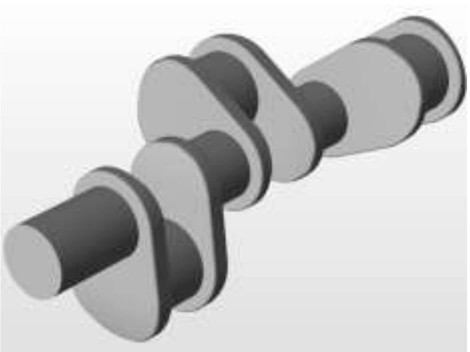


Fig Crankshaft

2.2 Shaft

A shaft is a rotating machine element, usually circular in cross section, which is used to transmit power from one part to another, or from a machine which produces power to a machine which absorbs power. The various members such as pulleys and gears are mounted on it. In a reciprocating engine, it translates reciprocating motion of the piston into rotational motion

2.3 Gears

The gears are rotating machine parts that usually have meshed teeth and are used to transmit torque from one shaft to another. The advantages of using gears as compared to another way of transmission are that, gears have very high efficiency and minimal losses which is ideal for power transmission. The gears that also undergo high levels of stress and need to be strong enough not to have any fatigue in the long term. Thus, the gears that used here are made of EN-8. The gears are 15 and 30 teeth. This ratio ensures that the power being produced at the flywheel it enough to have practical usage.

Fig Gears

2.4 Piston

A piston is a component of reciprocating engines, reciprocating pumps, gas compressors and pneumatic cylinders, among other similar mechanisms. It is the moving component that is contained by a cylinder and is made gas-tight by piston rings. In an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod and/or connecting rod. In a pump, the function is reversed and force is transferred from the crankshaft to the piston for the purpose of compressing or ejecting the fluid in the cylinder. In some engines, the piston also acts as a valve by covering and uncovering ports in the cylinder.

Fig Piston

2.5 Screws and Nuts

The screws and nuts are an important part of any mechanical component. They are components that are critical in holding towards different parts and components of the entire machine. The advantage of screws and nuts over the other types of fastening devices is that they are reliable in the long term, the do not need highly complex instruments to assemble them and they can easily be removed and put back together again and are thus performed in most of the machinery. The different types of screws and nuts that are used in this solenoid engines are cast iron.

Fig Screws and nuts

2.6 L-Bracket

The L-Bracket that is used here is as the name suggests in L in shape and is used to hold the shaft straight. The L brackets are made of stainless steel. Its main purpose is to provide support to the shaft and make sure that the shaft does not undergo any deformation or bending due to the various forces acting on it.

Fig L-Bracket

2.7 Flywheel

A flywheel is a mechanical device specifically designed to efficiently store rotational energy (kinetic energy). Flywheels resist changes in rotational speed by their moment of inertia. The amount of energy stored in a flywheel is proportional to the square of its rotational speed and its mass. The way to change a flywheel's stored energy without changing its mass is by increasing or decreasing its rotational speed. Since flywheels act as mechanical energy storage devices, they are the kinetic-energy-storage analogue to electrical capacitors, for example, which are a type of accumulator. Like other types of accumulators, flywheels smooth the ripple in power output, providing surges of high power output as required, absorbing surges of high power input (system-generated power) as required, and in this way act as low-pass filters on the mechanical velocity (angular, or otherwise) of the system.

The flywheel that is being used here is made up of mild steel. The flywheel is in cylindrical shape and its basic function is to transmit the energy. It is used to regulate the engine's rotation to make sure that is rotating at a steady speed. The amount of energy is present and stored in the flywheel as inertia force comes to play.

2.6 Solenoid

A Solenoid may be a tightly wound wire around a cylindrical pipe. This produces the magnetic attraction impact that was mentioned at the beginning of the paper. Power of the same magnet relies on numerous factors like, diameter of the pipe, the diameter of the wire, the amount of turns of wire over the magnet and therefore the amount of current that's being passed through the wire. The magnet that's used has 1500 copper turns and of 44 gauge and the inner material may be aluminum because it is a nonmagnetic material.

Fig Solenoid

3. ASSEMBLY

The above-mentioned parts are used in assembly and used in required numbers.

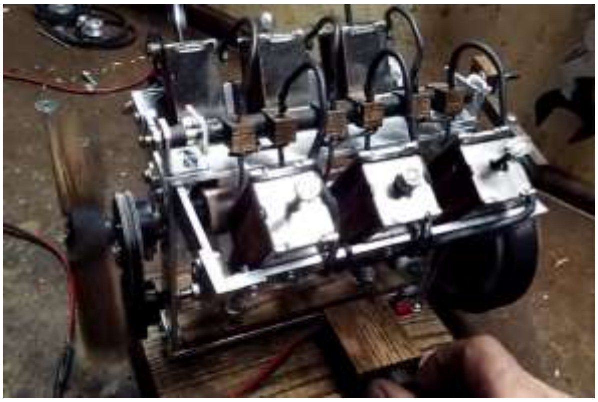
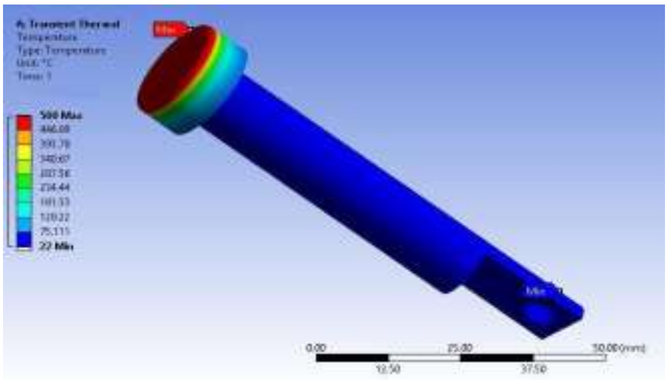


Fig V6 Solenoid engine

4. ANALYSIS

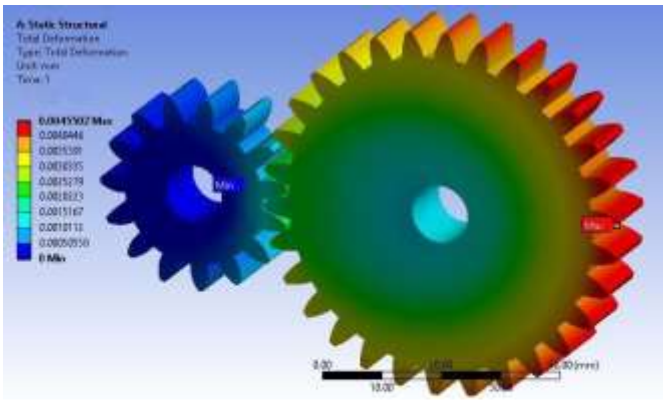
The analysis of piston and gears is done in ANSYS. Total heat flux and temperature distribution on the piston and stress distribution on the gears is done

The total heat flux in the piston is more at top when compared to the bottom.



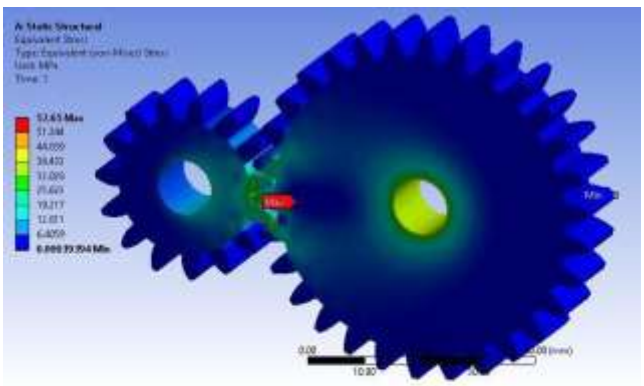
Temperature gradient in the piston

stress in two spur gears which is greater in larger one when compared to the smaller one



Total deformation in gears

The equivalent stress in the two gears is shown here, which is not important because the material used and the model are much higher than the necessary values, so that we can see no stress in two gears



5. CALCULATIONS

These calculations was conducted out on an exceptional level

Voltage = 39 V

Input current = 1 A

Input Power = Voltage × Current = 36 × 1 = 36W Max.

Force exerted by electromagnet on piston,

F1 = (N2 I 2KA)/2G2

Where, N = number of turns = 1000

I = Current flowing through coil = 1 A

K = Permeability of free space = 4π×10-7

A = Cross-sectional area of electromagnet

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

On substitution, we get Max. Force F1 = 24.18 N

Force exerted by permanent magnet Force F2 = (B2A)/2μ0 Where, B = Flux density (T)

A = Cross-sectional area of magnet (radius r = 0.0125 m) μ 0 = Permeability of free space = 4π×10-7

Now flux density B = Br /2 × [(D + z)/(R2 + (D + z)2) 0.5 – z/(R2 + z 2) 0.5]

Where, Br = Remanence field = 1.21

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 = 0.2547 T

Now substituting B in the equation of force, F2 = 12.67 N Since, force F1 and F2 are repulsive,

Total force F = F1 + F2 F = 36.85 N

Torque T = F × r

r = crank radius = 0.01m

Torque T = 0.3685 N-m

Mass of Fly wheel ω = (2πN)/60, where N = speed = 200rpm Therefore ω = 20.94 rad/s

Energy stored on flywheel E = T × θ

Where T = torque θ = Angle of rotation = 180o = π radians On substitution we get energy stored E = 1.157 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, $I = 5.277 \times 10^{-7}$ 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 = 2.154 Kg Output power

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

Where, N = speed = 200 rpm T = Torque = 0.3685 N-m

On substitution, we get Output power P = 7.836 W Efficiency = (Output/Input) × 100 = (7.836/39) × 100

Therefore, Efficiency = 20.09

6. CONCLUSION

Based on our calculations we have obtained an efficiency of 20.09% and it can be increased by improving the design and selecting suitable materials which perform well in the given conditions that is, making the mechanisms more fluid thereby reducing the friction and stresses induced. With that being said the current solenoid coils are limited by the fact that there is a high drop in efficiency due the unwanted heat generated by the coils. Even if this phenomenon is utilized for other purposes as done in an conventional Combustion Engine we are limited to today's technological advancements to further up the efficiency, however this model shows great promise for the future where today's limitations are overcome by new innovations.

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