

Design of Experimental Plan for Effect of Liquefied Petroleum Gas Analysis on Friction Power Loss in Spark Ignition Engine

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Abstract :

Internal combustion engine running on Liquefied Petroleum Gas are well proven technologies and work much like gasoline- powered spark ignition engine. This is normally used in spark ignition engine for bi-fueled petrol and LPG vehicles. Increasing focus on liquid petroleum gas (LPG) as clean, relatively low in cost and abundant source of energy to provide affordable fuel-efficient transportation, needs research for optimization approach to manage fuel, air, and combustion to achieve best result in vehicle power, fuel efficiency and low emissions. However power output of LPG fueled engine is reduced by 10-15% compared to petrol fuel.

In this study, exhaustive literature survey is carried out and experimental setup is discussed for further investigation. Basic task is to evaluate effect of LPG on various performance parameter of the engine with brake, indicated and friction power, thermal efficiencies, fuel consumption, volumetric efficiencies. Existing multi-cylinder petrol engine is modified for required set up in which Morse test, heat balance sheet and engine oils are also to be analyzed for tribological behavior of engine.

KEYWORDS: Brake Power, Frictional Power Loss, Dynamometer, Engine Efficiency, Indicated Power

I. Introduction

In the recent years, one of the major areas of research in the field of IC engine is use of alternative fuels. Gaseous fuels as LPG are promising alternative fuels for their higher octane number, higher calorific value and of course, lower exhaust emission. Because of these advantages very recently and better results have been obtained in terms of fuel economy and particularly the exhaust emission. Alternative fuels are very useful in reducing the pollution from conventional IC engine. Besides, alternative renewable fuels can play a major role in the economy of a country as well as the health of living beings of the globe. The composition varies depending on the source. Some of the important properties for Petrol and LPG are listed below.

Table 1 : Properties of LPG and Petrol Fuels.

Characteristics	Petrol	LPG
Chemical Formula	C ₈ H ₁₈	C ₃ H ₈ -30% C ₄ H ₁₀ -70%
Lower Heating Value	43500	46500
Density at 15°C, Kg/m ³	750	2.26
Stoichiometric Air fuel ratio	14.7	15.6
Flame Speed cm/s	37.5	37.0
Upper flammability limit in air, Kg of Air/Kg	7.6	5.0
Lower Flammability Limit in air, Kg of Air/Kg of fuel	1.3	9.6
Auto ignition temperature (°C)	371	405-450

* Source Indian Oil Corporation Ltd. (India) [03]

The performance of Engine under variable operating condition like different speed and variable load condition with necessary modification required for the smooth running of engine.

Purpose of morse Test :

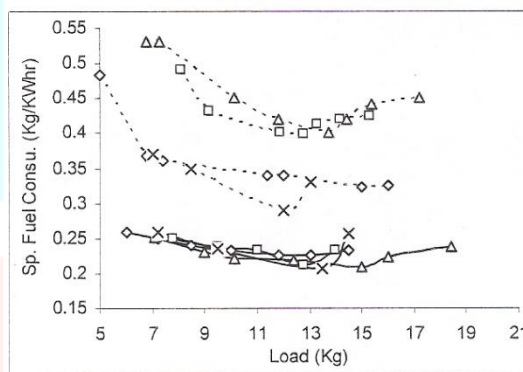
Purpose of Morse test is to find the approximate indicated power of a multi-cylinder engine fueled by gasoline and Liquefied Petroleum Gas which consist of running the engine against the dynamometer at a particular speed, cutting out the firing

of each cylinder which turns and noting the fall in brake power(BP) each time while maintaining the speed as constant. When one cylinder is cut-off, power develop is reduced and speed of the engine falls and accordingly the load on dynamometer is adjusted so as to restore the speed of the engine. This is done to maintain the frictional power constant, which is considered to be independent of the load and proportional to the engine speed. The difference observed in the brake power between all cylinder firing and one cylinder cut-off is the indicated power of the cut-off cylinder. The total of indicated power(IP) of all the cylinder would then give the indicated power of the Engine under test.

Morse Test is carried out to find the power developed in each cylinder in a multi-cylinder internal combustion engine and it basically gives the relationship between Indicated power and brake power. It is assumed that friction and pumping losses do not change and remain same when the cylinder is in firing condition as well as in inoperative condition. Using this test the frictional losses in the IC engine can be easily calculated. The main intention of carrying out this Morse test in IC engine is to provide an easy method of calculating the frictional losses. The total brake power of the engine is first calculated using a dynamometer and the process is repeated with one cylinder off at each step and the difference between total brake power and brake power of remaining cylinder gives the indicated power of first cylinder and so on. Once friction power(FP) is obtained the mechanical efficiency of the engine can be calculated.

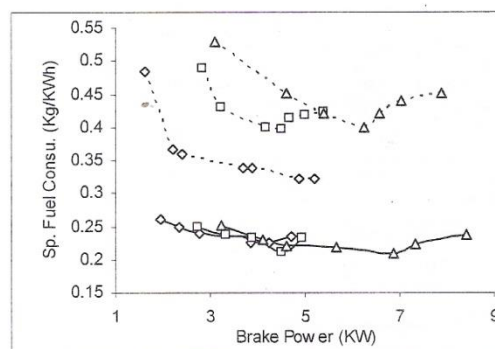
II. Literature Survey :

1. **Mistry, C and Gandhi, A [6]** They found from the test on conventional multicylinder (Maruti Make) engine was modified to work on dual fuel mode for both the LPG and Petrol fuels and they observed that brake thermal efficiency and indicated thermal efficiency increases with increase in speed and it will be higher for petrol than LPG. This is because of higher fuel consumption in case of LPG as compared to petrol. It is also found that brake power developed is higher in case of LPG whereas heat carried by jacket water is covered by exhaust gases and unaccountable losses are higher in petrol engine.



◇ 960 rpm △ 1350 rpm
□ 1040 rpm × 1900 rpm
Solid line- Petrol, Dotted line- LPG

Fig.1 : Specific fuel consumption Vs Load [6]



◇ 960 rpm △ 1350 rpm
□ 1040 rpm × 1900 rpm
Solid line- Petrol, Dotted line- LPG

Fig.2 : Specific fuel consumption Vs Brakepower [6]

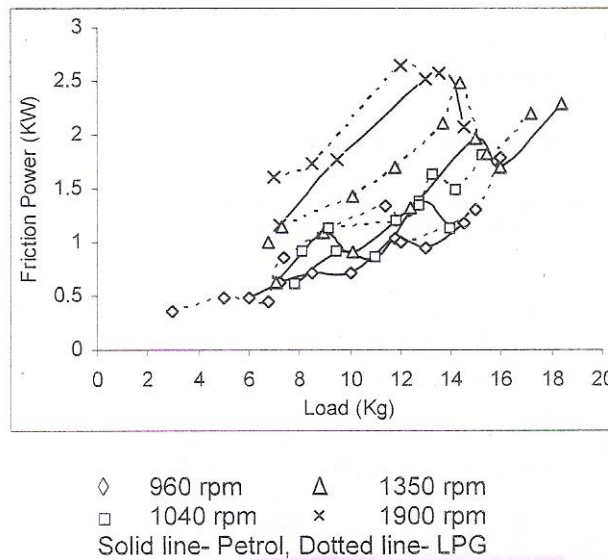


Fig.3 : Friction Power Vs Load [6]

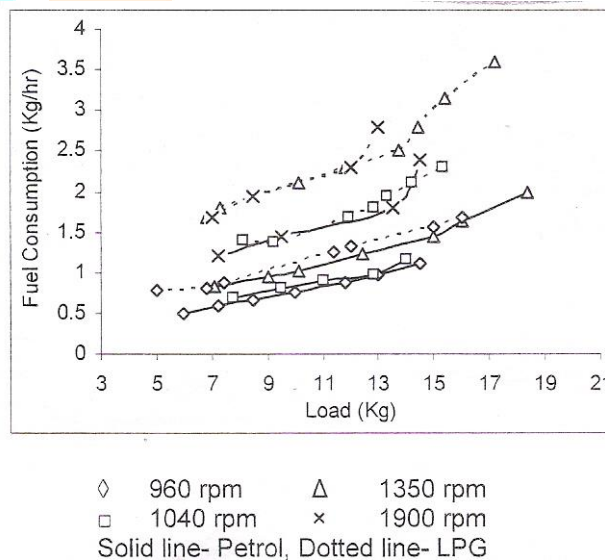


Fig.4 : Fuel consumption Vs Load [6]

2. **C. S. Mistry [3]** They found the results that Morse test indicate the frictional power increases with increase of the speed of an engine and it is also found that the frictional power to be higher for petrol compared to LPG which is because of short warm-up period to generate enough heat for gaseous fuel vapourization and to warm-up the lubricating oil.
3. **Ali M. Pourkhesalian, Amir H. Shamekhi and Farhad Salimi [5]** investigated the performance of a four stroke, four cylinder SI engine fueled with different alternative fuels. It was evaluated that the engine fueled with gaseous fuels resulted decrease in volumetric efficiency and power output.
4. **Norrizal Mustafa, Mas Fawzi, Fatahul Hakim Zulkifi, Shahrul Osman [4]** They discussed the effect of LPG on volumetric efficiency that the power output and volumetric efficiency of gasoline is higher compared to LPG because gasoline is injected in a liquid form and as it vepourizes it cools the air and thus produce improved volumetric efficiency. The vapourizer or liquid LPG fuel injection leads to discharging intake air because gaseous nature will occupy the space and reduce the amount of air entering in the engine cylinder. Most of LPG conversion inject the fuel at intake system or intake manifold and the vapourization of fuel depends on the factor such as pipes, thermal insulation, ambient air and liquid fuel temperature, shape and dimension of the intake system, heat of vapourisation of the fuel, load and the rotational speed of the engine. Even though, the power output of LPG fuel is lower than gasoline fuel due to its volumetric efficiency, the uses of LPG as a fuel for spark ignition engine still increasing in many countries due to its lower emission and economically.
5. **Jehad A. A., H. N. Gupta and B. B. Bansal [13]** developed a computer model for a four-stroke SI engine fuel with LPG in order to predict the effect of combustion duration and engine performance of each other using propane as a fuel and their study confirmed certain combustion duration had to be maintained to achieve best engine performance. They also suggested

that, the control of emission can be achieved by operating the engine at leaner mixture and their effect on the other variable like Brake Mean Effective Pressure (BMEP) and Basic Specific Fuel Consumption (BSF)

III. Design for Experimental Setup :

A Four stroke multi cylinder, water cooled existing petrol engine is used for experiments. Engine always coupled with dynamometer. The set up consist of engine with fuel and air flow measuring devices. Temperature sensing devices & digital counter for RPM measurement with implementation of LPG kit . The experimental set up comprises the following:

- * LPG Gas cylinder (30 Lit.)
- * Vaporizer
- * Solenoid valve
- * Pressure regulator

with the above, following apparatus are to be used -

- (i) Fuel Measuring Arrangement – for fuel measuring arrangement consist of a fuel tank, burette and suitable cock, all are mounted on a suitable frame work and panel board and supplied with fuel piping from fuel tank to engine.
- (ii) Thermocouples and thermometers-Temperature sensing devices
- (iii) Eddy Current Dynamometer – The Loading device used as an Eddy current dynamometer having the capacity 15 KW at 1500 – 2000 r.p.m.
- (vi) Instrumentation Required on the Set-up – (a) Engine charging circuit ammeter (b) U-tube manometer for air flow rate. (c) 50 ml capacity burette for fuel flow rate. (d) Electronic weight machine to measure LPG fuel consumption in Kg.
- (vii) Heat carried away by pulling water – It consist of suitable inlet and outlet piping with flow control valve. Rota meter is to be used for measuring rate of flow of cooling water and thermocouple with pocket connection for measuring inlet and outlet water temperature.

Modification in the set up-

- (i) Fuel Supply system- The main purpose of the carburetor is to meter fuel, vaporize it (in case of liquid fuel is used) with proper mixture of air & fuel as per the engine requirement before supplying it .But in case of LPG, fuel already in gaseous form , the conventional carburetor is used after proper modification for both petrol & Liquefied Petroleum Gas.
- (ii) Cut of the supply- The modification in the set up is done to cut of the supply of petrol when engine running on LPG.
- (iii) Introduction of LPG Kit consisting Gas cylinder, Vaporizer, Pressure Regulator.

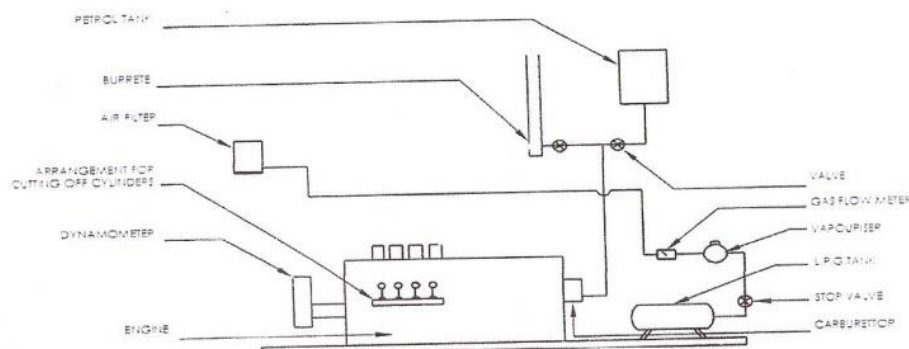


Fig. 5 : Tentative Experimental Setup

The friction horsepower can be measured by the following techniques.

- a) Measurement of FMEP from IMEP.
- b) Break down motoring test.
- c) Willians line method
- d) Morse test.

IV. Current Technology Under Development:

A conventional gasoline engine can be retrofitted into an LPG engine by either introducing an air/fuel mixer right before the throttle or fitting injectors directly into the manifold of the engine. It is necessary to investigate the various LPG supply methods to increase the powers of LPG engine[10]

The fuel supply method of an LPG engines are as :

- (i) supply of LPG with mixer at the throttle.
- (ii) Supply of LPG with injector at the air inlet manifold.
- (iii) Low pressure injection usually at the beginning of the compression stroke.
- (iv) High pressure injection near the end of compression stroke.

V. Conclusion

In this paper design of experimental setup for conducting required experimentation with Morse Test and proper modification to evaluate various performance parameters of spark ignition engine with petrol and LPG as a fuel are carried out. The effect of LPG on engine performance parameter and characteristics such as friction power loss, unaccountable heat losses, indicated power, brake power, basic specific fuel consumption, and volumetric efficiency are studied after exhaustive literature review and it is found that, the power output for LPG fuel engine is observed to be reduced by 10-15%. Also volumetric efficiency for LPG fuel is always less than petrol fuel; frictional losses are also more for LPG fuel. Fuel consumption is at higher side in case of LPG than petrol as well as thermal efficiencies is also high with petrol.

VI. Future Scope:

More research work may be performed on use of LPG in internal combustion engine to improve the performance of the engine by introduction of new technology for induction of LPG.

VII. Acknowledgement;

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