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Performance Analysis of Hydroxy Gas Generator by Varying Conditions of Electrolyte Concentration, Temperature and Time

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ABSTRACT
Demand and price on fossil fuel is increasing day by day,it is very much crying need to search for a alternative secondary fuel.Devloped countries are spending a lot of money on research and development of non conventional energy and eco friendly energy sources.To cope up with the problem hydroxy(HHO) gas is used as a secondary fuel for compression ignition and spark ignition engine for improving brake thermal efficiency, reducing fuel consumption and emissions from internal combustion engines which reduces fuel consumption that minimizes carbon deposition on the cylinder. In this project, hydroxy gas (HHO) was produced by the electrolysis process of an electrolyte (KOH(aq)) with 20 grade stainless steel electrodes in a leak proof pvc pipe tube (hydrogen generator).It has been observed that with a increased amount of KOH concentration the cell can produce HHO gas 207 ml/min and with 0.1M concentration of KOH and 27°C temperaure it can produce large amount of HHO gas which is 455 ml.

Keywords: Secondary fuel, HHO gas,Concentration,Temperature,Eco friendly.

1. Introduction

Increasing demand for coventional fuel related with limited non-renewable energy sources has resulted in a huge increase in crude oil prices. Scientists refer to that high exhaust gas concentration which is emitting from the industrial plants and the automobiles are hugely responsible for the global warming[1].Transportation sector consumes world total energy by 1.1 percent every year [2].For solving the above problem – researchers encouraged to seek for alternative solutions to be used in engines without the need for a dramatic change in the vehicle design.

Using hydrogen (H_2) as an alternative fuel which enhances the engine efficiency and runs with almost zero pollution effect has been researched well in the last decade.H_2 has some of its interesting properties such as high laminar flame speed, wide flammability range etc. which reveals hydrogen as an attractive fuel for internal combustion engines [3]. Besides, compared with traditional fossil fuels, H_2 is a carbonless fuel whose combustion does not generate emissions such as CO_2,HC and CO but there are concerns regarding the solutions both for the generation and storage of H_2 from the commercial point of views.Some researchers suggests that biogas [4-5], syngas [6], producer gas [7] either solely or with H_2 blends successfully in gasoline engines.

But nowadays, few researchers are working on HHO which doesn't have any kind of storage problem and more combustible than conventional fuel and hydrogen.Yull brown first discovered HHO gas in 1974 and the content of HHO gas are hydrogen gas (H_2) and oxygen gas (O_2) which are obtained by water electrolysis method [8] .

Eckman [9] proposed that when water is electrolysed and the gas products are not separated by a semi-permeable membrane,Rydberg clusters may be formed.These clusters are of a mixture of hydrogen and oxygen species including linear water molecules in the highly energized trigonal-bypyramidal geometry, monatomic and diatomic hydrogen, free electrons and oxygen.The extra energy stored in one litre of HHO due to Rydberg clusters is theorized to be 600±34J.Rydberg clusters are most common in solids and liquids and are typically stable from nanoseconds to hours.In the case of HHO or Brown's Gas these clusters have shown a life span of 11 minutes [9]. Due to these highly energized clusters HHO contains much more energy than equivalent stoichiometric ratio of hydrogen and oxygen in the form of extra electrons, this state has been explained as cold plasma.Cold plasma is a state of matter where the atom nuclei are relatively unenergetic or slowly moving, but the electrons are in highly energized states at higher atomic orbitals.If this is true HHO releases additional electrons during combustion that are stored in the gas resulting in higher electrical and thermal energy transfer compared to the equivalent mixture of hydrogen oxygen and water. Normally the presence of water in a burning fuel gas greatly reduces the heat energy due to the high specific heat capacity of water (4.18J/g-K), however the linear water content of HHO has greatly reduced hydrogen bonds and electrically transfers its electrons under combustion at the surface of the contacting material. The flame temperature generated by HHO can range from 150°C

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to over 9000°C [10] based on the contact materials' electrical conductivity, thermal conductivity, density and vapour point.

Li et al. [11] found that HC and CO emissions from the hydrogen-enriched gasoline engine were lower than the original gasoline engine. D. M. Madyira and W.G. Harding [12] in this paper, The generated HHO gas was supplied through intake manifold up to 0.45% by volume in S.I engine. Tests were conducted for a range of speed from 1000 to 3500 rpm and maximum load applied was 30% of full load. It was found that, addition of HHO enhanced power and torque and a significant reduction in CO and HC was observed. Also improved combustion was observed especially a low loads.

This work is different from previous work because previous works analyze the HHO effect on I.C engine rather than analysing the factor behind HHO gas production rate improvement. Noor Alam and K. M. Pandey [13] in this paper,the production of HHO gas has incresed about 30-40% with reduction in electrical energy consumption and one anode and cathode is used through the overall work so that the HHO gas production is comparatively low.But in this work,6 plate HHO cell is fabricated with 20 grade stainless steel to produce HHO gas so that the production rate is hugely increased compared to previous work.Moreover,the main target of this work is to produce HHO gas considering some factor rather than analysing electrical energy consumption.

Process of electrolysis involving the production of hydrogen and oxygen is carried out by HHO gas generator. In this process, A d.c is passed through electrodes to water, due to chemical reaction, the positive plates generate Oxygen and negative plates generate Hydrogen.

Hydrogen and oxygen do not form into O_2 and H_2 molecules rather they may remain in their monoatomic state and no atomic bond is broken which is an unstable state of H_2O vapor, more energy can be achieved compared to H_2 burning with O_2 [14].This hydrogen molecule acts as a fuel and oxygen molecule helps to burn the fuel. The heating value of hydrogen is high and for the presence of oxygen the proper combustion can be assured.

The resulting migration of ions in solution results in the production of hydrogen at the cathode and oxygen at the anode according to [15]:

Cathode (-): $4H_2O(l) + 4e^- \rightarrow 2H_2(g) + 4OH^-(aq)$

Anode (+): $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

The overall chemical reaction of water electrolysis can be written as follows :

$$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$$

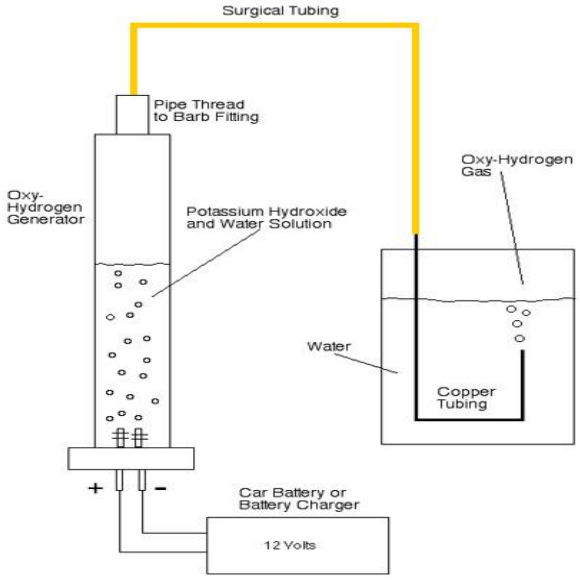

Fig 1: HHO Gas Production [16]

2. Experimental procedure

2.1 Material Selection and Desinging of HHO Cell Plate:

There are different materials could be used as an electrode. But each one has its own merits and demerits .From the overall search the selection of material for electrodes should be stainless steel thicker in size. The distance between each plate should be minimum and should have equal space all over the arrangement of electrodes. There are two methods of arrangements of electrodes -without-neutral and with-neutral. The without-neutral electrodes construction consists of number of positives P and negatives N plates which are all arranged alternatively, example if there are three set of positive and negative electrodes then P-N-P-N-P-N is the arrangement. Next with-neutral electrodes construction consists of number of positives P ,neutral Nu ,and negatives N plates which are all arranged in the following manner P-Nu-Nu- N-Nu-Nu-P-Nu-Nu-N,or , P-Nu-Nu-Nu-N-Nu-Nu-Nu-P-Nu-Nu-Nu-N, etc… The purpose of neutral plate is to prove better cooling effect while electro processing. Here the neutral plates are also of the same material and same size .But in this work the former one will be selected and designed as Nu-Nu-P-Nu-Nu-N which is shown in Fig. 2. For the connectivity among positive electrodes and negative electrodes, they are arranged not to make any shot circuit at any condition and mechanically should be strong to withstand the electrolyte corrosions.

For the electrodes metal sheet is needed and for our case the sheet metal is of stainless steel. The sheet was of 20 grade. It has a thickness of 1mm. the sheets were needed to be cut into certain dimensions. That is because for maximum gas production the sheets were needed to be in sandwiched form. The dimensions and the number of sheets are given below :

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Serial no.	Sheet Dimension(Inch×Inch)	Number of Sheets
1	6×3	12
2	61.5	4
3	6×1	1
4	4.5×1	1
5	3.25×1	1

Fig 2 : 6 Plate HHO Cell

2.2 Material Selection To Design a Container :

The container should have the following properties as follows: should withstand chemical corrosion, mechanical stress and strain, tremendous vibration and temperature. If it is transparent, it is easy to check the electrolyte level and its color and it should be a gas tight container, because HHO is a light weight gas compared to air. On the top of the container there are three holes a two holes in opposites are for positive and negative terminal, one hole for gas outlet through gas hose.In this experiment P.V.C tube is used as shown in Fig 4. because it has high temperature resistance.

2.3 Purpose of a Catalyst :

Electricity is not conducted by pure water properly. Adding a catalyst to the water creates an electrolytic solution and increases conductivity, allowing electrolysis to occur.For more HHO production catalysts such as NaOH, KOH, H_3C-COOH, $NaHCO_3$, K_2CO_3 or NaCl can be used.More concentration of the catalyst is important to keep electrical resistance-conductivity balance in the cell. Distilled water and KOH is the preferred electrolyte.Advantage of KOH over other electrolyte is - Electrodes stay clean and 95 - 100% pure HHO gas production along with the right generator design .

2.4 : Purpose of Bubbler Bottle :

Bubbler is otherwise called safety bubbler or collector, which has a simple arrangement. The container should be flexible and withstand the vibration and little bit pressure, transparent and should have feet of height as shown in Fig 1. These all conditionsare satisfied by a simple water bottle made of plastic. The three fourth of the bubbler should filled withwater. The gas incoming tube from the HHO generator should be dipped into bottom of the water level always.

For each and every incoming bubbler one back flow check valve has to be placed to avoid the back flow of the water into the HHO generator side. An important caution about the backfire is that we must ensure the water level in the bubbler at all times or otherwise it will lead to back fire explosion because HHO is ignited easily. To avoid this level of sever explosion we should use flashback arrester valve which are in market in different size and variety and if it is not available means we may use our own design with a help bronze wool as a backfire protection and do not try to store the HHO even if in small quantity level it may lead to larger explosion.

2.5 : Working Principle of HHO Gas Generator :

First, it has been observed by making a prototype model for HHO gas generator with single anode and cathode which is connected then 12V computer power supply and obsevervs it's burning properties which is shown in Fig.3. The experimental setup includes mainly the fabrication of an electrolyzer in which the electrolysis reactions would occur. The other important tasks includes material selection for electrodes, electrolyte selection, gas collection method development etc.Sanitary pipe (having 4mm thickness) is used to make the reactor container or the eletrolyzer. The designed electrolyzer is as shown in Fig.4 with a capacity of 6 liters solution. Sanitary pipe has some special properties other than visibility such as noncorrosive, nonconductive, nonreactive with electrolyte and it can withstand high pressure and temperature. Stainless steel is selected as electrode material as it is high corrosion resistant, non reactive with the electrolyte, good conductor, and capable to withstand high temperature and voltage. An electrolysis device is called an electrolyze cell, the process of using DC supply to the arranged electrodes which are immersed into the electrolysis split water into hydrogen and oxygen. The positive plate emits oxygen and negative plate emits hydrogen. When both are bubbled up and collected together – so called highly burnable fuel is produced. Storing this gas creates explosive effect so directly hosed into the air intake of the engine. Within the engine before firing this HHO gas is automatically mixed with filtered air and then combines with the fuel. By nature HHO supports with gas as well as diesel, another property.

The total experimental setup is presented in Fig.4

Fig 3 :Prototype Model For HHO Gas Generator

Fig 4 : Experimental Setup of HHO Gas Generator

An electrolyte with increased amount of catalyst can dramatically increase current supplied from battery due to the higher reduction of total electrical resistance in the solution.Several concentrations of electrolyte such as 0.01M,0.1M,0.2M,0.3M KOH solution are used to perform the electrolysis process. The plate electrode and KOH(aq) are found satisfactory in relation to the electrical power consumed in the experiment. A DC battery (similar to that is used in automobiles) is used as the main power source of this experiment. The terminal voltage of the battery is 12 V and current rating is 60 Amp/hr. The generated HHO gas is collected by the water displacement method. The gas collection container initially filled with water and is placed as inverted cylinder in a reservoir of water. As the gas is created, it will displace water from the container. The volume of gas can be determined by the amount of water displaced by the gas. Electric currents are measured by an ammeter (0 to 60 amps AC/DC ammeter) and voltages are measured by a digital multimeter.

3 Results and Discussion :

3.1 Theoretical Analysis :

According to Natalia Chraplewska, Kamil Duda and Milosz Meus [17], the optimal voltage on the electrode is 1.48V, while the amount of the produced gas depends on the current strength. The volume of the produced gas for a single pair of plates - a cell can be estimated from the following equation [17],

$$V=\frac{R.I.T.t}{F.PZ} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where, V: volume of gas [m^3],

R: gas constant (≈ 8.314472[$\frac{J}{mol.k}$]),

I: current [A], T: temperature [K],

t: time [s],

F: Faraday constant (≈ 96485.34[$\frac{c}{mol}$]),

P: ambient pressure [Pa], z: number of excess electrons (2 forH_2 , 4 for O_2).

3.2 Graphical Presentation :

a) Effect of electrolyte concentration :

No electrons are traveled from active electrode surface to the inert electrode surface in pure water.The resistance of the overall electrolyzer system is reduced due to increse the conductivity of pure water.Thus the overvoltage value on electrolyzer is dropped to a larger extent.Increasing amount of electrolytic concentration hydrogen and oxygen evolution is increased due to greater number of effective ionic collisions per unit time. Here shown in Fig. 5,when the concentration of electrolyte increased,the amount of HHO gas also increased .So,increasing electrolyte concentration will increase the production rate of HHO gas.

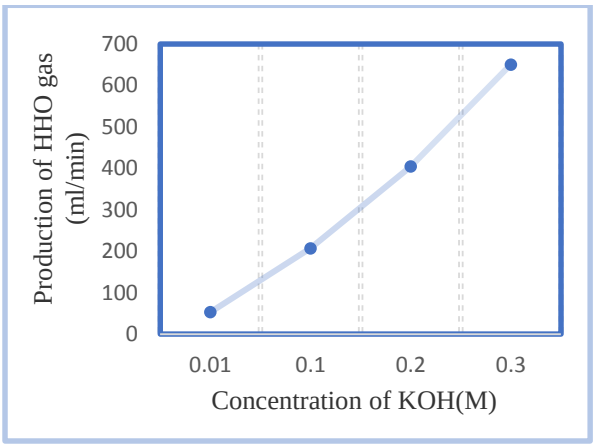

Fig 5 :Effect of Electrolyte Concentration

b) Effect of time at 0.1 M KOH :

HHO gas volume is calculated by 1 min interval with a 0.1 M concentration of KOH. As KOH concentration is not increase with time ,current flow through the electrode becomes constant after some time.As a result, HHO production rate is constant after some time period as shown in Fig. 6.

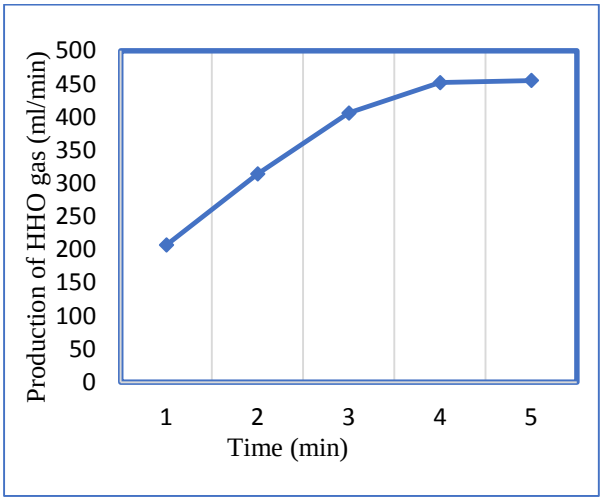

Fig. 6 : Effect of Time at 0.1 M KOH

c) Effect of temperature at 0.1 M KOH:

In most cases , such as room temperature water electrolysis, the electric input is larger than the enthalphy change of the reaction, so some energy is released as waste heat.High temperature electrolysis is more efficient economically than traditional room-temperature electrolysis because some of the energy is supplied as heat which is cheaper than electricity . Here shown in Fig. 7 ,when the temperature of water is increased the amount of HHO gas also increased so much.So,increasing temperature will increase the production rate of HHO gas.

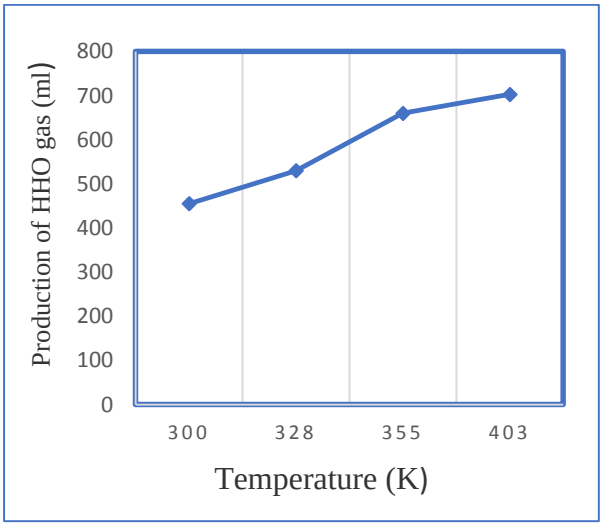

Fig 7 : Effect of Temperature at 0.1M KOH

4 Conclusions and Recommendations :

The main aim of this research work is to fabricate a 6 plate HHO fuel cell for HHO gas production and analysis are made by varying catalyst concentration,time and temperature in laboratory scale. The HHO cell plate named electrode are made from 20 grade stainless used for this project because it is cheap and it can withstand high temperature as wll as high current flows.HHO gas is collected by water displacement method for collecting data**.** It has been observed that with a incresed amount of KOH concentration the cell can produce HHO gas 207 ml/min and with 0.1M concentration of KOH and 27^{o}C temperaure it can produce large amount of HHO gas which is 455 ml. While designing the HHO generator the following important points should be taken care: selection of electrodes, distance between two electrodes, connectivity between electrodes, selection of catalyst, its level, merits and demerits, selection of container, electrical connectivity and plumping with gas tight arrangement ,backfire protection .

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