VOL. 10, NO. 1, JANUARY 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

CHARACTERISTICS OF ENGINE AT VARIOUS SPEED CONDITIONS BY MIXING OF HHO WITH GASOLINE AND LPG

Rajasekaran T.[1], Duraiswamy K.[2], Bharathiraja M.[1] and Poovaragavan S.[1]
[1]Department of Mechatronics Engineering, K.S. Rangasamy College of Technology, Tiruchengode, India
[2]Department of Computer Science and Engineering, K.S. Rangasamy College of Technology, Tiruchengode, India
E-Mail: rajeshsuba06@gmail.com

ABSTRACT

The major threat, the scientific community facing today is global warming and fuel source depletion. Entire world is looking out for low emission fuels. Hydrogen is a promising alternate green fuel. Since fuel hydrogen leads to several issues, hydrogen fuel cell can be added to the engine unit. In this experimental work testing is conducted on a 150cc single cylinder petrol engine. The test is conducted for mixing oxy-hydrogen (HHO) with gasoline and liquefied petroleum gas (LPG) at various engine speeds and measuring performance and emissions. The test outcome shows that both mixtures of hydrogen with gasoline and hydrogen with LPG lead to an effective minimization of fuel consumption and emission. By adopting HHO as supplementary fuel, both fuel consumption and emission are curbed; hence global warming can be reduced.

Keywords: HHO, electrolysis, fuel cell, emission, LPG, gasoline.

1. INTRODUCTION

The current scenario reveals that the increase of exhaust gas concentration from industrial plants and automobiles into the atmosphere is a major cause of the global warming [1]. The limited availability of non-renewable fuel has resulted to increase in oil prices. Though cost may play a major role another considerable problem is emission rate of fuels. There are many possible ways to solve these problems; one way is to use hydrogen as supplementary fuel in internal combustion (IC) engines. The methods of using hydrogen in IC engine are sole fuel and supplementary fuel. To avoid the problems of storage and refilling hydrogen fuel, one of the most economical technologies is the electrolysis of water to produce Hydrogen [2-4]. While using hydrogen as supplementary fuel the engine efficiency was considerably increased [5-6]. When hydrogen uses as the supplementary fuel, emission will be reduced normally [7-9]. Compared to conventional fossilized hydrocarbon fuels, hydrogen offers practically no carbon rich pollutants which are known to pose health risks. The only nontrivial pollutant from hydrogen engines is nitrogen oxides. However the characteristics of hydrogen fuel, such as a high flame speed and extensive lean burn operation possibilities, allow significant reductions in Nitrogen oxide [10]. The present study is about to implement some of the hydrogen benefits and to maintain the originality of the engine. This may be obtained by placing the HHO fuel cell to the fuel supply unit. This makes the fuel mixture along with HHO. The confined HHO production unit has been made to fit into the engine setup.

2. MATERIALS AND METHODS

In this experimental work, test has been conducted to find the performance and emission characteristics of single cylinder petrol engine operated with gasoline, LPG, gasoline with HHO and LPG with HHO. The details of engine, properties of fuels, fuel cell, LPG tank and control unit are discussed below.

2.1. Engine specification

A single cylinder, air cooled, spark ignition 150cc engine is used for testing purpose. The engine specification is shown in Table-1.

Table-1. TVS engine specification.

Engine type	4Stroke single cylinder
Bore stroke	57.0 x 57.8 mm (2.2x2.3 inches)
Displacement	147 cm
Compression power ratio	9.5:1
Maximum torque	12.30 Nm / 7500rpm
Maximum power	13.35HP / 8500rpm
Fuel system	Carburetor (mikuniBS29
Cooling system	Air

2.2. Properties of fuels

The properties of gasoline, LPG and hydrogen are given in Table-2.

VOL. 10, NO. 1, JANUARY 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

Table-2. Fuel properties.

Properties	Gasoline	LPG	Hydrogen
Chemical structure	C_8H_{18}	C_3H_8	H_2
Energy content (Lower calorific value) (MJ/kg)	43	46	120
Energy content (Higher calorific value) (MJ/kg)	47	50	142
Octane number	84 – 93	105	130
Flash point (ºF)	-45	-100 to -150	-
Auto ignition temperature (ºF)	495	850 to 950	1050 to 1080
Density (kg/m^3)	803	1.9-2.1	0.082
Flammability limits in air (vol%)	1.2-7.1	1.81 - 8.86	4-75

2.3. Fuel cell

Fuel cell is a device used to supply hydrogen gas as a fuel to the automobile engine [11-14]. Figure-1 shows the photograph of HHO fuel cell used in this experiment. In fuel cell anode and cathode are made up of same materials. The titanium coated 316-L stainless steel mesh is used as electrodes in the fuel cell. Sodium bicarbonates must be added gradually to assure heat generation control. The cell blocks are positioned inside an acrylic sheet box supported by the appropriate attachments and margin. The input for the cell is distilled water and sodium bicarbonate which is used as an electrolyte. The fuel cell used in the setup will convert the distilled water in to hydrogen gas. The calorific value of hydrogen produced from the fuel cell is three times greater than that of the gasoline. Carbureted engine is used in the experimental setup. Oxy-hydrogen is supplied through the intake manifold. Hydrogen being a light gas gets sucked into the carburetor.

Figure-1. Photograph of HHO fuel cell.

2.4. Auto-LPG storage tank

The LPG tank shown in Figure-2 is a safe metal container containing the Auto-LPG. It is safe for operation on road. Its capacity is up to 5kgs. The tank is fitted with a regulator switch to control the flow of gas as a safety precaution.

Figure-2. LPG storage tank with regulator (blue).

2.5. Control unit

A control unit in figure 3 has to be used to obtain appropriate electrolysis voltage and current (gas flow rate) to terminate the impairments of hydroxyl gas at low speeds.

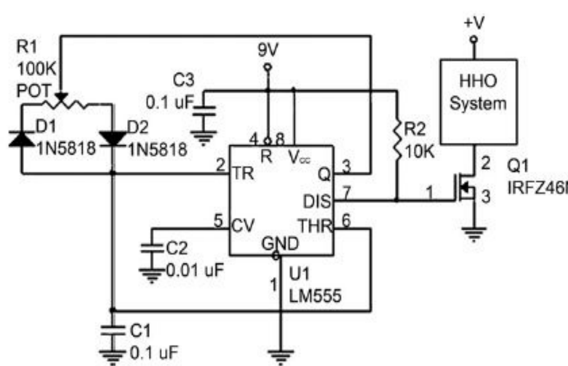

Figure-3. Circuit diagram.

3. EXPERIMENTAL SETUP

HHO gas is generated by an electrolysis process in a wet cell. The generated gas is mixed with a fresh air just before entering the carburetor. The block diagram of experimental setup is shown in figure 4. The testing is conducted for the taken engine operated with gasoline and LPG as main fuel without using fuel cell and with using fuel cell. The HHO, LPG fuel connection is made before inlet manifold this real time setup is shown figure 5. Octane rating of a fuel is increased by injecting HHO gas to the fuel mixture. Increasing the octane number leads to less fuel consumption [15-17].

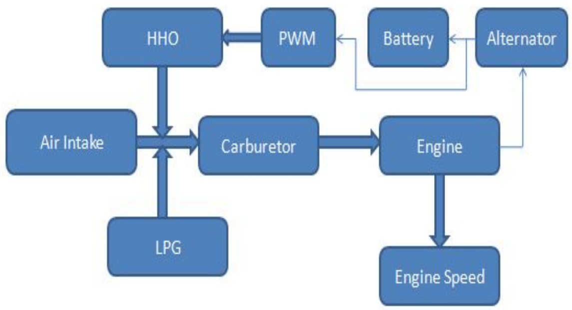

Figure-4. Block diagram of experimental setup.

Figure-5. Photograph of experimental setup

4. TESTING

Testing of the engine is conducted using fuel consumption burette and gas analyzer. A constant load test at variable speed (2000-6000 rpm) has been performed on this engine. The fuel consumption rate of the engine at no load condition is taken at different engine speeds. The readings are taken by setting the engine at a particular speed and the time taken for 10 CC fuel consumption is taken into account. The exhaust is sampled by a gas analyzer and the exhaust constituents have been identified and their concentrations have been evaluated. Gas analyzer has been used to estimate the concentrations of CO, HC, CO_2, O_2 and NO_x in the exhaust line. Tachometer was used to measure the speed of engine. The tests are conducted for the fuels as per plan.

5. RESULTS AND DISCUSSIONS

5.1. Performance

Figure-6 shows the fuel consumption at different speeds when the engine is operated with different fuels. Gasoline with HHO fuel gives reduced fuel consumption at all speeds and it is approximately 9.65% when compared with gasoline fuel. LPG with HHO fuel gives reduced fuel consumption at all speeds except medium speed and it is approximately 15.7% when compared with LPG fuel. At medium speed both LPG and LPG with HHO are showing the same value. Among all fuels LPG with HHO gives less fuel consumption. The calorific value of LPG and hydrogen are the reason for this result.

5.2. Emission

Figure-7 shows the concentration of carbon-monoxide for different fuels. While adding HHO to the engine running on gasoline there is a 27.53% decrease in CO emissions as compared to the gasoline alone. But in the case HHO addition to LPG 52.11% increase in CO emissions as compared to the LPG alone.

Figure-8 shows the concentration of HC for different fuels. While adding HHO to the engine running on gasoline there is a 15.69% decrease in HC emissions as compared to the engine on gasoline alone. Whereas in case HHO addition to LPG 9.52% increase in HC emissions as compared to the LPG alone.

Figure-9 shows the concentration of carbon-dioxide for different fuels. While adding HHO to the engine running on gasoline there is 9.27% increase in CO_2 as compared to gasoline only. In the case of HHO addition to LPG 22.37% decrease in CO_2 emissions as compared to LPG alone.

Figure-10 shows the concentration of oxygen for different fuels. In the case of adding HHO to the gasoline O_2 emission tends to be higher at lower speeds, but as the speed increases the O_2 in the exhaust seems to go lower to when compared to gasoline. In case of HHO addition to LPG, 10.46% decrease in O_2 emissions as compared to LPG alone.

Figure-11 shows the concentration of nitrogen oxides emission for different fuels. While adding HHO to the gasoline 25.54% decrease in NO_X emission as compared to the gasoline alone at low speeds. By the addition of HHO higher decrease in NO_X at higher speeds in gasoline. In case of HHO addition to LPG, the NO_X emission values are higher at lower speeds and slightly lower at higher speed when compared to LPG alone.

VOL. 10, NO. 1, JANUARY 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

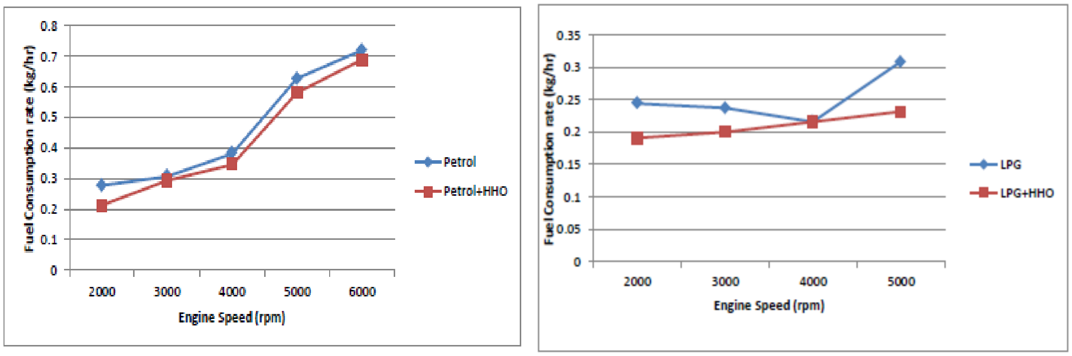

Figure-6. Effect of HHO gas on fuel consumption.

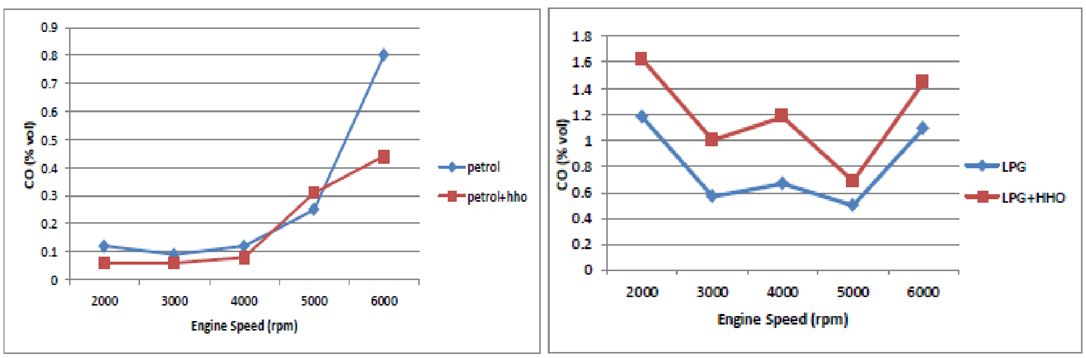

Figure-7. Change in carbon monoxide concentration with engine speed.

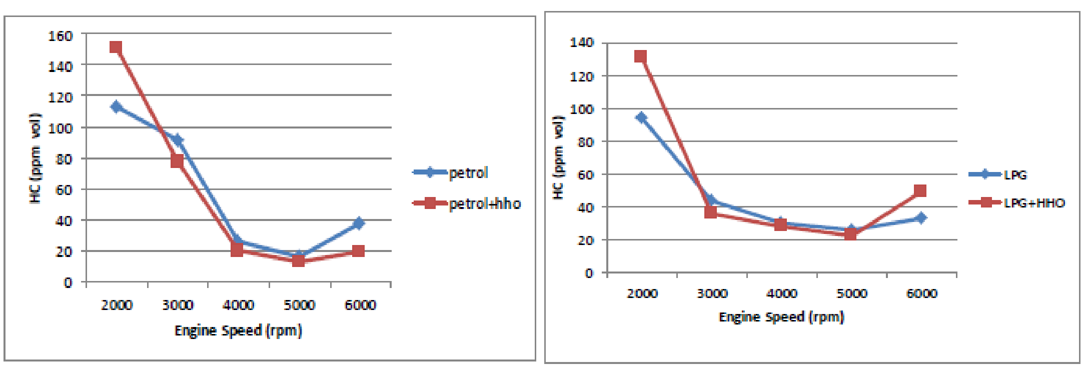

Figure-8. Change in hydro carbon concentration with engine speed.

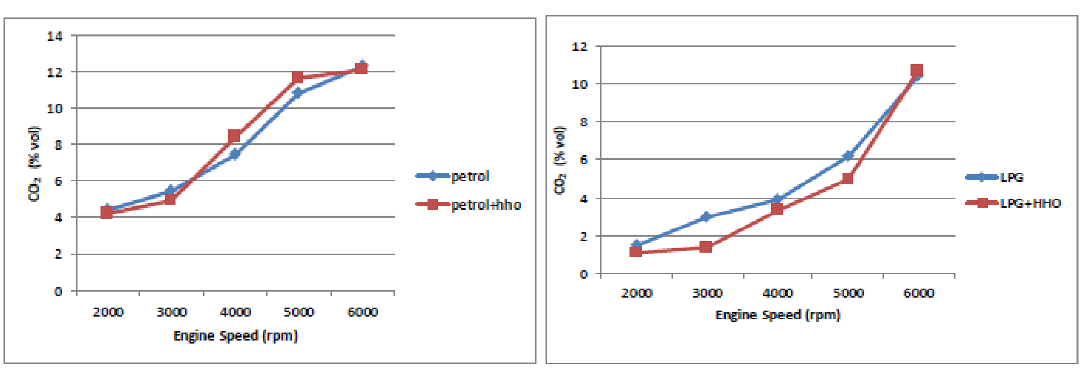

Figure-9. Change in carbon dioxide concentration with engine speed.

VOL. 10, NO. 1, JANUARY 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

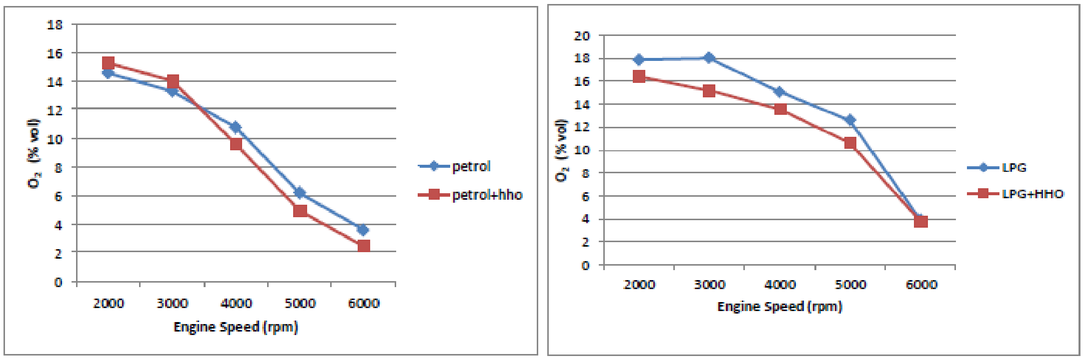

Figure-10. Change in oxygen concentration with engine speed.

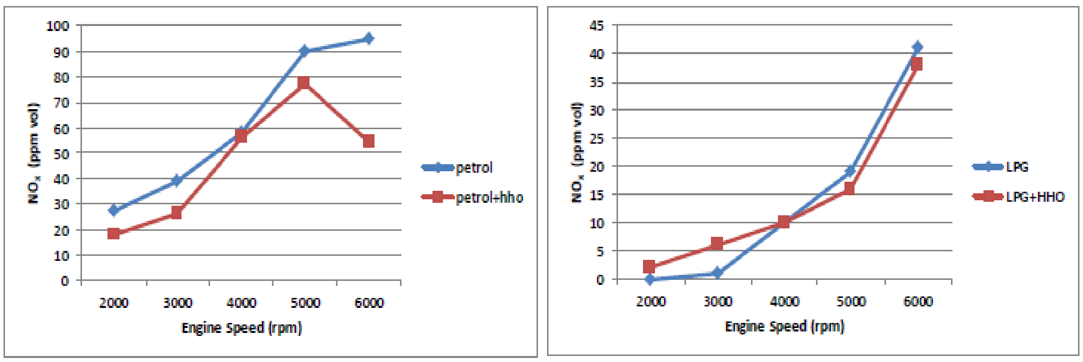

Figure-11. Change in nitrogen oxide concentration with engine speed.

6. CONCLUSIONS

The experimental results show that, by the addition of HHO to either gasoline or LPG gives us reduced fuel consumption rates. While in gasoline with HHO mixture a proportionately good result in all emission parameters. The following conclusions can be drawn.

a) HHO cell may be integrated easily with existing engine systems.
b) Fuel consumption rate has decreased by 9.65% for Gasoline Engines and 15.70% for Engine on LPG while introducing HHO.
c) CO concentration has been reduced 27.53% in gasoline fuel but using LPG fuel 52.11% of concentration is increased.
d) HC concentrations are highly reduced in medium speeds while using HHO for both fuels.
e) The concentration of CO_2 has been considerably decreased at lower speed but increased in higher speed for gasoline and decreased highly LPG when HHO added to the engine.
f) In both fuel exhaust oxygen concentration is highly low. This result shows the clean combustion of fuel and this lead to better fuel consumption and efficiency.
g) The NO_X average concentration has been reduced to about 25.54% at an average for gasoline and for LPG gives better results in higher speeds.

ACKNOWLEDGEMENT

This experimental work was conducted at the Thermal Engineering Laboratory of K. S. Rangasamy College of Technology, Tiruchengode. We express our sincere thanks to the all our faculty members from the Department of Mechanical and Mechatronics Engineering in conducting this experiment. We also express our sincere gratitude to the Management of K. S. Rangasamy College of Technology, Tiruchengode for providing necessary facilities in conducting this experiment.

REFERENCES

[1] Ishida H and Kawasaki S. 2003. On-board and roadside monitoring of NO_x and SPM emission from vehicles. Eastern Asia Society Transport Stud. 5: 2398-2407.

[2] Naohiro Shimizu, Souzaburo Hotta, Takayuki Sekiya and Osamu Oda. 2006. A novel method of ydrogen generation by water electrolysis using an ultra-short-pulse power supply. Journal of Applied Electrochemistry. 36: 419-423.

[3] Ruggero Maria Santilli. 2005. A new gaseous and combustible form of water. Journal of Hydrogen Energy. 31: 1114-1121.

[4] Appleby AJ. 1994. Fuel cell electrolytes: evolution properties and future prospects. J. Power Sources. pp. 15-34.

[5] Changwei Ji, Shuofeng Wang and Bo hang. 2010. Effect of spark timing on the performance of a hybrid hydrogen-gasoline engine at lean condition. Journal of Hydrogen Energy. pp. 2205-2209.

[6] S. Szwaja, K.R. Bhandary and J.D. Naber. 2007. Comparisons of hydrogen and gasoline combustion knock in a spark ignition engine. Journal of Hydrogen Energy. pp. 5079-5084.

[7] Ali Can Yilmaz, Erinc Uludamar and Kadir Aydin. 2010. Effect of hydroxyl (HHO) gas addition on performance and exhaust emission in compression ignition engines. Journal of Hydrogen Energy 35: 11369-11371.

[8] Shehata M and Abdel-Razek S. 2008. Engine performance parameters and emissions reduction methods for spark ignition engines. Engineering Research Journal. 120: M32-57.

[9] Praitoon Chaiwongsa, Nithiroth Pornswan Charoen and Preecha P. Yupapin. 2009. Effective hydrogen generator testing for on-site small engine. Physics Procedia. 2: 93-100.

[10] C.M. White, R.R Steeper and A.E. Lutz. 2006. The hydrogen-fueled internal combination engine: a technical review. International Journal of Hydrogen Energy. 31: 1292-1302.

[11] Bacon FT. 1969. Fuel cells, past, present and future. Electrochim Acta. 14: 569-85.

[12] Badwal SPS, Foger K, Zheng XG and Jaffrey DH. 1996. Fuel cell Interconnect device. United States patent WO 96/28855 A1. September.

[13] Bance P, Brandon NP, Girvan B, Holbeche P, O'Dea S and Steele BCH. 2004. Spinning out a fuel cell company from a UK university 2 years of progress at Acers power. Journal Power Sources. 131(1-2): 86-90.

[14] Baozhen Li, Ruka JR and Singhal CS. 2001. Solid oxide fuel cell operable over wide temperature range. United States patent. 6207, 311.

[15] Barclay FJ. 2002. Fundamental thermodynamics of fuel cell, engine, and combined heat and power system efficiencies. P I Mech Eng A J Power and energy. 216: 407-17.

[16] Ammar A. Al-Rousan. 2010. Reduction of fuel consumption in gasoline engines by introducing HHO into intake manifold. Journal of Hydrogen Energy. 35: 12931-12935.

[17] Sa'ed A.Musmar and Ammar A. Al-Rousan. 2011. Effect of HHO gas on combustion emission in gasoline engines. Fuel. 90: 3067-3070.

[18] Z. Dulger and K.R. Ozcelik. 2000. Fuel economy improvement by on board electrolytic hydrogen production. Journal of Hydrogen Energy. pp. 896-897.