EFFECT OF VARIOUS PARAMETERS ON PERFORMANCE AND EMISSION OF DIESEL-LPG DUAL FUEL ENGINE

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ABSTRACT

The conventional petroleum fuels for internal combustion engines are depleting rapidly, due to increase in the vehicular population. Moreover, these fuels cause serious environmental problems by emitting harmful gases into the atmosphere. Generally, pollutants released by engines are CO, NOx, Unburnt hydrocarbons, smoke and limited amount of particulate matter. At present, alternative fuels like methyl esters of vegetable oil (commonly known as biodiesels), alcohols etc. which are in the form of liquid and hydrogen, acetylene, CNG, LPG etc. in gaseous fuels are in the line to replace the petroleum fuels for IC engines.

Based on the literature available dual fuel engine gives better performance compared to conventional engines. Literature also shows that LPG is most suitable gaseous fuel for dual fuel internal combustion engine. In dual fuel engine flow rate of LPG decreases. It causes dripping of diesel while injecting into the cylinder. To avoid dripping injection pressure needs to be increased. Injection pressure of 140 bar was found optimum from 120, 130, 140, 150, 160 bar. At 140 bar performance and emission test were conducted for LPG flow rates of 2, 3, 4 and 5 LPM. The results shows that the LPG flow rate of 4 LPM in dual engine gives better performance compared to diesel engine. It also shows that the emission also reduces with 4 LPM flow rate of LPG in dual fuel engine compared to diesel engine and other LPG flow rates in dual fuel engine.

Keyword: - *Dual fuel engine, injection pressure, LPG flow rate, percentage energy substitution (PES), performance parameters, emission parameters.*

1. INTRODUCTION

Over few decades, a lot of research has gone into use of alternative fuels in IC engines. Vegetable oils seem to be a forerunner as they are renewable and easily available. In an agricultural country like India use of vegetable oil would be economical because of large productivity and reduced dependability on import of petroleum products [13]. But because of high viscosity and poor atomization of straight vegetable oils leads to improper mixing and causes improper combustion. Further to reduce viscosity problem researchers went for biodiesels of vegetable oils. The cost of production and performance losses shows other alternative to use gaseous fuels as alternative fuels in IC engines.

One approach in this direction is to utilize the gaseous fuels like biogas, LPG (liquefied petroleum gas), LNG (liquefied natural gas), hydrogen and acetylene gas. They have a high self-ignition temperature; hence they cannot be used directly in diesel engines [8].

1.1 Gaseous Fuels

Gaseous fuels are the best suited for IC engines since physical delay is almost nil. However, as fuel displaces equal amount of air the engines may have poor volumetric efficiency. There are quite few gaseous fuels that can be used as alternative fuels. Gaseous fuels are the most convenient requiring the least amount of handling and simplest and most maintenance free burner systems.

1.2 Liquefied Petroleum Gas

LPG is composed primarily of propane with some butane, propylene, butylene, and other hydrocarbons, unlike gasoline, which is a complex mixture of hydrocarbons. LPG's average octane value is 104, which is higher than gasoline's range of 84 to 97. The higher-octane value can produce significantly better vehicle performance than the lower octane gasoline.

Property	**LPG**
Molecular formula	C_3H_8 (propane) + C_4H_{10} (butane)
Octane number	100-110
Stoichiometric air-fuel ratio	15.5
Lower heating value LHV (kJ/kg)	46000
Density ρ (g/l)	535
Ignition temperature (^{0}C)	480

Table -1: LPG properties [15]

2. EXPERIMENTAL SETUP

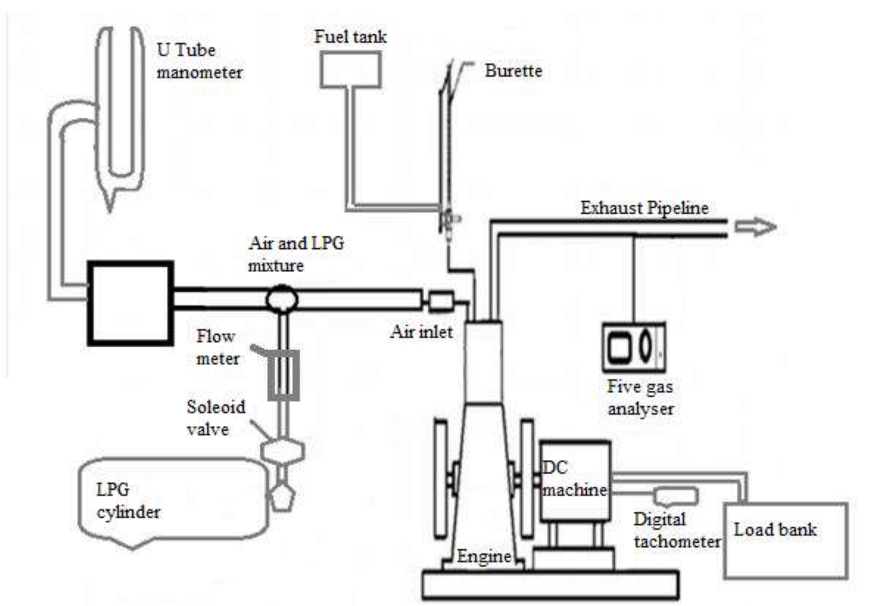

Figure -1: Experimental setup

Parameter	**Specification**
Make	Powerlite
Rated brake power	5.65 kW
Speed	1500 rpm
No of Cylinder	1
Method of cooling	Air cooled
Bore × Stroke	87.5 mm × 110 mm
Compression ratio	18:1

Table -2: Engine specification

3. EXPERIMENTAL PROCEDURE

The step by step experimental procedure is represented below for performance and emission testing:

1) Before starting the engine check lubricating oil level and then start it by means of mechanical lever.
2) First engine was run on diesel for 15 minute before starting of the test to stabilization and thereafter stabilization period of 15 was allowed for all other reading. The load on the engine was varied by means of load bank connected to the A.C. Alternator.
3) The observations were taken at time when exhaust gas temperature remain steady. For each loading condition, voltage and current output of the alternator, engine speed, time for 15 ml fuel consumption, exhaust gas temperature as well as exhaust gas constituents (CO, HC, NOX and CO2) were recorded.
4) The same procedure was conducted for each fuel.
5) Using experimentally observed data, the brake power, fuel consumption, brake specific fuel consumption and brake thermal efficiency were calculated.

4. RESULT AND DISCUSSION

4.1 Optimization of injection pressure

Optimum injection pressure of diesel is 120 bar. To use LPG in diesel engine quantity of diesel need to be reduced. Reduction in flow rate of diesel causes dripping of diesel affecting the atomization of fuel inside the cylinder. To avoid dripping of diesel, injection pressure is required to be optimized.

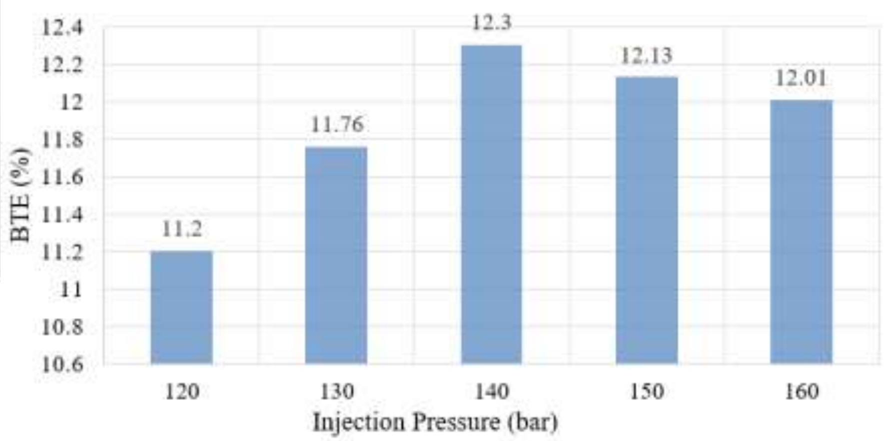

Chart -1: Injection pressure vs BTE

Three different injection pressure of 120 bar, 130 bar, 140 bar, 150 bar and 160 bar taken for optimization. Minimum flow rate of diesel expected in 0 % and 25 % load condition and maximum flow rate of LPG of 5 LPM.

4.2 Optimization of LPG flow rate

4.2.1 Variation in brake thermal efficiency

The brake thermal efficiency (BTE) of the engine is one of the most important parameter for evaluating the performance of the engine. It shows the combustion behavior of the engine to a greater extent. Chart 6.3 indicates the variations of brake thermal efficiency with brake power of the engine. It is noticed that the BTE of the engine increases with increases in brake power but as per increase in ratio of LPG and diesel B.T.E decreases.

Chart-2 shows the variation of brake thermal efficiency (BTE) with different proportion of diesel and LPG fuel combinations. The results were obtained in the form of increment in the BTE with increases in brake power from 1.41 kW to 5.65 kW due to reduction in diesel fuel consumption as per increase in LPG flow. If LPG is used as a conventional fuel, then the break thermal efficiency will be lower when compared to diesel because due to carbon content present in the LPG.

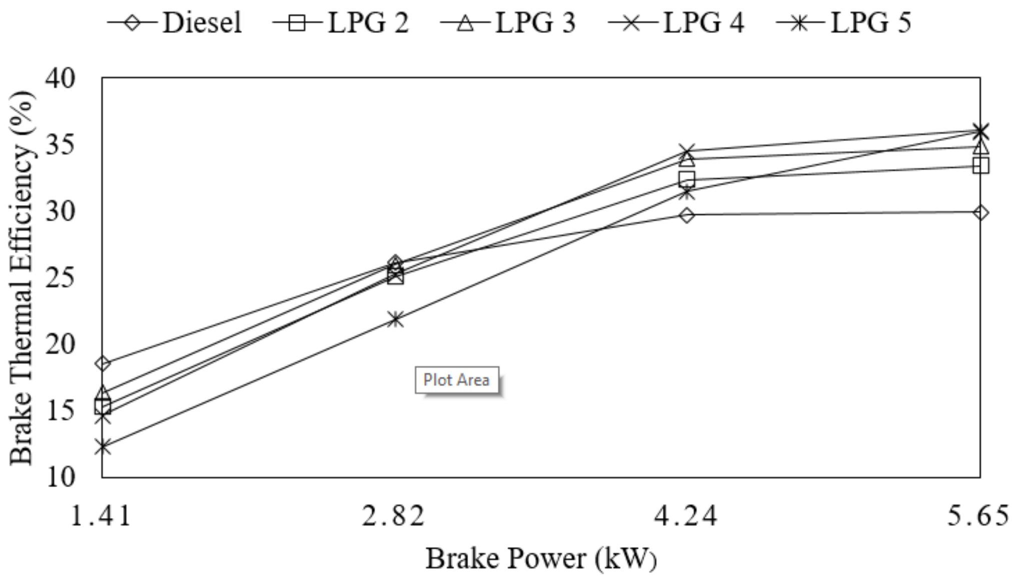

Chart -2: Variation in brake thermal efficiency

4.2.2 Variation in volumetric efficiency

As chart 6.5 shows that engine has very high volumetric efficiency which is slightly decreases with brake power (about 72.63% at low brake power and 70.30% at high brake power). But with slight reduction is seen in using dual fuel operation (about 62.34% at low brake power and 59.61% at higher load) due to increase of ratio of diesel and LPG, but in general the volumetric efficiency decreases with increases in brake power.

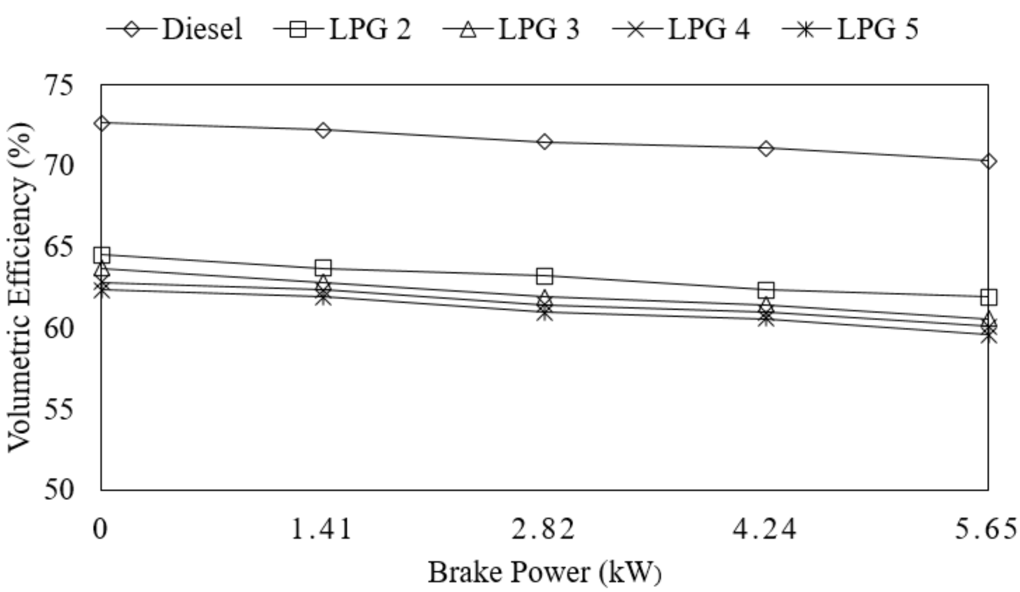

Chart -3: Variation in volumetric efficiency

4.2.3 Variation in Exhaust gas temperature

Chart-3 shows the variation of exhaust gas temperature (EGT) with brake power for diesel and different proportion of diesel and LPG exhaust gas temperature. EGT increases with increases in brake power but it decreases with increases in ratio of diesel-LPG for given brake power at part load. For full load the exhaust gas temperature increases with increase in LPG flow rate.

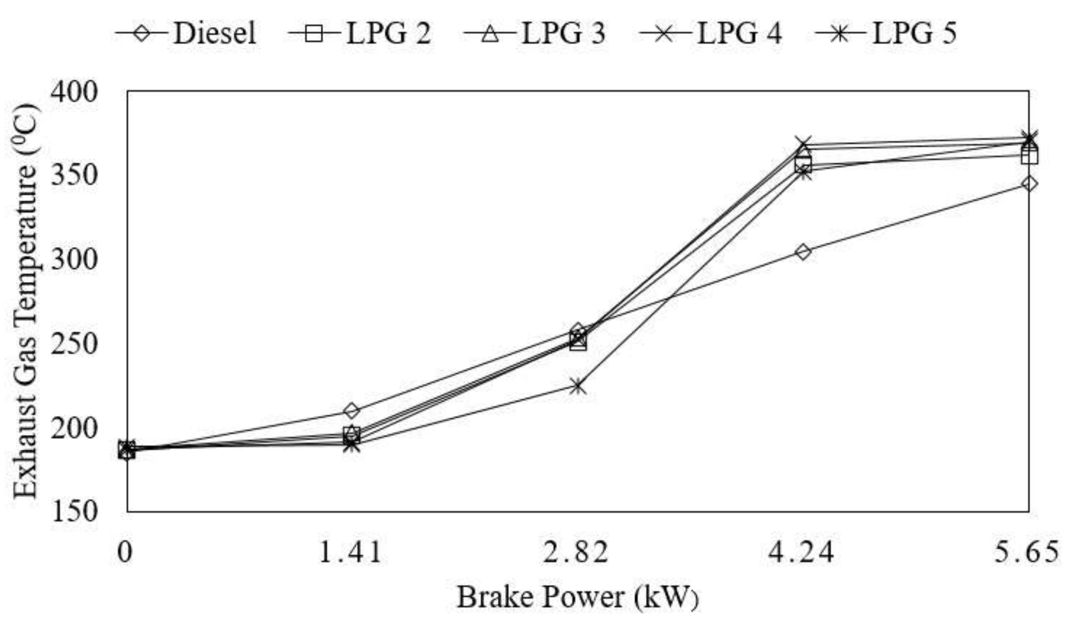

Chart -4: Variation in Exhaust gas temperature

4.2.4 Variation in Energy Substitution Ratio

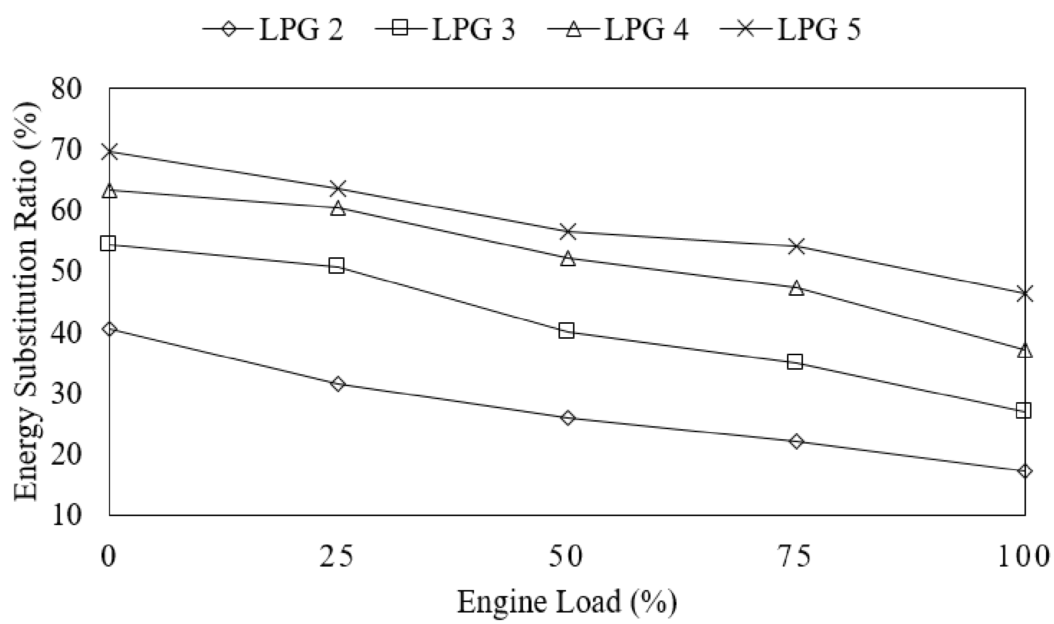

Chart -5: Variation in Energy Substitution Ratio

Chart-5 shows the variation of energy substitution ratio with change in load of the engine. The chart clearly shows that as the load increases, the energy substitution ratio decreases irrespective of the LPG flow rate. The flow rate of LPG is constant, so to produce more power with increase in load, diesel flow rate increases. So it causes to reduce the energy substitution ratio with increase in engine load.

4.2.5 Variation in Carbon monoxide (CO)

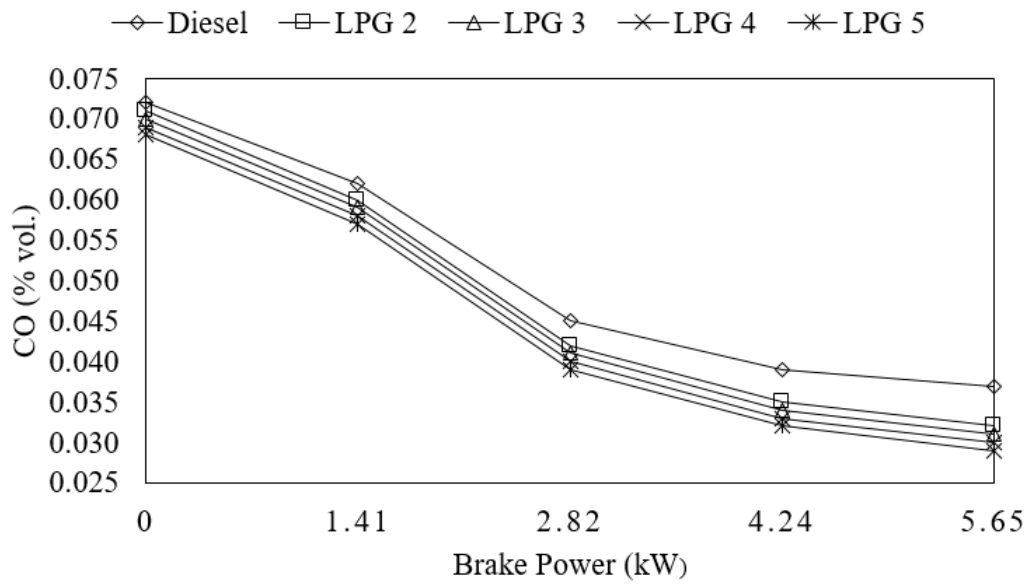

Chart -6: Variation in Carbon monoxide (CO)

4.2.6 Variation in Carbon dioxide (CO2)

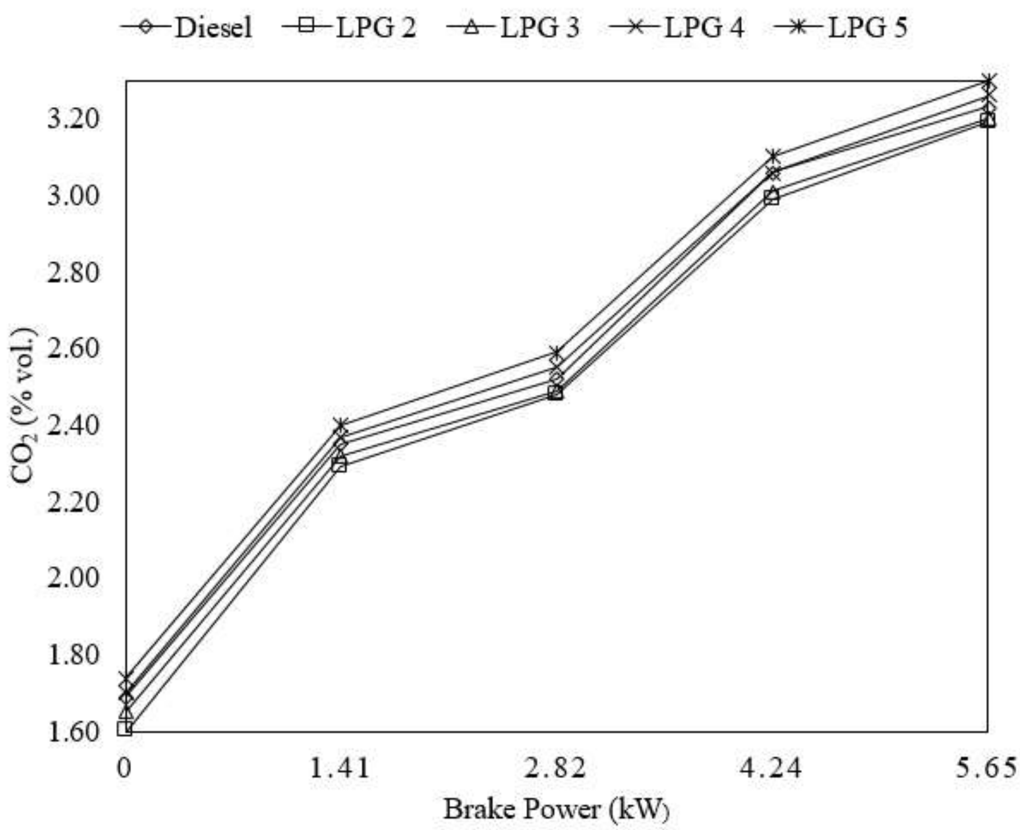

Chart -7: Variation in Carbon dioxide (CO2)

4.2.7 Variation in Hydrocarbon (HC)

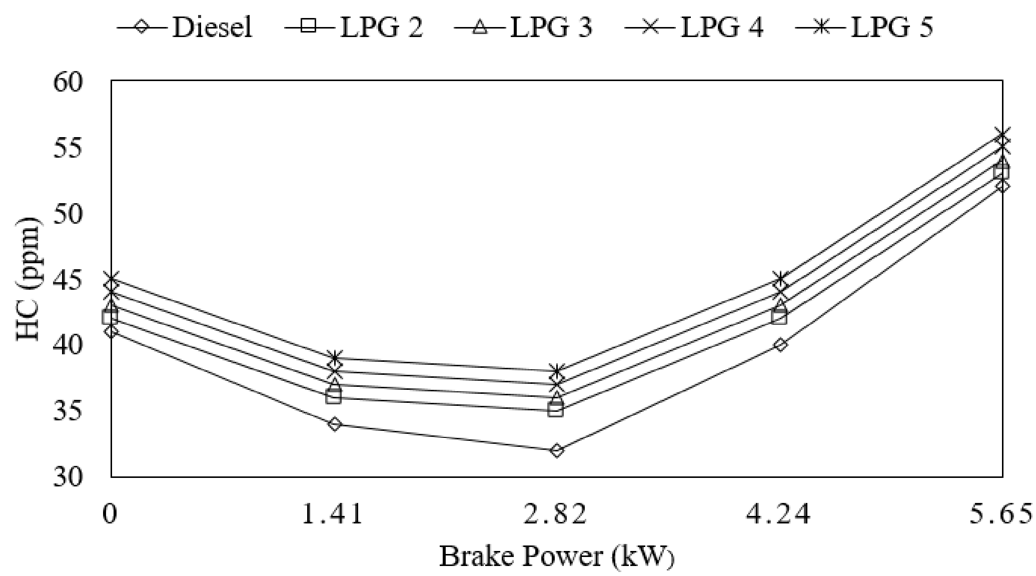

Chart -8: Variation in Hydrocarbon (HC)

4.2.8 Variation in Oxides of nitrogen (NOx)

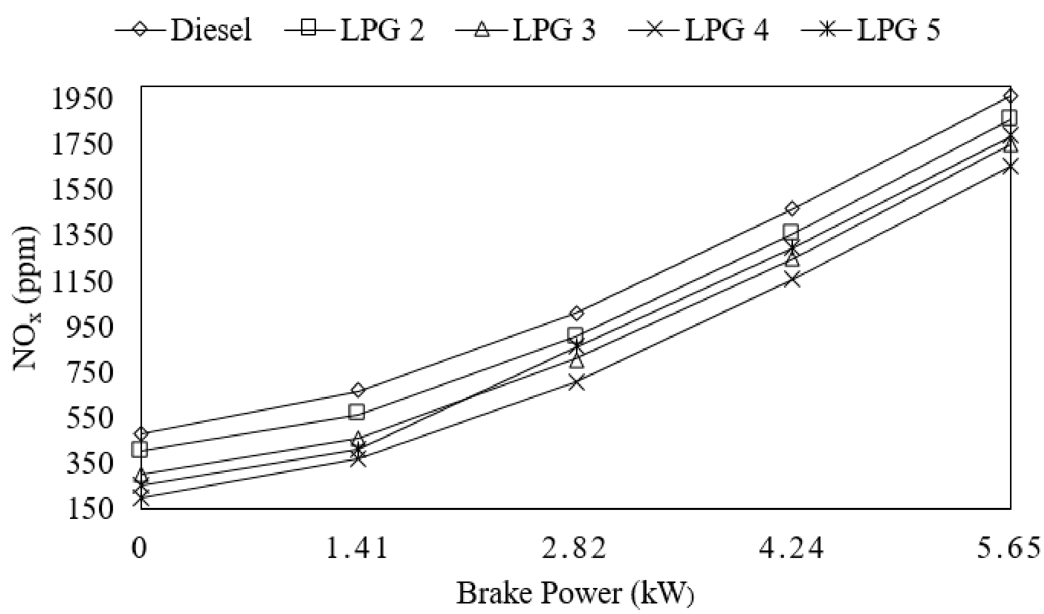

Chart -9: Variation in Oxides of nitrogen (NOx)

5. CONCLUSION

From the results of injection pressure it can be stated that dual fuel engine requires more pressure than the diesel engine. But we can increase injection pressure up to certain limit. After that if the injection pressure is increased, efficiency will reduce. From various injection pressures of 120, 130, 140, 150 and 160 bar, the optimum was 140 bar. At this pressure the performance and emission test of dual fuel engine shows that 4 LPM of LPG flow rate is optimum for dual fuel engine used for the experiment from all the tested flow rates of 0, 2, 3, 4, and 5 LPM. There is increase in break thermal efficiency in dual fuel engine compared to diesel engine at full load. Volumetric efficiency of dual fuel engine is lower than the diesel engine. Emission of carbon monoxide (CO) and oxides of nitrogen (NO_x) reduces while carbon dioxide (CO_2) and hydrocarbon (HC) increases in dual fuel engine compared to diesel engine.

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