ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 6, Issue 11, May 2017

Effect of Compression Ratio on Performance and Emission Characteristics of LPG-Ethanol Fuelled SI Engine- A Review

Ashish S. Lanje
Asst. Prof. PVPIT, Bavdhan

Abstract*—.Alternative fuels for both spark ignition (SI) and compression ignition (CI) engines have become very important owing to increased environmental protection concern, the need to reduce dependency on petroleum and even socioeconomic aspects. The investigations have been concentrated on decreasing fuel consumption by using alternative fuels and on lowering the concentration of toxic components in combustion products. As a gaseous fuel, gains from LPG have already been established in terms of low emissions of carbon monoxide, hydrocarbon. Ethanol is one of the fuel additive has some advantages such as better antiknock characteristics and it can be considered as renewable energy under the environmental consideration. In the present study evaluates the performance and emission characteristics of single cylinder, 4-stroke, and water cooled, and blends of LPG-Ethanol fuelled spark ignition engine at different compression ratio. The obtained result shows that blend of LPG-Ethanol fuel have closer performance to Gasoline fuel. However, the brake specific energy consumption shows an improvement with blend of LPG-Ethanol as a fuel replacement. The concentration levels of CO, CO2 and unburnt HC recorded are found to be lower than the gasoline fuelled engine.

Keywords- **Liquefied petroleum gas, Ethanol, emission and performance characteristics, compression ratio, spark ignition engine.**

I. INTRODUCTION

It is the dream of engineers and scientists to develop engines and fuels such that very few quantity of harmful emissions are generated and these could be let into the surroundings without a major impact on the environment. Air pollution is predominately emitted through the exhaust of motor vehicles and the combustion of fossil fuels. Government around the world has set forth many regulatory laws to control the emissions. The growing sector of transports, rise a big alarm either for the day-by-day increasing number of vehicles and for the sensible contribution to the degradation of air quality in urban areas, as well as for the global pollution. Due to high thermal efficiency and power density, IC engines are widely used for transportation and stationary power source. Kyto protocol calls for a reduction in greenhouse gas emission between 2008 to 2012 to the levels that are 5.2% below 1990 level in 38 industrialized countries. IC engines exhaust emissions, due to stringent emission norms caused engine manufacturer to examine the potential of alternative fuels. CO_2 reduction in mobility sector is a major challenge for next decade. 30 billion tons of CO_2 is added to atmosphere every year by the entire nation. One of the serious problems facing the modern technological society is the drastic increase in environmental pollution by Internal Combustion engines (IC engines). All transport vehicles with SI and CI (compression ignition) engines are equally responsible for the emitting different kinds of pollutants. Some of these are primary kinds having direct hazardous effect such as carbon monoxide, hydrocarbons, and nitrogen oxides while others are secondary pollutants such as ozone, which undergo a series of reactions in the atmosphere and become hazardous to health. The emissions exhausted into the surroundings pollute the atmosphere and cause global warming, acid rain, smog, odours and respiratory and other health hazards. The urgent need for alternative fuel is essential to replace the supplement conventional fuels. A pollutant is a component which changes the balance of environment and nature under normal condition. The major exhaust emissions HC, CO, NOx, CO_2, solid particles are and performance is increased by adding the suitable additives to the fuel reduced with the present technology.

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 (105) than petrol (91-97). The use of LPG in internal combustion engines yielded higher thermal efficiency and better fuel economy compared to unleaded gasoline. This is due to mainly the higher octane rating which permits greater engine compression ratio without the occurrence of knock. LPG also has higher heating value compared to other fuels and can be liquefied in a low pressure range of 0.7 to 0.8MPa at atmospheric pressure. Gaseous fuels such as liquefied petroleum gas (LPG) and liquefied natural gas (LNG) have 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. The use of LPG as an alternate fuel for road vehicles has been studied extensively in recent years i.e. approximately 4 million vehicles are operating on LPG worldwide. Most of these were mainly light, medium and heavy-duty trucks originally operated on gasoline and later converted to LPG using approved and certified conversion kits. Many investigations have reported favourable results

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 6, Issue 11, May 2017

from emission perspectives when LPG is used as an alternative fuel in spark ignition engines. About 55% of the LPG processed from natural gas purification. The other 45% comes from crude oil refining. Major constituent gases are propane (C_3H_8) and butane (C_4H_{10}), with minor quantities of propane (C_3H_6), various butanes (C_4H_8), iso-butane, and small amounts of ethane (C_2H_6). The composition of commercial LPG is quite variable. Being a gas at normal temperature and pressure LPG mixes readily with air in any proportion.

Alcohol is one of the fuel additive (Methanol, Ethanol) has some advantage over gasoline such as better antiknock characteristics and the reduction of CO and HC emissions. Since ethanol can be fermented and distilled from biomasses, it can be considered as renewable energy under the environmental consideration, using ethanol blended with gasoline is better than methanol because of its renewability and less toxicity. Some properties of ethanol with comparison to gasoline are given in Table I. The reduction of CO emission is apparently caused by the wide flammability and oxygenated characteristic of ethanol. Therefore, improvement in power output, efficiency and fuel economy. On the other hand, the auto-ignition temperature and flash point of ethanol are higher than those of gasoline, and the low Reid evaporation pressure which makes it safer for transportation and storage, and causing lower evaporative losses. The latent heat of evaporation of ethanol is 3–5 times higher than that of gasoline; this provides lower temperature intake manifold and increases volumetric efficiency. It contains 35% oxygen that helps in complete combustion of fuel and thus reduces harmful tailpipe emissions. Although having these advantages, due to limitation in technology, economic and regional considerations ethanol as a fuel still is not used extensively. Since ethanol is a liquid fuel, the storage and dispensing of ethanol is similar to that of gasoline. In the present study, to reduce the emissions and to improve the performance of petrol engine, the modification technique is used. The comparative properties of LPG, Ethanol and Gasoline are given in table I.

Table I Comparative properties of LPG, Ethanol and Gasoline

Characteristics	LPG	Ethanol	Gasoline
chemical formula	C_3H_8	C_2H_5OH	C_4 to C_{12}
Boiling point(^oC)	-44	78	30-225
Molecular Weight (Kg/Kmol)	44.1	46.07	114.2
Density at 15^oC(Kg/l)	0.53	0.79	0.7372
Research octane number	105	108.6	96-98
Stoichiometric air fuel ratio	15.6	9	14.7
Flame speed (m/s)	48	----	52.58
Upper flammability limits in air (%vol)	74.5	19	7.6
Lower flammability limits in air (%vol)	4.1	4.3	1.3
Calorific value (KJ/Kg)	46100	29700	43000

II. EXPERIMENTAL SET-UP

The engine used in the study is a single cylinder, water cooled with a dog dish cavity in a piston combustion chamber, four-stroke spark ignition naturally aspirated engine with a maximum rated power output of 2 kW at 1500 rev/min has a displacement of 661cc. For the purpose the provision made to conduct the experiment at different compression ratio and with different fuels. The details specifications of the engine are listed in Table II. The test rig used in this work mainly consists of the engine, direct current (DC) dynamometer and AVL Di-Gas 5-gas analyzer. The exhaust tail pipe from the engine was held by an extended arm and the probe of the gas analyzer was inserted into the exhaust tailpipe. AVL Di-Gas analyzer probe was positioned at the exhaust tailpipe for emission measurement. The analyzer has the capability of sampling various exhaust products such as hydrocarbon (HC), carbon monoxide (CO), and carbon dioxide (CO2) with the option of oxygen (O2) and oxides of nitrogen (NOx). Throughout the experiments the air control valve was fully opened. A manometer was used to measure the air flow rate, and the air box was also installed to reduce the air fluctuation into the engine. Since the experiment is was conducted at constant speed of 1500 rev/min, it was necessary to calculate the amount of LPG injected and ethanol is supplied into the engine. This amount was calculated with weighing machine and ethanol supply is control by using rotameter. Provision was also made for the measurement of exhaust gas temperature, engine body temperature, water inlet and outlet temperature, thermocouples are to be used. A non contact type digital tachometer is use for the measurement of speed of the engine. The test rig enables the study of the engine performance involving brake power, thermal efficiency, fuel consumption, volumetric efficiency and air-fuel ratio.

Table II. Test engine specification

Items	Specification
Make	Kirloskar
Bore	8705
Stroke	110
No. of cylinder	1
Engine type	4-stroke Spark ignition engine
Displacement	661cc
cooling	water cooling
starting	auto starting
maximum power	2kW @ 1500 rpm

III. TEST PROCEDURE

The experimentation work will be held on 4-stroke single cylinder spark ignition engine. The experimental procedure will be carried as given below-

1. Before start the engine check all the connections made properly or not.
2. Blend is made on the basis of weight. “on” the LPG cylinder regulator. Before start the engine ensure any leakages

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 6, Issue 11, May 2017

in the set up. LPG supply to the engine is controlled by a regulator or vaporizer. This converts the LPG into a vapour. Put the LPG cylinder on weighing machine for its consumption measurement. And different percent of ethanol by weight is maintained by using rotameter.

3. The mixture of LPG and ethanol is fed into the intake manifold. Where it is mixed with filtered air before being drawn into the combustion chamber.

4. While using gasoline as a fuel check that the throttling is at WOT position of carburetor so as the speed of the engine is regulated by governing mechanism alone with no setting for throttling.

5. Check that there should not be any air bubbles in fuel (gasoline, Ethanol) supply line.

6. When we apply load it will get heated up. So we will continually supply coolant water.

7. At different load conditions we will take shaft speed in RPM with the help of tachometer, using different fuels. (Gasoline, LPG-ethanol blends.)

8. following the first reading, compression ratio of the engine changed manually by putting the slits at the base engine.

9. From the result we will calculate brake thermal efficiency (η_{bth}) and brake specific energy consumption.

IV. RESULT AND DISCUSSION

A. Performance Characteristics

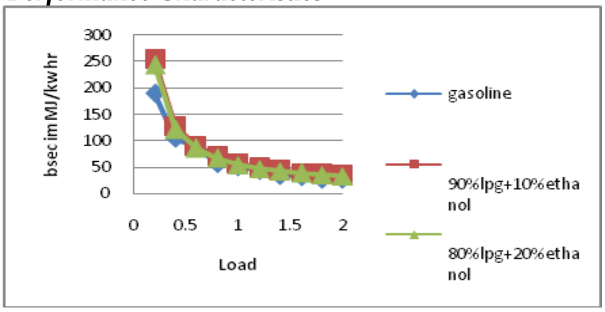

Fig 1. Brake specific energy consumption at compression ratio 10.

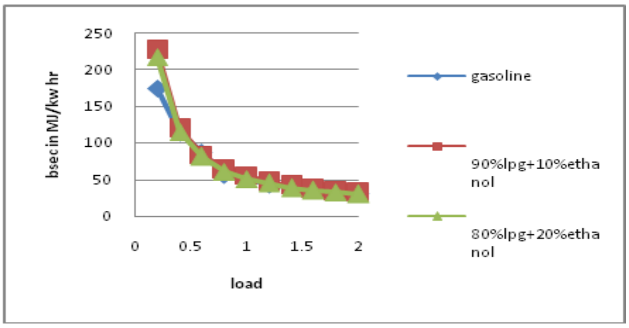

Fig 2. Brake specific energy consumption at compression ratio 11.

Above figure indicate that the brake specific energy consumption decreases as the load on the engine increases. As it can be clearly seen from this figure, LPG-Ethanol blends increases the specific fuel consumption of the engine in comparison with petrol. 90%LPG+10%Ethanol has more specific fuel consumption compare to 80%LPG+20%Ethanol. This graph shows BSEC of Gasoline and LPG-Ethanol blends values are gradually decreasing with respective increasing the Brake Power. Using Gasoline fuel the BSEC consumption values slightly lower than the using LPG-Ethanol blend as fuel. Because the C.V.of Gasoline is (43MJ/Kg) less compared to the LPG-Ethanol blends.

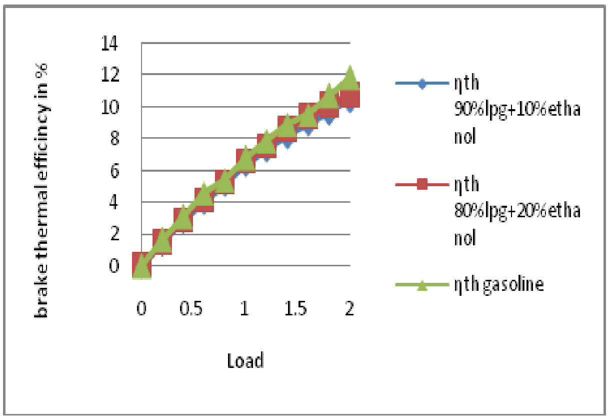

Fig 3.Brake thermal efficiency at compression ratio10

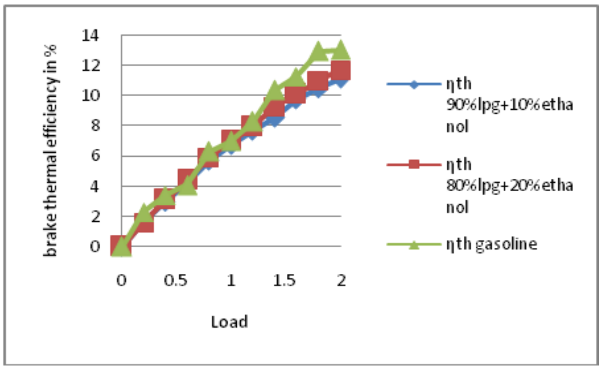

Fig 4.Brake thermal efficiency at compression ratio11

Above figure shows brake thermal Efficiency of the engine is gradually increasing with respective increasing the Power. However, the Brake Thermal efficiency increases when the compression ratio increases. When using Gasoline fuel the Efficiency values slightly higher than the using LPG-Ethanol blends as fuel. It is seen that for increasing compression ratio at constant speed of 1500rpm the maximum values of efficiencies for gasoline are higher than that of LPG-Ethanol blends.

B. Exhaust Emission Characteristics

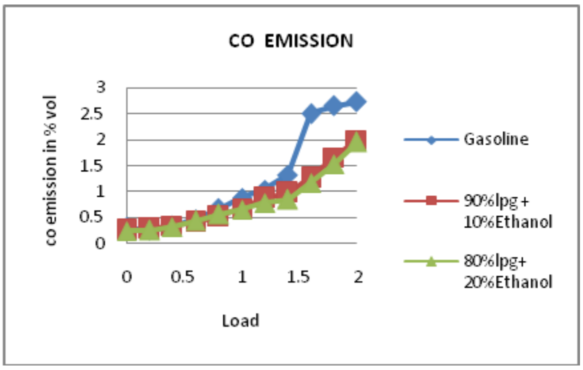

Fig 5. CO Emission at compression ratio 10.

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 6, Issue 11, May 2017

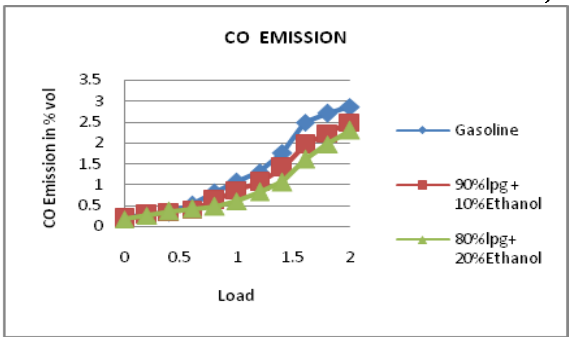

Fig 6. CO Emission at compression ratio 10.

CO Emission- CO is produced when there is not enough air in the combustion chamber. When the fuel does not burn completely; the carbon in the fuel will convert into CO. As it is seen in the compression ratio increases, CO emissions also increase with increasing load on engine. The maximum value of CO_2 emission for LPG-Ethanol blends is considerable lower than for the gasoline.

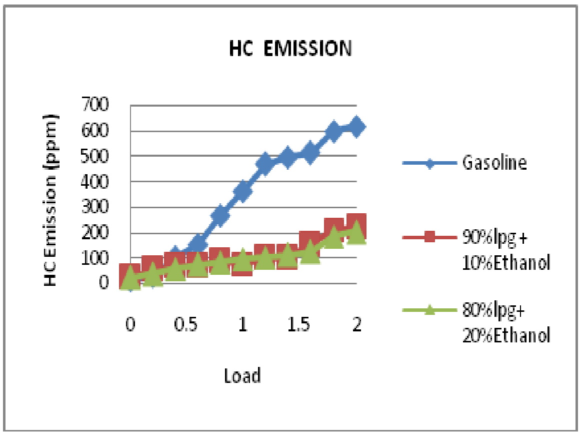

Fig 7. HC Emission at compression ratio 10.

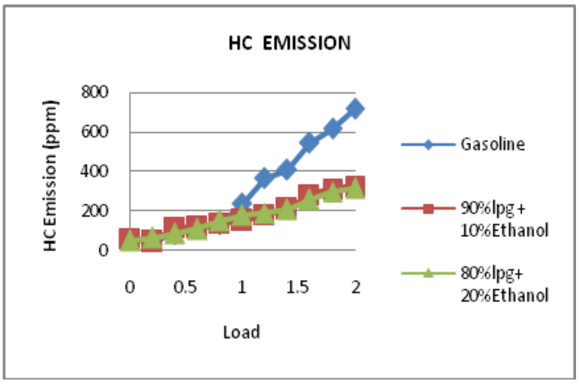

Fig 8. HC Emission at compression ratio 11.

HC Emission- From the graph, it is found that as the compression ratio increases, speed and HC emission increase. Maximum HC emission for LPG-Ethanol blends is less than that for gasoline. By increasing ethanol percentages reduces the emission of HC. HC emission increases with incomplete combustion of fuel and therefore it is higher for Gasoline when compared with LPG-Ethanol blends.

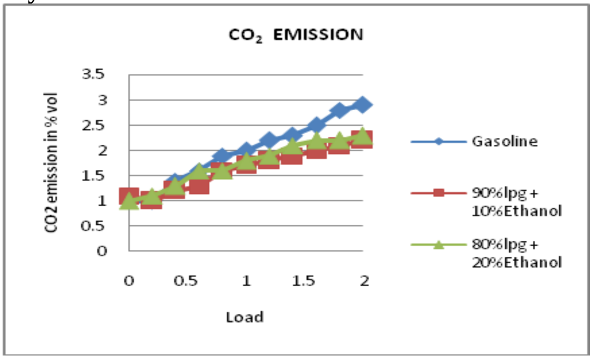

Fig 9. CO_2 Emission at compression ratio 10.

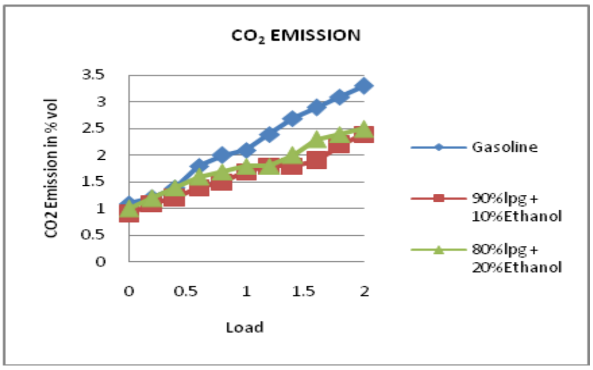

Fig 10. CO_2 Emission at compression ratio 11.

CO_2 Emission- From the graph, it is found that as the compression ratio increases, Brake power and CO_2 emission increase. When compared with LPG-Ethanol blends, CO_2 emission increases with incomplete combustion of fuel and it is higher for gasoline when compared with LPG.

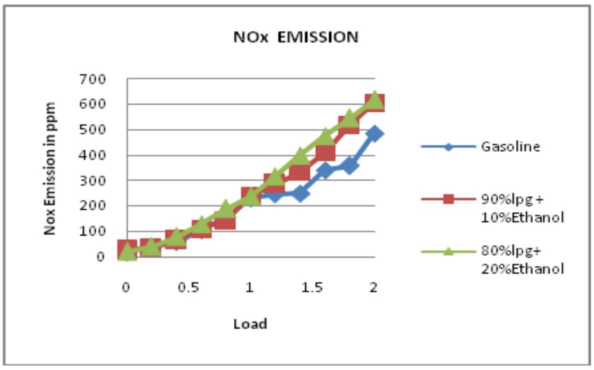

Fig 11. NOx Emission at compression ratio 10.

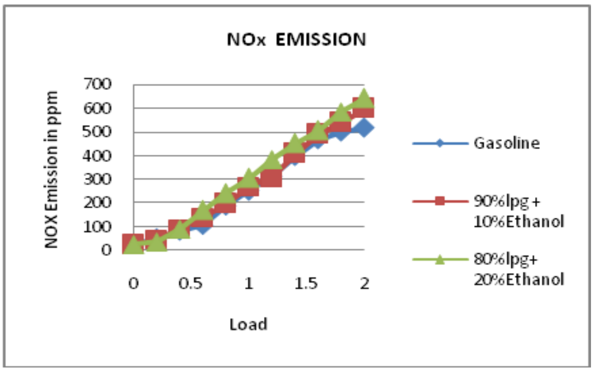

Fig 12. NOx Emission at compression ratio 11.

NO_X Emission- From the graph, it is seen that values of NO_X emission are more than of gasoline and increases with increase in load, compression ratio. This is due to the increase in in-cylinder combustion temperature. The formation of NOx is enhanced in an environment of high temperature and high oxygen concentration. Also the laminar burning velocity of LPG is more than that of the gasoline is about 0.46 m/s which reduce the combustion and subsequently the in-cylinder peak temperature increases.

V. CONCLUSION

As compression ratio increases, brake thermal efficiency increases. LPG and ethanol has a higher octane rating and hence the engine can run effectively at relatively high compression ratios without knock. The CO and HC emissions increase as the compression ratio, speed, and load increase. In the case of using LPG-Ethanol blend as a fuel in SI engines, the burning rate of fuel is increased, and thus, the combustion duration is decreased. Therefore, the cylinder pressures and temperatures Predicted for LPG are higher compared to gasoline. LPG is free of lead and has very low sulphur content. Combustion of gaseous fuels like LPG occurs in a nearly uniform fuel air mixture leading to a reduction in incomplete combustion. When using Gasoline fuel the BSEC consumption values slightly lower than the using LPG-Ethanol blend as a fuel. Because the C.V. of Gasoline is less compared to the LPG-Ethanol blends. When load increase on the engine the CO, HC and CO_2 emissions also increase. However, these emissions higher for Gasoline when compared with LPG-Ethanol blends.

REFERENCES

[1] U.S. Department of energy “Journal of Energy Efficiency and Renewable Energy”August 2003.

[2] Fuel properties, “IANGV Emission Report”, 31.03.2000.

[3] Advancements in automobile technology, october24, 2010.

[4] O. Badr, N.Alsayed and M.Manaf, “A parametric study on the lean misfiring and knocking limits of Gas-fuelled spark ignition engine”. Applied Thermal Engineering, vol. 18, pp. 579-594 (1998).

[5] Thirumal mamidi, Dr. J.G.Suryawnshi, “Investigation on SI engine using LPG as an alternative fuel”. International Journal of Engineering Research and Application (IJERA), vol. 2, Issue 1, Jan-Feb 2012, pp. 362-367.

[6] M.A. Ceviz, F. Yuksel, “Cyclic variation on LPG and gasoline-fuelled lean burn SI engine”. Renewable Energy 31, (2006), pp. 1950-1960.

[7] N.K. Miller Jothi, G. Nagarajan and S. Renganarayanan, “LPG fuelled diesel engine using diethyl ether with exhaust gas recirculation”. International Journal of Thermal Sciences 47 (2008), pp. 450-457.

[8] Venkata Ramesh Mamilla, V. Gopinath, C.V. Subha Rao and Dr. G.Lakshmi Narayana Rao, “Performance and emission characteristics of 4 stroke petrol engine fuelled with Biogas/LPG blends”. International Journal of Advanced Engineering Technology, vol. 2, Issue 1, January-March 2011, pp. 209-213.

[9] Dhanapal Balaji, Periyasamy Govindarajan and Jayaraj Venkatesan, “Emission and combustion of SI engine working under gasoline blended with ethanol oxygenated organic compound”. American Journal of Environmental science 6(6):(2010), pp 495-499.

[10] Huseyin serdar Yucesu, Tolga Topgil, Can Cinar and Melih Okur, “Effect of ethanol-gasoline blends on engine performance and exhaust emission in different compression ratio”. Applied Thermal Science 26 (2006), pp 2272-2278.

[11] Ibrahim Thamer Nazzal, “Experimental study of gasoline-alcohol blend on performance of Internal Combustion Engine”. European Journal of Scientific Research ISNN 1450-216X, Vol. 52 (2011), pp 16-22.

[12] C. Ananda Srinivasan and C.G.Saravanan, “Study of combustion characteristics of an SI engine fulled with Ethanol and oxygenated fuel additives”. Journal of sustainable Energy and Environment1. (2010), pp 85-91.

[13] Rong-Horng Chen, Li-Ben Chiang, Chung-Nan Chen, Ta-Hui Lin, “Cold-start emission of an SI engine using ethanol-gasoline blended fuel”. Applied Thermal Science 31 (2011), pp 1463-1467.

[14] Longfei Chen, Richard Stone and Dave Richardson, “A study of mixture preparation and PM emission using a direct injection engine fulled with stoichiometric gasoline/ethanol blends”. Fuel 96 (2012), pp 120-130.