PERFORMANCE ANALYSIS OF HIGH EFFICIENCY PETROL ENGINE

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Abstract: The objective of this project is to obtain high efficiency petrol engines by modifying the engine. Efficiency of petrol engine is mainly related to compression ratio of the engine. Normally compression ratio of petrol engine ranges around 6 to 9 when compression ratio is increased beyond 9, possibility of detonation will be increased. Scientists and R&D engineers are doing research to increase the efficiency of the engine without the possibility of detonation. In this project work compression ratio of engine is increased from 9 to 9.58 in order to achieve high thermal efficiency. The possibilities of detonation is minimize by mixing around 5% of anti-knock additives called toluene with the petrol. It has been found that the air standard efficiency of engine is increased from 58.36% to 59.47% and also marginal decrease in pollutants. Such as carbon monoxide, NOx is achieved by doing necessary engine modification.

1. Introduction
The internal combustion engine has domination the automotive vehicles market for over 100 years. Although remarkable improvements have been made over the past 30 years to reduce fuel consumptions, air pollution to nearly zero and almost double the vehicle efficiency. Increase in global warming and energy securing are pushing vehicles toward even greater efficiency improvement.[1-5]

Adding a high power electric motor and electric storage capacity to an internal combustion engine offers significant fuel savings. The engine can be shut off[8-16] at idle to avoid wasting fuel and the engine can be driven in reverse when braking to capture more energy is boost from the electric motor. The boost from the electric motor allows use of more efficient smallest engine. In the early days of the automobiles (20th century) there was spirited competition between vehicle powered by electricity and by internal combustion engines.[6-10] The internal combustion engine is dominating because of the high amount of energy in liquid fuels.

The efficiency of the petrol engine can be increased by simply grinding the bore or head of the engine. By grinding the bore or head of the engine there will be change in the length of the volume of stroke.

But due to grinding there will be some drawbacks. There will be detonation in the engine. The detonation can be decreased by providing anti knocking agent. There are various anti knocking agent in the markets. But each anti knocking agent has its drawbacks.

2. Literature Review
In SAE Journal paper titled Increased Efficiency through Gasoline Engine Downsizing," By authors Neil Fraser, Hugh Blaxill, Grant Lumsden , Michael Bassett, They have mentioned that, In order to achieve the required future CO₂ reduction targets, significant further development of both gasoline and diesel engines is required. One of the main methods to achieve this with the gasoline[34] engine in the short to medium term is through the application of engine downsizing, which has resulted in numerous downsized engines already being brought to production. It is, however, considered that there is still significant further CO₂ reduction potential through continued development of this technology[11-15].

This paper considers the future development of gasoline engine downsizing in the short to medium term and the various technologies that can be applied to further increase the efficiency of operation. As such this paper covers, among other areas, fundamental engine layout and design, alternative boosting systems, methods of increasing part-load efficiency and vehicle modeling, and uses analysis tools and engine test results to show the benefits achievable.

In BIT Journal paper titled Performance Improvement of 4-Stroke S.I. Engine Using Vapour Fuel Technology , By authors -Ratnesh Parmar, Simit Prajapati Mechanical Engineering Department, Babaria Institute of Technology, Vadodara Automobile Engineering Department, A.D.I.T., VallabhVidhyanagar, Anand, They have mentioned that, This paper covers information [30] on the performance improvement of four.
stroke IC engine by using vapor fuel technology. Due to the thermal losses and incomplete combustion, the efficiency of an IC engine is in the range of 25% to 30%. The efficiency may increase with the reduction in these losses. There are many losses in the engine like heat loss, friction loss, inertia loss, combustion loss etc.[29] In our project we had concentrated in minimizing the heat and combustion losses. For that it is necessary that maximum amount of fuel energy must be absorbed in combustion chamber of engine. The experiment was carried out on the 4-stroke petrol engine[22] in which the convention fuel intake system had been replaced by another system called “vapor fuel system”. In this fuel supply system, the fuel is supplied to engine in form of vapor. So this modification in fuel supply system improved the combustion in combustion chamber minimizing the heat and combustion losses and more power was absorbed by engine so there was the improved performance of the engine.[19] The engine was tested for the both conventional and fuel vapor system and the engine performance was checked for the each case.[11-16]

In IOSR Journal paper titled "Development of High Efficiency Engine by combining I. C. Engine and E C Engine," By authors Prof. V. K. Manglik Professor& Head of Department, Indus University, IIT&E, Rancharda Village, Ahmedabad-380015. They have mentioned that,Four stroke Diesel cycle and Otto cycle engines have very low thermal efficiency due to high amount of energy is lost in exhaust and also cooling of the engine. It is estimated about 35 percent of fuel energy is lost in exhaust of engine and 30 percent in cooling of engine. Out of the remaining 35 percent of energy of the fuel about 50% of energy gets converted in to work. The development of new engine is propose to use the energy of exhaust and also cooling of the engine in two more strokes of IC engine which will also work as steam engine.

Relationship Between Thermal Efficiency And Compression Ratio

Improving internal combustion (IC) engine efficiency is a prime concern today. A lot of engineering research has gone into the improvement of the thermal efficiency of the (IC) engines, so as to get more work from the same amount of fuel burnt. Of the energy present in the combustion chamber only a portion gets converted to useful output power. Most of the energy produced by these engines is wasted as heat. In addition to friction losses and [3] losses to the exhaust, there are other operating performance parameters that affect the thermal efficiency. These include the fuel lower calorific value, QLV, compression ratio, and ratio of specific heats. γ. Compression ratio is the ratio of the total volume of the combustion chamber when piston is at the bottom dead center to the total volume of the combustion chamber when piston is at the top dead center. Theoretically, increasing the compression ratio of an engine can improve the thermal efficiency[2] of the engine by producing more power output. The ideal theoretical cycle, the Otto cycle, upon which spark ignition (SI) engines are based, has a thermal efficiency, which increases with compression ratio, and is given by

\[
\eta_{thk} = 1 - \frac{1}{\gamma - 1}
\]

\[\text{Compressi}n\text{ Ratio}\]
\[R_c = \frac{V_s + V_c}{V_c}\]

\[V_s- \text{ Swept Volume}\]
\[V_c- \text{ Clearence volume}\]

Figure 1

3. Literature Survey

3.1 Detonation

Detonation or engine knock occurs simply when fuel pre ignites before the piston reaches scheduled spark ignition. This means that a powerful explosion is trying
to expand a cylinder chamber that is shrinking in size, attempting to reverse the direction of the piston and the engine. Causing sudden pressure changes in the cylinder and extreme temperature spikes that can be very damaging on engine pistons, rings, rods, gaskets, bearings, and even the cylinder heads[30].

Causes of Detonation:

**Ignition timing**

Improper ignition timing is usually down to incorrect setup, rather than any system failure. This can be corrected by checking the static timing and maximum advance. Most modern forced induction vehicles have an electronic device known as a "knock sensor" that will control the ignition timing by retarding it if it detects any "knock".

**Lean air fuel ratio**

A lean air/fuel mixture will promote detonation, because a lesser quantity of fuel, when vaporised, will absorb less heat. Thus a lean mixture increases heat, the root cause of detonation. For this reason, you will usually find that supercharged vehicles will, if anything tend to run a slightly rich Air/fuel mixture. In this way the extra fuel actually acts as a liquid intercooler.

**Exhaust gas back pressure**

Any restriction or blockage in the Exhaust system will increase back pressure, this Means that the hot exhaust gasses are kept in the combustion chamber for longer, Thus increasing chamber temperature and increasing the likelihood of detonation.

Reducing Detonation:

The two most common tricks (and easiest options) used by supercharger Manufacturers and engine tuners looking to obtain maximum performance without Detonation is 1. Use higher octane fuel, and 2. Retard the ignition timing.

Higher octane fuel burns more controllably and is not as likely to combust before the Flame front. This is why racing engines use 100+ octane fuel. The ONLY benefit of Racing fuel is that it moves us away from the detonation threshold, which allows us

Be more aggressive with power producing factors - i.e. raise compression, advance Timing, etc. So simply putting 100 octane fuel in a standard production car will not Produce a racing car as it is just not tuned correctly to take advantage of the Octane Rating. Retarding the ignition timing will delay the timing of the spark, which also moves Us away from your detonation threshold. Most popular "power programmers" or "Chips" increase engine power by advancing the ignition timing, and requiring us to run a higher octane fuel to avoid detonation.

**Antiknocking Agents**

An antiknock agent is a gasoline additive used to reduce engine knocking and increase the fuel's octane rating by raising the temperature and pressure at which auto-ignition occurs.

The mixture known as gasoline or petrol, when used in high compression internal combustion engines, has a tendency to knock (also called "pinging" or "pinking") and/or to ignite early before the correctly timed spark occurs (pre-ignition, refer to engine knocking). Thus providing anti knocking agent we can reduce the detonation and the efficiency will increase.

The typical antiknock agents in use are:

- Tetraethyl lead,
- Alcohol
- Methyl cyclopentadienyl manganese tricarbonyl (MMT)
- Ferrocene
- Iron Penta carbonyl
- Toluene

**Toluene**

Toluene formally known as toluol, is a colorless water insoluble liquid with the smell associated with paint thinner. It is a monosubstituted benzene derivative, consisting of a CH3 group attached to a phenyl group. Toluene is widely used as an industrial feedstock and a solvent. As the solvent in a common glue, toluene is sometimes used as a recreational inhalant and has the potential of causing severe neurological harm.

**Chemical Propeties**

Toluene react as a normal aromatic hydrocarbon in electrophilic aromatic substitution. Because the methyl group has greater electron realising properties that a hydrogen atom in the same position. Toluene is more reactive than benzene to electrophiles. It undergoes sulfonating to give p-toluenesulfonic acid, and chlorination by CI2 in presence of FeCl, to give ortho and para isomers of chlorotoluene.

**Vehicle Summary**

- Name: zeus 125
- Type: commuter
- Top speed: 101kph

**ENGINE SPECIFICATION**

- Displacement: 124cc
- Engine: 124cc,OHC

- Maximum power: 8.5bhp@7500rpm
- Maximum torque: 10Nm @3500rpm
  - Gears: 5 speed
- Clutch: wet multiplate type
  - Bore: 53.5 mm
  - Stroke: 55.2 mm
- Cylinder configuration: NA
- Engine block material: NA
  - Chassis type: NA
- Cooling type: air cooling
  - Carburetor: NA

**OTHER SPECIFICATION**
- Weight: 114.00 kg
- Ground clearance: 155.00 mm
  - Fuel tank: 12.00 ltrs
  - Wheel base1240.00mm
  - Electrical system ;NA
  - Head lamp: NA
- Battery type: 9.0 KC 10HR
  - Battery voltage 12V
  - Battery capacity: 2.5Ah

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**Compression Ratio Modification**

Before modification of engine

Swept volume: \( V_s = \frac{\pi}{4} d^2 h \)

\[
\frac{\pi}{4} \times 5.35 \times 5.52 = 124.027 \text{ cm}^3
\]

Compression ratio = \( R_c = \frac{V_s + V_c}{V_c} \)

Assume \( R_c = 9 \)

\[
9 = \frac{124.027 + V_c}{V_c}
\]

\[
8V_c = 124.027
\]

\[
V_c = 15.50 \text{ cm}^3
\]

Height

\[
V_c = \frac{\pi}{4} d^2 h
\]

\[
15.50 = \frac{\pi}{4} \times 5.35^2 \times h
\]

\[
15.50 = 22.4800588h
\]

\[
H = 0.68949 + 998 \text{ cm}
\]

Height of existing clearance volume = 0.6894

**After Modification of The Engine**

Height of new clearance volume =

6.894 - 0.4 mm (reduced) = 6.494 mm

Reduced new clearance volume \( V'_c = \frac{\pi}{4} d^2 h' \)

\[
V'_c = \frac{\pi}{4(5.35)^2(0.6494)} = 14.59
\]

New compression ratio = \( R_c = \frac{V_s + V_c'}{V_c'} \)

\[
124.027 + 14.59/14.59
\]

\[
R_c = 9.50
\]

**Performance Analysis**

**Before Modification of Engine**

Efficiency

\[
D = 1 - \frac{1}{R_c} \gamma - 1
\]

\[
1 - 9^{1.41} = 0.5847 = 58.47\%
\]
After Modification of Engine

Efficiency

\[ D = 1 - \left( \frac{1}{R_c} \right)^\gamma - 1 \]

\[ = 0.5936 \]

\[ = 59.36\% \]

Hence the air standard efficiency has been increased from 58.50% to 59.6%.

Advantages

Increased efficiency.
Reduced pollution.
Can be used in any four stroke engine.

Application

Can be used in any four stroke SI engine.

4. Conclusion

The project carried out by us made an impressing task in the field of mechanical department. It is used to increase the efficiency of four stroke petrol engine. The air standard efficiency of the engine has been improved from 58.47% to 59.6%.

References


