Experimental Analysis of SI Engine by HHO Gas Method

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ABSTRACT

The over usage of fossil fuel and the resulting drastic increase in pollution levels has made us realize the need for a new sustainable fuel which does not cause pollution. This search ended up with an innovative idea of using Brown gas as a fuel enhancer in internal combustion engines which uses fossil fuels as a primary source for combustion. Many developments have been made in this area with several experiments on gasoline as well as diesel internal combustion engines till now using HHO gas or brown gas as a fuel performance enhancer. This work involves the review of various developments which has taken place in this field. With the addition of HHO gas there was a net increase in brake power ranging from (2% to 5.7%) and increase in brake thermal efficiency which ranges from (10.26% to 34.9%). A decrease in specific fuel consumption was observed which ranged from (20% to 30%) along with a decrease in CO and HC emissions on an average of 18%and 14%respectively.

Keyword: - *HHO gas, SI engine, Oxygen economy.*

1. INTRODUCTION

The idea is to use electricity from the car's alternator to electrolyze water into HHO, a mixture of pure hydrogen and oxygen. This mix is fed into the intake air, where it is burned along with gasoline, thereby increasing our fuel economy anywhere from 15 to 100 percent. A trending global concern, toward lowering fuel consumption and emissions of internal combustion engines, is motivating researchers to seek alternative solutions that would not require a dramatic modification in engines design. Among such solutions is using H2 as an alternative fuel to enhance engine efficiency and produce less pollution. Now a day's hopes have again been raised about production and development in ''hydrogen economy'' sector because most of them agreed that hydrogen is best alternative fuel to replace the existing fossil fuels as hydrogen is having the clean burning characteristics. For an engine running only with hydrogen the exhaust gases doesn't contains carbon oxides, hydrocarbons, particles and lead compounds excluding the unburned hydrocarbons or the carbon oxides provided by oil burning inside the combustion chamber. The hydrogen gas is acting as a light gaseous fuel. It is having high heating value on mass basis, wide flammability that gives wide mixture range in air which permits extremely lean or rich mixtures to support combustion. It requires lower amount of energy to start ignition process which results in extremely high-speed flames. Its energy released by combustion per unit mass of chemically correct mixture remains high. The combustion properties of hydrogen have much influence on its performance as an engine fuel. There are mainly two different ways available to introduce hydrogen in combustion chamber for burning process.

1.1. NECESSITY

Hydrogen is the most abundant element present on earth. The ever increasing demands for fossil fuels have left us with very miniscule reservoirs. Increase in global warming due to the emission of carbonaceous matter to the atmosphere. Need to develop efficient engines in order to improve transportation. Hydrogen has a very high calorific value compared hydrocarbons. It is not a pollutant and also does not contaminate the ground water. Vapor compression and vapor absorption are two thermodynamic cycles used to produce cooling or heating effects. In a vapor-compression refrigeration cycle, four processes are occurred: isentropic compression in a compressor, constant-pressure heat rejection in a condenser, throttling in throttle device, and constant-pressure heat absorption in an evaporator. Schematic of the vapor-compression refrigeration cycle is presented in Hydrogen is the most abundant element present on earth. The ever increasing demands for fossil fuels have left us with very miniscule reservoirs. Increase in global warming due to the emission of carbonaceous matter to the atmosphere. Need to develop efficient engines in order to improve transportation. Hydrogen has a very high calorific value compared hydrocarbons. It is not a pollutant and also does not contaminate the ground water.

2. OBJECTIVE

1) To increase the efficiency of gasoline engine with the addition of HHO gas.
2) To decreases fuel consumption and improve engine thermal efficiency increases
3) To evaluate the effect of combustion with HHO addition, as an engine performance improve, into gasoline fuel on engine performance and emissions
4) To control the exhaust gas emissions

3. Literature Review

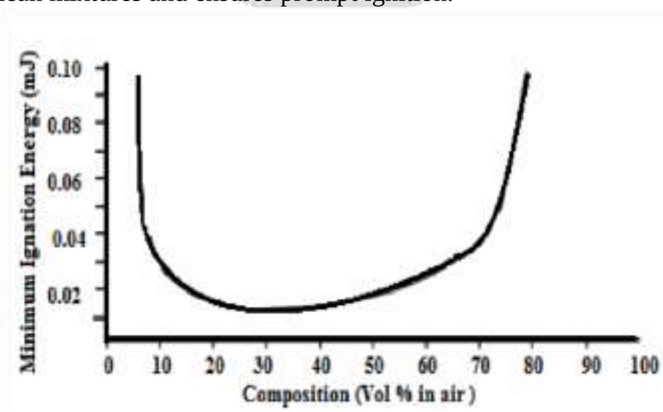
Al-Rousan have designed, integrated and tested a compact HHO generating device on a gasoline engine. Their results showed that nitrogen oxides (NOx), carbon monoxide (CO), and fuel consumption were reduced by 50%, 20%, and 30%, respectively, with an addition of HHO gas.

EL Kassaby in his work showed the advantages of CO_2, CO and HC reduction, while NOx increased, with higher H_2 %, which are as follows: reduction of these 3 was attributed to enhanced combustion kinetics, as H_2 combustion produces the oxidizing species of OH and O radicals that benefit the chemistry of Hydrocarbons (HCs) combustion. Besides, gasoline fuel flow was reduced with $H_{2\ enrichment}$ to maintain constant global mixture equivalence and compare the engine performance with pure gasoline so, lesser HCs content is in the fuel, which cuts the formation of CO, $CO_{2\ and}$ HC and promotes economic fuel consumption. Furthermore, hydrogen has a higher diffusion coefficient than that of the gasoline, and so, the gaseous H_2 can disperse thoroughly in the charge and allow for greater mixture homogeneity and combustion completeness. On the other hand, NOx increase was attributed to the higher adiabatic flame temperature of hydrogen.

Adding HHO to the fuel-air mixture has the immediate effect of increasing the octane rating of any fuel as explained by Al-Rousan. Octane rating indicates how much a fuel can be compressed before it ignites. This fact causes the fuel-air mixture (without HHO) to ignite percent the density of air. Moreover, it is not a corrosive gas and can be used in engines with no toxic effects to humans. It ranks second in flammability among other gases, but if and when it leaks, hydrogen rises and diffuses to a non-flammable mixture quickly. Hydrogen ignites very easily and burns at a high temperature, but tends to burn out quickly. A mixture of hydrogen and air will burn when it contains as little as four percent up to as much as seventy five percent of hydrogen in the mix.

3.1 Properties of Hydrogen

Hydrogen has a wide flammability range in comparison with all other fuels. As a result, hydrogen can be combusted in an internal combustion engine over a wide range of fuel-air mixtures. A significant advantage of this is that hydrogen can run on a lean mixture. Generally, fuel economy is greater and the combustion reaction is more complete when a vehicle is run on a lean mixture. Hydrogen has very low ignition energy. The amount of energy needed to ignite hydrogen is about one order of magnitude less than that required for gasoline. This enables hydrogen engines to ignite lean mixtures and ensures prompt ignition.



Hydrogen has a small quenching distance, smaller than gasoline. Consequently, hydrogen flames travel closer to the cylinder wall than other fuels before they extinguish. Thus, it is more difficult to quench a hydrogen flame than a gasoline flame. Hydrogen has a relatively high auto ignition temperature. This has important implications when a hydrogen-air mixture is compressed. In fact, the auto ignition temperature is an important factor in determining what compression ratio an engine can use, since the temperature rise during compress ion is related to the compression ratio. Hydrogen has a high flame speed at stoichiometric ratios. Under these conditions, the hydrogen flame speed is nearly an order of magnitude higher than that of gasoline. This means that hydrogen engines can more closely approach the thermodynamically ideal engine cycle. Hydrogen has very high diffusivity. This ability to disperse in air is considerably greater than gasoline and is advantageous for two main reasons. Firstly, it facilitates the formation of a uniform mixture of fuel and air. Secondly, if a hydrogen leak develops, the hydrogen disperses rapidly. Thus, unsafe conditions can either be avoided or minimized.

3.2 Accessories that complete the Design.

Crankcase ventilation is even more important for hydrogen engines than for gasoline engines. As with gasoline engines, unburnt fuel can seep by the piston rings and enter the crankcase. Since hydrogen has a lower energy ignition limit than gasoline, any unburnt hydrogen entering the crankcase has a greater chance of igniting. Hydrogen should be prevented from accumulating through ventilation. Ignition within the crankcase can be just a startling noise or result in engine fire. When hydrogen ignites within the crankcase, a sudden pressure rise occurs. To relieve this pressure, a pressure relief valve must be installed on the valve cover. Hydrogen has a very low volumetric energy density at ambient conditions. Even when the fuel is stored as a liquid in a cryogenic tank or in a compressed hydrogen storage tank, the volumetric energy is small relative to that of gasoline. Hydrogen has a three times higher calorific value compared to gasoline (143 MJ/kg versus 46.9 MJ/kg). Some research has been done into using special crystalline materials to store hydrogen at greater densities and at lower pressures.

4. Experimental Setup and Test Procedure

HHO generator used in this study is shown in Fig.3.1. It consists of separation tank (1) which supplies the HHO cell (2) with continuous flow of water to prevent the increase in the temperature inside the cell and to provide continuous hydrogen generation. Oxygen–hydrogen mixture generated from the dry cell will be back to the top of the tank with some water droplets. $2H_2O \rightarrow 2H_2+O_2$ Water droplets will separate and fall to the bottom of the tank with the rest of the water, while hydrogen and oxygen gases are directed to the engine intake manifold. The HHO flow rate was measured by calculating the water displacement per time according to the setup shown in Fig.3.1. The HHO gas leaves the separation tank and flows into the water open pool. Bushing the water down of the inverted graduated cylinder. The volume of gas collected in the graduated cylinder per unit of time was measured as the HHO flow rate. Therefore, the cell productivity can be calculated from the following equation:
HHO productivity

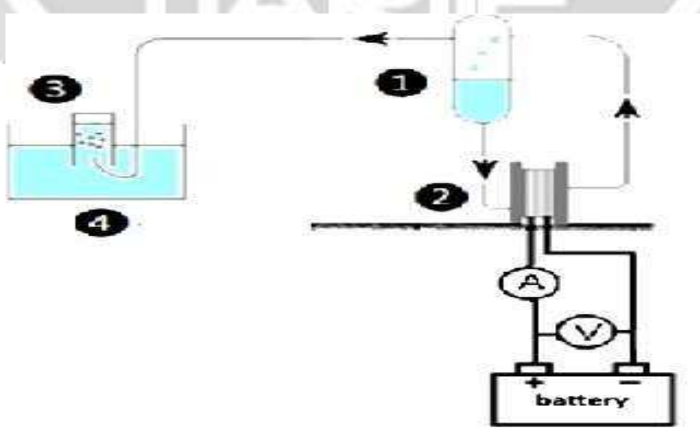


Fig-2 Schematic diagram of HHO gas generation system.

HHO Dry Cell

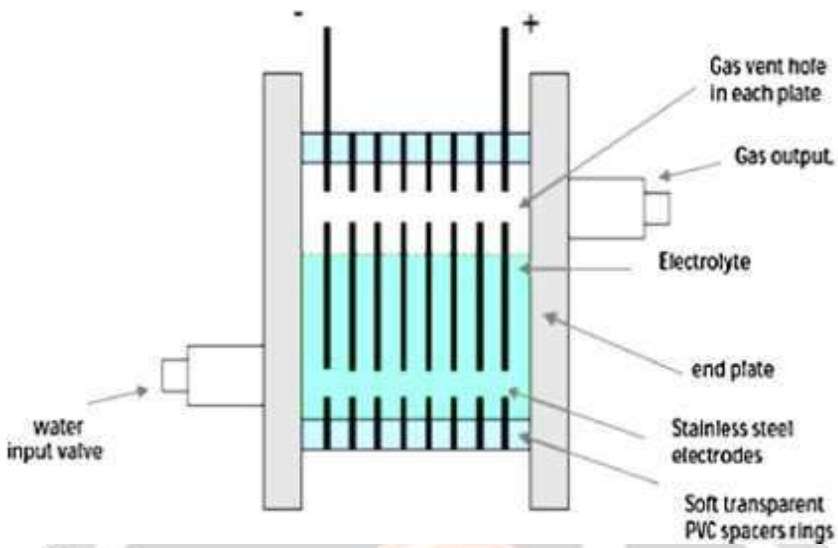


Fig-3 Schematic diagram of HHO dry cell

4.1 Construction and working.

This project consists of a small electrolysis fuel cell, Non-return valves, safety valve, 12V Battery, Two stroke SI engine and carbon filter. The electrolysis fuel cell is used to generate HHO gas (electrolysis process) by using 12-volt battery. The carbon filter is used to absorb the water and dirt particles from HHO gas. And then these gases pass to the engine after the carburettor and control the gasoline charge. The dynamo is use to charge the battery and diodes are used to convert the AC supply in DC.

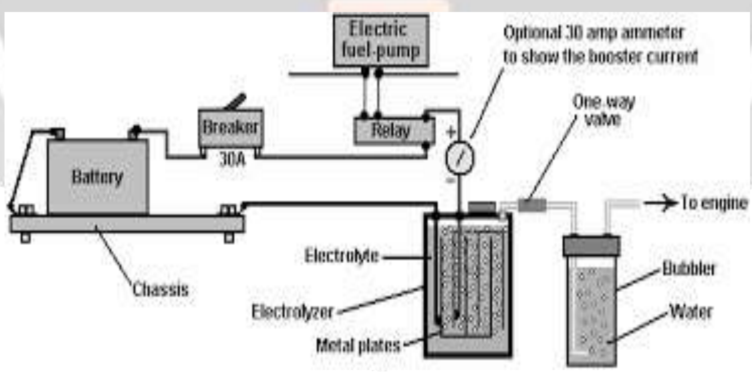


Fig-4 Layout of HHO gas method

Hydrogen fuel cell is use to generate the HHO gas. It consists of separation tank in which to two electrodes made up of stainless steel of battery one is anode and other is cathode are dipped in water and then 12-volt supply given to the terminal and electrolysis process get start which helps to generate the HHO gas. Then this gas is passing through the non-return valve and then carbon filter. In carbon filter moisture and dirt particles will absorb and then supply to the inlet of engine after the carburettor. This supply of HHO gas at inlet of engine helps to improve combustion process and also control the exhaust gas emission.

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Fig-4 Actual setup of HHO

5. Results

Fig. 4 shows the effect of KOH concentrations on the HHO cell average efficiency. It is found that 6 g/L of KOH as catalyst gives better efficiency at different engine speeds. It is also found that 4 g/L of NaOH gives better highest thermal efficiency compared to other NaOH concentration at different engine speeds as shown in Fig. 4.

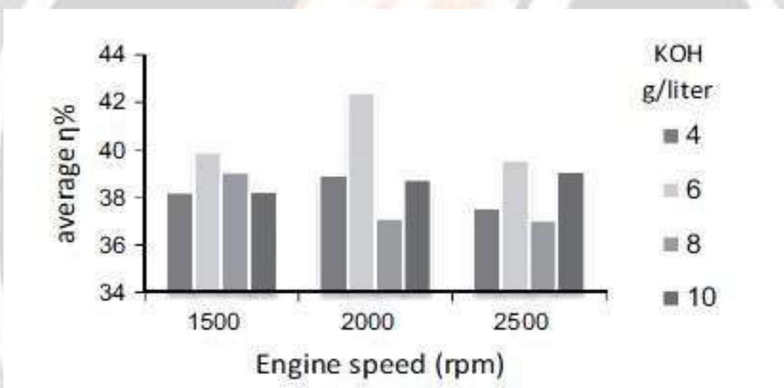

Chart No.1 Average efficiencies for using different concentrations of KOH at different engine speeds.

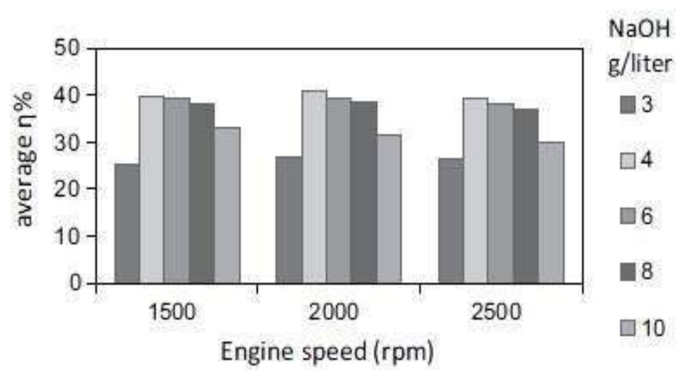

Chart No.2 Average efficiencies for using different concentrations of NaOH at different engine speeds.

6. Engine Performance

Figs.4 and 5 shows the effect of introducing HHO gas to the combustion on both thermal efficiency and specific fuel consumption. It is noted that HHO gas enhances the combustion process through increasing engine thermal efficiency and reducing the specific fuel consumption. Comparing HHO gas to commercial gasoline fuel, HHO is extremely efficient in terms of fuel chemical structure. Hydrogen and oxygen exist in HHO as two atoms per combustible unit with independent clusters, while a gasoline fuel consists of thousands of large molecules hydrocarbon. This diatomic configuration of HHO gas (H_2 and O_2) results in efficient combustion because the hydrogen and oxygen atoms interact directly without any ignition propagation delays due to surface travel time of the reaction. On ignition, its flame front flashes through the cylinder wall at a much higher velocity than in ordinary gasoline/air combustion. The released heat of HHO facilitated breaking of the gasoline molecules bonds and hence increasing reaction rate and flame speed and then combustion efficiency is increased.

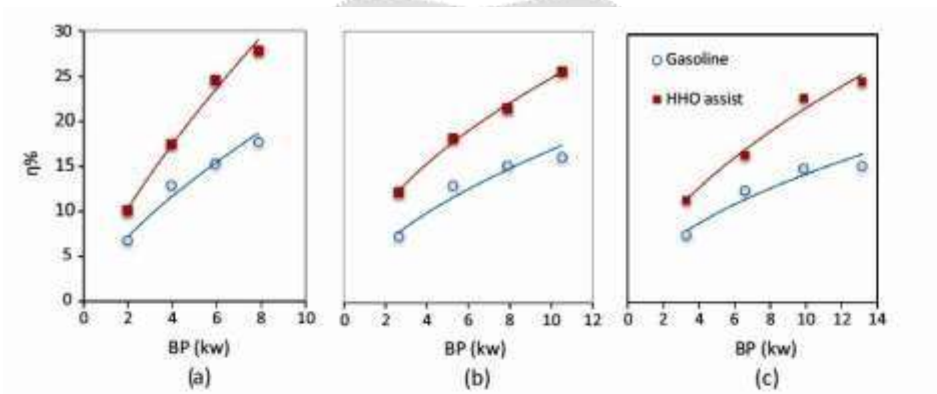

Fig.No.6 Overall thermal efficiency improvement with HHO over pure gasoline fuel at different engine speeds (a) 1500rpm, (b) 2000rpm and (c) 2500rpm

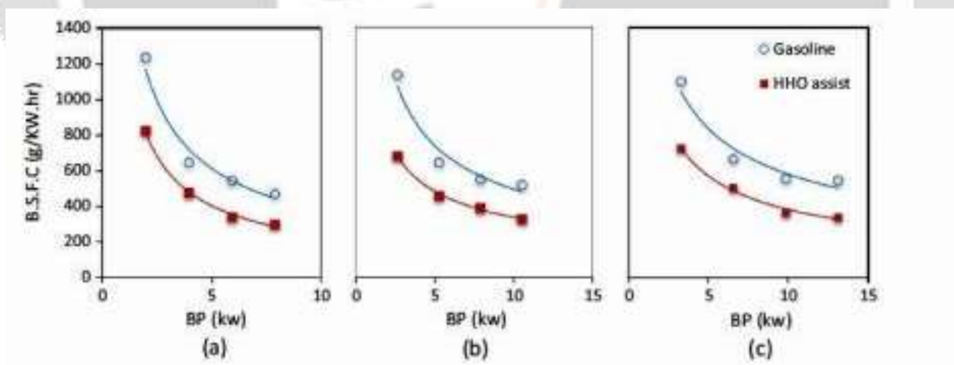

Fig.No.7 Effect of varying the engine dynamometer load on BSFC (a) 1500rpm, (b)2000rpm and (c)2500rpm.

7. CONCLUSION

After studying from the papers, the laboratory experiments were carried out to investigate the effect of HHO gas on the emission and performance of a Skoda Felicia 1.3 GLXi engine. A new design of HHO fuel cell has been performed to generate HHO gas required for engine operation. The generated gas is mixed with a fresh air in the intake manifold. The exhaust gas concentrations have been sampled and measured using a gas analyzer. The following conclusions can be drawn.

1. HHO cell can be integrated easily with existing engine systems. No major hardware modifications are required.

2. The brake thermal efficiency has been increased up to 10% when HHO gas has been introduced into the air/fuel mixture which reducing fuel consumption up to 34%.
3. The concentration of NOx, CO and HC gases has been reduced to almost 15%, 18% and 14% respectively on an average.
4. The best available catalyst was found to be KOH, with concentration 6 g/L.

The proposed design for separation tank takes into consideration the safety precautions needed when dealing with hydrogen fuel.

8. REFERENCES

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