UTILIZATION OF HYDROGEN FOR ELECTRICITY PRODUCTION BY TWO STROKE INTERNAL COMBUSTION ENGINE GENERATOR SYSTEM

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Abstract

This study proves the use of hydrogen as an alternative source of energy. The hydrogen is used as the catalyst in the generator to generate power to operate a wall fan. By using the chemical reaction of the water, aluminum, and caustic soda, the researchers harness hydrogen as the by-product of the reaction chamber of the generator. For the study to be accomplished, the need to fulfil the problems encountered in the process of making a hydrogen generator in a budget-friendly community was demanded. For the design, the researchers utilized simple materials that the normal households can gather. Based on the related studies and literatures consulted, it is deemed that the use of hydrogen can be an alternative source of energy for the fossil fuels. While the fossil fuels emits greenhouse gases in its combustion, the hydrogen produces non-harmful vapor in the environment. This statement is clearly demonstrated in the test done for the study. The materials are considered to withstand the pressure of the hydrogen by analyzing and evaluating the reaction in the chamber.

Keywords: Hydrogen Engine Generator, Chemical Reaction, Water, Aluminum, and Caustics Soda

The Philippines, as a tropical archipelago, has the potential to generate a lot of energy from natural resources (solenergy.com.ph 2016). The Philippines is blessed with indigenous renewable energy sources, which can power its energy needs well into the future (opinion.inquirer.net 2019). But, the uncertainty and insecurity of the future of energy brought about by remarkable global oil demand, supply challenges in the oil market and drastic impact of global climate change heighten the vulnerability of the Philippines to global oil market while being a net importer of crude oil. Thus, making an alternative source of energy comes to the fore of the researches for the production of electricity.

As stewards of the environment, human beings are responsible for preserving and protecting the natural resources for the future generation (www.epa.illinois.gov). By using chemical reaction to split water into hydrogen and oxygen and use it as a fuel, man can save production and energy costs, furthermore, reducing the negative impacts of extraction and processing of raw materials on the environment. In a broad sense, innovating creates an ethic of resource efficiency, hence, using products to their fullest potential.

Innovating is the application of better solutions that meet new requirements, unarticulated needs and existing market needs. By innovating an alternative way of producing an electricity, it will help a lot to the normal household wherein the major problem is the lack of electricity without the negative effect on the environment.

Republic Act No. 9513 or the 'Renewable Energy Act of 2008' was codified in December 2008 to affirm the government's commitment to accelerate the utilization of renewable energy (RE) resources in the country. This is to effectively reduce harmful emissions and achieve economic development while protecting health and the environment. Renewable energy is an essential part of the country's low

emission development strategy and is vital to addressing challenges of climate change, energy security, and access to energy (http://ap.fftc.agnet.org 2008).

When using hydrogen as fuel to power a generator, it is completely clean technology and the only byproduct is water. There are no environmental dangers like oil spill, adds no greenhouse gases to the environment. Hydrogen can easily be produced when electricity and water are utilized in the electrolysis process.

Hydrogen as fuel to a generator is considered to be a high efficient, low polluting fuel that can be a huge change in the power generation industry and the world. Using hydrogen as fuel will help the industry to become less dependent on imported fuel that is becoming costly nowadays. Hydrogen powered 2-stroke ICE generator will cost less because it has the highest energy content and its output is also considered as a clean energy similar to electricity produced by a fossil fuel.

The researchers are very interested in innovating a gasoline generator to a hydrogen powered 2-stroke ICE generator. The researchers brainstormed and came up with the idea that one of the most efficient ways of harnessing hydrogen is to use them as fuel of a generator, which may lessen the problems with the fossil fuel consumption and will greatly help electricity consumers in far flung areas in the Philippines because sending hydrogen by pipeline than sending electricity over long distances by wire is considered to be cheaper. (https://www.azocleantech.com 2008)

Statement of the Problem

The general problem of the study is: How will the use of Hydrogen Powered 2-stroke ICE generator benefit those who lives in far flung areas?

Specifically, it sought to answer the following

question:

1. What should be the appropriate design for making hydrogen powered 2-stroke ICE generator?
2. What are the equipment and materials needed to generate electricity using hydrogen powered 2-stroke ICE generator?
3. What are the test to be performed that can ensure the efficiency of the hydrogen powered 2-stroke ICE generator?
4. What are the advantages of using hydrogen powered 2-stroke ICE generator instead of using gasoline powered generator?

Objective of the Study

1. To develop appropriate design in producing hydrogen powered 2-stroke ICE generator.
2. To determine the appropriate equipment and materials needed to produce electrical energy from hydrogen using hydrogen powered 2-stroke ICE generator.
3. To test the viability and efficiency of the generator.
4. To determine the properties and advantages of hydrogen powered 2-stroke ICE generator that is eco – friendly, easy to use, requires low maintenance cost and operation compared to gasoline powered generator.

Significance of the Study

Because of the decreasing amount of fossil fuels available for the next generations, alternative way of producing energy must be harnessed and developed. This study aims to be significant to the following:

Students of mechanical engineering and other allied fields like electrical engineering, chemical engineering and industrial engineering will be able to identify the advantages of using hydrogen gas as fuel in generators and how it improves the efficiency of the generator.

School. This research will benefit the school because the product will become a laboratory apparatus for the mechanical engineering students which will further increase their knowledge of renewable energy resources.

Community. This research is significant to the community members because it will inform them of the different methods of producing electricity for electronic devices such as smartphones or even to light up bulb.

Environment. This research is significant to the environment because this hydrogen powered 2-stroke ICE generator is eco-friendly. There will be no dangers like oil spill, adds no greenhouse gases to the environment.

Researchers. This research is significant to the researchers because it will help them to be aware and become knowledgeable about the processes involved in the hydrogen powered 2-stroke ICE generator. It would help them to become better analysts.

For the Future researchers to have additional information on the conduct of an in-depth study using hydrogen gas.

Scope and Delimitation of the Study

This study will focus on the demonstration and analysis of Hydrogen Powered 2-stroke ICE generator. One of the major concern in the study is the cost to benefit ratio and the impact of the generator in the environment.

Hydrogen will be used to fuel the generator, using chemical reaction the researchers will extract hydrogen gas from aluminum with water as its catalyst to increase the rate of chemical reaction.

Theoretical Framework

This section provides review of related concepts, principles, and studies that were relevant for examining the problem and serves as guide to examine the relationships between factors affecting the study. This includes the conceptual principles of the study and research framework. Different media were used to collect information that utilizes different materials found from books and internet in acquiring information related to the study.

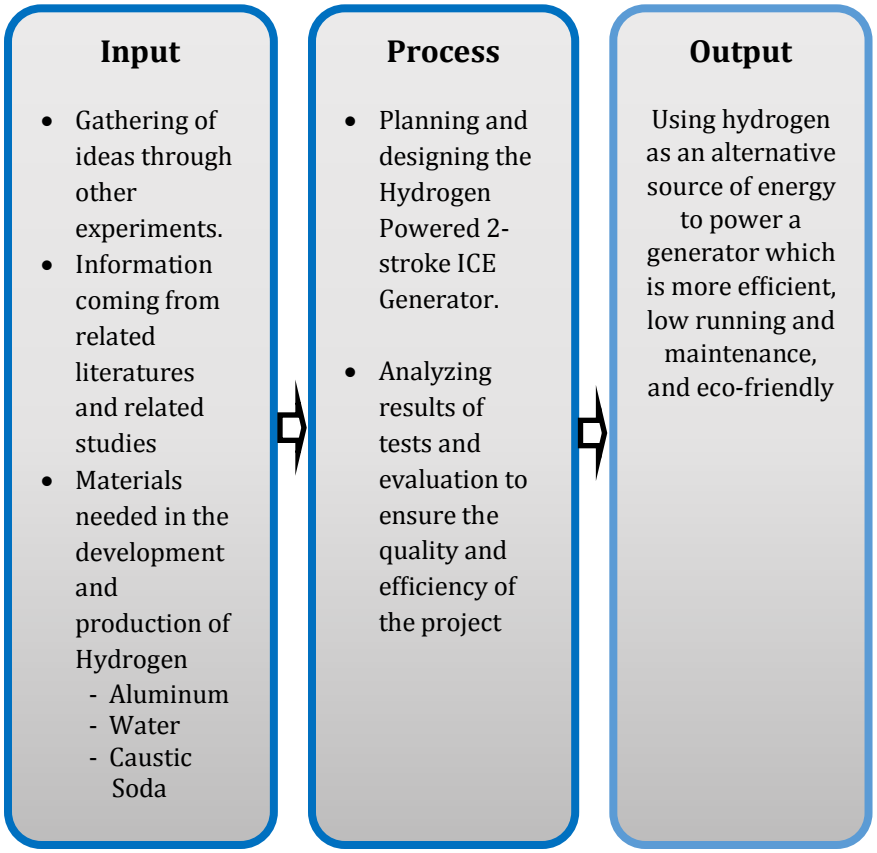

Figure 1. Theoretical Framework of the Study

Related Literature

Phair, J.W., (2006) discussed the separation membranes in hydrogen and oxygen production and future power generations. He stated that the hydrogen can be harnessed through the use of fossil fuels and considered as a potentially excellent alternative for transport due to the concern over the dwindling oil reserves and global warming. Membrane separation has the advantage over other separation methods in that it is simple and potentially less energy intensive. Where the aspects of critical design of the membrane such as multiple design, nano-structure control, the need for surface layers and fabrication processes are also reviewed while representing the areas where research and development effort is likely to be directed in the future.

The article briefly explains the other way to harness hydrogen through membrane separation.

Bowen, C.T., (1984) designed a two parallel alkaline water where the objective is the evaluation of new anode, cathode, and separator materials on an industrially-significant scale of hydrogen generation. Using a porous Teflon cloth impregnated with potassium titanate shown to have the lowest resistance factor of the separators tested, but its fragility and hydrophobicity are of concern. The other one is the felted polysulfone that has shown robustness, gas tightness and low resistivity required. He stated for all the separators, effective resistivity has been found to depend in the free space allowed, the strength of this effect increasing with separator hydrophobicity. Furthermore nickel electrodes, plasma-sprayed with nickel/aluminum or nickel/stainless steel powders, gave good electrocatalytic activities with high stability.

This article by Bowen, C.T. (1984) discussed the ups and downs of materials that can enhance the generation of hydrogen through the use of alkaline water by the process of electrolysis.

De Jesus, A., (2012) introduced another method of hydrogen production, the reduction of water using aluminum or its alloys. Because of its light weight and great strength, aluminum is widely used for structural purposes and also offers important advantages for its potentially wide employment as an energy carrier. Its high energy density of 29 MJ/kg, and the fact that it is the most abundant metal in the Earth's crust, and its highly negative standard redox potential (εO = -1.66 V) makes it an excellent reducing agent capable of producing hydrogen gas upon contact with the water in a corrosion process that does not entail production of CO2.

Also, he stated that the storage of hydrogen at standard temperature and pressure requires a volume of 3000 – fold larger than for gasoline, and in a liquid state it is necessary to take it to temperatures of -253°C through cooling systems, which entails additional important energy costs. This literature states the required measurements of the container that will be used to store hydrogen. Because it is crucial for the safety of the researchers and user, having the standard size, based at specific standard temperature and pressure is needed.

According to Nikolaev, V.D., (2005), it is not the H_2O that makes the engine run. It's what the H_2O does to the inefficient gasoline concerning combustion efficiency. Gasoline is about only 18% efficient on average when it comes to actual power produced by the combustion process. Adding hydrogen to gasoline and oxygen "H_2O" causes efficient gasoline to burn at a rate of 95% efficiency.

This literature explains that hydrogen gives an increase performance, horsepower, and cleaner emissions from the gasoline which is now being supplemented by the hydrogen.

According to Borman & Ragland (1998), even though combustion is beneficial there is the need to look at the

downside that is associated with combustion-environmental pollution. It is one of the main causes of pollution to the environment, the combustion emission which are carbon monoxide, hydrocarbons, nitrogen oxides, and sulfur oxide. Natural gas is one of the most combustible materials. It is a clean-burning fuel however was difficult to transport. After World War II, extensive pipelines were built to distribute natural gas to be used to repair destructions caused by war.

Veziroglu, E., (2003), states that the advantage of using hydrogen is that it can make a huge impact to the energy sectors because it can provide viable and sustainable options for meeting the world's energy requirements. Hydrogen can be applied in transportation, buildings, utilities, and industry. Using hydrogen systems can reduce the climate impacts of continued fossil fuel utilization. The advantage of using the hydrogen system is, it creates a huge impact in providing energy which is essential nowadays and can be used as an alternative source of electricity. Using hydrogen rather than fossil fuels helps to reduce greenhouse gases which fossil fuel emits.

Also, Veziroglu, E., (2010), further stated that, hydrogen generator can be developed through the help of tubular catalytic reactors, where the gas inside the reactor produces wet hydrogen and borate through the process of exothermic hydrolysis reaction of an aqueous sodium borohydride solution in contact with no-noble catalyst particles. The gas is soluble to water and not harmful to the environment.

This literature explains that hydrogen can be produced by exothermic hydrolysis and can produce a non-harmful gas to the environment.

Turns, S., (1996) discussed that the prospect of using hydrogen as a fuel in an automotive fuel cell is attractive and can be combusted in an internal combustion engine directly through the atmosphere with oxygen. The generation of

hydrogen from fossil fuels is feasible but that idea may create difficulties in transport and handling of hydrogen gas. Hydrogen production through electrolysis of water is in principle the cleanest route because this process produces only hydrogen and oxygen. Furthermore, electrolysis would make it possible to generate hydrogen locally, thus avoiding many transportation problems. However, the energy required to electrolyze water must come from somewhere to activate. So he stated that if fossil fuels will be burnt to generate electricity for the production of hydrogen, the industry has not advanced very far towards a true hydrogen economy.

This article describes the use of the hydrogen for the economy. It also stated that the concepts of using hydrogen as an alternative fuel or energy source should not rely on burning fossil fuels for its production.

In the article prepared by Alinejad, B. and Mahmoodi, K. (2009) one of the many authors of the International Journal of Hydrogen Energy, they discussed a method of generating hydrogen by hydrolysis of highly activated aluminum nanoparticles in pure water. The method is simple but they can generate a 100% efficient and pure hydrogen in a large scale of highly activated aluminum in water by hydrolysis, using milled aluminum as salt particles or nano-millers with different salt to aluminum mole ratios. The brittle nature of the salt particles will fracture the aluminum particles by their sharp edges that leads to an incrementing hydrolysis kinetics. Meanwhile the salt particles are driven into newly created surfaces of aluminum particles, producing salt gates that will be removed in the water environment, causing the hydrogen generation reaction to proceed. Where the reaction created another product called aluminum oxide hydroxide that can be easily separated from water and nature friendly. The highest average rate of hydrogen generation in this study is 75 mL/min per 1g of aluminum.

The article stated another way to developed

hydrogen production by focusing on using aluminum as the catalyst.

In the paper prepared by Soler, L., Macanas, J., Munoz, M. and Casado J. (2007), one of the many authors of Journal of Power Sources, it discussed about the aluminum and aluminum alloys as sources of hydrogen for fuel cell application, where the process is based on aluminum corrosion, consuming only water and aluminum which are cheaper materials than other compounds used in hydrogen generation. In principle, their method does not consume alkali because the aluminum salts produced in the hydrogen generation undergo a decomposition reaction that regenerates the alkali. As a consequence, this process could be feasible as an alternative for hydrogen production to supply fuel cells. The preliminary results in their test showed that an increase of base concentration and working solution temperature produced an increase of hydrogen production rate using pure aluminum.

This article stated that the used of aluminum can increase the hydrogen generation better than any other compounds.

In 2005, Kravchenko, et.al (2005) discussed the activation of the aluminum metal and its reaction with water. They dope the aluminum based metal composites with gallium, indium, zinc or tin as the hydrogen generating materials in reaction with water. They study it by using the powder x-ray diffraction, DTA, and EDX. The sample that contains up to 80% aluminum were demonstrated to be multiphase mixtures contains dispersed grains of aluminum based solid solutions as well as components of foundry alloy, zinc, and tin and a liquid phase which is eutectic with a melting point of 6 degrees. The rate and amount of hydrogen generated is based on the quantitative and qualitative compositions of alloys as well on the time and conditions of their storage.

Vargel, C. (2004), stated that Sodium Hydroxide is highly soluble in water, and sodium hydroxide solutions are strong bases. The attack of aluminum is uniform and regular. The dissolution rate depends on the concentration. The dissolution rate sharply increases with temperature. To plunge a piece of aluminum into sodium hydroxide solution presents a real hazard of projections, due to the very violent release of hydrogen gas resulting from the attack. This process has to be carried out under strictly controlled conditions, always close to the following typical set of parameters: NaOH concentration: 50 g Temperature: 50–60 ° C. This states that sodium hydroxide can be a uniform catalyst to the chemical reaction of aluminum and water for the production of hydrogen. During the process, Sodium hydroxide or commonly known as caustic soda yields high temperature. Although it presents a real hazard to the environment and people, it gives a good number to the production of hydrogen gas from aluminum and water.

Related Studies

The design of the Hydrogen Generator of Reagon, R. et. al. (2018) in their study uses electrolysis, that consists of an electrolytic cell which is also called an electrolyser. This generators used a plastic container in which stainless steel blade were used, since the rate of generation of gas mainly depends on the concentration of electrolyte solution, hence, more current input is necessary to increase the amount of hydrogen. In relation to the study, the researchers use plastic container which serves as the reaction chamber where the production of hydrogen will occur without using electric current (Reagon, R. et. al., 2018),

Mahmood, Y. Rafa, Y.J &Al Salib, (2018), stated that using H_2O as source for hydrogen provides clean reaction with no contaminants. It is found out in the study that the suitable water solution should be chosen depending on the purpose of the work. Mineral water should be used for slow releasing of gas while sea water helps to provide a high

speed generation of gas that produce high power of up to 30 volts with high current of 10 amps. The gas that can be collected can be used as engine fuel, for electricity generators and cars.

This study provides an additional knowledge to what kind of water is better than using tap water.

According to Martinez, S., (2005), high purity hydrogen gas was generated from the chemical reaction of aluminum with sodium hydroxide. Several molar relations of sodium hydroxide/aluminum were investigated in this study. An estimation of the amount of energy produced from the reaction of 100 aluminum cans with caustic soda showed that the hydrogen production is feasible to be scaled up to 5kWh in a few hours. This study is environmentally eco-friendly which also shows that green energy can be produced from aluminum waste at a low cost.

As stated by this study, having the desired amount of aluminum, especially in a form of 100 cans with caustic soda can produced up to 5kWh in a few hours, and that the production is eco-friendly so is the hydrogen powered generator.

The U.S. Department of Energy (2008), opined that although the concept of reacting aluminum metal with water to produce hydrogen is not new, there have been a number of recent claims that such aluminum water reactions might be employed to power portable applications such as emergency generators and laptop computers, and might even be considered for possible use as the hydrogen source of fuel cell powered vehicles in the vicinity of room temperature. The reaction between aluminum metal and water to form aluminum hydroxide and hydrogen is the following: 2AI + 6H2O = 2AI(OH)3 + 3H2. The gravimetric hydrogen capacity is 46 g H2/L.

The study stated that to produce a promising results

in the production of hydrogen to be used in the production of mechanical energy or electrical energy, chemical reaction should take place between aluminum and water with sodium hydroxide as a catalyst. Apart from using the product in fuel cell, the study also states that it can also be a fuel for combustion and candidate alternative for gasoline to be used in the hydrogen powered generator.

According to the Research group, Materials & Energy Research Center (2010), their aim is to enhance hydrogen generation rate in aluminum particles using the heat released during the reaction. The study accomplished their aim by developing fresh surfaces by milling aluminum particles together with salt. The salt not only serve Nano millers but also used to surround activated particles and preventing the re-oxidation of bare surfaces in air. Using the salt with water and aluminum can increase the efficiency of hydrogen production.

This study is related to the research because it stated the enhancement of the efficiency in hydrogen production with the help of salt, as support for enhanced water and aluminum reaction.

According to Jerew, B., (2013), using electrolytic cells it generates hydrogen and oxygen gas from water using electric current but the generated hydrogen is less than that which was used to split the water molecules in the first place. In order to increase efficiency in a hydrogen generator, one needs to consider the metal catalyst used. One example of metal catalyst is platinum which does not corrode and last for a long time. The problem is, platinum is an expensive metal catalysts.

This study defines that using and testing the platinum as a catalyst increases the efficiency of the hydrogen generator. The problem of using platinum is, it is expensive and the objective of this study is to produce a low cost hydrogen powered 2-Stroke ICE generator.

As stated by Stefano, P., (2008), the major challenge for the future commercial use of PEM or the Polymer Electrolyte Membrane is the electrolysis for hydrogen production. The process on how the hydrogen generator produce hydrogen is through the use of polymer electrolyte membrane with sputtered iridium oxide anode. The anode is caused, by activating the potential value between 0 and 1.2 V for the iridium catalyst, to electrochemically activate the electrolysis. The achieved high efficiency is combined with sufficient electrode stability since the oxidation of the carbon substrate during the anodic polarizations is almost negligible.

This study is related to the research because it uses a different method of producing hydrogen but still it focuses on the harnessing of hydrogen with the use of polymer electrolyte membrane with sputtered iridium oxide anode.

Ayaji, A. & Akerele, O. (2013) stated in their research that the development of generator using the scrapped lead from an old battery can be used as an electrode to start up the process for electrolysis of water with sodium hydroxide. It can produce 27 liters of hydrogen gas within 30 minutes, which simply proved that hydrogen generator can be easily replicated with readily available materials.

The research discusses a different method of harnessing hydrogen through the process of electrolysis and stated that their concept of hydrogen generator can be easily replicated using scrapped materials.

Oh and Plante (2012) used two-stroke engine vehicles to constitute a major share in terms of ideas and contribute significantly to lessen air pollution. The two-stroke engine has been used for small recreational vehicles because of its high power density, low cost, and simple, lightweight design. Oh's hydrogen engine matched the rated power of the original gasoline engine, with an achieved best-point gross indicated thermal efficiency of 42.4%. The brake thermal efficiency at rated power is 32.3%.

This study shows the comparison of brake thermal efficiency and specific fuel consumption at rated power of 7.4 kW between the hydrogen and gasoline as a fuel. By comparing the Hydrogen and the Gasoline powered Generator, Oh and Plante matched the original rated power of the gasoline two stroke engine by using Hydrogen to fuel the two stroke Engine.

Method

This section presents the research design in pursuing the study and includes how the development of the project was done in accordance with the systematic procedure and processes. This section also includes the design, selection, identification of materials, methods, and techniques used.

1. *Data Gathering*. Applied research is a design to solve or to investigate practical problem of the modern world, rather than to acquire knowledge for knowledge's sake. It focuses on the analysis and solving social and real life problems. The researchers gathered data based on the design of a hydrogen powered generator. The goal of the research is to create a generator that can produce electricity.

2. *Design*. The design of Hydrogen Powered 6-stroke ICE Generator was based on the hydrogen powered generator project entitled NEW HYDROGEN GENERATOR IS MORE EFFICIENT AND LESS EXPENSIVE by Jerew B. (2013) and the availability of materials in the market. It is especially designed for easy operation.

3. *Selection and identification of materials*. The Hydrogen Powered 2-stroke ICE Generator consists of several components designed to meet the specifications of the study.

4. *Fabrication*. The researcher works as a group in every aspect of the study including civil works, electrical, electromechanical and process.

5. *Testing process*. Testing of the Generator was conducted to determine the workability of the engine.

Materials

Peak Power: 900W
Rated Power: 800W
Rated Voltage: 220V; 3.5 A
Speed Nominal 1800 R/min
Frequency: 120 Hz
Weight 21kg

Figure 3. Two Stroke Genertor

(2) 2 Liters Absolute Distilled Drinking Water Bottle

Polyethylene Terephthalate

Figure 4. Bubbler

15 Gallons

Figure 5. Plastic Container

1 Kilogram

Figure 6. Activated Carbon

3/8mm 4 meters

Figure 7. Level Hose

3.5 Liters

Figure 8. Water

Sodium Hydroxide

3 cups

Figure 9. Caustic Soda

½ Kilograms of Aluminum Scraps or ½ Kilograms of Aluminum Cans, Aluminum Foils (Minimum of ½ Kilograms of Aluminums)

Figure 10. Aluminum Scraps

Bill of Quantities

Below is a table for the prices of the following materials:

Table 1. Cost of Materials

Description	Quantity Needed	Unit	Price
Generator	1	770Watts;120Hz	P 4,800.00
Plastic Container	1	15 gallons	100.00
Caustic Soda	2	1 Kilogram	478.80
Hose	1	3/8 Diameter	P 40.00
Mineral Water Bottle	2	2 liters	102.00
Activated Carbon	1	1 Kilogram	P 299.70
Total:			P 5,820.50

Generator – Where the discharged hydrogen will be connected.

Plastic Container – Serves as the Reaction Chamber of the Project, this is where we will put the Caustic Soda, Aluminum Cans and the water are mixed together for the chemical reaction process to occur

Caustic Soda - Serves as the Catalyst for the Aluminum/ Water Reaction.

Hose - Used to connect all the components together, and enabling the hydrogen to travel to the Generator.

Mineral Water Bottle – Used for the bubbler and for the Activated Carbon Filter.

Activated Carbon – Used to filter the impurities before entering the Generator.

Step by step Procedure

Step 1: Get 15 gallons container as the reaction chamber for the hydrogen powered 2-stroke ICE generator, punch a hole on the upper part of the container at least 2 inches below the lid. This is where the hydrogen will travel. Be sure to seal off properly the holes to prevent hydrogen leak.

Step 2: Cut 3 meters of thermal tube that will be connected to the container and to the bubbler.

Step 3: Get (2) 2 liters container to be used as the bubbler and carbon filter. Fill the bubbler with 0.8 liters of H_2O and fill the other container with 0.5 liters of Activated Carbon and tissue paper.

Step 4: With the use of thermal hose, connect the bubbler and the carbon filter with each other then connect the bubbler to the reaction chamber.

Step 5: Connect the carbon filter to the 2T engine's air filter

Step 6: Use the designed encasement to keep the equipment safe and to avoid damaging the devices.

Step 7: By following the OMM the project is ready to use.

Results and Discussion

Table 2. Prior to Testing

Trial	Water	Caustic Soda	Aluminum
1	5 Liters	400 grams	1 Kilogram
2	6 Liters	400 grams	½ Kilogram
3	6 Liters	400 grams	½ Kilogram
4	6 Liters	400 grams	1 Kilogram

Table 3. Results of Testing

Trial	Production of Hydrogen	Starting Time	Running Time	Voltage	Running Time in Kilowatt-hour
1	High	20 minutes	6 minutes	220 Volts	0.077 KWhr
2	High	25 minutes	7 minutes	220 Volts with 1 Load	0.089 kWhr
3	High	25 minutes	17 minutes	220 Volts with 1 Load	0.22 kWhr
4	High	10 minutes	3 minutes	220 Volts with 3 Loads	0.026 kWhr

Discussion

October 7, 2019 (Test #1)
5 Liters tap water
400 Grams Caustic Soda
1kg aluminum scrap.

After 20 minutes of reaction in the chamber, the researchers produced enough hydrogen for the generator to run. The running time of the generator using a mixture of 2T oil and Hydrogen was 6 minutes only with one wall fan as the load. After the test, the researchers observed that the reaction chamber was deformed due to high pressure inside the chamber because of the continuous hydrogen production. Using hydrogen as a fuel with the mix of 2T oil, the exhaust produces water vapor and less smoke than using gasoline. The smoke coming out the generator changed in thickness and odor, the smoke coming out was caused by the 2T oil.

October 11, 2019 (Test #2)
6 liters tap water
400 grams' caustic soda
½ kilo aluminum scrap

Several changes were made in the 2nd testing like additional water inside the chamber was used, changing the tubes to have bigger diameter and resistance to temperature than the previous test, the researchers added relief hose to control the pressure in the reaction chamber, and the researchers placed the reaction chamber partially submerge in water to help control the temperature inside. After 25 minutes of reaction in the chamber, the researchers produced enough pressure and hydrogen to make the generator work. The generator ran for a total of 7 minutes after it stopped working due to lack of hydrogen and pressure that is entering the generator. The Combustion chamber was deformed again due to the high temperature and high pressure of the chamber where the hose that was connected became soft and was unable to be used again.

October 16, 2019 (Test #3)
6 liters tap water
400 grams caustic soda
½ kilo aluminum

With the same ratio of caustic, aluminum and water, the researchers have done the 3rd trial with minor changes, The researchers changed once more the tubes that were used to a bigger diameter and heat resistant. And, the researchers decided not to submerge the combustion chamber, instead the researchers sprayed it with water to dilute and to lower the temperature of the chamber and avoid deforming the chamber again. After 25 minutes of reaction time, again there was enough hydrogen to run the generator. The generator ran for a total of 17 minutes before it stops again. The changes that were made in this trial was very helpful. The bigger diameter of the hoses used helped the hydrogen to travel easier. The chamber was not deformed because the

water that has been sprayed helped to control the pressure inside. The mistake learned in the 2nd trial is that the water became stagnant around the chamber, the reason why when the chamber became very hot, the water became hot as well.

October 30, 2019 (Test #4)
6 liters tap water
400 grams caustic soda
1kg aluminum

For this test, the researchers used the same method of not submerging the reaction chamber but instead sprayed it of water to dilute and to lower the temperature. The researchers also changed the volume of the reaction chamber to 15 gallons and tried to increase the aluminum from half kilos to 1 kilogram of aluminum. Considering the larger container and the larger amount of aluminum, the chemical reaction is expected to be far stronger than the other trials the researchers did. Smaller scraps of the aluminum produced large amount of Hydrogen and considerably shortens the reaction time, hence would have a shorter production time. The reaction in the chamber was faster than the other trials which is only 10 minutes. The generator ran for almost 3 minutes because it was loaded with 3 wall fans. The change observed in this test, for them to conclude is that the reaction in the chamber can cause the generator to power 3 wall fans in 3 minutes. It means that the generator can run longer compared to the past trials with a single load using a 15 gallons.

Summary

Fossil fuels continuously pollute and harm our environment. So, the demand for renewable energies is growing rapidly in recent years. The researchers propose using hydrogen as an alternative fuel source that can be collected through a chemical reaction of water, aluminum, and caustic soda. The hydrogen releases a non-harmful gas that can help to lessen the pollution in our environment.

Hydrogen is the basic feedstock of fuel cells, which are a promising future energy source. As fuel cell technologies mature and reach commercial development, the possibility of hydrogen to fuel vehicles for transportation and power generators will become reality.

In this thesis, the researchers analyzed and evaluated the ratios of water, aluminum, and caustic soda that react with each other and produce hydrogen as a by-product. With the help of the related studies and literature, the authors gathered the data to examine if the hydrogen is a reliable source of energy. They learned that hydrogen can be harnessed through different methods. They chose the chemical reaction method because in their mindset this research is not only to prove that hydrogen can be used to power generators but, at least, to be budget-friendly to the households that will appreciate their hard work. The temperature can melt the container and the possibility to explode if the activity of hydrogen is too much for the container to handle. So, they used the possible little amount of ratios between the three enough to power the generator. They reached the right amount of ratios between the water, aluminum, and caustic soda through four trials. After the production process to gather pure hydrogen, the gas undergoes in the two process of filtration and then flows to the generator. In the trials, it was observed how long the generator worked based on the amounts of the hydrogen produced in the chemical reaction of the mixture, enough to power one wall fan to multiple wall fans to test the limits of the hydrogen generator.

Conclusion

It was concluded that the use of hydrogen as an alternative fuel for fossil fuels is possible after 4 sets of trials. Where the right ratios for a single wall fan load are a half kilos of aluminum, 6 liters of tap water and 400 grams of caustic soda has produced 900 watts in 17 minutes of run

time and for the generator. For the multiple loads the set was adjusted where the volume of the container changed to 15 gallons, with almost the same ratios of 6 liters of water, 400 grams of caustic soda, and 1 kilogram of aluminum. The multiple load reaction time in the chamber was faster than the other tests considering the change in the volume of the container or the reaction chamber. The reaction time for producing hydrogen is 10 minutes and can power the generator for almost 3 minutes with multiple loads.

The system design is as follows, hydrogen is extracted from a chemical reaction through water, aluminum, and caustic soda. After collecting enough hydrogen, the gas will now flow to the bubbler that will help to remove/filter the fumes of electrolyte from the collected HHO. After the air filtering in the bubbler, the hydrogen gas will go to the container for activated carbon that will help to remove the impurities and contaminants using the chemical absorption called carbon filtering. After, the pure hydrogen will now flow to the generator to serve as fuel where the combustion of the pure HHO will result in the conversion of chemical energy to mechanical energy where the generator will work for the generation of power to supply electricity to the wall fans that were used in the trials. The equipment and materials used in the trials conducted for hydrogen generator was a plastic container of 15 gallons for the collection of hydrogen with the help of chemical reaction between the water, aluminum and caustic soda, two pieces of 2 liters absolute distilled drinking water bottle for the bubbler and the activated carbon, generator, and wall fan. To ensure the efficiency of this hydrogen generator the researchers needed to perform trials in the amount of the hydrogen it can produce. The efficiency in the performance of the production of hydrogen can be determined according to the ratios of the materials in the chemical reaction in the chamber. After the four trials, the researchers deemed that the hydrogen generator has more advantage instead of the use of gasoline powered generator since the hydrogen generator releases a non-harmful vapor, it also lessen the

greenhouse gases and pollution that can help the environment now and in the near future. Using hydrogen as an alternative source of energy can make a huge impact to the energy sectors because it can provide viable and sustainable options for meeting the world's energy requirements if produced for commercial quantity. If the hydrogen can be used as a replacement in fossil fuels, it can also be develop in many ways and harness hydrogen through different methods. One of the method is electrolysis that utilizes the electricity in a battery to harness the hydrogen in the water. The researchers chose the method of chemical reaction for this hydrogen generator because this method can be used in the community as a budget-friendly generator. The researchers used simple materials that can be easily obtained, however it is also possible to still develop a hydrogen generator using more durable materials that can hold large amount of hydrogen. In this thesis, the researchers proved that the hydrogen can be used as an alternative source of energy in a low cost generator system for the normal households.

Recommendation

1. The container of the hydrogen should be improve for better safety.
2. Based on the trials conducted, the longer the needed generator running time, the better to double the right ratios of the water, aluminum, and caustic soda.
3. Regardless of the volume, the strength of the reaction chamber is crucial for the production and running time of the system. As long as it can withstand high pressure for balancing the production to consumption, the running time will not be such a problem.
4. Double checking of gas leakages in the container, valves, and hoses is a must for it will maintain the pressure of the chamber to normal and prevent it from losing its pressure at the certain time in the middle of operation.

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