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Research Paper

EXPERIMENTAL PERFORMANCE ANALYSIS OF SINGLE CYLINDER TWO STROKE PETROL ENGINE USING GASOLINE AND LPG

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Present work shows a comparison of performance by using petrol and LPG at no load and different load condition. Work was done in I.C. engine lab of mechanical engineering department UIT RGPV Bhopal and found that fuel consumption was minimum at 2250 RPM in case of both fuels at no load and fuel consumption is minimum at 50% of the load in case of both fuels at loading condition. The experiment also shows that LPG gives maximum Brake Thermal Efficiency (BTE) at 50% of load and 31.32% less Fuel Consumption (FC) than petrol at load, low Brake Specific Fuel Consumption (BSFC), low Brake Specific Energy Consumption (BSEC) than petrol at the loading condition of the engine. The experiment also shows that LPG consumption at different loading was also lower than the petrol and found minimum at 50% of the load and at no load condition, consumption of LPG is comparatively lower than the consumption of petrol. For this experiment minor modification was required wherever done to run the engine by LPG without any problem using some necessary attachments like attachment for lubrication, etc. This article presents the comparative testing results of a two stroke, single cylinder, air cooled, modified, petrol engine operating on petrol and LPG. This comparative performance analysis shows that LPG is one of the better substitutes of petrol. Detailed comparative analysis of the engine performance using petrol and LPG has been made by the graph plotted between various parameters like Fuel Consumption (FC) and speed (RPM) for no load and for the different loading conditions, graphs between load and Fuel Consumption (FC), load and Brake Specific Fuel Consumption (BSFC), load and brake specific energy consumption (BSEC), and load and Brake Thermal Efficiency (BTE) and also done economic analysis. The present study shows that LPG is one of the better substitutes of petrol in terms of performance, consumption and cost.

Keywords: I.C. engine, Performance of I.C. engine, LPG and Petrol

INTRODUCTION

Liquefied Petroleum Gas (LPG) is one of the members of natural gases and has been declared as the cleaner fuel. LPG is increasingly chosen as the preferred burning fuel for all types of vehicles due to its

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advantageous fuel properties (Yusuf *et al.*, 2005). A lot of researches have been done to prove that vehicles using LPG as the burning fuel shows no decreased in efficiency compared to the conventional fuel operating vehicles along with its advantage of reduction in emission gases from the exhaust of an engine (Mustafa and Gitano-Briggs, 2008). Besides that, LPG has the capability to reduce the noise from a running engine, helping to effectively decrease noise pollution in urban areas especially during the traffic congestion period (Seshaiah, 2010). There are currently over 4 million road vehicles using LPG in countries such as Italy, Holland, Japan, the USA, and Australia due to the vast advantages of LPG usage. Due of the abundance of LPG an important energy and environmental advantages, LPG has been promoted for usage in vehicles (Orhan Durgun and Hakan Bayraktar, 2005; and Seshaiah, 2010). However, the use of LPG requires that fueling, maintenance and storage facilities to be upgraded to a certain standard to ensure operational safety of its (Semin Ibrahim *et al.*, 2009). LPG is stored as a liquid in a separate steel or composite vessel at the pressure of 10 bars, although it can stand a pressure of 20-30 bars (Kansu Wan and Kwankaomen, 2010). LPG supply to the engine is controlled by a regulator or vaporizer, which converts the LPG to vapors. The vapors are fed to a mixer located near the intake manifold, where it is metered and mixed with filtered air before being drawn into the combustion chamber where it is burned to produce power, just like gasoline (Ceviz and Yuksel, 2006). The LPG energy content (High Heating Value, HHV) is 46.23 MJ/kg (Zuhadi Salhab, 2011). The higher octane rating and the low carbon and oil contamination characteristics of LPG result in a documented longer engine lifetime, up to twice that of the gasoline engines. Because the fuel mixture is fully gaseous, cold start problems associated with liquid fuel are eliminated (Rosli Abu Bakar *et al.*, 2002; and Albela Pundkar *et al.*, 2012). LPG has relatively high energy content per unit of mass; the range of LPG vehicles is equivalent to that of petrol vehicles. Due to low maintenance cost, economic market price and environment friendly characteristics LPG are becoming a popular alternative for gasoline (Shinichi Goto *et al.*, 2000). LPG has the following characteristics against gasoline (Syed Yousufuddin and Syed Nawazish Mehdi, 2008; and Lawankar and Dhamade, 2013).

- Relative fuel consumption of LPG is about eighty percent of that of gasoline by volume.
- LPG has a higher octane number, which enables a higher compression ratio to be employed and gives more thermal efficiency.
- Due to the gaseous nature of LPG fuel distribution between cylinders is improved and smoother acceleration is achieved.
- LPG tank is heavier and requires more space than a gasoline tank because LPG is stored under pressure.
- Engine life is increased for LPG operated engine as cylinder bore wear is reduced & combustion chamber and spark Plug deposits are reduced.
- Starting load on the battery for an LPG operated engine is higher than gasoline engine due to higher ignition system Energy required.

- LPG system requires more safety. In case of leakage LPG has hazardous, it may catch fire.
- LPG required more volume (15 to 20% more) as compared to gasoline.

Although LPG has a great deal of advantages, it has some limitations too, as listed below (Thirumal Mamidi and Suryawanshi, 2012; and Deepak Bharadwaj *et al.*, 2012);

1. LPG is a non-renewable fossil fuel. If LPG uses faster than its generation, it will begin to deplete.
2. LPG is denser than air, in case of any leakage it will accumulate in low lying areas, it may catch fire.
3. A bulky storage tank is needed to store LPG. Hence, the larger boot area is required to place the storage tank in place. That also reduces the storage capacity.

Table 1: Properties of Gasoline and LPG

Characteristics	Gasoline	Propane
Chemical formula	C8H18	C3H8
Boiling point (°C)	30-225	-44
Molecular weight (kg/Kmol)	114.2	44.1
Density at 15 °C kg/l	0.705	0.507
Auto ignition temperature (°C)	285	480
Octane number (RON)	91.8	112
Octane number (MON)	89	99.5
Stoichiometric air fuel ratio (kg/kg)	14.7	15.6
Upper Flammability limits in air (% vol)	7.6	74.5
Lower Flammability limits in air (% vol)	1.3	4.1
Lower calorific value (KJ/kg)	44000	46500
Higher calorific value (KJ/Kg)	46530	50150

Source: Bayraktar and Durgun (2003) and ETSAP (2010)

4. It was revealed that there exist a number of countries with underdeveloped technologies for LPG distribution system and therefore, limits its usage. LPG is only used in residential homes as heating and cooking gas.
5. The contents of propane in LPG are different for most countries. For instance, LPG contains more than 90% propane in the UK, whereas in Italy the level can be as low as 20% and 70% in India.

This fluctuation proves to be a barrier to standardization of LPG vehicles around Europe and the rest of the world.

EXPERIMENTAL SETUP

The setup consists of single cylinder, two stroke, and air cooled petrol engine connected to an electrical type dynamometer and loading unit (rheostat type) for loading. It is provided with necessary instruments for measurements of various parameters. The setup has stand-alone consisting of air box, fuel tank, manometer, fuel measuring unit, etc. Present study performs in thermal engineering lab of

Figure 1: Experimental Setup at UIT RGPV Bhopal

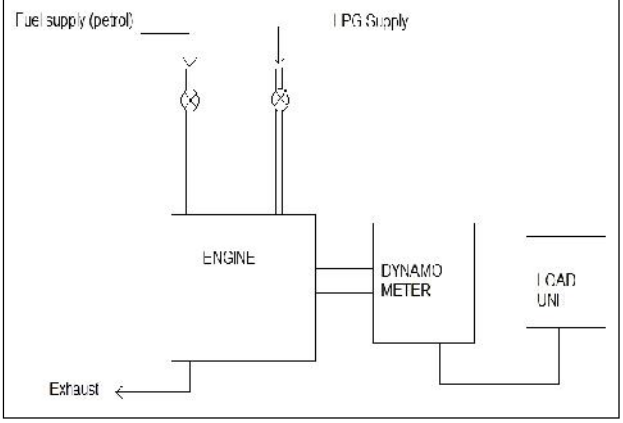
UIT RGPV Bhopal (M.P.), set up image shown in Figure 1.

The main aim of this experiment is to investigate the effect on performance of gasoline and LPG in single cylinder, two stroke, and petrol engine. Performance investigation of LPG and gasoline were evaluated in a two stroke, single cylinder spark ignition engine operated at different-different speed at no load condition and at constant speed in varying load condition. Engine tests were carried out at different speed (rpm) at no load and find speed (RPM) at which minimum fuel consumption takes place and at loading condition engine test was carried out at constant speed (2250 rpm) for fuel consumption in case of gasoline is used as a fuel. The same test is carried out for engine by using LPG as a fuel with few additional components and modification, require for safe operation of two stroke spark ignition engine operated with LPG. Technical specifications of the test engine are given in Table 2 and simplified block diagram of the experimental setup in Figure 2.

Table 2: Detailed Specifications of the Test Engine Setup

Parameters	**Details**
Name of manufacturer	Brand new assemble engine Bajaj make
Speed	800-6000 RPM
No of Stroke	Two stroke
Fuel used	Petrol
No of cylinder	Single
Type of cooling	Air cooled
Type of starting	Kick start
Fuel intake measurement	Calibrated burette
Dynamometer	Electrical type (2 KW)
Loading system	Rheostat loading
Air intake measurement	Orifice and water manometer
Exhaust gas calorimeter	Water cooled type

Figure 2: Block Diagram of Experimental Setup



Modified Experimental Setup

A number of problems encountered in using LPG directly as fuel in two stroke petrol engine. Due To problems encountered in starting of the engine, lubrication problem, etc. various additional components like arrangement for lubrication, and few modifications are require for engine operation. Following additional components require for LPG operation are: (i) Gas vaporizer, (ii) Pressure regulator, (iii) LPG tank, (iv) Weighing Machine (WM), (v) Mixer and Tee, (vi) Pipe for LPG, lubricant and vacuum, (vii) Lubricant Bottle (LB).

Gas Vaporizer: It is the most important part of the modified experimental set up without vaporizer engine cannot be operated through LPG fuel. A vaporizer is a device that transforms liquid phase LPG to vapor phase LPG. LPG Vaporizers are used for vaporizing liquid fuel gases (i.e., propane, butane, natural gas) or even other gases for use in various heating or other processes. In the first stage LPG is firstly vaporized and successively

reduced in pressure. The second stage chamber is very sensible to the vacuum pressure. The vacuum pressure causes the flow of LPG to the engine to increase or decrease depending on the pressure difference. Any pressure difference is transferred to the second stage chamber and the membrane will allows for a greater flow of gas to enter the engine.

Pressure Regulator: A pressure regulator is a valve that controls the flow of a liquid gas at certain pressure. Gas pressure regulators are used to regulate gas flow and are not used for measuring flow rates. A pressure regulator's primary function is to match the flow of gas through the regulator to the demand for gas placed upon the system. If the load flow decreases, then the regulator flow must decrease also. If the load flow increases, then the regulator flow must increase.

LPG Tank: Available in 18 different approved sizes to suit most vehicles in India. The two variant available are called; Cylindrical type and toroidal type. The tank also has different capacity variants. LPG cylinder of 2 kg capacity is used in this experiment.

Weighing Machine: Weighing scales are used in many industrial and commercial applications. In present experiment electronic (digital type) weighing machine is used for calculating the consumption quantity of LPG, which have least count of one gram and maximum capacity of weighing machine is 10 Kg. Electronic type weighing machines have an advantage over mechanical balances due to the following reasons; (i) Compactness, (ii) Good accuracy and Ease of operation, (iii) Ruggedness and reliability.

Mixer and Tee: The mixer has an extremely importance. The right air- fuel ratio depends on the mixer and this is the reason for the existence of mixer. The mixer for vehicles equipped with engine between carburetor and engine. Mixer are metallic and non metallic. We have use metallic mixer for experiment in this test. T-shape metallic valve is used to control the supply of lubricating oil to the engine .It is fitted near the mixer in the lubricant supply pipe. Arrangement for controlling the quantity of lubricating oil is also given with tee.

Pipe for LPG, Lubricant and Vacuum: Pipe use to supply LPG, from LPG tank to vaporizer is called LPG or fuel pipe. It is larger in diameter than lubricant and vacuum pipe shown. LPG pipe should have better quality because continuous supply of LPG can damage the pipe when it is use very long time. Pipe through which lubricant is supplied to the engine is called lubricant pipe, it connect lubricant bottle with mixer through tee. It is transparent in colour. Pipe which is provided for air is called air or vacuum pipe, its one end is connected to the mixer and other is connected to vaporizer.

Lubricant Bottle: In two stroke petrol engine lubricating oil is mixed with petrol in petrol tank but when engine is operated with LPG attachment for lubrication of engine is require which supply lubricant to the engine directly. Special bottle for lubricant is attached to the engine for proper lubrication when engine is operated with LPG.

RESULTS AND DISCUSSION

Two stroke stationary petrol engine was operated under different speed at no load by using petrol and LPG respectively and find the

speed (rpm) at which minimum fuel consumption takes place in both cases when engine is operated with LPG and petrol and plotting the graph between speed (rpm) and Fuel Consumption (FC) for both LPG and petrol fuel. With the help of graph compare and investigate the fuel consumption for both of the fuel. By investigating the graph we find minimum fuel consumption takes place at 2250 rpm for both of the fuel. Again engine was operated at different loading condition and at steady state speed (2500 rpm) and determine various performance parameter like Fuel Consumption (FC), Brake Specific Fuel Consumption (BSFC), Brake Specific Energy Consumption (BSEC), and brake thermal efficiency. By plotting graphs between load and fuel consumption, load and BSFC, load and BSEC, and load and brake thermal efficiency and then comparing the performance for LPG and petrol fuel, we find that LPG becomes better substitute of petrol fuel because cast of commercial LPG cast is less than the cast of petrol fuel.

The results obtained by Performing the experiment on the Engine by using gasoline and LPG respectively at different-different speed and different-different loading conditions are discussed. In the present investigation the fuel consumption (when petrol is used) is increase with the speed (RPM). It becomes minimum at 2250 rpm and then increase with speed up to maximum speed limit of the engine.

When LPG is used as a fuel, fuel consumption follow same pattern as in case of gasoline, in this case minimum consumption of LPG takes place also at 2250 rpm. In this case fuel consumption increases with the speed (RPM) and minimum at 2250 rpm then increase up to maximum speed limit, when engine is running at no load. Variation of Fuel Consumption (FC) with speed (RPM) is shown in the graph (Figure 3).

When engine is operated at loading keeping speed (RPM) constant and investigate the consumption of fuel when load is increased. For loading condition of engine by using relation we can determine Fuel Consumption (FC), Brake sSpecific Fuel Consumption (BSFC), Brake Specific Energy Consumption (BSEC) and brake thermal efficiency. And plot graphs between load and various parameters (FC, BSFC, BSEC, BTE)

Figure 3: Graph Between Fuel Consumption and Speed (RPM) at No Load Condition

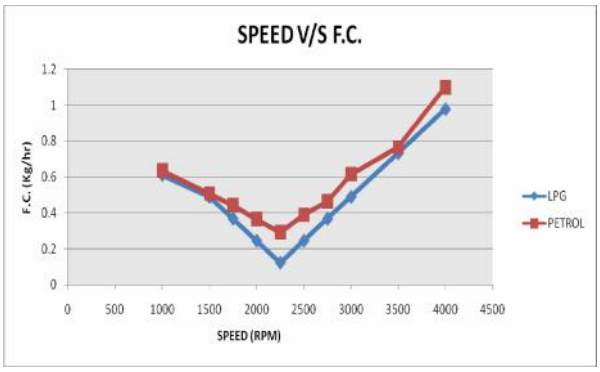


Figure 4: Graph Between Fuel Consumption (FC) and Load

Figure 5: Graph Between Brake Specific Fuel Consumption (BSFC) and Speed (RPM)

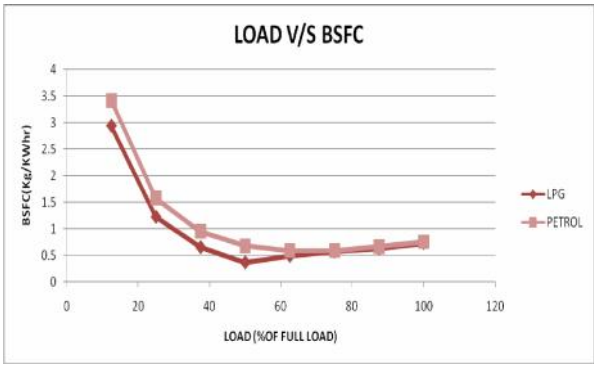


Figure 6: Graph Between Brake Specific Energy Consumption (BSEC) and Load

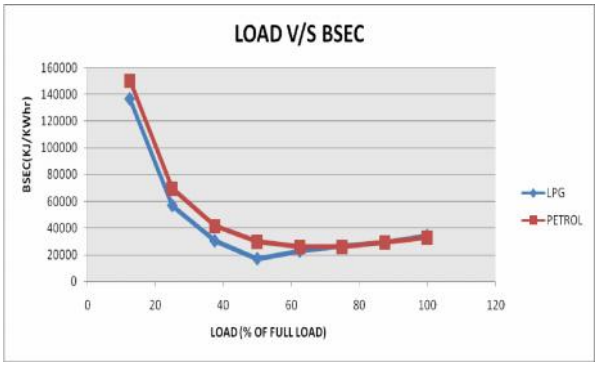
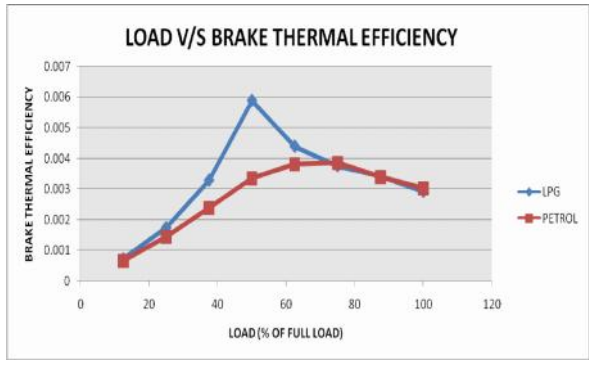


Figure 7: Graph Between Brake Thermal Efficiency and Load



and by studying the graphs (Figures 4 to 7) we can compare performance of the SI engine operated with LPG and petrol and find operation of engine is better, efficient and economical by LPG fuel then petrol fuel. Consumption of lubricating oil is also less in case of LPG fuel operation that makes operation of engine by LPG is more economical.

CONCLUSION

On the basis of experimental results following conclusion can be drawn;

- Consumption of LPG fuel is slightly lower than the petrol at no load condition. LPG consumption is16.92% less than the petrol consumption at 2250 RPM at which minimum consumption of fuel takes place for both of the fuel.
- LPG consumption is also low compare to petrol when engine is operated at loading condition. Fuel consumption decreases with load increase and minimum when load on engine is 50% of the full load for both fuels than fuel consumption again increases with load. After 75% of loading fuel consumption is nearly same for both of fuel. At 50% of loading LPG consumption is 31.32% less than the petrol consumption.
- Brake Specific Fuel Consumption (BSFC) and Brake Specific Energy Consumption (BSEC) is comparatively lower for LPG fuel. BSFC and BSEC for both of the fuel are approximately same after 64% of the loading on the engine. Before 64% of the loading on engine, BSFC and BSEC both are comparatively low for LPG fuel.
- Brake thermal efficiency for LPG fuel is more than the petrol fuel at same load. In case of LPG fuel BTE is maximum at 50% of the loading and in case of petrol fuel BTE is maximum at 75% of loading. In low

loading condition BTE is lower and it increases with load up to a certain limit the start to decrease with load. BTE of engine when LPG is used as a fuel is higher than the petrol fuel.

- Results obtained after experiment indicate that LPG characteristics are very close and superior to petrol. It can be one of the better alternate fuels for petrol engine and can be used as a one of the alternate fuel for petrol engine, which is cheap and satisfactory performance.
- From economy point of view LPG fuel is comparatively less in cast (auto gas or LPG 51.52 Rs./liter.) than the petrol (75.08 Rs./ liter.) and in case of petrol fuel lubricating oil consumption is more than the LPG fuel operation. This means that operation of engine by LPG is more economical then the petrol fuel operation.

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