International Journal of Information, Engineering & Technology

Volume 11, Issue 7, PP 114-124, ISSN: 2360-9194, December, 2022
DOI:427214543811812
Double Blind Peer Reviewed International Research Journal
https://arcnjournals.org
arcnjournals@gmail.com
Journal Series: Global Academic Research Consortium (garc)

Design and Construction of Hydroxyoxygen (HHO) Fuel Cell

[1]Muhammad Hussaini, M.B., Oumarou[2] and G.M. Ngala[3]
[1]Department of Mechanical Engineering, College of Agriculture, Science and Technology Gujba, Yobe State School of Engineering
[1&2]Department of Mechanical Engineering, University of Maiduguri

Abstract: *The advancement in technology in our world today which results in global warming has led researchers to look for another source of renewable energy such as hydrogen. In this research, the design and construction of a fuel cell were carried out using the electrolysis of water and potassium solution; by splitting hydrogen and oxygen and recombining them to form hydroxyoxygen (HHO) gas. The materials used in the construction of the fuel cell are Water; potassium; 45Amhs/12v battery; Candle wax; Fuel Tank; Reactor; Safety Bubbler; Battery Cables and; Thread. The performance had been tested and works effectively having an output power of 3.4Watt producing 0.5 litres of Hydroxyoxygen gas (HHO gas). HHO gases sometimes leak through the candle wax that serves as a sealant. The cell if coupled with a burner and small generator can work as a stove and HHO-operated generator respectively. It is recommended that further work should be carried out on how to control gas leakages.*

Key words: *Electrolysis, Hydrogen, HHO Gas, Water, Potassium, Energy.*

1.0 Introduction

In our modern days, the world had become advanced in technology. Many machines were developed and run on fossil fuels that generate a lot of emissions of pollutants into the atmosphere that results in global warming. All these pollutants need to be addressed in other to be minimized. Hydrogen is one of the most common elements that are known to exist and the first element found in the periodic table that is with the letter H. The ratio of hydrogen is 80% and is the main substance of the visible universe and is common on Earth. Many stars consist of the sun; which liberates energy by fusing hydrogen with helium. In fact, the sun ball formed these two elements. In a process called fusion, in this way four hydrogen atoms combine to form one helium atom generating the energy as radiation. This radiation energy is one of the most abundant sources of energy. It provides us with light, and heat makes plants grow, and makes the wind blow and rain fall, (International Energy Agency, 2013). On earth, the most familiar hydrogen compound is water where two atoms of hydrogen combine with one atom of oxygen (H_2O). All the complex molecules of life contain hydrogen. (Winter, 2009). Electrolysis is a well-known process that converts water into hydrogen and oxygen using electricity. Electrolysis opens the door to hydrogen production from any primary energy source that can be used for electricity generation and heating etc. (Thomas, 2001).

1.1 Statement of Problem

Using raw Biomass in rural areas for cooking causes air pollution that provokes eye irritation, environmental problems, and other health challenges.
Lack of access to electricity or liquefied petroleum gas (LPG) has led the rural dwellers not to use electricity for cooking and another domestic usage.

1.2 Significance of the study

1. Reducing carbon emissions into the atmosphere due to cooking with raw biomass.
2. Free from eye irritation due to cooking with fire firewood produces smoke,
3. Promote the use of hydroxyoxygen gas for cooking in the absence of the National grid or LPG gas, especially in rural areas.

1.3 Aim and Objectives

The aim of this work is to Design and construct a Hydroxyoxygen (HHO) fuel cell, while the objectives are to:
i. design and construct the reactor that will split the hydrogen and oxygen from water and potassium solution.
ii. construct the fuel tank and safety bubbler that are capable of holding the reactor and the solution.

1.4 The Scope of the study.

This work is focused around the use of water and potassium ("Jarkanwa'').

2.0 Literature Review

A fuel cell is an electrochemical device use for splitting hydrogen and oxygen and recombines to form hydroxyoxygen (HHO) gas, (Rajasthan, 2014).
HHO-hydroxyoxygen (HHO) is diatomic structure which was formed from the molecule of two atoms for both the gases oxygen and hydrogen. HHO is free from release of harmful gases and it doesn't emit or produce any contaminants into the atmosphere when burned. Er-Dong, (2008).

In electrolysis, an electrical current is passed through a conductive substance (the electrolyte) in order to drive a non-spontaneous reaction. The reaction which is endothermic requires an input energy, (Pervez, 2016) in order to decompose water into hydrogen and oxygen. Water is filled into the fuel tank where it will be demineralized and will have zero conductivity and by introducing potassium hydroxide (KOH), it becomes conductive. When the reactor receives DC supply from the battery, it ionizes the molecules of hydrogen and oxygen .Thereafter bringing them together to form hydroxyoxygen (HHO).Desilva, (2015).A fuel cell is a device that generates electricity by a chemical reaction. Every fuel cell has two electrodes called respectively, the anode and cathode (Smithsonian, 2017).HHO is also known as "Brown gas "which derived from the name of Professor Yull Brown who found some unique properties of HHO (Schlapbach, 2001).

In advanced fuel cell systems, the heat released by the stack can be purposely recovered for internal (1) or external (2) heating. Examples follow:
(1) Heat can be used for conditioning reactant gases = pre-heating + humidification;
(2) Heat can be used for providing space and/or heating. (Swisher, 2002). Cogeneration by heat recovery is a powerful means to increase the overall efficiency of fuel cells systems up to 80-85 %(Jobwerx, 2004). It is very advantageous in high temperature fuel cell system. Hydrogen readily oxidizes in contact with platinum and oxygen (Vogt, 2010). While this is favourable for conversion to heat, critical safety issues are to be paid attention to. Due to the broad range of Flammability (4-75%), premixing hydrogen and oxygen prior to oxidation can easily lead to uncontrolled combustion in the mixing chamber. In order to avoid premixing, an approach where hydrogen and air are supplied from separate sources to the catalytic active combustion area was adopted. Catalytic hydrogen combustion can reach temperatures of up to 1000°C. (Eth-Zurich, 2014). Hydrogen burns differently than either propane or natural gas. In particular, hydrogen's rate of diffusion and flame velocity are roughly ten times greater than the propane or natural gas ones. The great advantage of burning hydrogen is that, Hydrogen doesn't produce pollution, but only NOx. (H_2Nitidor, 2015).
The properties of hydrogen according to Rajasthan, (2014) are: Energy density: 120-140Mj/kg at STP; Critical pressure: 12.96 bar; Triple point temperature: -259.19^{o}c; Critical temperature: -240^{o}c; Molecular weight: 2; Triple point pressure: 0.077bar; if hydrogen gas doesn't leak, it will produce 3xmuch energy compared to natural gas and; Octane number: +130.

A method by which water is split into hydrogen and oxygen is called electrolysis. The discovery of electrolysis and its use to split water dates back to the 1800$_s$ when William Nicholson and Anthony Carlisle observed the evolution of gases during early experiment to replicate the voltaic pile (the world's first battery, invented by alessondro Volta).There are two main technologies for water electrolyte in use today alkaline electrolytic cells (AEC) and proton exchange membrane electrolyser cells (PEMEC).(Jassen,2001).High temperature water electrolysis is a third method which is currently in the research and development stage. This type of cell is known as solid oxide electrolytic cell (SOEC).These three technologies share number of similarities with their fuel cell operating in reverse. In PEMEC system, it also operates in the reverse as fuel cells (Sami Tuomi, 2013).

Rajasthan, (2014). Constructed a home gas, by hydrogen fuel cell. This was utilized and used as HHO stove. A process of electrolysis was used to generate HHO gas (hydroxyoxygen).Through a burner for heating or cooking purpose. A reactor was constructed to have one hundred and ten plates (110).The power supply was 220volt from the National grid. A NAOH was used as additive into the water and the safety bubbler was made of steel.

The output of hydrogen was about 504 litres while 254 litres for oxygen in an hour which had accumulated up to 758 litres. This supply of hydrogen gas was connected to HHO stove. The work had been tested and found to have worked efficiently. Hydrogen is a very explosive gas and the problem in using hydrogen is the risks of fire or bursting. Other problems associated with hydrogen include storage and its production cost.

Jason (2018), Constructed improvised Hydrogen Fuel cell to generate cooking gas with an additives of KOH solution, gives out hydrogen gas when electric current is passed into it.But this hydrogen cannot be directly used as it contains moisture .In order to remove moisture, and it is sent into dryer. The dryer ensures that the hydrogen gas is completely moisture free. The fuel cell is connected to the dryer through a gas pipe. The hydrogen that is moisture free cannot directly use as cooking fuel as the amount of hydrogen expose to fire is very critical. It is passed to the collecting chamber through gas injector. The burner rim used has minute holes and sufficient amount of hydrogen is exposed to fire through the burner. The fuel cell stack and electrodes conditioner. The fuel cell stacks contain 32 sub stacks of fuel cells.

3.0 Materials and Method

3.1 Materials and Equipment used

The materials used in the construction of the fuel cell are: Water; potassium; 45Amhs/12vBattery; Candle wax; Fuel Tank; Reactor; Safety Bubbler; Battery Cables and; Thread.

3.1 Method/procedure

Is used electrolysis to produce hydrogen gas or HHO gas by splitting of water into hydrogen and oxygen. When a fuel reactor receives a DC supply and it ionizes the molecules of hydrogen and oxygen and separated it to form hydrogen and oxygen. And then further to recombine to form hydroxyoxygen (HHO).HHO cell, (2010).

$$20H_2O(L) + KOH(aq) \rightarrow 2H_2(g) + O_2(g) + K_{-(aq)} + OH_{-(aq).}$$

The hydrogen gas rise up to the upper portion of the fuel tank and flow through the hose and goes to the safety bubbler and can be used for producing heat and goes out through the out let of the safety bubbler through the hose up to the injector needle for burning. The complete setup of the fuel cell is as shown in figure1 below.

Plate1. Block diagram of complete setup process (Enel, 2013).

Reactor

Strips of metals were cut to 13.5 x 1.5 cm from a stainless steel that comprises 16 plates with gap of 1.5mm that form a complete reactor.

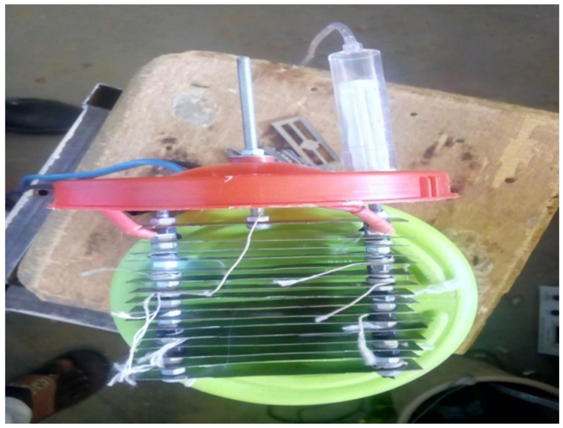


Plate 2. Reactor with a series of plates

Bubbler

Two perforated holes were produced on the top of the bubbler that serves as an inlet and outlet of the HHO gas. The bubbler is half filled with water, and a hose from the fuel tank is connected to the bubbler through the inlet. Another hose is also connected at the top of the bubbler that serves as the outlet of the hydroxyoxygen gas (HHOgas).

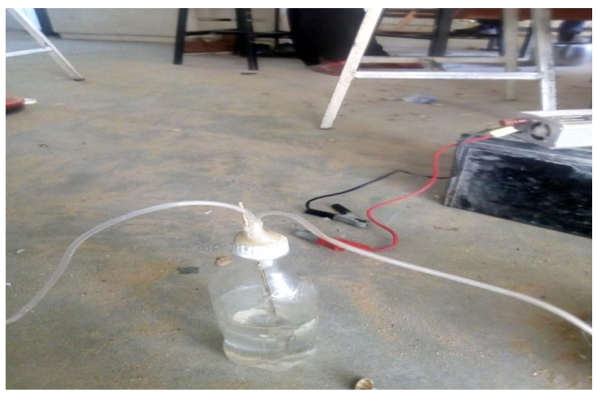


Plate 3. Safety Bubbler

Fuel Tank (electrolyser).

It had been made from a thermoplastic which produced from chlorination of polyvinyl chloride (PVC) resin. The fuel tank (electrolyser) has connected with two terminals that connect the reactor. And a hole was produced at top of the fuel tank and a hose was connected through the hole this serves as the out let of the HHO gas.

Plate 4. Fuel tank (electrolyser)

A Candle wax

The holes were produced on the surface of the fuel tank where cables were connected to the reactor and the outlet for HHO gas which a hose was fixed. All these points were sealed with candle wax to avoid leakages.

Battery

A battery of 12volt /45Amps was selected and used in a closed container that has two terminals of both positive and negative terminals and with an opening where a solution of hydrogen sulphide (H_2SO_4) can be introduced into it. The battery serves as a reservoir for storing energy and releases energy when needed.

Plate 5. Battery

Rectangular Stainless Steel

A rectangular strips of metals made from stainless steel were cut to a size of 13.5x 1.5cm these were used for construction of the reactor. For each sets of the strip one serve as anode while the other as cathode.

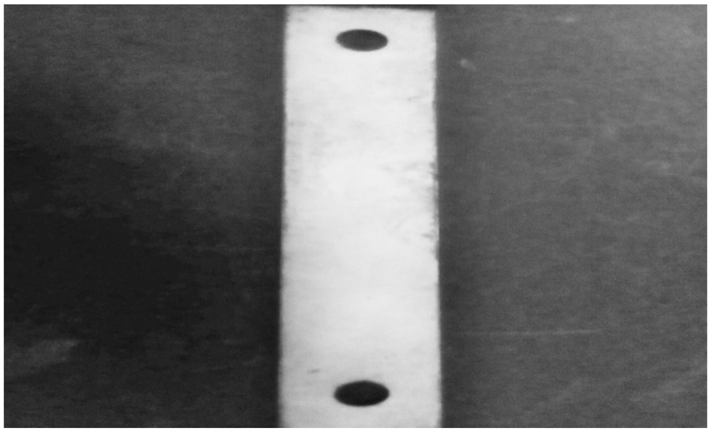


Plate 6 A rectangular stainless steel plates (13.5x1.5cm)

Thread

It had been used to worn the thread round both anode and cathode to separate the strip sheet of metal from contact with the nut.

Battery Cables

A copper cable with clips at both ends of the cables and are used to make connections between the two terminals of the battery and to that of fuel tank

2.2.1 Design Analysis

To get a desirable out put the following must be considered:

a) $lenght\ of\ the\ plate.$
b) $breath\ of\ the\ plate.$
c) $Diameter\ of\ the\ circular\ hole\ on\ the\ plate.$

$surface\ area\ of\ expose\ to\ H_2\ is\ given\ by\ Rajashthan(2014)$

$$surface\ area\ expose\ to\ H_2 = 2circle\ area - area\ of\ rectangular\ plate \quad (1)$$

$$2circle\ area = 2\pi r^2 \quad (2)$$

$$Area\ of\ rectangular\ plate = lb \quad (3)$$

$r = radius\ of\ the\ circular\ hole = 3cm$
$\pi = 3.142$
$Arbitrary\ selection$
$length\ of\ the\ plate\ = 13.5cm$
$breath\ of\ plate = 1.5cm$
$using\ equation\ 2\ \ 2circular\ area = 2 \times \pi \times 3^2 = 56.55cm^2$
$applying\ equation\ 3\ area\ of\ rectangular\ plate = 13.5 \times 1.5 = 20.25cm^2$
$Recalling\ equation\ 1\ surface\ area\ expose\ to\ H_2 = 56.55 - 20.25 = 36.30cm^2$
$The\ electrical\ resistantance\ to\ electrolyte\ is\ given\ by\ Kaveh\ (2012)$

$$R = \frac{\rho l}{A} \quad (4)$$

$A\ standard\ gauge\ for\ density\ of\ stainless\ steel\ is\ given\ by\ Yieh\ (2018)$

$$\rho = 7.7g/cm^3 \quad (5)$$

$The\ output\ power\ of\ the\ cell\ is\ given\ by\ Rajashthan\ (2014)$

$$output\ power\ of\ fuel\ cell = IV \quad (6)$$

$I = current$
$V = voltage$
$lenght\ of\ the\ battery\ cables = 200cm$
$Recall\ equation\ 4$

$$R = \frac{7.7 \times 200}{36.30} = 42.42\Omega$$

$$I = \frac{V}{R} = \frac{12}{42.42} = 0.28A$$

$out\ put\ power\ of\ the\ fuel\ cell = I \times V = 0.28 \times 12 = 3.4watt$
$volume\ of\ pvc\ tank\ is\ given\ by\ Jason\ (2018)$

$$volume\ of\ pvc\ fuel\ tank = \pi r^2 h \quad (7)$$

$height\ of\ the\ fuel\ tank = 138cm$
$Diameter\ of\ the\ fuel\ tank = D/2 = 6/2 = 3cm$
$volume\ of\ the\ fuel\ tank = \pi r^2 h = 3.142 \times (67.5)^2 \times 138 = 1975.32cm^3$

$$convert\ to\ liters = \frac{V}{10^3} = 1.975liters \simeq 2liters$$

$$\frac{2}{3}\ of\ fuel\ tank\ fill\ with\ water\ and\ additives = \frac{2}{3} \times 2 = \frac{4}{3} = 1.33liters$$

$the\ amount\ of\ hho\ gas\ in\ liters\ will\ be\ = 2 - 1.33 = 0.67liters$
$therefore\ hho\ gas = 0.67liters$
$The\ energy\ out\ put\ is\ given\ by\ Akanksha\ (2014)$
$Energy\ density\ of\ H_2 = 130\ Mj/kg$
$Density\ of\ \ H_2 = 0.085\ gm/l\ \ \ at\ room\ temperature$

$$Energy\ out\ put = 0.67 \times 0.085 \times 0.001 \times 130 = 7.4035 \times 10^{-3}\ Mj/hr \quad (8)$$

3.0 Results and Discussions

The work was completed and tested where HHO gas flows through the nozzle to the air and a flame was brought close to the gas and ignited then burning continues as shown in the figures below.

The following are the results obtained

Table 1: Results obtained from the constructed fuel cell.

Requirements	Calculated values	Measured values	Difference
Output power	3.4watt	3.5watt	0.1watt
HHO gas produced	0.61	0.5l	0.1l
Energy output	7.403x10^{-3}Mj/hr.	7.0x10^{-3}Mj/hr.	0.403x10^{-3}Mj/hr.

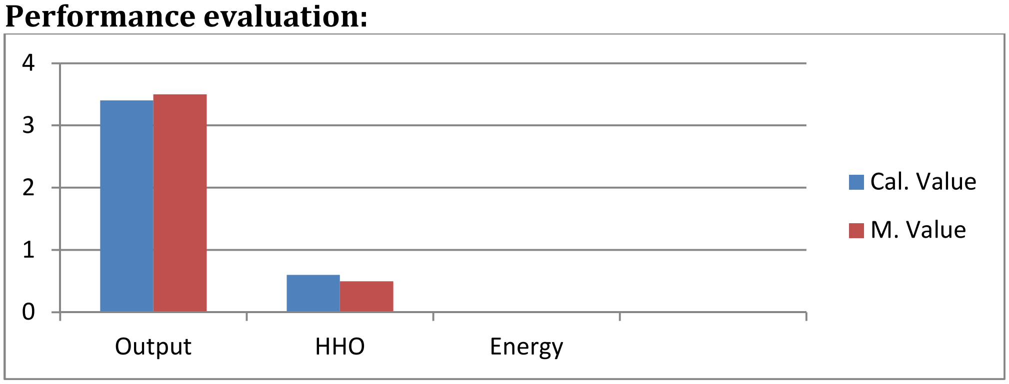
Source: Experiment (2018)

Table 1 above shows that in the design, the fuel was expected to give an output power of 3.4 watt while after the construction the power was measured to be 3.5watt with a difference of 0.1watt additional.

In fuel cell design, the hydroxyoxygen gas (HHOgas) which could be produced was expected to be present was 0.6 litres and when it was constructed the measured value of hydroxyoxygen gas (HHO gas) was measured to have 0.5 litres which resulted in a difference of 0.1litre.

By virtue of the design of the fuel cell, the expected energy output was 7.403x10^{-3}Mj/hr. while fuel on completion, the measured value was found to be 7.0x10^{-3}Mj/hr. The difference was 0.403x10^{-3}Mj/hr. the complete setup of the constructed fuel cell is shown in figure 8 below.

Performance evaluation:



The graphical representation of the results obtained

Plate 8. Complete setup

Conclusion

-The design and construction of the fuel cell were carried out successfully using the method of electrolysis.

- A quantified amount of 10 grams per litre of potassium was used to form the solution (electrolyte).
- The fuel cell was tested and produces about 0.5 litres of hydroxyoxygen gas (HHO gas); an output power of 3.5 W and an energy output of $7.0x10^{-3}$Mj/hr.

REFERENCES

Akanksha, PB. Chaurasia (2014),'Home Gas by Hydrogen Fuel cell' International Journal of science and Research vol. 3 pg. 1-3

Desilva Ts. L.seneverathne, T.N and TD.Warnasoria (2015),'HHO generator and approach to increase Fuel Efficiency in Spark ignition Engine *'European journal of Advances in Engineering and Technology*

Er-Dong Wang, Peng –Fesh and Chun-Yudu Xiao-Rui Wang (2008),Á mini-type hydrogen generator from aluminium for proton exchange membrane fuel *cell' journal of power sources.*

Enel, F. (2013), 'The world first hydrogen fuelled power plant' Available: http//www.enel.com accessed March 2018.

HHO cell (2010), 'HHO Cell configurator' Available: http//www.hho4free.com accessed 20th July, 2018.

International Energy Agency (2013), 'Energy Technology essentials' Available: http//www.iea.org accessed 14th July 2018.

Jason ElroyMartis, (2018),'improvise Hydrogen Fuel Cell to generate cooking Gas '*International Journal of science and Technology Research*'vol. 7 ISSN: 2278-7798.

Kaveh M, Nasir B., Hossein M., (2012),' Electrical Efficiency of Electrolytic Hydrogen production' international of Electrochemical Science. Vol.7 pg.3314-326.

Pervez A., Chris N. Christodoulou, G.N Karagiorgis(2016),'Fuel cell Technologies and Hydrogen/ Hybrid Automobiles' Cyprus Journal of science and Technology.

Sheref SA., F.Barbir and TN Veziroghi (2003),'Principle of Hydrogen Energy storage and utilization '*Journal of Science and Industrial Research*, Vol.62 pg. 32-63.

Sami-Tuomi, Ánnukka Santasalo-Aeronio, PetriKannien, Tanja Kallio (2013),'Hydrogen production by Methanol water and alkaline membrane cell '*Journal of power sources* Vol.229 pg.32-35