LONG TERM CONTINUOUS USE OF AUTO- LPG CAUSES THERMAL PITTING IN AUTOMOTIVE S. I. ENGINE PARTS

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Abstract

The LPG has been suggested as a convenient, clean burning less pollutant fuel. LPG is among the many alternative proposed to replace gasoline in the short term due to its excellent characteristics as a fuel for spark ignition engines. Since LPG burns cleaner with less carbon build-up, oil contamination, engine wear is reduced and the life of some components such as piston rings, bearings are much longer than with gasoline. The high octane of LPG also minimizes wear from engine knock. On the other hand in the LPG run SI Engine it is observed that the hot spots lead to surface pitting on the Engine Cylinder Block, Head, Valves, Valve stem & clearance increase in Valve guides. Apart from this, some time it may lead to development of cracks & distortion in Cylinder Heads. This can be attributed to rise in temperature of the damaged / pitted area near combustion chamber. This also leads to increase in the level of automotive exhaust emissions, fuel consumption and thus affect the environment badly. This may also be a contributing reason for global warming particularly in metros.

Keywords: *Fuel, Exhaust emissions, Environment and Global warming.*

1. Introduction

The increasing cost of liquid hydrocarbons in recent years accompanied by the tough rules and regulations regarding exhaust emissions has stimulated interest in alternative fuels for automotive engines. LPG Has been suggested as a convenient, clean burning less pollutant fuel. Therefore it is also known as green fuel. However, the selection of an alternative fuel is not the end of the task. The selected fuel has to be exploited to its best capacity to serve the task for which it was chosen. Fuel consumption and heat losses from the engine are related; in country like ours the fuel consumption can improved by optimizing the amount of heat generated in combustion chamber and surroundings. Since LPG burns cleaner with less carbon build-up, oil contamination, engine wear is reduced and the life of some components such as piston rings, bearings are much longer than with gasoline. The high octane of LPG also minimizes wear from engine knock.

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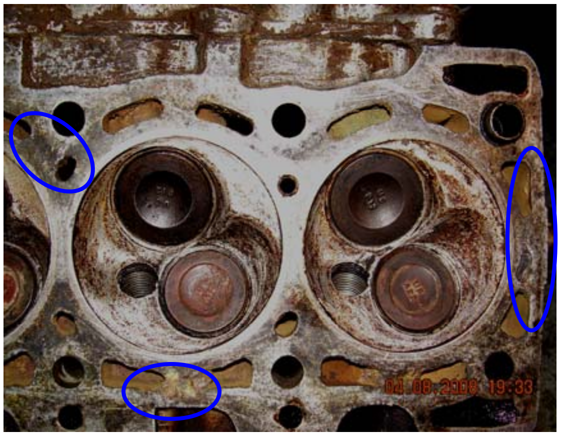
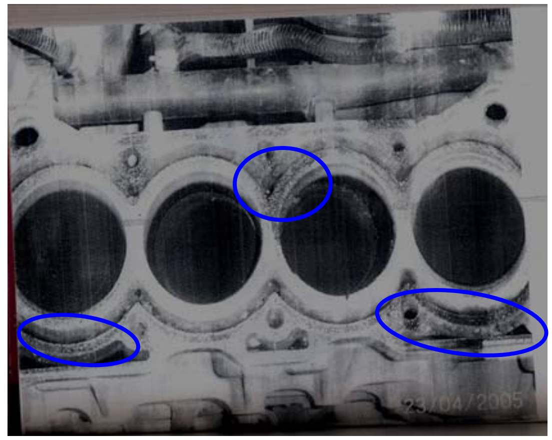
Experimental research into the use of LPG in spark ignition outboard engines presented with bottled LPG dosed gaseous form. The aim of the study was to determine the basic parameters and quantify the emission index, when LPG is used instead of gasoline. The result obtained indicate that with the use of LPG, specific fuel consumption, $CO2$ and CO emissions were much lower without noticeable power loss but in contrast, NOx emissions were much higher.





Physical Observations: Three & Four Cylinder S I Engines after 1000 hrs. Approx. run on LPG

2. Brief Literature Review and Problem Formulation

After reviewing the literature and applying our previous experiences, investigations & observations the Engine Systems can be optimized & evolved to provide precision cooling with necessary changes in Engine operational settings, to reduce excessive heating & irregular temperature gradient across the cylinders of the engine. In the present scenario the designs of S I engine being used in automotives by various manufacturers are not properly suitable to out climate condition. As our country is among tropical countries where the variation in the temperature is having very vast range i. e. from 0C to 50C in various regions of the country. Today research and development in the field of gasoline engines have to face a double challenge on one hand; fuel consumption has to be reduced, while on the other hand, ever more stringent emission standards have to be fulfilled. Looking in to this vast varying temperature rang it is very difficult to say that which temperature is most suited to operating condition of engines and gives best performance levels as for as SFC & BP is concerned .

2.1 Heat transfer in I. C. engine Satisfactory engine heat transfer is required for a number of important reasons, including material temperature limits, lubricant performance limits, emissions, and knock. Since the combustion process in an internal combustion engine is not continuous, as is the case for an external combustion engine, the some component temperatures are less than the peak combustion temperatures. Heat transfer to the air flow in the intake manifold lowers the volumetric efficiency, since the density of the intake air is decreased. The heat transfer rate in an engine is dependent on the coolant temperature and the engine size, among other variables. There are complex interactions between various operational parameters.

2.2 Engine cooling system There are two types of engine cooling systems used for heat transfer from the engine block and head; liquid cooling and air cooling. With a liquid coolant, the heat is removed through the use of internal cooling channels with in the engine block. However, liquid systems are subject to freezing, corrosion, and leakage problems that do not exit in air systems.

2.3 Engine energy balance An energy balance is obtained through experiments performed on instrumented engines. An engine instrumented to determine the quantities of heat
rejected to oil, water and to the ambient air. Flow meters are installed in the water, and oil circuits and thermocouples measure the inlet and out let temperatures.

2.4 Cylinder heat transfer measurements There are a wide range of temperature and heat fluxes in an internal combustion engine. The values of local transient heat fluxes can vary by an order of magnitude depending on the spatial location in the combustion chamber and the crank angle. The source of the heat flux is not only the hot combustion gases, but also the engine friction that occurs between the piston rings and the cylinder wall. When an engine is running at steady state, the heat transfer through out most of the engine structure is steady. The piston and valves, since they are moving, are difficult to cool, and operate at the highest temperature. Temperature measurements indicate that the greatest temperatures occur at the top or crown of the piston, since it is in direct contact with the combustion gases.

2.5 Effect of engine temperature on fuel economy for S.I. engine Temperature control is very important for combustion engines as temperature is a critical factor both for chemical reactions and mechanical stresses. Traditionally, temperature control is performed by feedback of a global quantity, the coolant temperature, which however is a poor indicator of specific temperatures. In gasoline engine combustion takes place at a stoichiometric contour, generating the highest temperature the fuel can attain with air, irrespective of the air fuel ratio in the cylinder. A spark ignition SI engine cycle is used to predict the cycle, performance and exhaust emission of an engine for the cases of using gasoline and LPG.

We tried to investigate the best option to run the SI engine and simultaneously to maintain the emission norms. The experimental study is carried out on a three cylinder, four strokes, petrol carbureted, water cooled 800 CC engine test rig connected to eddy current type dynamometer. The objective of this work was to examine engine performance parameter, like specific fuel consumption (SFC), brake power (BP) and also exhaust emission on varying engine temperature.

3. Methodology of Research Work

Liquefied Petroleum Gas (LPG) (mainly propane) is among the many alternatives proposed to replace gasoline in the short term due to its excellent characteristics as a fuel for spark ignition (SI) engines. This paper presents a discussion on the parameters that affect the engine's heat inputs mainly during power stroke, with suggestions to minimize it. The effect of the equivalence ratio, compression ratio, spark plug location, flame speed, combustion duration at different speeds and chemical properties on the heat flow rate around combustion chamber. Fuel consumptions and heat losses from the engine are related; by reducing the amount of heat lost to the surroundings initially the fuel consumption can be improved.

3.1 Availability and suitability of propane as an SI engine fuel The basic criterion for selecting any alternative fuel is:

1. Availability 2. High specific energy content. 3. Easy transportation and storage.
4. Minimum environmental pollution and resource depletion. 5. Good safety and handling properties.
It is known that with propane, when used in vapour form engines tend to operate at leaner mixtures, with higher calorific value, lower density and boiling point, propane, (Table 1), significantly improves engine operation and life when compared with gasoline.

Table 1 ***Properties comparison between LPG and gasoline Characteristic***

	Propane	Gasoline
Chemical formula	C3H8	C8H18
Boiling point (°C)	– 44 30	–225
Density at 15 °C (kg/l)	0.507	0.75
Research octane number	100	96–98
Stoichiometric air–fuel ratio (kg/kg)	15.6	14.7
Flame speed (m/sec)	48	52–58
Up/Low Flammability limits in air (% vol.):	74.5, 4.1	7.6, 1.3
Lower calorific value (kJ/kg)	46.365	42.1

3.2 Practicality of LPG as an SI engine fuel In the present study, LPG is considered to consist of only propane LPG and other gaseous fuels have common properties that provide them some Advantages and Disadvantages relative to gasoline. Before discussing its usability for engines, its properties are compared with those of other engine fuels in Table 1. If the properties of propane are compared with those of gasoline and alcohols, the following benefits and/or shortcomings can be expected when it is used as the SI engine fuel. Propane has lower density and stoichiometric fuel–air ratio than gasoline, and thus, it could reduce the specific fuel consumption and exhaust emissions. If a propane fueled SI engine operates at the same equivalence ratio as a similar gasoline fueled engine, higher effective power could be expected due to the higher calorific value of propane. However, as will be explained below, this advantage may be balanced by decreasing volumetric efficiency. On the other hand, propane can be used at higher compression ratios due to its higher octane number, and as a consequence of this property, engine performance, that is engine power and thermal efficiency, would be increased.

The above mentioned properties of propane make it an attractive alternative fuel for spark ignition engines. The most important drawback of this fuel is that it reduces the engine volumetric efficiency and consequently the fresh charge mass, which is mainly due to its rising inlet temperature and its entering the intake system in the gaseous state. This problem can be removed by cooling, i.e. offsetting the heat in the inlet manifold.

From the point of view of the engine performance parameters, operation with propane reduces the brake-specific fuel consumption (BSFC) as it can work with leaner air–fuel ratios than gasoline. However, because of the loss of volumetric efficiency, which is mainly due to high inlet or suction temperature that causes a drop in the fresh charge mass, engines run on LPG tend to produce 3–5% lesser power than when run on gasoline. It was observed that by offsetting the heat in the inlet manifold, a gain of up to 8% in volumetric efficiency with respect to gasoline was achieved, accompanied by an increase in engine power output levels equal to that of gasoline.

The efficiency of an engine is affected by the amount of heat lost to the coolant or the surroundings. The fraction of heat of combustion that ends up in useful mechanical power output defines the performance and efficiency of the engine. Due to heat losses from the engine, present-day SI engines operate at efficiencies ranging between 10% and 30%, depending primarily on air–fuel ratio, compression ratio, engine speed, ignition timing and engine load condition. In addition to these operating variables, many other design features influence heat losses, such as spark plug location, engine size and valve size.

3.3 Effect of spark timing The effect of the spark timing on the engine's heat losses at different equivalence ratios, advancing the spark timing causes an increase in the percentage of heat losses, because advancing the spark causes the combustion to be completed within TDC, hence, more time would be available for the combustion products to lose heat to the surroundings. The percentage heat loss increases as the mixture is enriched, reaching its peak at mixtures within stoichiometry, because of the higher thermal energy released. This situation drastically changes at richer than stoichiometric mixtures because of the poor combustion. Further, that the greater the spark advance the greater the tendency of the engine to knock (represented by knocking index, KI.

3.4 Effect of compression ratio and spark plug location Before starting to discuss the effect of these two factors, it would be proper to define a term used to describe the spark plug position, i.e., 'XSP'. XSP represents the ratio between the spark plug locations from the nearest wall to the cylinder diameter. The effect of the compression ratio and spark plug location on the percentage heat loss. It is clearly seen that increasing the compression ratio increases the percentage heat losses due to increased overall cylinder temperature and the near-TDC completion of combustion. Further, shifting the spark plug location from the edge towards the centre reduces the percentage heat losses as it reduces the flame travel path and hence reduces the combustion duration. This is valid up to compression ratios of 9.0, beyond which, due to knocking a higher rate of energy release causes a higher percentage of heat losses to the surroundings.

3.5 Effect of combustion duration and flame speed The lengthening the combustion duration or lowering the flame speed causes an increase in the heat loss since the products of combustion have more time to lose some heat to the surroundings. This effect dominates at lower engine speeds, perhaps due to lesser turbulence inside the cylinder. In the following discussion, the effect of heat losses on some of the engine's performance and emission parameters will be studied. This is believed to be due to the suppression of the dissociation of certain products of combustion (like CO2 and H2O) and variable specific heat losses. However, because of the increased thermal energy which does not end up in useful work (since more of the heat is lost), excess heat loss increases the BSFC and decreases the thermal efficiency.

3.6 Effect on engine power The effect of percentage heat losses on engine power can be explained that the decrease in the percentage heat losses increases the engine pressure and temperature. The present analytical study showed that engine design and operating parameters have an effect on the percentage heat losses from the engine. Increasing compression ratio, the need for near central spark locations, larger valve areas and the aim for leaner air–fuel equivalence ratios to have a favorable effect on reducing heat losses, though care must be taken to avoid knocking. It can be concluded that the Increase in percentage heat losses reduces the cylinder peak pressure and temperature, causing the engine power to drop because a lesser fraction of the thermal energy ends up as useful work.

Comparisons show that if LPG fueled SI engines are operated at the same conditions with those of gasoline fueled SI engines; significant improvements in exhaust emissions can be achieved. However, variations in various engine performance parameters and the effects on the engine structural elements are not promising.

4. Investigation and Testing

(1) Effect of Engine Operating Parameters using Gasoline & LPG as Engine Fuels.
(2) Temperature of Engine Systems under Different Operating Conditions.
(3) Performance Comparison in Dual Fuel Operation & Emission Characteristics.

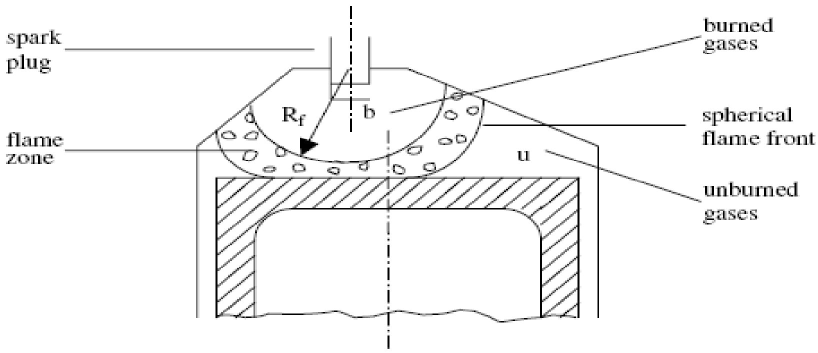


Fig. 1. Schematic representation of cylinder contents during combustion period.

5. Conclusions

Experimental results given in several literatures have confirmed the reliability and accuracy for predicting the cycles and performance of SI engines running on gasoline and gaseous fuels. An extensive investigation of the combustion, cycle, performance parameters and exhaust emissions of an SI engine running on gasoline and LPG has been performed. From the obtained results and various comparisons, the following conclusions can be drawn:

1) In the case of using LPG in SI engines, the burning rate of fuel is increased, and thus, the combustion duration is decreased. As a consequence of this, the cylinder pressures and temperatures predicted for LPG are higher than those obtained for gasoline. This may cause some damages on engine structural elements.
2) LPG reduces the engine volumetric efficiency and, thus, engine effective power. Furthermore, the decrease in volumetric efficiency also reduces the engine effective efficiency and consequently increases specific fuel consumption.
3) LPG decreases the mole fractions of CO and NO included in the exhaust gases.
4) In summary, LPG has negative effects on engine performance, fuel economy and engine structural elements when it is used at the same fuel–air equivalence ratios as gasoline, however, it has positive effects on obnoxious exhaust emissions such as CO and NO.

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