Experimental Investigation of Engine Performance for Petrol Engine Working on Fuel Blended with Hydrogen

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Abstract— Alternate fuel have a great importance and should have replenishing capacity. We spend one third of income for vehicle fueling. The vehicles emit harmful emissions like CO, No_x, HC, etc. in the form of smoke. These emissions are harmful and pollutes the environment. Water is one of the free recourses and by applying the technique of electrolysis, it can be converted into hydrogen with oxygen, its chemical term is Oxy-Hydrogen and in general "Free Energy". A predetermined level of Oxy-Hydrogen is mixed with filtered air and that mixture is added to the engine intake. This mixed Oxy-Hydrogen ignites in the combustion chamber releases extra energy from the Oxy-Hydrogen which leads to complete burning of the fuel. Oxy-Hydrogen is popular and common gas produced from electrolysis. The outcome we get by this project is that there is increase in mileage of the vehicles up to certain percentage according to their specification & running condition of vehicle & also there is a reduction of harmful emissions up to certain percentage. There is increase in the life of engine lubricating oil up to certain service timing & reduction in suspended carbon particles inside the combustion chamber. From above description we can say that the fuel efficiency and vehicle performance are increased. The emissions of harmful and toxic gases are reduced up to some percentage. This is the safest method to give clean & healthy environment to the next generation people by installing this Oxy-Hydrogen model in all two and four wheelers gasoline vehicles.

Key words: Hydrogen as an IC Engine Fuel, Engine Performance for Petrol Engine

I. Introduction

As we know that current global economy faces problems in the fossil fuels and fossil fuels end in the nearest future. The increasing demand for petroleum fuel associated with limited non-renewable stored quantities has resulted in a huge increase in crude oil prices. In the last few years, ordinary people experienced this by paying more at the pumps. Another reason is that, these fossil fuels are also harmful for the environment. It affects the protection layer of the earth i.e. Ozone layer as well as global warming effect & greenhouse effects.

The world is entering a particular innovative period with a number of options for sustainable energy development which has never existed before. Two whole new generations of cars, not yet built today, will be scraped in 2030. The effects of future (geo) political developments on the global energy flows and markets are unknown today. In this context, it is a very ambitious aim to point out today who will be the winners in 30 years from the competing different technologies.

The use of alternative fuels greatly reduces harmful exhaust emissions like carbon monoxide, carbon dioxide, sulphur dioxide and particulate matter. Another reason for alternative fuels is that they can often be produced domestically using a country's resources and that in turn strengthens the economy.

Consequently we have seen a shift toward automobiles that consume less fuel. 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.

II. Conventional Fuel Sources VS Hydrogen as a Fuel Source

Energy content of some fuels compared with gasoline:[1]

Fuel type	MJ/L	MJ/kg	Research octane number
Ethanol	21.2[2]	26.8[2]	108.6[3]
E85 (85% ethanol, 15% gasoline)	25.2	33.2	105
Liquefied natural gas	25.3	~55	
Autogas (LPG) (60% propane + 40% butane)	26.8	50.	
Aviation gasoline (high-octane gasoline, not jet fuel)	33.5	46.8	100/130 (lean/rich)
Gasohol (90% gasoline + 10% ethanol)	33.7	47.1	93/94
Regular gasoline	34.8	44.4[4]	min. 91
Premium gasoline			max. 104
Diesel	38.6	45.4	25

Fig. 1: Conventional Fuel Sources Vs Hydrogen as a Fuel Source

A number of companies have built automobiles with prototype or modified engines which operate on hydrogen fuel.

A. *Advantages of hydrogen as an IC engine fuel include*

1) Low emissions. Essentially no CO or HC in the exhaust as there is no carbon in the fuel. Most exhaust would be H20 and N2
2) Fuel availability. There are a number of different ways of making hydrogen, including electrolysis of water.
3) Fuel leakage to environment is not a pollutant.
4) High energy content per volume when stored as a liquid. This would give a large vehicle range for a given fuel tank capacity.

B. *Disadvantages of using hydrogen as a Fuel*

1) Heavy, bulky fuel storage, both in vehicle and at the service station. Hydrogen can be stored either as a cryogenic liquid or as a compressed gas. If stored as a liquid, it would have to be kept under pressure at a very low temperature. This would require a thermally super-insulated fuel tank. Storing in a gas phase would require a heavy pressure vessel with limited capacity.
2) Difficult to refuel.
3) Poor engine volumetric efficiency. Any time a gaseous fuel is used in an engine, the fuel will displace some of the inlet air and poorer volumetric efficiency will result.

4) Fuel cost would be high at present-day technology and availability.
5) High NOx emissions because of high flame temperature.

III. OXY- HYDROGEN

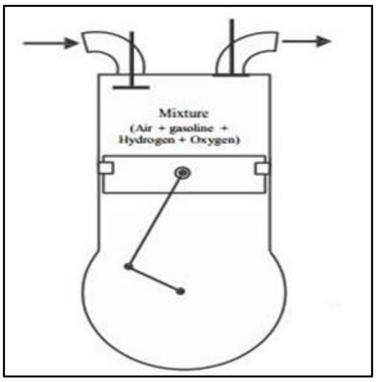

Fig. 3: Engine using mixture of Oxy-Hydrogen and Gasoline as fuel

Oxy-hydrogen is an enriched mixture of hydrogen and oxygen bonded together molecularly. Oxy-hydrogen gas is produced in a common -ducted electrolysis cell then sent to the intake manifold to introduce into combustion chamber of the engine. Oxy –hydrogen gases will combust in the combustion chamber when brought to its auto ignition or self-ignition temp. For a stoichiometric mixture at normal atmospheric pressure, auto - ignition of oxy hydrogen gas occurs at about 570°C (1065°F). The minimum energy required to ignite such a mixture with a spark is about 20 micro joules. At normal temperature and pressure, 'oxy-hydrogen gas' can burn when it is between about 4 and 94% hydrogen by volume. When ignited, the gas mixture converts to water vapor and releases energy. The amount of heat released is independent of the mode of combustion, but the temperature of the flame varies. The maximum temperature of about 2800°C is achieved with a pure stoichiometric mixture, about 700°C hotter than a hydrogen flame in air. Oxy -hydrogen gas has very high diffusivity. This ability to disperse in air is considerably greater than gasoline and it is advantageous in mainly two reasons.

Firstly, it facilitates the formation of homogeneous air fuel mixture and secondly, if any leak occurs it can disperse at rapid rate. Oxy hydrogen gas is very low in density. This results in a storage problem.

A. Hydrogen Fuel Enhancement

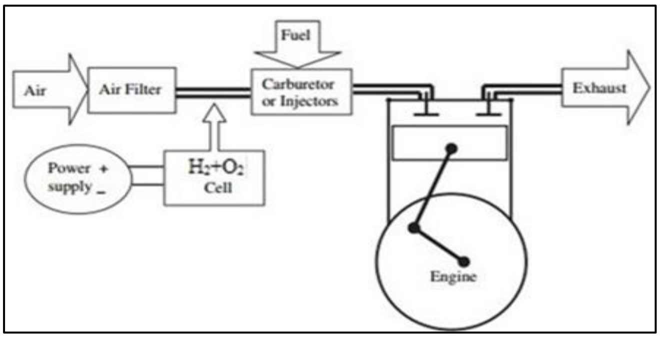

Fig. 4: Hydrogen Fuel Enhancement

It is the process of using a mixture of hydrogen and conventional hydrocarbon fuel in an internal combustion engine, in an attempt to improve fuel economy, power output, emissions, or a combination thereof. Methods include hydrogen produced through an electrolysis cell, storing hydrogen on the vehicle as a second fuel, or reforming conventional fuel into hydrogen with a catalyst. There has been a great deal of research into fuel mixtures, such as gasoline and nitrous oxide injection. Mixtures of hydrogen and hydrocarbons are no exception.

Some sources say that contamination from exhaust gases has been reduced in all cases, and it suggest that a small efficiency increase is sometimes possible. Many of these sources also suggest that modifications to the engine's air-fuel ratio, ignition timing, emissions control systems, electronic control systems and possibly other design elements, might be required in order to obtain any significant results. A modified vehicle in this way may not pass mandatory anti-smog controls. Due to the inherent complexity of these subsystems, a necessity of modern engine design and emissions standards, such claims made by proponents of hydrogen fuel enhancement are difficult to substantiate and always disputed.

IV. ELECTROLYSIS

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 faradic, 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 faradic efficiency.

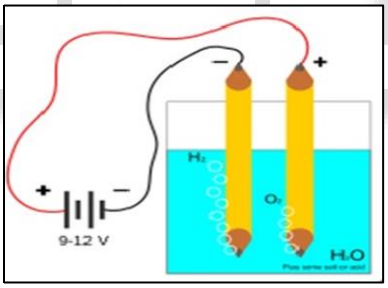

Fig. 5: Simple setup for demonstration of electrolysis of water

A. Equations

In pure water at the negatively charged cathode, a reduction reaction takes place, with electrons (e^-) from the cathode being given to hydrogen cations to form hydrogen gas (the half reaction balanced with acid)

Reduction at cathode: $2\,H^+(aq) + 2e^- \rightarrow H_2(g)$ (1)

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

1) Oxidation at Anode

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

The same half reactions can also be balanced with base as listed below. Not all half reactions must be balanced with acid or base. Many do, like the oxidation or reduction of water listed here. To add half reactions they must both be balanced with either acid or base.

2) Cathode (Reduction)

$2\,H_2O(l) + 2e^- \rightarrow H_2(g) + 2\,OH^-(aq)$ (3)

3) Anode (Oxidation)

$$4\ OH^{-}(aq) \rightarrow O_2(g) + 2\ H_2O(l) + 4e^{-} \quad (4)$$

Combining either half reaction pair yields the same overall decomposition of water into oxygen and hydrogen

4) Overall Reaction

$$2\ H_2O(l) \rightarrow 2\ H_2(g) + O_2(g) \quad (5)$$

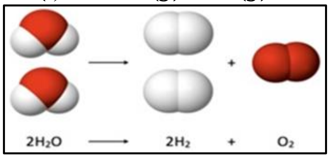

Fig. 6: Overall chemical equation

The number of hydrogen molecules produced is thus twice the number of oxygen molecules. Assuming equal temperature and pressure for both gases, the produced hydrogen gas has therefore twice the volume of the produced oxygen gas. The number of electrons pushed through the water is twice the number of generated hydrogen molecules and four times the number of generated oxygen molecules.

V. PROTOTYPE AND MODEL

The prototype consists of two spiral coils made of 316-stainless steel marine threaded wire from which one acts as anode and another as cathode. Each coil have 160 cm long wire with 251 cm^2 area approximately as it is a threaded wire there is space between the threads which increases the total surface area. As the pure water is very less conductive it is necessary to add either acid (HCl, KCl, H_2SO_4, etc.) or base (KOH, NaOH, Na_2CO_3,$NaHCO_3$, etc.) for which we have selected $NaHCO_3$ (Sodium Bicarbonate also known as Baking Soda), as it releases Na^+, H^+ and CO_3^{-2} ions and the water has H^+ ion and O^{-2} ion .H^+ ion has the higher capacity to lose the electron than the Na^+ ion hence it will migrate to cathode and O^{-2} ion has higher capacity to receive the electrons than CO_3^{-2} ion hence it will migrate to anode.

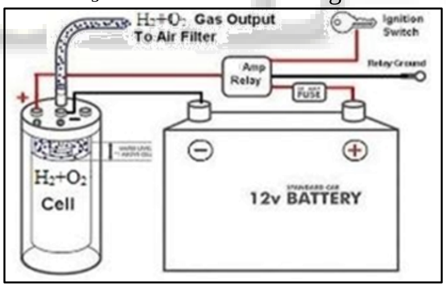

Fig. 7: Oxy-Hydrogen cell (generator)

If any acid is selected as an additive to water such as HCl to increase the conductivity then in the electrolysis process Cl- ions will be received at anode instead of O-2 ions which will be a great disadvantage and also in an acidic solution of water metal will erode faster than basic solution of water.

When the process starts the electricity passes through the electrolyte and the diffusion of water starts and the hydrogen will be received at cathode and oxygen will be received at the anode.

As the process goes on the temperature rises in the cell and a certain rise in temperature will helps to improve the electrolysis process.

The mixture of the hydrogen and oxygen will pass through air tight valve then it goes to air inlet through a nozzle, then the oxy-hydrogen can be inducted through air inlet pipe which goes combustion chamber and ignites with the petrol in the power stroke.

Selection of the material for electrodes was tough choices since wide range of materials are being used as electrodes. Each metal has a different level of activity, electrical resistance and corrosion resistivity. Platinum and gold are known to be two of the best choices for being used as electrodes, but these materials are two much costly to use as electrodes. The most common material used for electrolysis is stainless steel because of good conductivity, less corrosion and erosion properties related to other material. We have selected a threaded wire instead of plates for electrodes because of following reasons

- Threaded wire is more ductile than plates.
- Overall area of wire is more than plates and it can be accommodate in less volume with more surface area.
- If more than two plates are used than the amount of charge will decrease and it will be a disadvantage in case of threaded wire there are only two coils hence the charge will not decrease.

The preparation of prototype was very hard since the coil covers most of the area then it is difficult to pass the wire though a small hole from the vessel. One connection from each coil is necessary to pass the electricity.

The main problem with the prototype was to make it air tight. A waterproof model is much easy to make than an air tight model and for that we have selected some valves which fits properly with nozzle to make it air tight. To cover the space near the hole made for valve we placed some cotton around it and then applied a strong bonding material (fevikwik) which burned the cotton partially made it hard enough to make it air tight.

To cover space around holes made to pass the wire outside the vessel we used adhesion material (M-seal) since the area near the holes is filled with water hence no need to make it air tight.

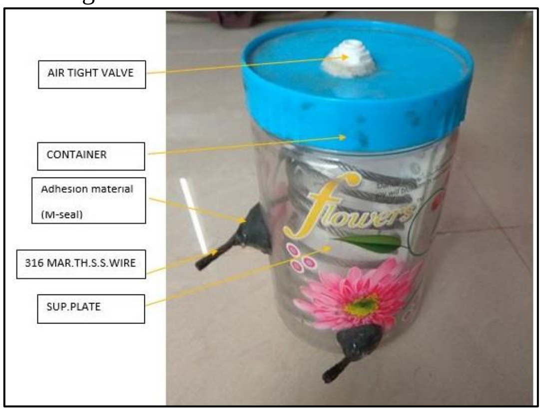

Fig. 8: Prototype

VI. EXPERIMENTAL SETUP

A. Setup-1 (Experiment for Fuel Efficiency, Fuel – Petrol)

- For analysis, the foremost step was complete drainage of petrol.
- A sample of 20 ml petrol was taken to know the running time, before and after adding oxy-hydrogen.
- Analysis was done in standby position.
- The difficulty in taking such a small amount was that such a lesser amount can't be fully utilized by engine so we disconnected the fuel line with the tank and

connected to another source where direct pouring can be done.

- Analysis was done by taking 20ml without any additive.
- Then after analyses with 20 ml petrol with the addition of oxy-hydrogen was performed.
- Oxy-hydrogen was induced in the engine through small hole in the air suction pipe below the fuel tank by inserting a nozzle through the hole

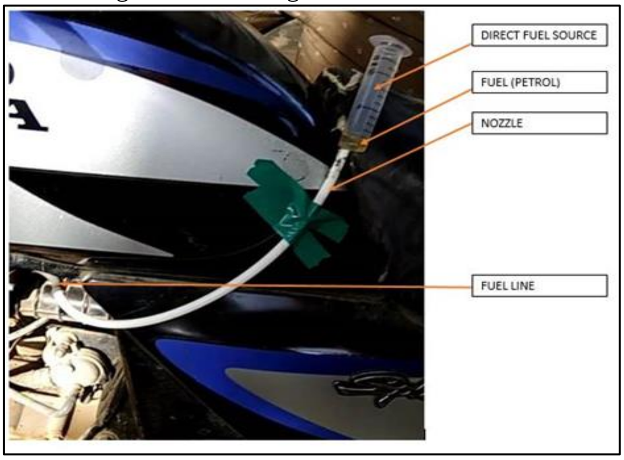

Fig. 9: Experiment for Fuel Efficiency, Fuel – Petrol

B. Setup-2 (Experiment for Fuel Efficiency Fuel – Petrol Plus Oxy- Hydrogen)

The setup remains almost same except the addition of oxy-hydrogen.

- Oxy-hydrogen is generated in the prototype which runs on a battery (35ahr, 12volts). Prototype and battery was connected with a highly conductive copper wire.
- Then after generated oxy-hydrogen is directed towards the engine through a nozzle which is connected to the air suction pipe.
- It is necessary to confirm that there is no gas leakage so we made the joints air proof.

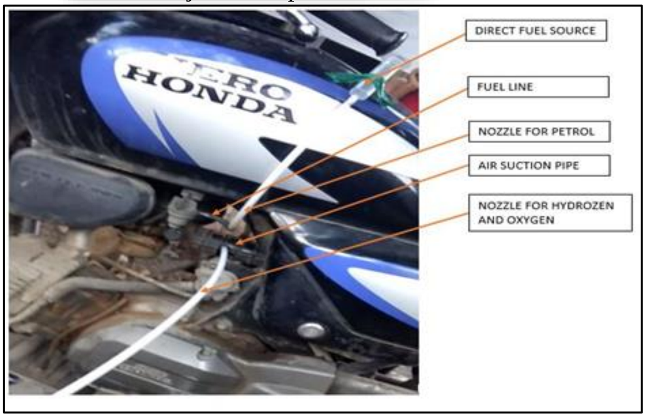

Fig. 10: Experiment for Fuel Efficiency Fuel – Petrol Plus Oxy- Hydrogen

C. Setup-3 (Experiment for Emissions Levels, Fuel – Petrol Plus Oxy- Hydrogen)

To find out the emissions we took the bike to the PUC Centre.

- We arranged the prototype connected it to the battery, ran the prototype and inserted the oxy-hydrogen in the engine as discussed in the setup-2.
- To find out emissions levels smoke meter was inserted in the exhaust pipe.

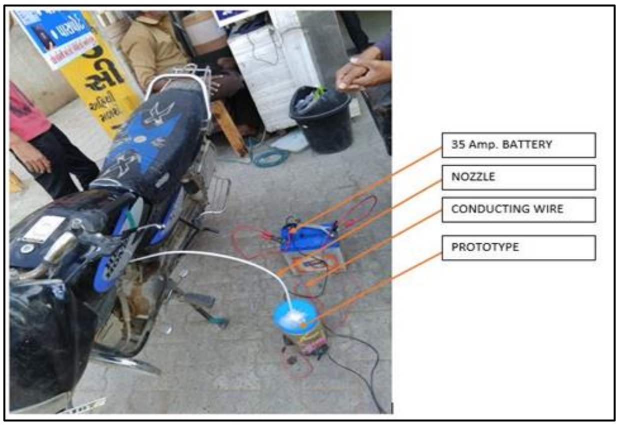

Fig. 11: Experiment for Emissions Levels, Fuel – Petrol Plus Oxy- Hydrogen

VII. Testing

A. Experiment-1 (Test for Fuel Efficiency, Fuel – Petrol)

- A sample of 20ml petrol was taken using a beaker and supplied to the engine through the fuel line.
- Experiment was done with bike on standby position.
- Running time with 20ml petrol was noted down with a stopwatch.
- Throttle response was constant throughout the experiment.

B. Experiment-2 (Test for Fuel Efficiency, Fuel – Petrol Plus Oxy- Hydrogen)

- This time oxy-hydrogen was also introduced in the engine through the nozzle along with petrol.
- 20ml of petrol was taken using a beaker and supplied to the engine through the fuel line.
- Running time was noted down with 20ml petrol and oxy-hydrogen.
- Throttle response was constant throughout the experiment.

C. Experiment-3 (Test for Fuel Efficiency, Fuel – Petrol Plus Oxy- Hydrogen)

- This time also oxy-hydrogen was supplied as a fuel in the engine along with petrol.
- 20ml of petrol was taken using a beaker and supplied to the engine through the fuel line.
- Running time was noted down with 20ml petrol and oxy-hydrogen.
- Throttle response was constant throughout the experiment.

D. Experiment-4 (Test for Emissions Levels, Fuel – Petrol)

- Emissions levels are noted down at a PUC Centre with a smoke meter.
- Engine was running only on the petrol.
- Bike was in standby position.

E. Experiment-5 (Test for Emissions Levels, Fuel – Petrol Plus Oxy- Hydrogen)

- Emissions levels are noted down at a PUC Centre with a smoke meter.
- Engine was running on petrol Plus oxy-hydrogen.
- Bike was in standby position.

VIII. RESULTS

A. Results for Fuel Efficiency, Fuel - Petrol

- Analysis was derived from a 100cc single cylinder four stroke Hero-Honda splendor bike.
- A sample of 20ml petrol was taken to know the running time before and after adding oxy-hydrogen.
- Analysis was done in standby position
- Analysis was done by taking 20ml petrol without any addition.
- As discussed above we took the analysis in standby position and measured the running time with 20ml petrol which was 00:04:16 (4mins. 16seconds).

B. Results for Fuel Efficiency, Fuel – Petrol Plus Oxy-Hydrogen

- Thereafter two analyses with 20ml petrol with the addition of oxy-hydrogen were performed.
- Oxy-hydrogen was injected in the engine through a small hole in the air suction pipe below the fuel tank by inserting a nozzle through the hole as shown in the picture.

Fig. 13: Results

- The results from two analyses with oxy-hydrogen and 20ml petrol were 00:05:12 (5mins. 12seconds) and 00:05:26 (5mins. 26seconds).
- From results it can be easily seen that bike runs approximately 1min more with the addition of oxy-hydrogen. Hence, we can say that fuel efficiency is improved.

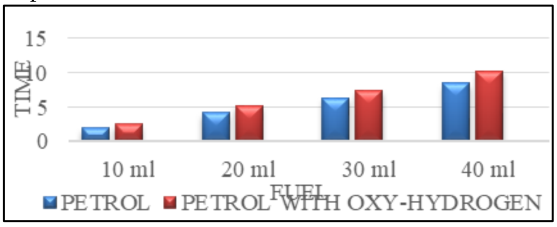

Fig. 13: Results

C. Results for Emissions Levels

The emissions were determined by PUC, before and after the addition of oxy-hydrogen and the result can be seen easily in the picture.

Emission level of CO was 0.054 with engine running only on petrol.

Emission level of HC was 10 with engine running only on petrol.

Emission level of CO was 0.041 with engine running on petrol Plus oxy-hydrogen.

As we can see from the results, CO emissions reduces 24% by adding oxy-hydrogen while the HC emissions remains the same for both.

IX. CONCLUSION

- Performance: Stand-by time of engine was increased substantially from which we can say that there is less fuel consumption for a given amount of fuel due to addition of oxy-hydrogen which can be noticed by the below comparison
- Exhaust: There was a noticeable change in the amount of carbon monoxide with and without adding of oxy-hydrogen with the fuel which can be seen below.

These results were quite satisfying. Hence, it is proven that by adding oxy-hydrogen as a fuel along with petrol in an I.C. engine we can increase the fuel efficiency without any major modification in the bike without causing any harm to the engine or bike. As well as we can also reduce the emissions levels hence we can say that it is eco-friendly.

REFERENCES

[1] Barreto L, Makihira A, Riahi K. The hydrogen economy in the 21st century: a sustainable development scenario. Int J Hydrogen Energ 2003; 28:267e84.
[2] Bacon FT. The high pressure hydrogen oxygen cell. J Ind. Eng. Chem. 1960; 52(4):301e3.
[3] Fodor Dinu-research and experimental results regarding the burning of lean mixtures with added on board produced hydrogen.
[4] D. Fodor, “Some possibilities for Using Lean Mixtures with the DACIA 1300 Engine”, A IV-a Confer in ta National a demoto are, automobile si masini agricole, Brasov, 1982;
[5] Hekkert MP, Van Giessel J-F, Ros M, Wietschel M, Meeus MTH. The evolution of hydrogen research: is Germany heading for an early lock-in? Int. J Hydrogen Energ. 2005; 30:1045e52.
[6] Momirlan M, Veziroglu TN. Current status of hydrogen energy. Renew. Sust. Energ. Rev. 2002; 6:141e79.
[7] Schulte I, Hart D, Vorst R. Issues affecting the acceptance of hydrogen fuel. Int J Hydrogen Energ. 2004; 29:677e85.
[8] Ajoko, Tolumoye John, “generation of power through hydrogen –oxygen fuel cells”
[9] Santilli RM. A new gaseous and combustible form of water. Int. J Hydrogen Energ. 2006;31:1113e28.
[10] Abdel-Aal, H. K.; Hussein, I. A. Electrolysis of Saline Water under Simulated Conditions of P.V. Solar Cell. Proceeding of 9th WHEC, Paris, 1992, pp. 439-442.
[11] Bockris, J. O.M. Energy: The Solar Hydrogen Alternative. Australia and New Zealand Book Co., Sydney, 1975.

