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Experimental Investigations of Exhaust Emissions of four Stroke SI Engine by using direct injection of LPG and its analysis

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ABSTRACT: *Gaseous fuels such as liquefied petroleum gas (LPG) and liquefied natural gas (LNG) have been widely used in commercial vehicles. In this project the main aim is to evaluate the exhaust emission by running the conventional engine on Liquefied Petroleum Gas (LPG) as an alternative fuel for four-stroke spark ignition engine. The primary objective of the study is to determine the performance and the exhaust emissions of the engine using LPG as a fuel. The engine used in the study is originally single cylinder; four-stroke spark ignition engine with certain modifications is to make to permit the experiments to run on LPG fuel. During the running, the engine was coupled to a ropeway dynamometer to measure several engine performance parameters and a 5-gas analyzer is to be inserted into the engine exhaust tailpipe for measuring the exhaust emissions. Experimental investigations have been carried out to emissions of single cylinder four-stroke spark ignition engine at full throttling position of engine and different load conditions is used to different fuels (Gasoline and LPG). Exhausts are the five gasses measured by the latest technology exhaust analysers are: HC, CO, CO2, O2 and NOx.*

Keyword: *Exhaust, Emission, Four-stroke SI Engine, LPG, Injector, Analyser etc.*

I. INTRODUCTION

Traffic exhaust emissions are significant sources of air pollution in the world and may threaten human health and cause global warming effect. Therefore, governments are compelled to minimize motor-vehicle pollution problems with more stringent emission standards for reducing pollution-related chemicals and improving air quality. In most Asian countries, motorcycles contribute to air pollution more than other vehicles. Previous research shows that three-way catalytic converter used in spark ignition (SI) engines could reduce most exhaust pollution, such as HC, CO and NOx, towards achieving exhaust standards. However, converters are expensive to apply in motorcycles and would not reduce carbon dioxide (CO2), a major cause of global warming effect. It may be more acceptable, especially cost wise, to address the problem in the design and manufacture of motorcycles. Exhaust pollution from a motorcycle gasoline engine contains nitrogen oxides (NOx), carbon monoxide (CO) and unburned hydrocarbon emissions (HC). HC emissions are the results of incomplete combustion and could be used to evaluate the combustion inefficiency. NOx emissions are affected by the air/fuel ratio, the burned gas fraction of the in-cylinder unburned mixture, and spark timing. Increasing the burned-gas fraction and decreasing spark timing could reduce NOx emission levels. These solutions, however, would reduce combustion rate and engine torque. Controlling the air/fuel ratio could have a greater effect on NOx emission and could reduce NOx levels up to 98% at an air/fuel ratio of 23.5. However, it is difficult to achieve so high an air/fuel ratio in a conventional gasoline engine. Carbon monoxide (CO) emission of gasoline engine depends heavily on the air/fuel ratio. While a lean combustion decreases the amount of CO in exhaust gas, a spark-ignition engine is often operated closely to stoichiometric mixture, making CO emissions considerably difficult to reduce without an exhaust treatment like a catalytic converter. Nevertheless, a conventional motorcycle gasoline engine could reduce overall exhaust pollution if it could operate with high air/ fuel ratio.

In a previous paper, introduced a new design system for gasoline fuel engines, called semi-direct injection (SDI) system for application in motorcycle engines. By increasing swirl ratio to 3.8 and injecting fuel when the intake valve is opened, the SDI system can make a stratified mixture and extend the air/fuel ratio lean limit to 24. CO is tremendously decreased by 92.9% and a relatively low combustion temperature in lean burn decreases NOx by 32%. Furthermore, brake specific fuel consumption (BSFC) decreases to 11% compared with an original gasoline engine at low- and part load. As a result, SDI engine produces lower CO2, as well. From this result, we can affirm that SDI system in motorcycle engine can help to improve air quality and reduce greenhouse gas. To become a viable product, the SDI system should reduce CO2, as well as exhaust pollution. This could be achieved with a method that allows switching between stratified mixture at low load, and a homogeneous mixture at full load. This cannot be done in the current design. The SDI engine could have better results with CO2 and exhaust emission if there were an increase in the stratification of mixture.. Liquefied petroleum gas (LPG) in gaseous phase could be an alternative fuel for an SDI system. Previous research has observed that the brake mean effective pressure (BMEP) of gasoline is higher than LPG, while LPG fuel consumption and emission, which includes CO, HC and CO2, are lower than gasoline.

II. LPG AS AN ALTERNATIVE FUEL FOR IC ENGINE

The gaseous nature of the fuel/air mixture in an LPG vehicle's combustion chambers eliminates the cold-start problems associated with liquid fuels. LPG defuses in air fuel mixing at lower inlet temperature than is possible with either gasoline or diesel. This leads to easier starting, more reliable idling, smoother acceleration and more complete and efficient burning with less unburned hydrocarbons present in the exhaust. In contrast to gasoline engines, which produce high emission levels while running cold, LPG engine emissions remain similar whether the engine is cold or hot. Also, because LPG enters an engine's combustion chambers as a vapour, it does not strip oil from cylinder walls or dilute the oil when the engine is cold. This helps to have a longer service life and reduced maintenance costs of engine. Also helping in this regard is the fuel's high hydrogen-to-carbon ratio (C3H8), which enables propane-powered vehicles to have less carbon build-up than gasoline and diesel-powered vehicles. LPG delivers roughly the same power, acceleration, and cruising speed characteristics as gasoline. Its high octane rating means engine's power output and fuel efficiency can be increased beyond what would be possible with a gasoline engine without causing *Destructive Knocking.* Such fine-tuning can help compensate for the fuel's lower energy density. The higher ignition temperature of gas compared with petroleum based fuel leads to reduced auto ignition delays, less hazardous than any other petroleum based fuel and expected to produce less CO, NOx emissions and may cause less ozone formation than gasoline and diesel engines.

Properties/fuels	**Gasoline**	**LPG**
Chemical structure	C7H17/C4 to C12	C3H8
Energy density	109,000-125,000	84,000
Octane number	86-94	105+
Lower heating value (MJ/Kg)	43.44	46.60
High heating value (MJ/Kg)	46.53	50.15
Stoichiometric air/fuel ratio	14.7	15.5
Density at 15˚C ,kg/m3	737	1.85/505
Auto ignition temperature o K	531	724
Specific Gravity 60° F/60°	0.72-0.78	0.85

Experimental Setup and Test Procedure:

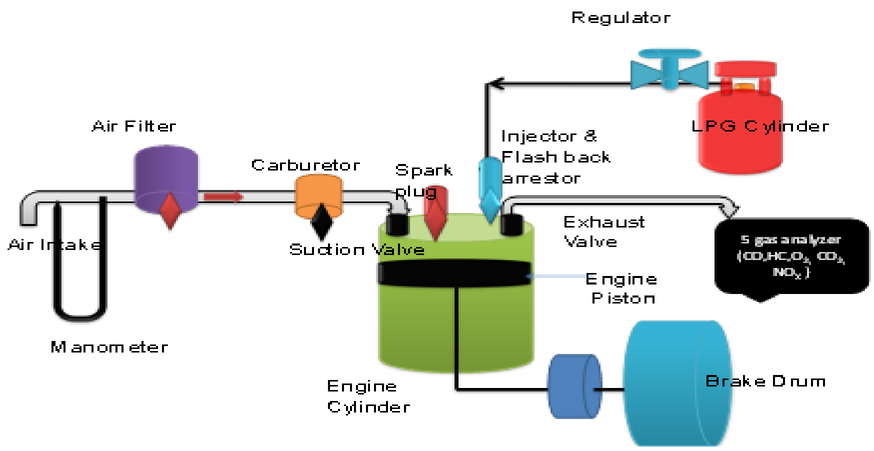
Experiments were conducted on a Bajaj saffier type, four stroke, single cylinder, air-cooled petrol engine test rig. Figure 1.0 shows the schematic experimental set up. Rope brake dynamometer was used for loading the engine, five gas analyzer tested exhaust emission contain CO, CO2, NO_x, O2 and HC.

The fuel flow rate was measured on the volumetric basis using a burette and stopwatch also. The engine was Operated at a rated constant speed of 300, 400, 500, 600 r/min. The emission characteristic was measured by using five gas analyzer. The tests were conducted with neat petrol and LPG. Petrol injected in the combustion chamber through carburettor and LPG Direct injected in the combustion chamber through injector. LPG fuel Injector mechanically operated on/off.

It consists of following components:-

1. Fuel tank, 2. Engine, 3. Rope brake drum type dynamometer, 4. Five gas analyzer, 5. Injector
6. Flash Black arrestor, 7. LPG regulating valve

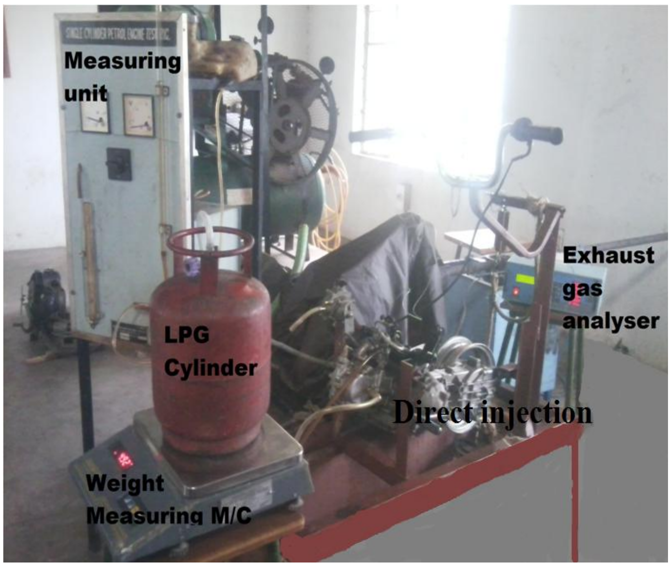
ARRANGMENT OF ENGINE



Schematic view of experimental setup

III. ENGINE SPECIFICATIONS

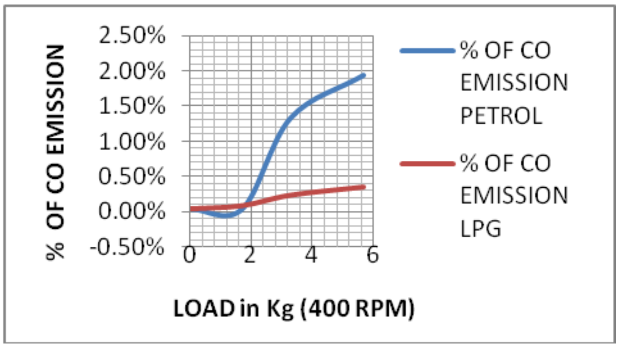
Bajaj saffire.
Type- Single Cylinder 4-Stroke SI engine, Rated Power- 5.4 KW, Rated RPM- 5800, Stroke- 56.9 mm
Bore- 50 mm, Displacement - 92.2 cc

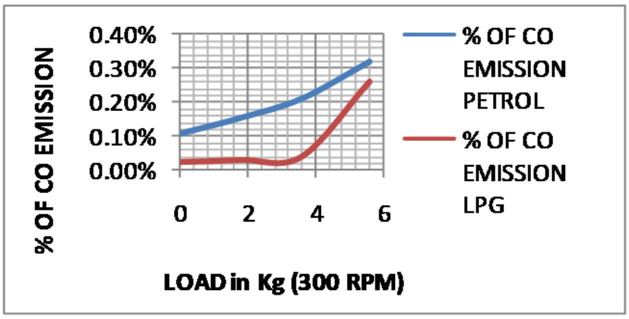


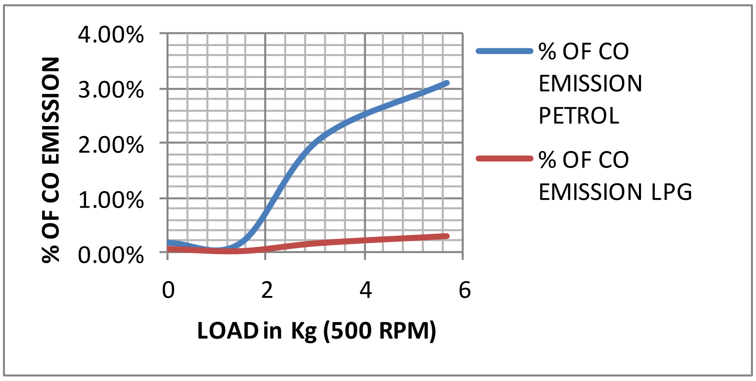
IV. RESULTS AND DISCUSSION

Effect of Exhaust Pollution of the % CO

% CO EMISSION VS LOAD



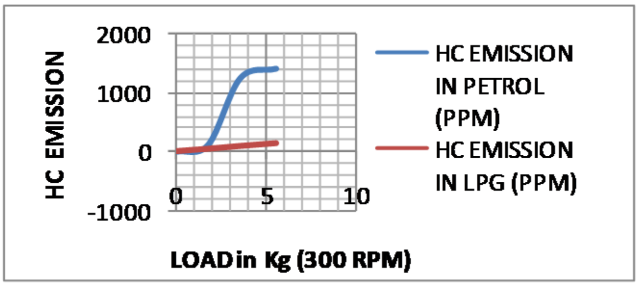


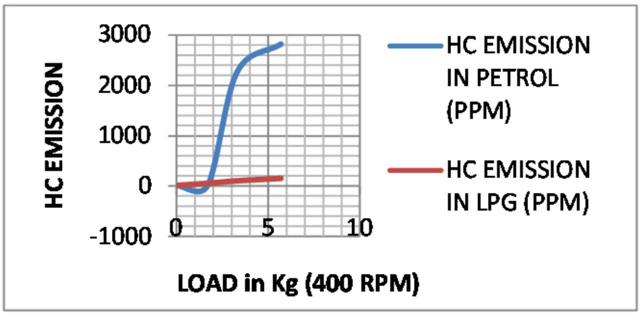


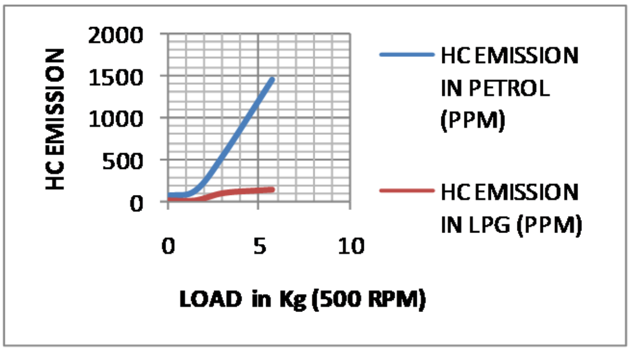
With rich fuel-air mixture, there is insufficient Oxygen to burn fully all the carbon in the fuel to CO_2 also CO high temperature produces. Maximum is generated when an engine runs rich fuel ratio. Poor mixing, local rich regions and incomplete Combustion will also be the source for CO emission. In this experiment Load engine will be increases so increases fuel-air mixture rich, amount oxygen is less so emission of CO will increases. CO emission produced by DI engine is even lower than original petrol engine. The value of CO concentration increases steadily with increases load.

Effect of Exhaust Pollution of the HC in PPM

HC EMISSION VS LOAD





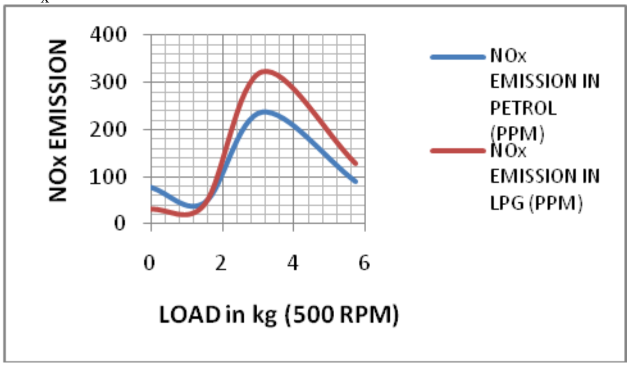


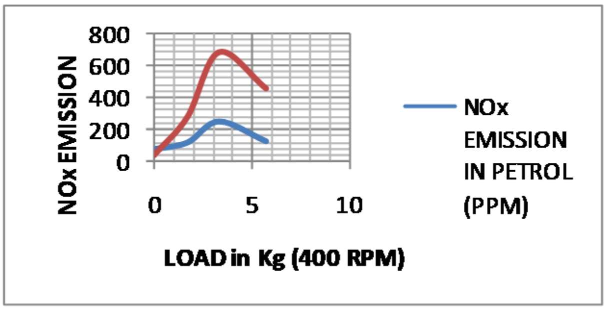
Petrol is in liquid from and LPG is in gaseous state so in combustion chamber quench layer containing Unburned and partially burned fuel-air mixture is left at the wall more in petrol. It is evident that it is a strong function of air –fuel ratio. With a fuel –rich mixture there is not enough oxygen to react with all the carbon, resulting in high level of HC and CO in the exhaust products. If air-fuel ratio is too lean poorer combustion occurs, against resulting in HC emission. Piston blowby gases and fuel evaporation

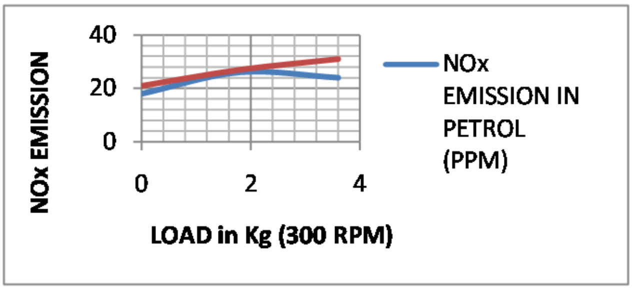
And release to the atmosphere through vent in the fuel tank and carburetor after engine shut- down, are also sources of unburned hydrocarbon. A quench layer containing unburned and partially burned fuel-air mixture is left at the wall when the flame is extinguished as it approaches the wall. Any engine oil left in a thin film on the cylinder wall, piston and perhaps on the cylinder head. In this experiment LPG injected in combustion chamber direct . HC emissions with varying engine speed for LPG and gasoline were illustrated in Fig. Load goes on increases with constant speed, emission of HC increases but in petrol HC emission rate is high than LPG. Load goes on increases, so increases combustion temperature and increases rich condition the fuel that the time oxygen quantity will be a less. That the reason HC is increases. As comparing between gasoline (C_7H_{18}) and LPG (C_3H_8) contain of hydrogen is less in LPG, so emission of HC is also less than gasoline.

Effect of Exhaust Pollution of the NO_x in PPM

NO_x **VS LOAD**

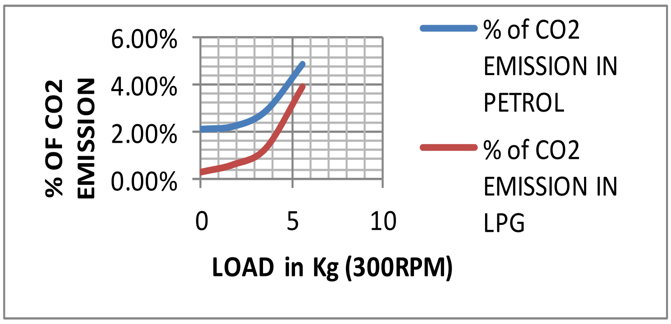


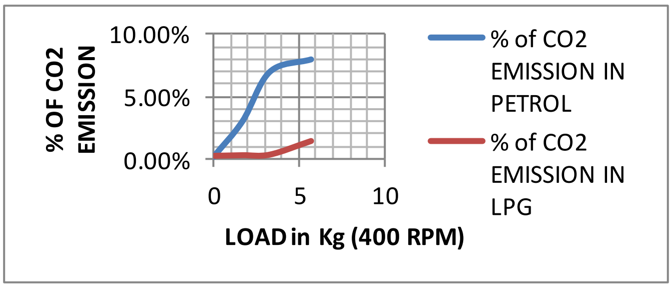


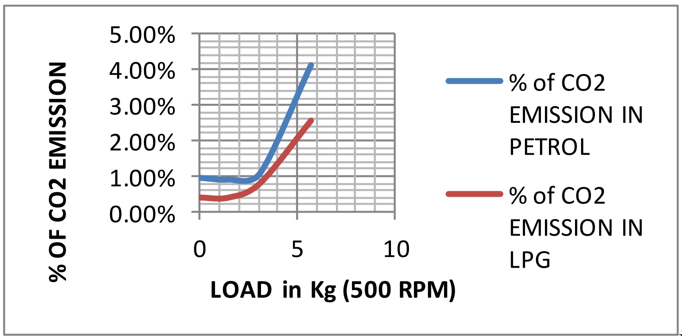


Higher the burned temperature, the higher the rate of formation of NOx, Most of the NO with a small amount of NO_2. Maximum NOx emission occurs in stoichiometric fuel-air ratio at slightly lean condition Excess of oxygen react with the nitrogen. In this experiment NOx in DI engine is always higher than original engine. The results regarding NOx also indicate that NOx emission from LPG is higher than petrol. Combustion temperature is high in LPG systems, so NOx emission is high in LPG because CV of LPG higher than petrol.

Effect of Exhaust Pollution of the % CO_2
% CO_2 EMISSION VS LOAD







LPG gas has low carbon and high octane no. fuel Produces lower CO_2 than petrol. With rich fuel -air mixture, there are insufficient Oxygen to burn fully all the carbon in the fuel to CO_2 also CO High temperature produces. Maximum is generated when an engine runs rich fuel ratio. In this experiment LPG direct injected in combustion chamber and petrol mix with air injected through carburetor in combustion Chamber.
Conclude that LPG direct injected system CO_2 emission is higher than gasoline. Because of carbon contain in gasoline is high than LPG.

V. CONCLUSIONS

In this exhaust emission test five types of emission are to be tested. These emissions are CO, CO_2, HC, O_2, and NO_x. These are five types of emission are test will be perform on four stroke SI engine. Test will be performs on petrol and LPG.

Engine emitted CO emission in various speed, LPG system has been CO emission emitted less than petrol system. The CO emission is reducing in LPG then Gasoline for same load and rpm In Direct injection. Engine speed and load increases, so increasing percentage of CO in petrol system. As compare to gasoline HC is low in LPG direct injection as load increase HC increases. In HC emission also more in petrol system. Engine speed and load increases, so increasing percentage of HC in petrol system. HC emitted percentage is high in petrol system because hydrogen and carbon contain in petrol (C_8H_{18}) is high and low calorific value than LPG. Also petrol is in the liquid state and LPG is in gaseous state. The CO_2 emission of LPG is also lower than Gasoline for same load and rpm In Direct injection. In CO_2 emission in petrol system is always be more than LPG. Because of carbon contain is less and calorific value is more so LPG is emitted CO_2 less than petrol. Engine speed and load increases. NO_x is slightly increases in LPG In Direct injection. In The results regarding NOx also indicate that NOx emission from LPG is higher than petrol. Combustion temperature is high in LPG system NOx emission is high in LPG because CV of LPG higher than petrol. In NOx emission also more in LPG system.

REFERENCES

1. Yuh-Yih Wu, Bo-Chiuan Chen, Anh-Trung Tran(*Emissions and Performances Improvement of Semi-Direct Injection Spark Ignition Engine Fuelled by LPG)*Journal Aerosol and quality Research , ISSN:1680-8584, Taiwan Association for Aerosol Research .
2. Seshaiah N. (*Efficiency and exhaust gas analysis of variable compression ratio spark ignition engine fuelled with alternative fuels)*International journal of volume 1, Issue 5, 2010 pp.861-870.

3. Meghare D, Kannake D. R., S. S. Sontakke (*Experimental investigations on LPG as alternative Fuel for two wheeler)* International Journal of Engineering and Innovative Technology (IJEIT) Volume 2, Issue 1, July 2012 ISSN: 2277-3754
4. Albela H.Pundkar, S.M. Lawankar, Dr. Sameer Deshmukh(*Performance and Emissions of LPG Fueled Internal Combustion Engine)*International Journal of Scientific & Engineering Research Volume 3, Issue 3, March -2012 1 ISSN 2229-5518 IJSER © 2012 http://www.ijser.org
5. Syed Yousufuddin, *(Performance and Emission Characteristics of LPG-Fuelled Variable Compression Ratio SI Engine)*Turkish J. Eng. Env. Sci.32 (2008) , 7 – 12.@TUBITAK
6. Tasic, Ppgorevc, Brajilih *(Gasoline and LPG Exhaust Emission comparison)* Advances in production engineering and management 6(2011)2,87-94 ISSN 1854-6250.
7. Mayank Jha, Archana Singh, R.K Tyagi and M K Verma (*Comparative Study of Exhaust Emission of Commonly Used Fuel in an Internal Combustion Engine)*JECET; December 2012 –February 2013; Vol.2, No.1, 52-56.
8. Ganeshan V.‘‘internal combustion engine ” third edition Published By the Tata McGraw-Hill Publishing company Limited, 7 West Patel Nagar New Delhi 110008. Pp185-234,313-355.371-407
9. www.cryton.co.za on dt.26.06.2012
10. www.freepatentsonline.com on dt.26.06.2012
11. aaqr.org/Articleslnpress/AAQR-11-09-OA-0142-Prof.pdf on dt. 13.07.2012
12. www.tsme.org/tsme-icome01/paper/AEC/AEC004. pdf on dt. 13.07.2012