# Experimental Investigation On Use Of LPG-Ethanol Blends As A Fuel In Spark Ignition Engine

Ashwini R.Warade[1], S. M. Lawankar[2]

[1]*M.Tech Student, Thermal Engineering Government College of Engineering, Amravati,*
[2]*Asst. Professor, Department of Mechanical Engineering, Govt. College of Engineering, Amravati.*

## Abstract

The concerns about clean environment and high oil prices forces for research on alternative fuels. The research efforts directed towards improving the performance of S.I. engine using LPG-Ethanol blends as a fuel. The paper deals results of performance and emissions of a single cylinder, four stroke, S. I. engine by Gasoline and LPG-Ethanol blend as a fuel. The performance of engine was studied at constant speed, with the engine operated at various loading conditions. Performance parameters considered for comparing are brake thermal efficiency and exhaust gas temperature of the engine. There is improvement in brake thermal efficiency by using LPG-Ethanol blends as compared to gasoline at various loads. Exhaust gas temperature using gasoline as a fuel is having less value compared to LPG-Ethanol blends. For LPG-Ethanol blends as a fuel concentration levels of CO and HC recorded are found to be lowered than gasoline fueled engine while NOx found to be increased as percentage of ethanol increases.

**Keywords** – Liquefied petroleum gas, Ethanol, Spark ignition engines, Dual fuel engine, Combustion characteristics, performance characteristics.

## "1. Introduction"

Rapid depletion of fossil fuels and as pollutant resulting from these categories are massively expelled to ruin the healthy climate is demanding an urgent need of an alternative fuels for meeting sustainable energy demand with minimum environmental impact.

### 1.1 Need of Alternative Fuels

As society is facing the dual problems of fast depletion of fossil fuels and environmental degradation, there is an urgent need to reduce dependence on petroleum derived fuels for better economy and environment. These fuels are essentially non-petroleum and result in energy security and environmental benefits. These fuels are available either in one form or other for more than one hundred years. Identification of alternative fuels for use in I.C. Engines has been subjected to studies throughout the globe. Performance tests have shown suitability of variety of alternative fuels such as hydrogen, alcohols, biogas, producer gas and various types of edible and non edible oils. However, in Indian context, the bio-origin fuels like alcohols, vegetable oils, and biogas can contribute significantly towards the problems related to fuel crises. Many automobiles were modified to be used with various alternative fuels as other choices instead of gasoline and diesel. Alternative fuel such as natural gas, hydrogen, biomass, vegetable oil and alcohol fuel are sought as an option for automobile. As a fuel for spark-ignition engines, alcohols (methanol and ethanol) and LPG have some advantages over gasoline.

### 1.2 Ethanol and LPG as an Alternative Fuels for SI Engine

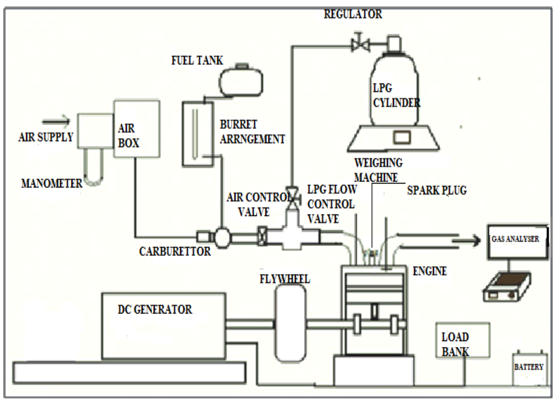
Ethanol ($C_2H_5OH$) is a high performance fuel. It is considered the most suited alcohol to be used as a fuel for spark ignition engines. The most attractive properties of ethanol include its ability to be produced from renewable energy sources, its high octane number, and its high laminar flame speed. Drawbacks include its relatively low heating value and the fact that it is corrosive to metal and rubber parts of the engine.

Liquefied petroleum gases (LPGs) are by-products of natural gas productions and refineries, and they are widely used in commercial vehicles. LPGs mainly consist of mixtures of hydrocarbons such as propane ($C_3H_8$), propene ($C_3H_6$), *n*-butane

($C_4H_{10}$), isobutene (methyl-propane), and various proportions of other butanes ($C_4H_8$). The high 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. Ethanol and LPG represents good alternative fuels for gasoline and therefore must be taken into consideration in the future for transport purpose. Using LPG as a fuel gives significant reduction in CO, HC, $CO_2$ emissions, and $NO_X$ emissions are higher because of higher flame temperature in the combustion chamber. While formation of NOX could be potentially lower with ethanol as combustion temperature is lower. Gasoline-ethanol blend fuelled and LPG-Gasoline fuelled vehicles have shown better emission performance as compared with gasoline vehicles.

## "2. Experimental Set Up and Experimental Procedure"

The engine used in this study is a single cylinder four-stroke water cooled spark ignition engine with a crown on the piston top surface. The detail specifications of the engine are listed in table 1 To calculate the load on the engine generator is been mounted on the engine shaft which supply the electricity and through which the load can be given to the engine, the position of the generator is close to the engine shaft so the engine with generator is Compact in structure. An AVL Digas444 analyzer is been used for experimentation purpose. An arrangement for analyzer probe insertion is been made in the exhaust line. The analyzer has the capability of sampling various exhaust products such as hydrocarbon (HC), carbon monoxide (CO), and carbon dioxide (CO2) and oxides of nitrogen (NOx).




Φιγυρε 1: Εξπεριμενταλ σετ υπ

When the engine is operated on gasoline, a simple carburetor is attached in the suction of Engine While running the engine on LPG-Ethanol blend LPG is supplied in the inlet manifold through the venturi section where due to venturi depression the air fuel mixture occurs and is then discharged in the inlet and also ethanol is supplied in the inlet manifold by rotameter. In order to measure brake power, the engine is coupled with a generator; maximum of 2kW of load was given to the engine while performance studies and at the constant speed of 1500 rpm. As the engine is water cooled constant water supply was maintained during experimentation for engine body cooling. Simple weighing bridge method was used to calculate amount of LPG consumed and for gasoline fuel consumption a simple burette method was used.

Ταβλε 1: Σπεχιφιχατιονσ οφ ενγινε υσεδ

| ITEM | SPECIFICATION | |
|---|---|---|
| Engine type | Spark ignition | |
| Number of cylinder | 1 | |
| Cylinder Bore | 87.5 mm | |
| Cylinder stroke | 112 mm | |
| Maximum power | 5 kW | |
| Ignition Timing range | 10-45 Degree BTDC | |
| Method of loading | DC Generator with Load Bank | |
| Method of cooling | Water cooled | |
| Valve Timing | **Opens** | **Closes** |
| Intake | 12 BTDC | 56 ABDC |
| Exhaust | 56 BBDC | 12 ATDC |



Ταβλε 2: Προπερτιεσ οφ φυελ

| Properties | LPG (70%C4H10+30% C3H8) | | Ethanol | Gasoline-ne |
|---|---|---|---|---|
| | $C_4H_{10}$ | $C_3H_8$ | $C_2H_5OH$ | |
| Density ($Kg/m^3$) | 2.52 | 1.91 | 789 | 700 |
| Molecular mass (kg/moles) | 58.12 | 44.09 | 46.06 | 100.2 |
| Auto ignition temperature($^oc$) | 405 | 470 | 365 | 280 |
| Calorific value (KJ/Kg) | 49510 | 50350 | 29700 | 47300 |
| Stoichiometric fuel-air ratio | 0.0646 | 0.0638 | 0.1112 | 0.0659 |
| Research Octane number | 94-96 | 107 | 108.6 | 96-98 |

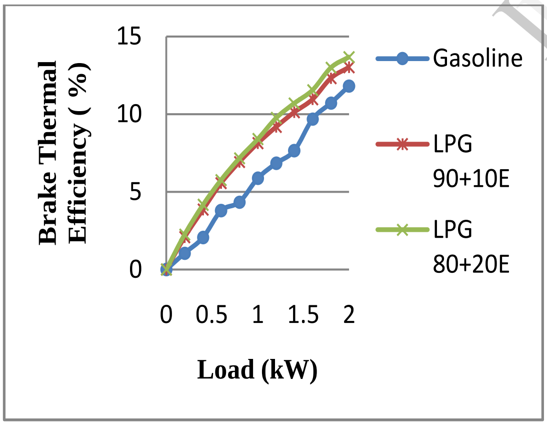
Experiments were performed with gasoline fuel and blends of LPG with Ethanol. A separate arrangement is made to supply LPG and Ethanol. The engine is allowed to stabilize the speed *i.e.* 1500 rpm. To maintain the speed of the engine the governor of the engine is linked to the butterfly valve which is provided in the inlet manifold. The generator is been mounted on the engine shaft which supply the electricity and through which the load can be given to the engine, maximum of 2kW of load was given to the engine while performance studies and at the constant speed of 1500 rpm. Switch on the load terminal on the generator so as the load on the engine can be increased likewise. Experiments are initially carried out on the engine using gasoline as a fuel in order to provide base line data.

## "3. Results and Discussion"

## Performance Characteristics

### 3.1 Brake Thermal Efficiency

Brake thermal efficiency is the function of actual power gain from total supplied energy input. The thermal efficiency of LPG-Ethanol blend is good compared to that of gasoline; this is due to less amount of fuel consumed. 20% Ethanol blend with LPG gives more efficiency than 10% Ethanol blend.




Φιγυρε 2: Λοαδ ϖ/σ βρακε τηερμαλ εφφιχιενχψ

Fig shows the variation of brake thermal efficiency with respect to brake power for the engine using gasoline, blend of LPG and Ethanol (10% and 20%).From Figure it is found that, as the load increases, there is considerable amount of increase in brake thermal efficiency. The maximum brake thermal efficiency with petrol is 11.81% at BP 2 kW and maximum brake thermal efficiency with LPG 90+10E is 13% at BP 2 kW; with LPG 80+20E is 13.68% at 2 kW.

### 3.2 Exhaust Gas Temperature

Fig shows the variation of exhaust gas temperature with respect to brake power for the engine using gasoline, blend of LPG and Ethanol (10% and 20%)

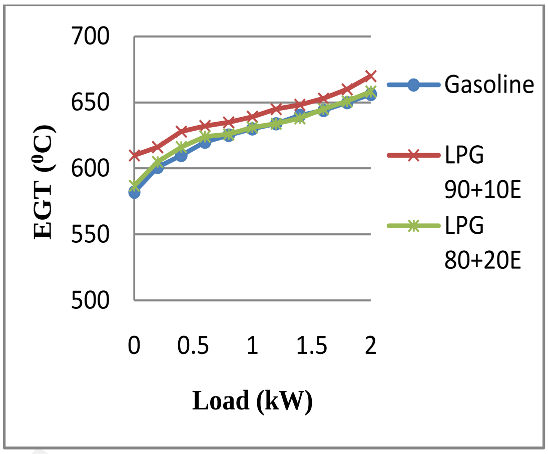


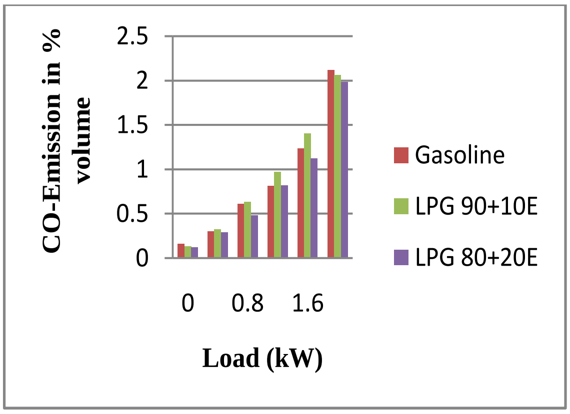

Figure 3: Load v/s exhaust gas temperature



From Figure it is found that, as the load increases, there is increase in exhaust gas temperature. The exhaust gas temperature using gasoline as a fuel is having less value compared to LPG-Ethanol blends.

## Emission Characteristics

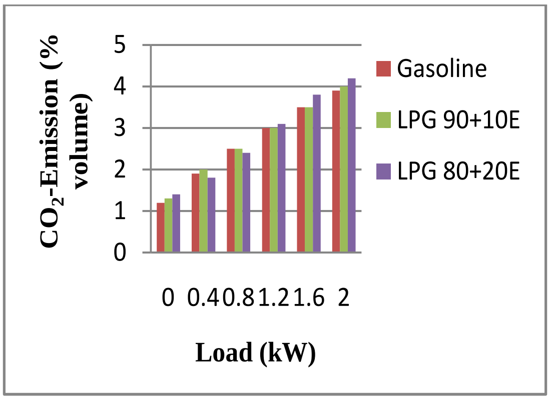
### 3.3 CO Emission




Φιγυρε 4: Λοαδ ϖ/σ ΧΟ εμισσιον

Carbon monoxide is product of incomplete combustion of fuel. Formation of carbon mono-oxide indicates loss of power result of oxygen deficiency in combustion chamber. The CO emission increases with incomplete combustion of fuel and it is higher for petrol compared with LPG-Ethanol blends.CO emission for 20% ethanol blend is lower than 10% ethanol blend by 4.04% at load of 2kW.

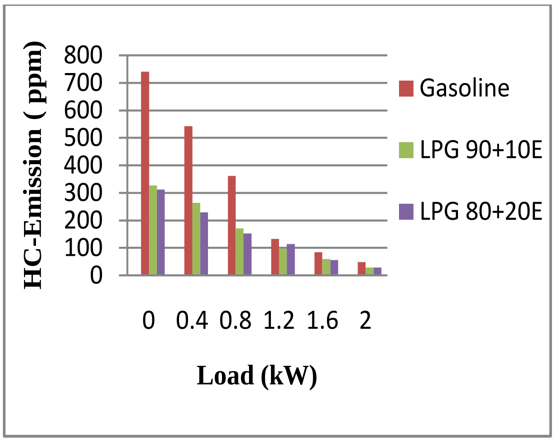
### 3.4 $CO_2$ Emission




Φιγυρε 5: Λοαδ ϖ/σ ΧΟ$_2$ εμισσιον

From the above figure it is found that $CO_2$ emission increases with increase in load. As a result of the lean burning associated with increasing ethanol percentages, the $CO_2$ emission increased because of the improved combustion. $CO_2$ emission is higher for LPG-Ethanol blends when compared with gasoline. $CO_2$ emission for 20% ethanol blend is 4.87% higher than 10% ethanol blend.

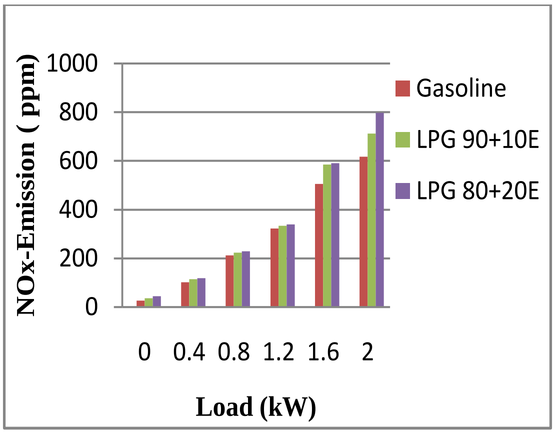
### 3.5 HC Emission




Φιγυρε 6: Λοαδ ϖ/σ ΗΧ εμισσιον

From the above figure it is found that there is decrease in Hydrocarbon emissions with increase in load. Hydrocarbon is also product of incomplete combustion of fuel. The formation of hydrocarbon is due to lack of proper air supply. HC emission indicates power loss. It is found that HC emission is higher for petrol compared with LPG-Ethanol blends. HC emission for 20% ethanol blend is lower than 10% ethanol blend by 5.35% at load of 2kW.

### 3.6 NOx Emission




Φιγυρε 7: Λοαδ ϖ/σ ΝΟξ εμισσιον



From the above figure it is found that NOx emission increases with increase in load. Nitrogen oxides are generated from oxygen and nitrogen under high pressure and temperature conditions in the engine cylinder. NOx emission for LPG-Ethanol blends is higher than gasoline by 15.21% while 20% ethanol blend having higher value than 10% ethanol blend by 12.07% at load of 2 kW.

## “4. Conclusions”

In this study, performance of single cylinder spark ignition engine fueled with LPG-Ethanol blend and gasoline was studied, based on the experimental study, the following results of LPG-Ethanol blends and Gasoline can be concluded:

1. Brake thermal efficiency for LPG-Ethanol blend is good compared to gasoline.20% Ethanol blend with LPG gives 5.23% more efficiency than 10% Ethanol blend with LPG.
2. Using LPG-Ethanol blends exhaust gas temperature is more compared to Gasoline at all loading conditions
3. CO emission for LPG-Ethanol blend is less as compared to that of Gasoline. CO emission for 20% ethanol blend is lower than 10% ethanol blend by 4.04%.

4. $CO_2$ emission for gasoline is less compared to that of LPG-Ethanol blend.
5. With increase in load there was reduction in Hydrocarbon emission. The hydro carbon emission for LPG-Ethanol blend was less compared to Gasoline.
6. NOx emission for LPG-Ethanol blends is higher than gasoline by 15.21% while 20% ethanol blends having higher value than 10% ethanol blend by 12.07% at load of 2 kW.

## Nomenclatures

BTE- brake thermal efficiency
CO– Carbon monoxide
$CO_2$–Carbon dioxide
EGT- Exhaust gas temperature
HC- Hydrocarbons
NOx- Nitrogen dioxide
RPM- Revolution per minute
LPG- Liquefied Petroleum Gas

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