Generation of HHO and Its effect on Engine Performance

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Abstract— This paper is about making an efficient Hydrogen-Hydrogen-Oxygen (HHO) generator, that produces Hydroxy gas which can be used to increase the fuel efficiency in an IC engine. In combustion engine products of combustion expand through a piston in order to generate power so here high pressure products act as a working fluid. Presently there are three types of combustion engines Spark ignition engine, Diesel engine and Turbine engine. In these engines unburned fuel remains in some amount after the burning process. This causes the air pollution which is one of the major challenges for automobile industry. HHO generator is an efficient approach that used to increase the fuel efficiency in a combustion engine by increasing the energy produced per mole of fuel during the ignition process. As a result the amount of unburned fuel in a combustion engine will reduced. The proposed approach is based on an ordinary HHO generator. Although people use HHO generators in practice a very little research has been carried out in implementing an efficient system. In this research we mainly focused on finding an efficient configuration of an ordinary HHO generator that is efficient than an ordinary system. Therefore, such a system will be able to increase the power of a spark ignition engine while reducing the air pollution.

Keywords: HHO, Hydroxy generation, electrolysis, internal combustion engine, spark ignition system

I. Introduction

In the present scenario the growing concern of the people living in every part of society is the ever increasing price of fuel and the harmful effects caused due to higher level of pollutants in the atmosphere. The increasing demand for petroleum fuel associated with limited non-renewable stored quantities has resulted in a huge increase in crude oil prices. Consequently we have seen a shift toward automobiles that consume less fuel. We spend one third of our income for our vehicle fuelling and the vehicle gives harmful decomposed materials like CO, NOx, HC etc. in the form of smoke. These materials are all effects of the engine's performance and pollute the environment. It is explicit that we use fuel in abundant amount and pollute the atmosphere. This has encouraged researchers to seek an alternative fuel that can be used in engines without the need for a dramatic change in the vehicle design. To avoid these drawbacks, a thought was given to add an alternative to improve the combustion efficiency of the engine, reduce operating cost and increase its productivity. The Secondary fuels that we use should have the same efficiency or greater efficiency of the engine when used with ordinary fuel. Contemporary research into secondary sources of energy for transportation focuses mainly on electric/battery, hybrid and hydrogen powered vehicles. Such focus assumes that the current technology has to be discarded and cannot be improved. However, it is possible to introduce interim technology to alleviate the current challenges arising from continued reliance on fossil fuels. Such challenges include increased greenhouse gas (GHG) emissions with consequent global warming and climate change impacts.[1]

It is cheaper, safer, tremendous explosive and never pollutes the atmosphere. While crossing a gas or diesel operated car we can feel the smell of the respective fuels, it shows that the fuel is not completely burnt. It is explicit that we waste fuel and pollute the atmosphere. To avoid these drawbacks, some level of HHO is mixed with filtered air, which is after the air filter system and before the engine in take system of the car. This mixed HHO ignites releasing the extra electrons into the igniting fuel and thus the added extra energy from the HHO leads cent percent of complete burning of the fuel. The HHO has Polymorphism that is it acts differently - before burning, while burning, and after burning. Before burning of Hydrogen, which is a lightest gas with one proton and one electron and more efficient fuel three times of the explosive power when compared to fuel gas and five times than petrol. Actually, the Hydrogen requires little bit of energy of ignition to produce wide level of tremendous flammable temperature in the speed of lighting and there is no chance to compare with other fuel in this world. As a result of fact it increases the engine performance, torque, and mileage and minimums fuel consumption. During burning the HHO into the engine with a tremendous explosion on that area and gives off high power of energy and automatically reverts to water vapour at once. Due to this action the engine not only getting higher torque but also gets easily cooled from 10 to 20 times faster than other fuels. For example after combustion of fuel in the engine the level of temperature is approximately 250ºF, but on the other hand mixing of HHO with same fuel means the engine temperature reduces approximately from 150ºF to 200ºF only because of vapours formations after combustion. Thus the engine life period gets wider, and reduces lubricating oil degradation beyond the limit of Km. Then oil changing period also gets lengthened. It leads in decrease of the maintenance cost and increase of interval of maintenance. After burning the HHO, the engine gives steam and some percentage of oxygen on the exhaust side and the stream is automatically converted into water form in the atmosphere. Thus the exhausts emission also controls from 10% to 50%. The pollution also reduces and remaining Oxygen comes out from the exhausts. In this study one of the goals was to test if the addition of HHO gas as source of active intermediate substances would result with measurable effects on engine operation and fuel consumption.[2]

II. Literature review

Al-Rousan et al. [1] in his research explained that studies on the electrolytic separation of water into hydrogen and oxygen date back to the 19th century. More recently, there has been considerable research in the separation of water into a mixture of hydrogen and oxygen gases. These studies were initiated

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by Yull Brown in 1977 via equipment generally referred to as electrolysers and the resulting gas is known as “Brown’s gas” or HHO. Also research and development, incentives and regulations, and partnerships with industry had sparked isolated initiatives. But stronger public policies and educational efforts are needed to accelerate the process. Decisions made today will likely determine which countries and companies seize the enormous political power and economic prizes associated with the hydrogen age now dawning.

Al-Rousan et al. [1] after reviewing the existing literature on acceptance, risk perception and customer satisfaction, described the development of a model that illustrates important aspects in influencing a person’s attitude toward a new product. “Values”, “wants” and “perception” are the three components found to influence acceptance. The consumers themselves are affected by “social background” and “experience”. He also gave suggestions on how to use marketing methods, education projects and product exposure in order to maximize the likelihood of a successful introduction of hydrogen as an alternative fuel. His paper focused on the analysis of the main technological trends, the role of governments in steering the transition and the evaluation of the speed and direction of the transition to hydrogen. He showed that the interest in hydrogen is increasing rapidly and that overall the variety in research projects is increasing. Different governments play an active role in stimulating research and development, which broadens the variety of research topics.

He also described a long-term hydrogen-based scenario of the global energy system in qualitative and quantitative terms illustrating the key role of hydrogen in a long term transition toward a clean and sustainable energy future

El Kassaby et. al. [2] in his research work constructed a simple innovative HHO generation system and evaluates effect of hydroxyl gas HHO addition, as an engine performance improver, into gasoline fuel on engine performance and emissions. The HHO cell was designed, fabricated and optimized for maximum HHO gas productivity per input power. The optimized parameters were the number of neutral plates, distance between them and type and quantity of two catalysts of Potassium Hydroxide (KOH) and sodium hydroxide (NaOH). The performance of a Skoda Felicia 1.3 GLXi gasoline engine was evaluatedwith and without the optimized HHO cell. In addition, the CO, HC and NOx emissions were measured using TECNO TEST exhaust gas analyzer TE488.

The stated advantages of CO2, CO and HC reduction, while NOx increased, with higher H2 %, would be reasoned as follows: reduction of these 3 was attributed to enhanced combustion kinetics, as H2 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 H2 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, CO2 and HC and promotes economic fuel consumption. Furthermore, hydrogen has a higher diffusion coefficient than that of the gasoline, and so, the gaseous H2 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. Hydrogen has higher flame speed and its gasoline blend can be combusted faster. Still, as H2 addition widen the mixture flammability limit to leaner fuel equivalence, the reaction rate will be reduced and combustion would be prolonged in lean conditions.

III. PRINCIPLE

A DC electrical power source is connected to two electrodes, or two plates (typically made from some inert metal such as platinum, stainless steel or iridium) which are placed in the water. Hydrogen will appear at the cathode (where electrons enter the water), and oxygen will appear at the anode. Assuming ideal reaction, the amount of hydrogen generated is twice the amount of oxygen, and both are proportional to the total electrical charge conducted by the solution. However, in many cells competing side reactions occur, resulting in different products and less than ideal reaction.

Electrolysis of pure water requires excess energy in the form of over potential to overcome various activation barriers. Without the excess energy the electrolysis of pure water occurs very slowly or not at all. This is in part due to the limited self- ionization of water. Pure water has an electrical conductivity about one millionth that of seawater. Many electrolytic cells may also lack the requisite electro catalysts. The efficiency of electrolysis is increased through the addition of an electrolyte (such as a salt, an acid or a base) and the use of electro catalysts.

Currently the electrolytic process is rarely used in industrial applications since hydrogen can currently be produced more affordably from fossil fuels.

A pure stochiometric mixture of oxy hydrogen may be obtained by water electrolysis, which uses an electric current to dissociate the water molecules:

$$\text{Electrolysis: } 2\,H_2O \rightarrow 2\,H_2 + O_2$$

The reactions which occur at the cathode and anode are given below. In the negatively charged cathode, reduction reactions take place, with electrons (e^-) from the cathode being given to hydrogen cat ions to form hydrogen gas.

$$\text{Cathode (Reduction) Reaction: } 2H^+_{(aq)} + 2e^- \rightarrow H_2(g)$$

At the positively charged anode, an oxidation reaction occurs, generating oxygen gas and giving electrons to the cathode to complete the circuit.

$$\text{Anode (Oxidation) Reaction: } 2H_2O_{(l)} \rightarrow O_{2(g)} + 4H_{(aq)} + 4e^-$$

The same overall decomposition of water into oxygen and hydrogen is given in the reaction below.

$$\text{Overall Reaction: } 2H_2O_{(l)} \rightarrow 2H_2\,(g) + O_2\,(g)$$

We use this HHO Gas, “perfect fuel” as an ADDITIVE gas to supplement the diesel or petrol fuel inside the engine and make it burn better and hence prevent the huge combustion losses inside the engine.

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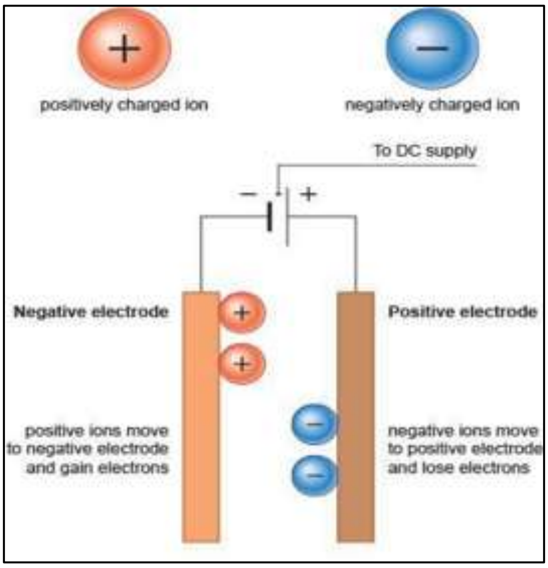

Fig. 1: Electrolysis process [2]

A. Fuel Cell:

A fuel cell is a device that directly converts the chemical energy from a fuel into electricity through a chemical reaction. Fuel cells are of two types namely wet cell and dry cell. In HHO generator we are using dry cell. Dry HHO cell is actually a design improvement over the wet HHO cell type. The end result of hydro-oxy gas is the same in both types - the difference relies on the electrolyte reservoir and electrodes plate displacement.

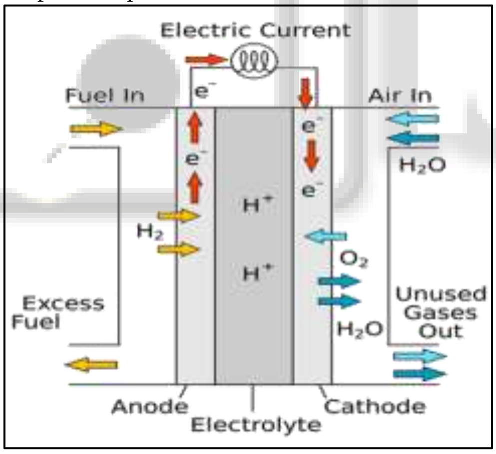

Fig. 2: Working of fuel cell [3]

B. Assembly and Working:

1) Setup

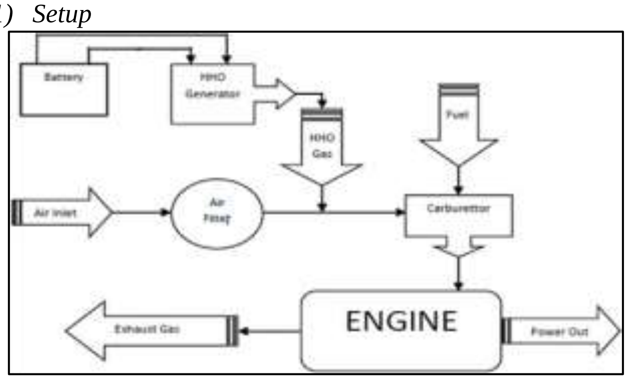

Fig. 3: schematic layout of installed HHO generation system on a vehicle or IC engine system [4]

It consists of HHO dry cell which is supplied with the electric current through the vehicle battery. The gas produced from this cell by electrolysis process is conveyed though a hose pipe after the air filter and before the carburetor. The mixture of air and HHO gas is mixed with the conventional fuel in the carburetor according to the stochiometric ratio and sucked into the IC engine through the intake manifold as per the throttle requirement.

IV. CONSTRUCTION:

The actual assembly is similar to the schematic layout of the system. It consists of a backing plate, dry cell assembly and reservoir cum bubbler assembly. The dry cell is initially assembled on the backing plate at its centre as shown in Fig. (12). the backing plate and dry cell unit is fitted on the bumper using pipe U clips. The reservoir is connected at the top of the backing plate on the front side close to the shock absorber. The reservoir is at an elevated height than the dry cell to provide manometric head for better flow of electrolyte to the dry cell. Bottom outlet of reservoir is connected to inlet port of dry cell with transparent hose. The outlet of dry cell is connected with transparent hose to reservoir top port connected to dip tube. The other port at reservoir top end is the gas outlet port. It is connected using transparent hose before the carburetor. A hole is to be drilled in the throttle tube which is before the carburetor for connecting the gas carrying hose.

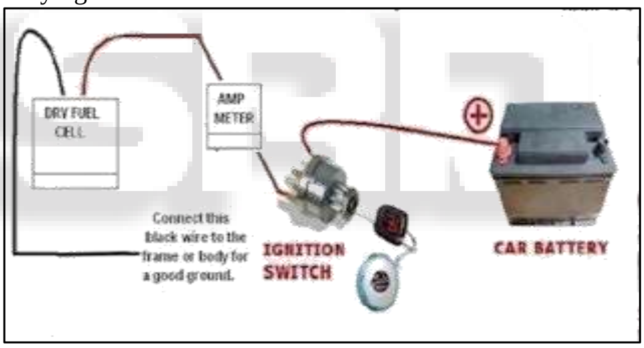

Fig. 4: Electrical connection to power dry cell [2]

Electrical connections are made as shown in fig.(4) Two crocodile pins are connected at the end of wires for easy, fast and safe connection. These positive and negative terminals are connected to the positive and negative electrode plates respectively. This completes the electrical circuit with a starter switch.

V. WORKING

"Electrolysis is the process by which ionic substances are decomposed (broken down) into simpler substances when an electric current is passed through them." As we switch on the starter, the electrical circuit is completed and current starts to flow from the battery to the dry cell and electrolysis process is triggered. Current flows from negative terminal to the electrolyte. K^+ ions are attracted towards anode (negative electrode) and OH^- ions are attracted towards cathode (positive electrode). This causes the electric current to flow from negative to positive electrode due to flow of ions. All cathode, anode and net cell reactions are mentioned above in chapter 1 methodology. As output of this electrolysis process, HHO gas obtained from the cell.

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A. *Overall Cell reaction*

$$2H_2O + KOH = K^+ + OH^- + 2H_2 + O_2$$

This $2H_2 + O_2$ is called as HHO gas or technical name for it is Brown's gas. This HHO gas produced from dry cell contains some water particles in it. So it cannot be given directly to engine. This output of dry cell is given to the reservoir, where reservoir acts as bubbler and the output HHO gas with water particles is fed to the electrolyte through dip tube. Water particles from HHO mix with electrolyte in reservoir and the HHO gas is liberated in the form of bubbles. This HHO gas in Pure and dry form will be collected in reservoir free space at top and then discharged through outlet at top end of reservoir. This pure and dry HHO gas is being supplied in between carburetor and air filter to the hole made in throttle tube through transparent hose connected to it.

While engine operation this HHO gas is also sucked in carburetor as secondary fuel with atmospheric air and conventional primary fuel that is petrol. This mixture of petrol, atmospheric air and HHO gas is sucked during suction stroke.

This is the detailed working of HHO generator.

VI. ADVANTAGES

1) Less current implementation for each cell is needed due to the volumetric size of the electrolyte within the closed chamber
2) More slim and compact in design which is a major benefit in modern vehicles which all have very compact engine bays
3) Less frequent maintenance is needed for the whole dry HHO cell system
4) Less corrosion occurs on the anode plates due to the restricted volume of electrolyte solution per second
5) Less current means less heat generation which can turn into steam inefficiency.
6) Unlike batteries, fuel cells have no "memory effect" when they are getting refuelled. The maintenance of fuel cells is simple since there are few moving parts in the system.

VII. DISADVANTAGES

1) Hydrogen is currently very expensive, not because it is rare (it's the most common element in the universe!) but because it's difficult to generate, handle, and store, requiring bulky and heavy tanks like those for compressed natural gas (CNG) or complex insulating bottles if stored as a cryogenic (super-cold) liquid like liquefied natural gas (LNG).
2) 2. It can also be stored at moderate temperatures and pressures in a tank containing a metal-hydride absorber or carbon absorber, though these are currently very expensive.
3) Application
 Fuel Cell today categorizes the use of fuel cells into three broad areas: portable power generation, stationary power generation, and power for transportation. We also include a category for fuel and infrastructure, relating to the production, distribution, storage and dispensing of fuels for fuel cells, as this is crucial to implementing fuel cell technology.

VIII. FUTURE SCOPE

The scope of this work is to introduce some of the hydrogen advantages while maintaining the original specifications of the engine. This may be attained by introducing an HHO cell to the fuel supply system, so that a fuel mixture of gasoline and HHO gas is obtained. A compact unit for generating HHO gas was designed to fit the engine specifications and to be installed in the engine compartment next to the radiator.

IX. CONCLUSIONS/DISCUSSION

1) The use of HHO in gasoline engines enhances combustion efficiency, consequently reducing fuel consumption and thereby decreasing pollution. HHO cell can be integrated easily with existing engine systems.
2) The concentration of CO gas has been reduced to almost 15-30 % on an average.
3) The concentration of HC gas has been reduced to almost 5-15 % on an average.
4) The mileage of the of the engine was seen to be improved by about21.22%.
5) The proposed design for reservoir cum bubbler takes into consideration the safety precautions needed when dealing with hydrogen fuel.

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