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A Parametric Study of Four Stroke Single Cylinder S.I Engine Converted from C.I Engine Fuelled With LPG for Enhancement of Performance

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Abstract— The use of alternative fuels for engine is regarded as one of the major research areas for the age. Gaseous fuels in general are promising alternative fuels due to their economical costs, high octane numbers and lower polluting exhaust emissions. LP Gas being cleanest, most efficient fossil fuel provides greater environmental security. The increased use of LP Gas could help the nation meet its environmental, economic and national security goals. The objective of this research is to improve LPG fuelled spark ignition engine performance and emission, by optimizing the compression ratio and spark timing for single cylinder, four stroke, diesel engine, converted in to spark ignition engine by modification. From literature review, it was found that LPG SI engine performance and emissions are better at compression ratio from 9 to 15 & spark timing advanced from 20° to 40° BTDC. Testing was carried out on GL-400, single cylinder, four stroke, air cooled, diesel engine without any modification and performance and emission parameters are calculated from observed parameters at various load and speed. Then diesel engine converted into LPG fuelled spark ignition engine by changing the compression ratio and modifies the head for installing ignition system. The compression ratio change from 9 to 13.8 and also change the spark timing from 25° to 35° BTDC to measure the performance and emission parameters for LPG engine. From the experimental research work, it is found that brake specific fuel consumption was decrease, brake thermal efficiency increase and improve in exhaust gas emissions as compression ratio increase from 9 to 13.8 & spark timing advanced from 25° to 35°BTDC. Finally conclusion arise that, compression ratio 13.1 and 30° spark advance angle is best suitable for the LPG fuelled S.I. engine's performance parameters and exhaust gas emissions

Keywords- Compression Ratio, Spark timing, Liquefied Petroleum Gas (LPG).

I. INTRODUCTION

Diesel engines are the main prime movers for public transportation vehicles, stationary power generation units and for agricultural applications. Hence it is very important to find a best alternate fuel, which can fully or partially replace diesel which emits fewer pollutants to the atmosphere from diesel engines [1]. Use of gaseous fuels in the engines reduces reactive hydro carbons and also do not pose the problems of atomization. LPG fuel enjoys higher octane rating facilitating its use in spark ignited engines to work with higher compression ratios. Liquefied petroleum gas and natural gas fueled engines could be operated lean with an equivalence ratio as low as 0.7 resulting lower in-cylinder temperatures that reduce NOx emission levels. The engine test results showed that alternative fuels exhibit longer ignition delay, with slow burning rates [2]. LPG is obtained from the process is the process of natural gas and crude oil extraction and as by-product of oil refining. Its primary composition is a mixture of propane and butane. It has higher octane number (112).The use of LPG in internal combustion engines yielded higher thermal efficiency and better fuel economy compared to other SI engines. This is due to higher octane rating which permits the engine run at higher compression ratio without the occurrence of knock. LPG also has higher calorific value compared to other fuels and can be liquefied in a low pressure range of 7 to 8 bar at atmospheric pressure. Gaseous fuels such as liquefied petroleum gas (LPG) and liquefied natural gas (LNG) have

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been widely used in commercial vehicles, and promising results were obtained in terms of fuel economy and exhaust emissions. LPG gas as a low carbon and high octane number fuel produces lower carbon dioxide (CO_2) emission as compared to gasoline [3]. As the gaseous fuel requires 4 to 15 percent of more intake passage volume than liquid fuels which reduces the VE and hence maximum power output will also be reduced. SI engines burn a premixed air-fuel mixture followed by compression before a spark ignites the mixture. Octane rating of a fuel indicates how slowly the fuel will burn and how well the fuel will resist pre-ignition before the spark plug fires. Higher octane fuels can be burned at high compression ratios (CR). The higher CR of an engine, the more efficient is the engine and more is the power generated with given amount of the fuel. LPG has high octane rating 110 that allows CR to be high up to 15:1, which is in the range of 8:1 to 9.5:1 for gasoline engines [4].

II. EXPERIMENTAL SETUP AND PROCEDURES

The engine used in this study was a GL-400 7.5 HP, single cylinder, 4-stroke, air cooled, and naturally aspirated diesel engine. First performance and emissions parameters was measured than it converted in to LPG fuelled spark ignition engine by modification of head for install spark plug and implement ignition system. Conduct the experiment at different compression ratio from 9 to 13.8 and spark timing 25°, 30° and 35° BTDC. The experimental setup also consists following instruments for measuring different parameters.

TABLE-1 TECHNICAL SPECIFICATION OF TEST ENGINE

MODEL	**GL-400**	**H.P.**	7.5
Bore (mm)	86	**Max. Torque – kgm**	1.7 (16.5 NM)
Stroke (mm)	63	**Consumption of Fuel (S.F.C)-gn/h.p./hr.**	220
Displacement (cm^3)	395	**Lub oil consumption-kg/hr.**	0.011
Compression ratio	18:01	**Capacity of oil sump- Liter**	1.2
RPM	3600	**Dry weight-Kg.**	45

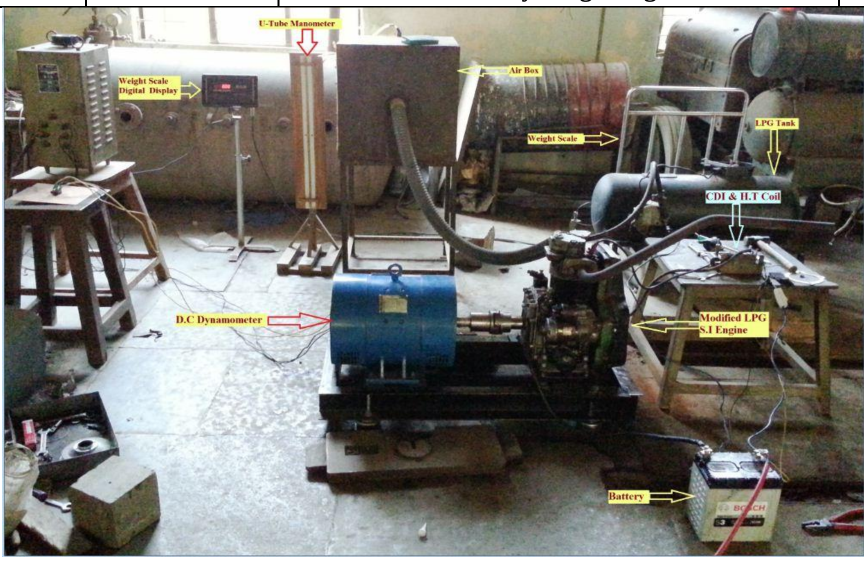

Fig.1. Actual photograph of experimental setup.

DC dynamometer- the engine was coupled with DC dynamometer for measurement of engine output power and multi-meter was used to measure the output voltage and current from dynamo. Electrical bulb was used as load bank for different load on dynamometer. Each bulb consumes 500W of power and is controlled by switch for changing the load condition. Burette- was used to measure fuel consumption of diesel and weigh scale for measure the amount of LPG consumption.

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Tachometer- for measure the speed of engine range from 0-9999 rpm, infrared thermal sensor- used for measure the temperature of inlet air and DBT of ambient air. Exhaust gas analyzer- used to measure the emission of CO (%vol.) and HC (ppm).
The experiment was first performed on diesel engine and then diesel engine converted into SI engine fuelled with LPG as an alternative fuel. The experiment was carried out at compression ratio 9, 10, 11.3, 12.4, 13.1 and 13.8, spark timing 25°, 30° and 35° BTDC. Following procedure was adopted for experimentation. Set the required compression ratio and spark timing. Start the engine with help of self start arrangement. Allow the engine to run for 20 minutes at 1800 rpm by adjusting the throttle position. Load was applied to the system by operating the electrical bulb bank. Note down all the required parameters. Repeat the procedure for different spark timing and the compression ratio. To change the compression ratio, switch off the engine and allow it to cool for some time, then add or remove required no. of shim plate between crank case and cylinder block.

III. III. MODIFICATION FOR DIESEL ENGINE INTO LPG FUEL S.I ENGINE.

To convert diesel engine in to the LPG engine following modification are to be required in the existing engine. 1. Chancing the compression ratio by inserting shim plate in between cylinder head and crankcase. Thickness of shim plate which I have selected is 0.3 mm. so, by placing different no. of shim plate we get different compression ratio. 2. Modification in cylinder head for the insertion of spark plug in place of injector for ignites LPG air mixture. 3. Ignition system and spark plug are required. In an ignition system mainly four types of coil are required, battery for current supply, spark plug for generation of spark. 4. Venturi and carburetor are provided for easy mixture formation of air-gas and maintain the correct air supply into the mixture. 5. Modification in flywheel: diesel engine flywheel has no attachment of magnetic coil and it is heavy in weight. But in dedicated LPG engine, flywheel with magnetic pick up coil attachment is required and it is light in weight. 6. LPG conversion kit for supply LPG fuel to the engine**.**

IV. RESULT AND DISCUSSION

4.1. Effect of compression ratio on engine performance.

4.1.1. Brake specific fuel consumption.

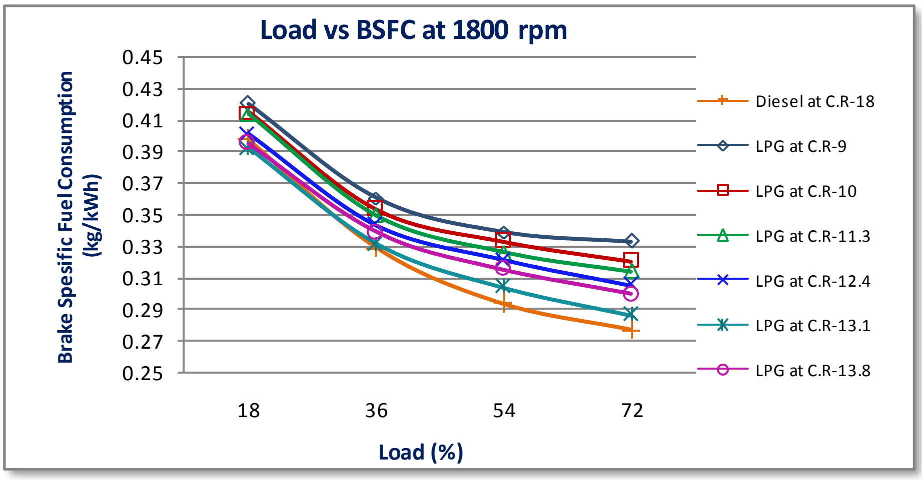

Fig.2. load v/s BSFC

Fig.2. Shows that the Brake specific fuel consumption decrease as compression ratio increase. At 1800 rpm and 72% load, BSFC decrease by 3.71% from 9 to 10 compression ratio, decrease by 2.04% from compression ratio 10 to 11.3, decrease by 2.95% from compression ratio 11.3 to 12.4, decrease by 5.97% from compression ratio 12.4 to 13.1, and increase by 4.66% from

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C.R 13.1 to 13.8. Again BSFC decrease by 8.83% from spark timing 25° to 30° BTDC and increase by 3.04% from 30° to 35° BTDC.

4.1.2. Brake thermal efficiency.

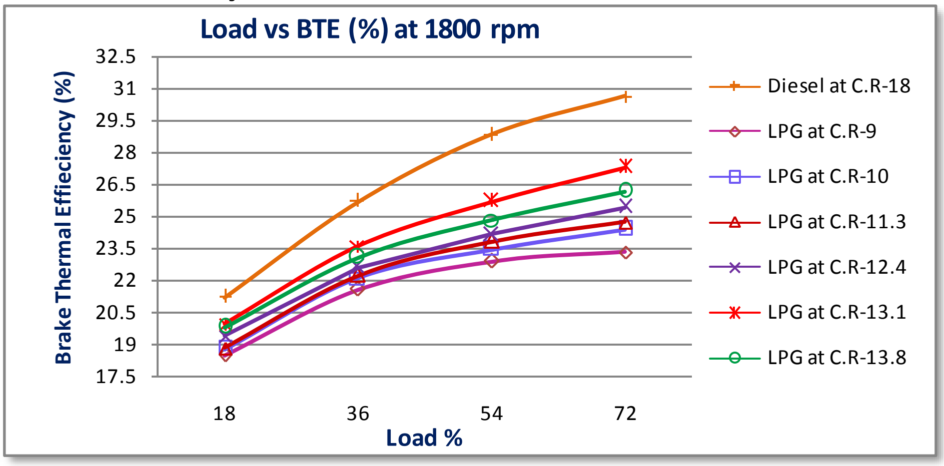

Fig.3. Load v/s BTE

Figure-3 shows that the brake thermal efficiency increase as compression ratio increase. The BTE was maximum about 27.34% at 1800 rpm and highest load for compression ratio 13.1. Again spark timing increase from 25° to 35° BTDC the BTE was maximum about to 30.20 which is 10.47% higher than the BTE at 25°BTDC. The BTE was decrease about to 4.20% from 13.1 to 13.8 compression ratio at 72% load and 1800 rpm.

4.1.3. Volumetric efficiency

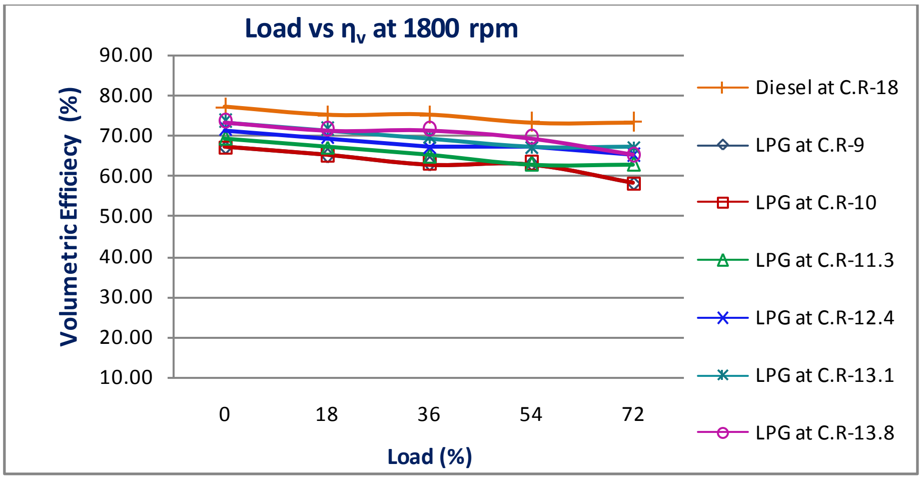

Fig.4. Load v/s volumetric Efficiency

As shown in figure-4 the volumetric efficiency decreased significantly as compare to diesel engine due to gaseous form of LPG which replaces volume of air. For LPG engine volumetric efficiency was increase as compression ratio increase from 9 to 13.1 due to decrease fuel consumption. Maximum volumetric efficiency was about to 67.20% at compression ratio 13.1, 1800 rpm and 72% load.

4.2. Effect of compression ratio on engine emissions.

4.2.1. CO emissions:

The CO emission decrease as compression ratio increase from 9 to 13.8 and increase as spark timing increase due to complete combustion and increase combustion duration lead to reduce temperature of burning gas, which increase CO emission. Minimum CO emission was about to 0.49

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%vol. at compression ratio 13.8, 0.51 %vol. at compression ratio 13.1, 1800 rpm and 72% load. The CO emission was increase about 3.85% from spark timing 25° to 35° BTDC at C.R. 13.1.

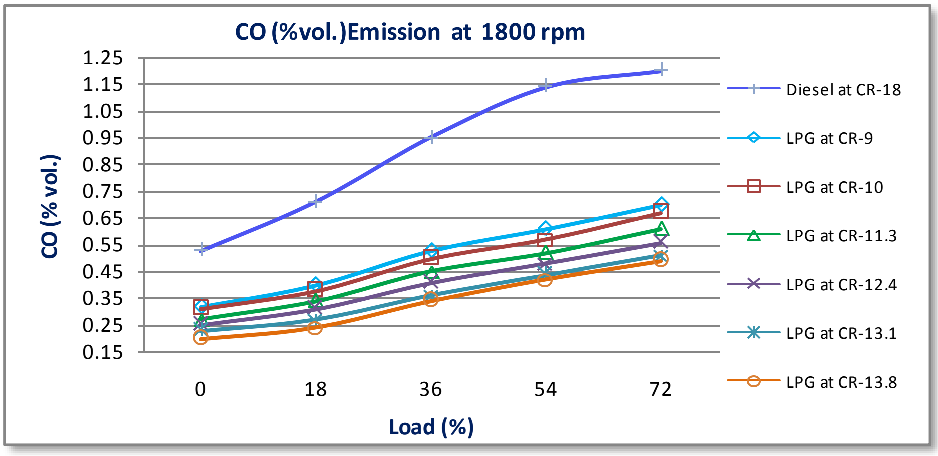

Fig.5. Load v/s CO emissions

4.2.2. HC emissions

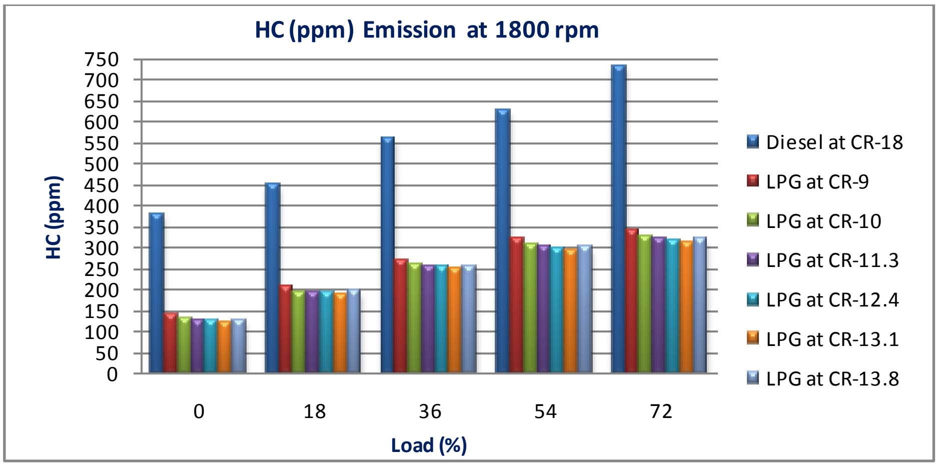

Fig.6. Load v/s HC emissions (ppm)

HC emission reduced as compression ratio increase as well as spark timing increase. At 1800 rpm & 72% load, minimum HC emission was about to 315 ppm at compression ratio 13.1, it was 7.89% less than HC emission at compression ratio 9. Again spark timing increase HC emission was minimum about to 306 ppm at spark timing 35°BTDC and it was 2.80% less than emission at spark timing 25° BTDC.

4.3. Effect of spark timing on engine performance

4.3.1. Brake specific fuel consumption

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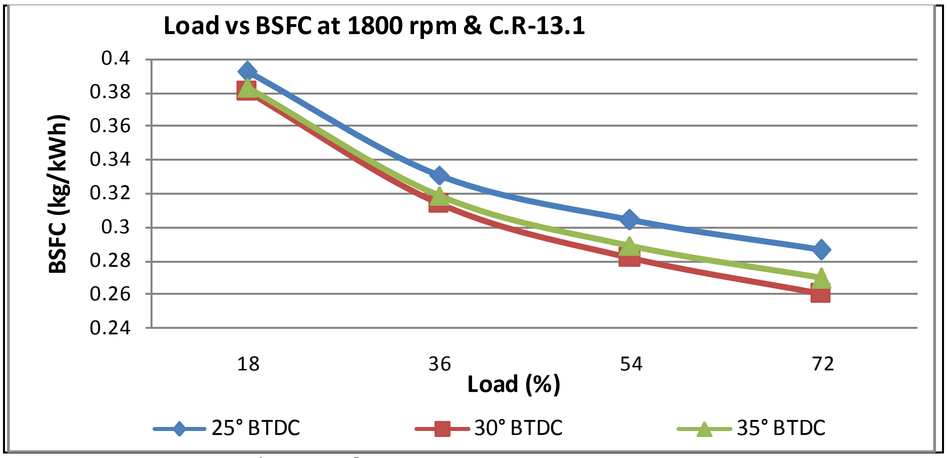

Fig.7. Load v/s BSFC at 13.1 compression ratio

From figure-7, Minimum brake specific fuel consumption found was 0.26 kg/kWh at compression ratio 13.1, spark timing 30° BTDC, 1800 rpm and 72% load for LPG fuelled engine. Which is 8.83% less consumption than consumption at compression ratio 13.1, spark timing 25° BTDC, 1800 rpm and 72% load.

4.3.2. Brake thermal efficiency

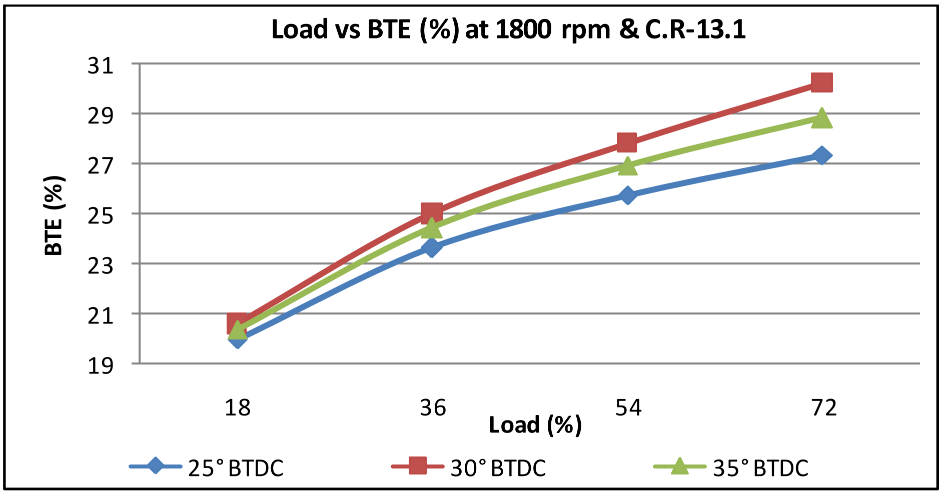

Fig.8. Load v/s BTE at compression ratio 13.1

Figure-8 shows, at 1800 rpm and 72% load, brake thermal efficiency was increase about to 10.47% as spark timing vary from 25° to 30° BTDC, decrease about to 4.60% with increase spark timing from 30° to 35° BTDC.

4.4. Effect of spark timing on engine performance:

4.4.1. CO emissions:

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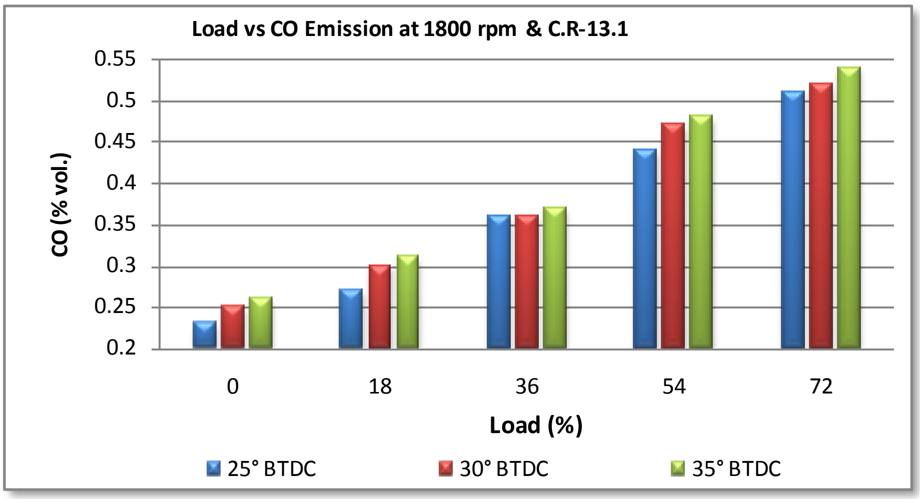

Fig.9.Load v/s CO emissions at C.R-13.1

From figure-9, at 1800 rpm and 72% load, CO emission was found to be increase about to 2% for 30°BTDC as compare to 25°BTDC, increase about to 3.85% for 35°BTDC as compare to 30°BTDC. Reason for increase the CO emission is reduce temperature of burning gas. As spark timing advanced more time available for combustion process, complete combustion takes place, reduce the oxidation and dissociation process of CO at lower temperature of after burning gases, this lead to increase the CO emission as spark timing was advanced.

4.4.2. HC emissions:

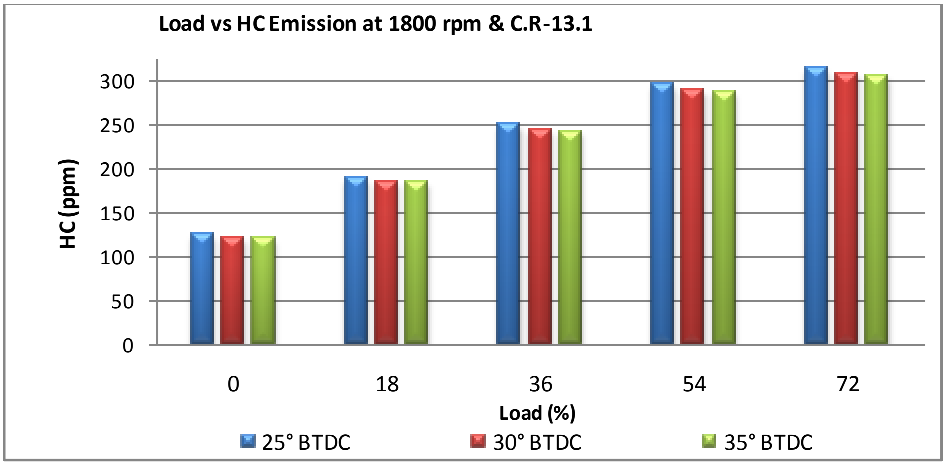

Fig.10. Load v/s HC emissions at C.R-13.1

Figure-10 shows that, maximum HC emission was found about to 315ppm at 25° BTDC, 1800 rpm and 72% load, as spark advance increase up to 35° BTDC it was decrease about to 306ppm and it was 2.85% reduction as compare to 25° BTDC. HC emission increase with increase load and speed on engine due to increase fuel consumption of LPG. Reduction of the HC emission with increase spark advance is due to increase time duration for combustion process, which leads to complete combustion of LPG-air mixture.

V. CONCLUSION

- Brake thermal efficiency increase as compression ratio increase and maximum value was found at compression ratio 13.1. The BTE was also increase as spark timing increase and best suitable spark advanced was 30° BTDC while using LPG as a fuel.

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- Brake specific fuel consumption was improves as compression ratio increase up to 13.1 due to reduced fuel consumption of LPG. Minimum BSFC was found at C.R 13.1 and spark timing 30° BTDC for LPG as a fuel.
- While using LPG as a fuel, CO emissions decrease as compression ratio increase and minimum CO emissions was at compression ratio 13.1. Again it was increase as spark timing advanced from 25° to 35° BTDC due to lower the burning gas temperature as combustion duration increase.
- HC emissions in LPG engine were significantly decreased as compare to diesel engine emissions. It was decrease as compression ratio increase. Minimum HC was found at compression ratio 13.1 and spark timing 30° BTDC.
- LPG is viable alternative fuel for the diesel engine.
- Existing diesel engine was successfully converted into LPG SI engine.

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