

Experimental Investigation of a Two Stroke SI Engine Operated with LPG Induction, Gasoline Manifold Injection and Carburetion

V. Gopalakrishnan and M.Loganathan

Abstract— In this experimental work the single cylinder two stroke air cooled SI engine was used for investigation. The intake manifold was modified for LPG induction and gasoline injection. The engine is operated at 3000 rpm on various throttle positions. The LPG kit is used to supply the gas to the engine. The flow control valve is used to vary the LPG flow. The engine was operated for 20%, 40%, 60%, 80% and 100% throttle condition. At each throttle position the best brake thermal efficiency value was selected. This LPG manifold induction results were compared with gasoline manifold injection and carburetion. It was found that LPG induction the engine operate relatively lean air fuel mixtures compared to other modes. The brake specific fuel consumption (BSFC) and the engine exhaust emissions are reduced. The brake thermal efficiency was higher than gasoline manifold injection and carburetion. The HC and CO emissions are reduced in LPG induction mode. But the exhaust gas temperature and NOx found higher with LPG induction. The maximum power output for LPG was lesser than that with of gasoline.

Index Terms— Manifold induction, Manifold injection, LPG induction, Gasoline, S.I Engine.

1 INTRODUCTION

All over the world two stroke cycle engines have been used for extensive applications because they possess the properties of lightness, compactness and high specific power compared with the four stroke cycle engines. However, under increasing stringent future legislation, the conventional two stroke cycle spark ignition engines with the major drawbacks of irregular combustion and short-circuiting undoubtedly cannot meet the requirements of exhaust emission. Manifold induction and injection system to improve power output and reduce the exhaust emissions but will not reduce fuel short circuiting. In view of the above studies were conducted in a two stroke SI engine with LPG and specially developed electronically controlled fuel injection system. Several researchers have investigated the effect of LPG and fuel injection in spark ignition engines. Latusek and Burrahm [1] have also focussed on the use of LPG for 2S and 4S SI engines. LPG has been reported to produce more HC emissions than gasoline in a 2S engine. Smit et al. [2] tested a 1.4 liter, four cylinder dual fuel spark ignition engine fitted with a multipoint gasoline injection and single point vaporized LPG injection.

The results showed that use of LPG decreased the maximum brake mean effective pressure and improved the thermal efficiency. Fulcher et al [3] studied the use of liquefied petroleum gas as a motor vehicle fuel has potential emissions advantages over gasoline injection. The

relatively high hydrogen to carbon ratio of LPG compared to gasoline provides a substantial reduction in carbon dioxide and hydro carbon emissions from LPG fueled vehicles. Campbell et al [4] observed a reduction in power of up to 18% with LPG than its gasoline counterpart, as well as reduced volumetric efficiency. Loganathan and Ramesh [5] compared manifold injection of LPG and gasoline on a 150cc scooter engine. 2% improvement in peak efficiency was reported from operation on LPG compared to gasoline. However, this work also reported higher HC, NO and reduction in brake power. Briggs et al. [6] compared premixed operation of gasoline and LPG with direct injection of LPG from cylinder head of a two stroke motor cycle engine. Significant reduction in HC and CO was reported for direct injection at idling. However, higher HC emissions were also observed from premixed operation of LPG against gasoline. Murillo et al. [7] reported that the increased HC emission with LPG in a carbureted four stroke spark ignition engine. Vasu and Nagalingam [8] used 145 cc air cooled two stroke SI engine with LPG and mechanical mixer fuel supply system. The experimental results showed a significant improvement in brake thermal efficiency and reduction in CO emissions. A slight increase in HC levels and the peak power reduction in the LPG operated engine compared to gasoline were observed. The Improvement realized by Watson and Phong [9], due to the evaporation of fuel in the inlet port during injection, therefore resulting in a cooler and denser air-fuel mixture entering the cylinder. Liquid phase LPG injection system also provides reduce NOx and HC emissions attributed to lower peak combustion temperatures. Yamato et al [10] investigated the influence of injection timing on the performance of a manifold injection gas engine by firing tests. They found that the in-

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cylinder fuel distribution in the engine in the direction of the cylinder axis was changed by the variation in injection timing. In general, work has concentrated on injecting fuel after the ports close as it will reduce short circuiting. Attempts have been made to run the engine in the stratified and homogeneous modes. Li et al. [11] investigated a 125cc, 4S-SI engine using an electronically controlled LPG injection system. Results showed 40% reduction in CO and 23% reduction in peak NO emissions against a LPG mixer system. However, the part load HC emissions were comparable.

2 EXPERIMENTAL SETUP AND PROCEDURE

The experimental setup consists of a two stroke single cylinder SI engine, eddy current dynamometer, weighing machine, airflow meter, temperature indicator and exhaust gas analyzer. The engine specifications as shown in Table.1.

TABLE 1
ENGINE SPECIFICATIONS

Type of engine	Air cooled, single cylinder Two-stroke, S.I engine
Bore x Stroke	61 mm x 68.2 mm
Make	TVS-king
Compression Ratio	7.7:1
Displacement volume	199.3cc
Power	3.2 @ 3000 rpm,
Mixture induction	Reed valve
Scavenging system	Loop scavenging

The engine was connected to an eddy current dynamometer and controller. The LPG and gasoline fuel flow is measured using an electronic weighing machine. Air flow is measured by a turbine flow meter. In order to reduce the fluctuation of the incoming air, a surge tank is fitted with the inlet manifold. The throttle body and throttle position sensor was used to fix the throttle position. The engine lubrication was achieved by adding lubrication oil with inlet air stream. The properties of LPG and gasoline are shown in Table .2.

TABLE 2
PROPERTIES OF LPG AND GASOLINE

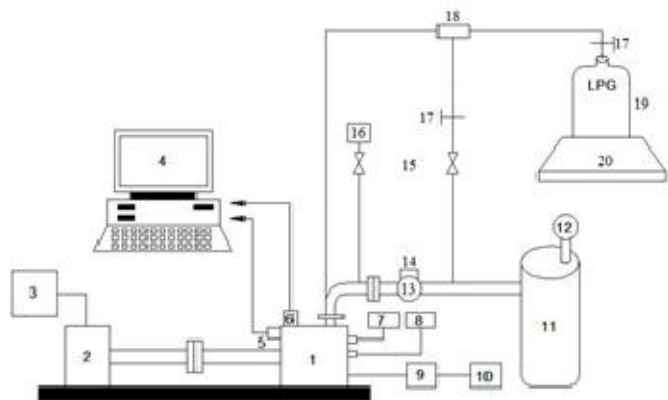
Property	LPG	Gasoline
Composition (vol.%)	30C3H8- 70C4H10	C7H15
Flame speed (m/s)	0.382	0.375

Flammability limits in air (vol.%)	2.15-9.6	1.4-7.6
Lower heating value at 1 atm and 15°C (MJ/kg)	45.7	43.5
Octane number	105	95
Density at 1 atm and 15°C (kg/m ³)	560	735
Stoichiometric air-fuel ratio	15.5	14.9
Auto ignition temperature (°C)	485-545	257

A NDIR gas analyzer (Make: HORIBA, Japan) was used to measure exhaust gas emissions of HC, CO, and NOx concentrations. The photo graph view of LPG induction is shown in Fig.1 and the schematic of the test setup is shown in Figure 2.



Fig. 1 Photo graph view of LPG induction



1.Engine 2.Eddy current dynamometer 3.Dynamometer controller 4.Data acquisition system 5.TDC sensor 6.Pressure sensor 7.Temperature indicator 8.Engine speed indicator 9.Ice path 10.Exhaust gas analyzer 11.Air surge tank 12.Air flow meter 13.Throttle body 14.Throttle position sensor 15.control valve 16.Lubrication oil tank 17.ON-OFF valve 18.Vaporizer 19.LPG cylinder 20. Weighing machine

Fig.2. Schematic of experimental setup.

3 RESULTS AND DISCUSSION

In this section the experimental results obtained under different throttle conditions at constant speed of 3000 rpm were discussed. The performance and emissions of LPG manifold induction were compared with gasoline manifold injection and carburetion.

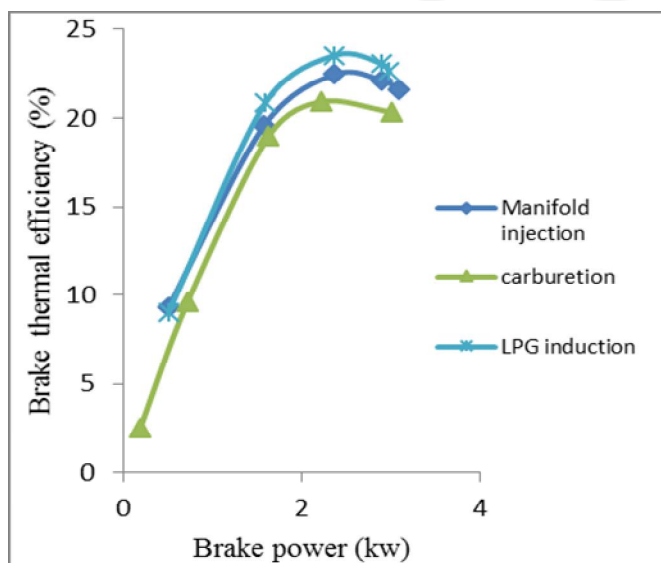


Fig.3. Comparison of brake thermal efficiency

Figure. 3 Shows the variation of brake thermal efficiency with the brake power. It was found that for LPG induction the maximum brake power and brake thermal efficiency is 2.9 kW and 22.6% respectively. For the same brake power of 2.9 kW, the brake thermal efficiency obtained for gasoline manifold injection and carburetion are 21.5% and 20.3% respectively. The

increased brake thermal efficiency for LPG induction system is due to lean mixture operation and better mixing of LPG and air in the combustion chamber. However the brake power for LPG manifold induction was inferior to gasoline manifold injection and carburetion.

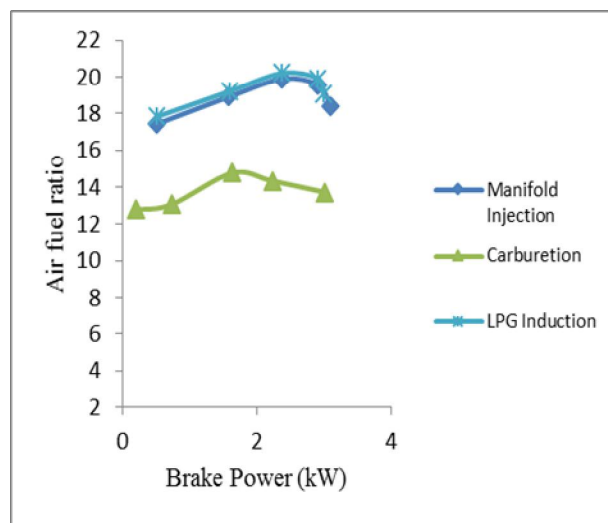


Fig.4. Comparison of Air fuel ratio

Figure 4 shows the effect of brake power with air-fuel ratio. The maximum air-fuel ratio is 20.2 for LPG induction at brake power of 2.3 kW. The air-fuel ratio for gasoline manifold injection and carburetion is 19.8 and 14.7 respectively at the same power. It is obvious that the air-fuel ratio falls at maximum load due to rich mixture in wide open throttle at which less air goes to the engine. Because of lean operation in middle throttle condition the LPG induction gives maximum thermal efficiency of 23.5% (A/F: 20.2) compared with 22.4 % and 18.9% for gasoline manifold injection and carburetion. Due to dissociation at high temperatures following combustion, molecular oxygen is present in the burned gases under stoichiometric conditions. This increases the temperature and the number of moles of the burned gases in the cylinder.

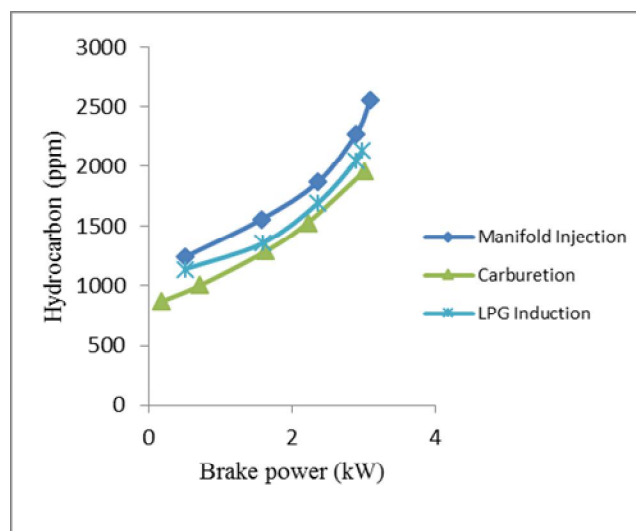


Fig.5. Comparison of HC emissions
Gasoline manifold injection experiences a significant increase in HC emissions compared with LPG induction and carburetion as

show in figure .5. At maximum brake power of about 3kW HC reduction was obtained 10% for LPG induction against the gasoline manifold injection. This is due to leaner air fuel operation in middle throttle. However, at a lower power of about 0.5kW, HC reduction was only about 5%. In full load condition the HC emission is increased for all modes of operation. This is due to rich fuel operation in full throttle.

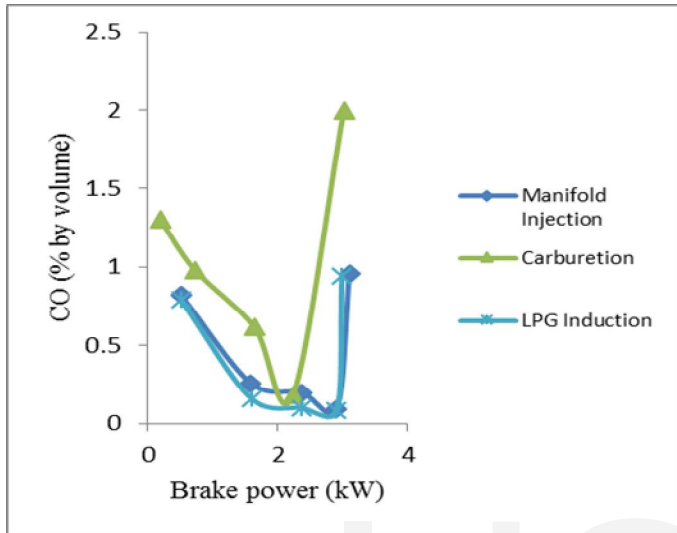


Fig.6. Comparison of CO emissions

The CO emission levels are reduced for LPG induction compared to gasoline manifold injection and carburetion. As shown in figure 6, for every load condition at constant engine speed the emissions of CO for gasoline carburetion was always significantly higher. This is due improper mixing of air fuel in the carburetor. The reason for reduction of CO in LPG induction mode is due lean air fuel ratio in middle load. The lambda value when running on LPG manifold induction was slightly higher than that gasoline manifold injection. This resulted also in a slightly less power on LPG manifold induction compared with gasoline.

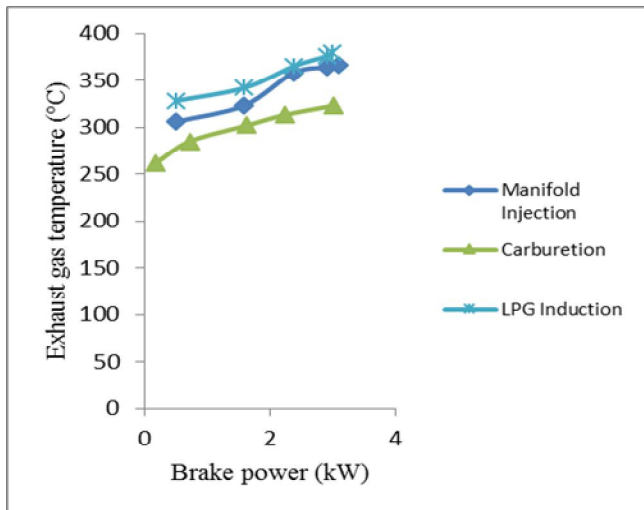


Fig.7. Comparison of Exhaust gas temperature

The variation of exhaust gas temperature with brake power is shown in fig. 7. In LPG induction mode the engine is operated

with leaner mixtures compared to other modes. Due to that the exhaust gas temperature are slightly higher with LPG than that of gasoline manifold injection and carburetion.

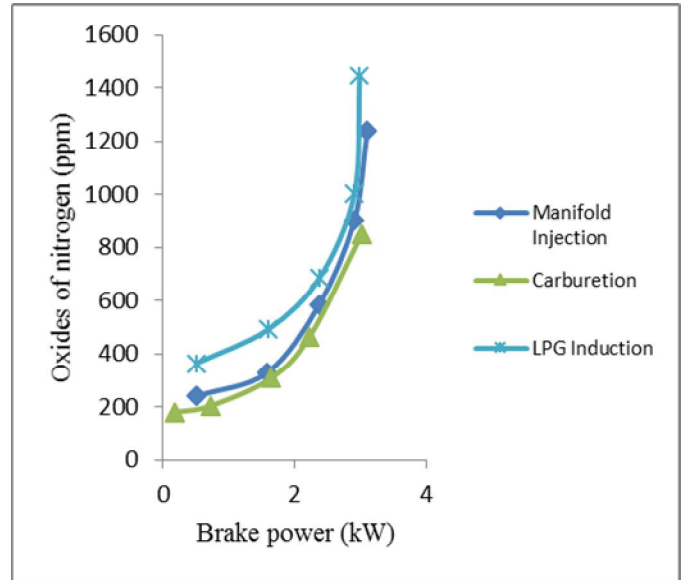


Fig.8. Comparison of NOx emissions

The variation of NOx emission levels are shown in Figure. 8. It is higher with LPG induction due to higher temperatures reached in this cycle. Since the flame velocity of LPG is higher than gasoline, the ignition timing can be retarded and this can help lower NOx levels. As the fuel takes its latent heat from air for vaporization. This is not the case with LPG as it is inducted as a gas.

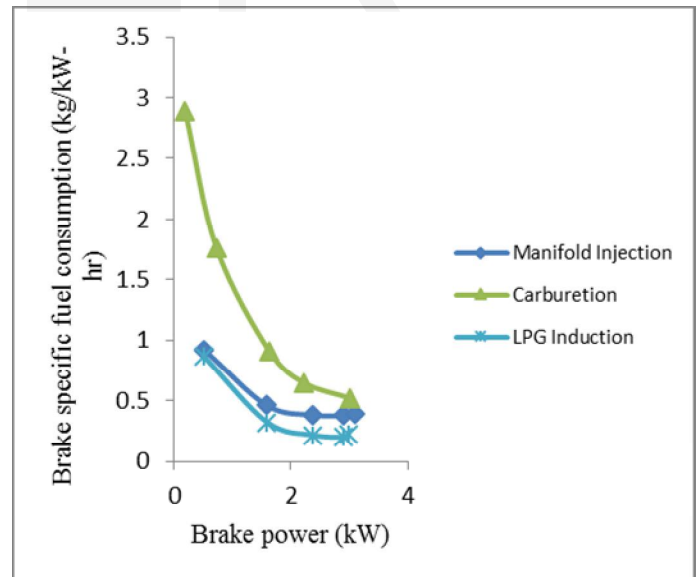


Fig.9. Comparison of brake specific fuel consumption

The variation of brake specific fuel consumption (BSFC) with brake power is shown in fig.9 brake specific fuel consumption is lower with LPG induction. The reason for lower fuel consumption for LPG manifold induction is due to lean operation and fast flame propagation velocity.

4 CONCLUSION

Based on the experiments conducted on a modified two-stroke engine with LPG induction, gasoline manifold injection and carburetion the following conclusion are drawn.

- The LPG manifold induction produced less brake power due to less volumetric efficiencies of gaseous fuel operation.
- The brake thermal efficiency increases with LPG manifold induction.
- The lean mixture limit of the LPG manifold induction was slightly better than that for gasoline manifold injection and this can be attributed to their slightly faster burn rates, and better mixture preparation.
- HC and CO emission for LPG manifold induction is lower than that of gasoline manifold injection and carburetion.
- The BSFC is less in the LPG manifold induction compared to gasoline manifold injection and carburetion.
- The NO_x and exhaust gas temperature of the LPG manifold induction is higher than gasoline manifold injection and carburetion.

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