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Hydro-Gen 25% Report

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This B.S. thesis is written in partial fulfillment of the requirements in EML 4551. The contents represent the opinion of the authors and not the Department of Mechanical and Materials Engineering.

Ethics Statement and Signatures

The work submitted in this B.S thesis is solely prepared by a team consisting of Ngin Mang, Juan Barrera, Thwin Siss, and Alejandro Paya it is original. Excerpts from others' work have been clearly identified, their work acknowledged within the text and listed in the list of references. All of the engineering drawings, computer programs, formulations, design work, prototype development and testing reported in this document are also original and prepared by the same team of students.

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Abstract

In the past few years automotive companies have been searching for technological advantages to increase fuel millage in order to protect the environment, while still providing an entertaining driving experience for their customers. With gas prices on the rise, the average American wants a car that can do everyday activities whilst spending the least amount of fuel possible. Not only customers are demanding for better gas millage, but the government as well. In fact, president Obama passed the Fuel Economy Reform Act, which states that by the year 2025 new cars are to have gas millage of 54.5 miles per gallon. In our senior thesis we will attempt to address this issue by designing and building an HHO generator. This generator uses the principle of electrolysis to split water into its two molecules, hydrogen and oxygen, in gas form. This gas will be introduced into the combustion chamber of an engine to increase its power, burn less gas, and exhaust water particles out to the environment.

Problem Statement

With such high demand for more efficient engines, our mission is to design and create a device that will increase engine efficiency without jeopardizing its performance. Such device is an HHO Generator. This generator uses electric current (electrolysis) to produce hydrogen from water; the hydrogen will be introduced into the combustion chamber of an engine through the intake manifold. We will attempt to make it compact and affordable, in order for it to be appealing to customers.

Building this generator comes with some challenges. We need to make sure that the amount of energy put into the cell to split the water molecules is less than the amount of output energy of the generator. In order to overcome this challenge we will need to make it as efficient as possible. This includes coming up with a creative design to get as much hydrogen out with the least amount of current running through the cell. More concerns include implementing very conductive wires and plates into our system. Taking these aspects into consideration will make the HHO generator a productive addition to any internal combustion engine.

Motivation

Most of the Car manufactures around the world are developing hydrogen-fueled vehicles. Mostly fuel cell electric vehicles (FCEVs) but some company such as BMW, Honda and Mazda are developing cars powered by hydrogen fueled internal combustion engines (H₂ICEs). Mainly due to the high demand of oil and its main associated problems for the environment such as air pollution and gas emissions. The only problem with the hydrogen car is that since it's not in high demand there are only very few places where you can refuel. Thus the distance you can travel with the vehicle is limited. Dual-fuel internal combustion engine vehicles that combine gasoline and hydrogen could be the alternative solution to enthusiast for speeding up the introduction of hydrogen in the vehicles. Vehicle conversion to dual-fuel operation is technically feasible and low cost.

Literature Survey

Using water electrolysis to produce hydrogen has been studied for a long time. Some records indicate that hydrogen has been used by man as an alternative fuel source in many different levels of fields such as commercial, military and industrial sectors since the late 19th century. Electrolysis is one of the favorite fields of the study and scientific experiment for many researchers all around the world. The electrical power source is connected to two electrodes that are made out of typical metal (such as stainless steel, platinum or, titanium) which are in the electrolyte water, hydrogen will be produced at the negatively charged electrode (cathode) where the electron enters. The oxygen will be produced at the positively charged electrode (anode).

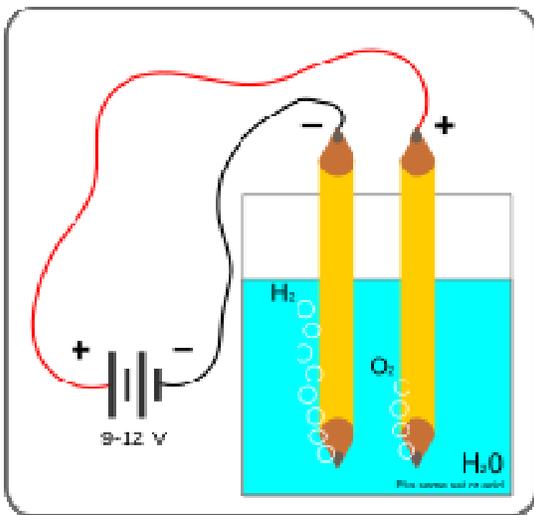


Figure 1 Principle of Electrolysis

Ideally the amount of hydrogen produced is twice the amount of the oxygen moles. Electrical charge conducted by the solution is proportional.

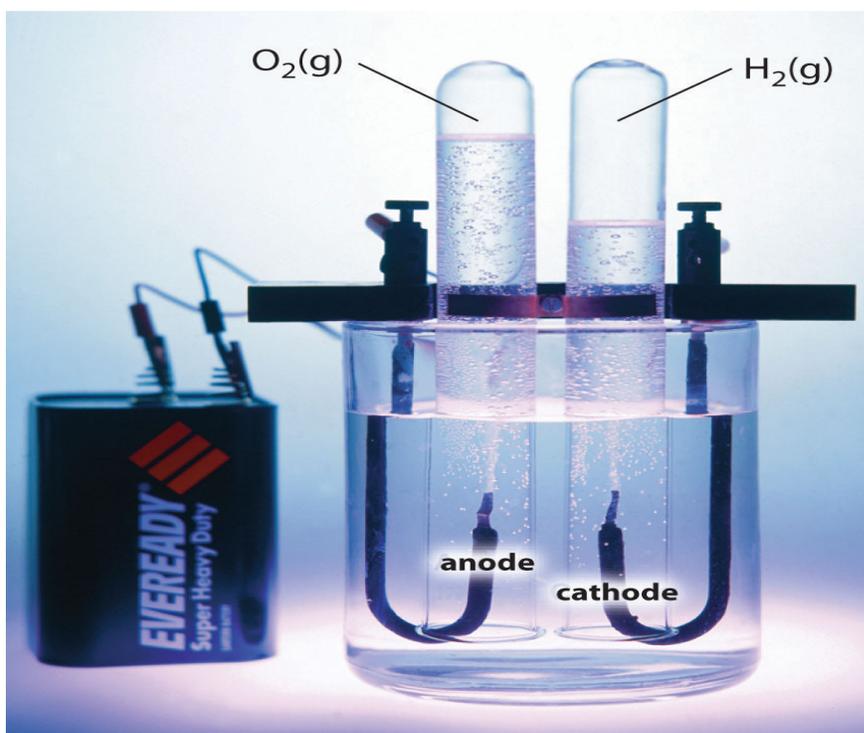
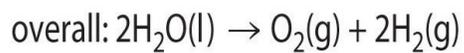
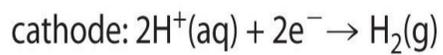
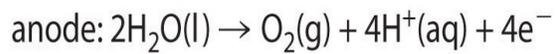


Figure 2 Electrolysis Photograph

Projective Objectives

1. Design and build a practical and economical way to increase engine efficiency in combustion engines.
2. Build HHO generator that splits water's molecules, using the process of electrolysis. Yielding a mixture of hydrogen and oxygen gas, also known as HHO gas.
3. Adapt the generator in a conventional internal combustion engine to push the HHO gas into the air intake.
4. Overcome the energy loss that is input into electrolysis with a higher power output by the engine.

Conceptual and Proposed Design

In electrolysis, people have tried different ways to increase the output of gas while decreasing the input of current. Some designs are more effective than others. Some people have tried to improve the conventional way, called "wet system", consisting on plates or tubes submerged in water, while others have tried a design called "dry cell" where the water run through the plate.



Figure 3 Circular Cell

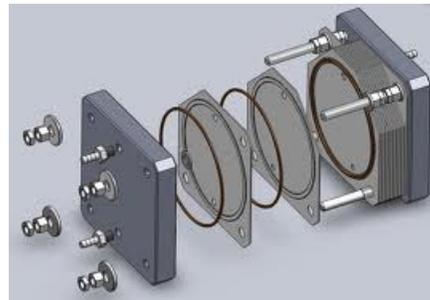


Figure 4 Square Cell

Dry cell designs are cheaper. This design can vary in shape or size, making in it very easy to install anywhere. The material used for the plates is stainless steel 316, and uses regular rubber O-rings to separate them. At the same time the amount of current input required to produce hydrogen is small.

The wet system design consists in a more complicated manufactured process. This design is more expensive since the parts and the arrangement are more likely hard to produce. This system uses two different diameters of tubes in order to accommodate one inside the other one with different polarities, positive the inner and negative the outer. As a container, this kit uses a material capable to satisfy some important parameters. Resist higher temperatures, since the

electrolysis process generates a significant amount of heat. The pressure built inside, sometimes up to 60 psi. And very important, it has to be a dielectric material in order to avoid electrolysis between the tubes and the inner wall of the container.

The effectiveness of this system is higher than the dry cell system, although more current input is necessary the amount of hydrogen out is greater. Despite the cost of fabrication of this system and our limited budget we are choosing this design for our project in order to obtain a better production of hydrogen.

Timeline

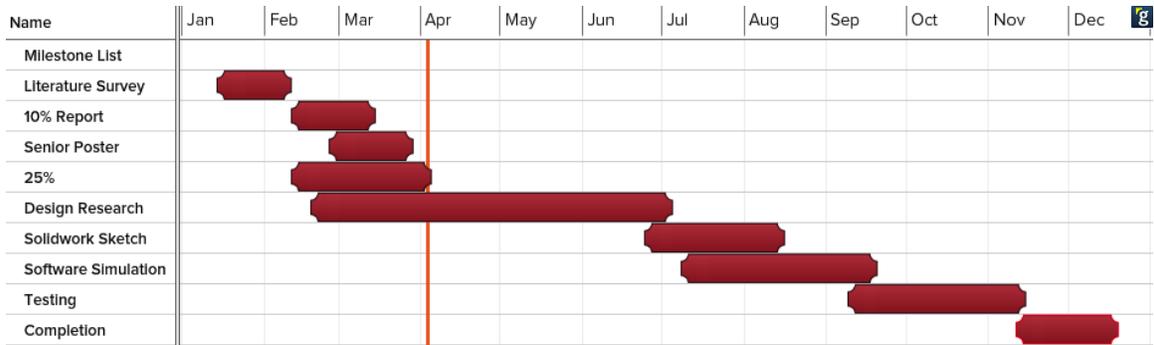
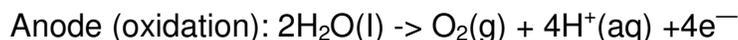


Table 1 Timeline

Analytical Analysis

In order to quantitate the process of electrolysis, we have found some equations that relate the current needed to obtain a certain volume for a gas. The process for this calculation at room temperature and at 1 atm is:

1. Write the half-reactions that take place at the anode and at the cathode.



2. Calculate the number of moles of electrons that were transferred.

Knowing:

- Amperes X time = Coulombs
- 96,485 coulombs = 1 Faraday (F)
- 1 Faraday = 1 mole of electrons

Example:

- $60(\text{amps}) * 3600(\text{seconds}) = 216,000(\text{coulomb})$
- $216,000\text{C} * \left(\frac{1\text{F}}{96,485\text{C}}\right) = 2.239\text{F}$
- $2.239\text{F} * \left(\frac{1\text{ mole e}^-}{1\text{F}}\right) = 2.239\text{ mole e}^-$

3. Calculate the moles of hydrogen and oxygen produced using the number of moles of electrons calculated and the stoichiometries from the balanced half-reactions. According to the equations, 2 moles of electrons produce 2 mole of H₂ and 4 moles of electrons produce 1 mole of O₂ gas.

$$2.239\text{ mole e}^- * \frac{2\text{ mole H}_2}{2\text{ mole e}^-} = 2.239\text{ mole H}_2$$

$$2.239\text{ mole e}^- * \frac{1\text{ mole O}_2}{4\text{ mole e}^-} = 0.560\text{ mole O}_2$$

4. Calculate the volume of each gas using ideal gas law ($V=nRT/P$).

Where n: number of moles.

R: Boltzmann constant = 0.08206 (L atm/mol K)

T: temperature in kelvin.

- Volume of Hydrogen gas:

$$\circ \frac{(2.239 \text{ mole H}_2)(0.08206 \text{ L} \frac{\text{atm}}{\text{mole}} \text{K})(298\text{K})}{1 \text{ atm}} = 54.75 \text{ L of H}_2$$

$$\circ \frac{(0.56 \text{ mole O}_2)(0.08206 \text{ L} \frac{\text{atm}}{\text{mole}} \text{K})(298\text{K})}{1 \text{ atm}} = 13.69 \text{ L of O}_2$$

These calculations have shown that for a current of 60 amps during a period of 1 hour, the electrolysis of water yields 54.75 liters of hydrogen gas and 13.69 liters of oxygen gas.

Major Components

The main component in a Hydrogen-on-Demand system is the HHO or Hydroxy gas generator. This device can be a simple one cell unit or have as many cells as needed to produce the quantity of HHO gas desired. Electrolysis is the driving force for such generator. it separates chemically bonded compounds by passing an electric current through them. Another component used to produce HHO is an Electrolyte. Any substance containing free ions that behaves as an electrically conductive medium. Catalyst is the correct term because of the function it performs to speed up the production of HHO gas.

Another important component for regulation is the Amp Meter, this is a tool used to measure the amperage flowing through a wire or other conductive material. It is a very important tool when adjusting your HHO generator or Hydrogen on demand system for maximum output.

Structural Design

The team conducted research to find information about hydrogen generators in general. Many design specifications do not meet our need or standard that we were trying to reach. According to this specific critical research, we need to come up with a better plan and design to meet our efficiency goals.

Many design alternatives were looked at to determine the best way to generate the highest amount of hydrogen possible. The chosen design model will be reevaluated to seek optimum efficiency. Sizing plays an important aspect of the design, specifically the stainless steel plates or tubes that will submerge under the water. The optimal tube design has been chosen for this project. The alternative designs will also be tested to assure that we have chosen the best design that is suitable for our application.



Table 2 Turbo Star Pipes

Tube Specifications:

Stainless Steel Grade 316L is used where corrosion resistance and good mechanical properties are primary requirements. It is also widely used in

applications where corrosion resistance is required. This cell is an electrolysis cell similar to Stan Meyer - hydrogen oxygen (HHO) - Energy cell . Stanley Meyer was a pioneer in electrolysis. This cell is built with 12 concentric 316L grade stainless steel seamless pipes and spacers.

The outside pipes are 9-1/8" inches long by 3/4" outer diameter and the inner pipes are 10" inches long by 1/2" outer diameter and the wall thickness is .035". To connect power (12 v or 24 v battery) simply attach (-) negative voltage to inner tubes and (+) positive to the outer tubes. You need to connect a wire to each of the 12 tubes.

AISI 316L Stainless Steel Property	Value	Units
Elastic Modulus	2e+011	N/m ²
Poisson's ratio	0.265	N/A
Shear Modulus	8.2e+010	N/m ²
Density	8027	kg/m ³
Tensile Strength	4.85e+08	N/m ²
Yield Strength	1.7e+08	N/m ²
Thermal Expansion Coefficient	1.65e-005	/K
Thermal Conductivity	14.6	W/(m·K)
Specific Heat	450	J/(kg·K)
Material Damping Ratio	N/A	

Structural and Prototype Cost Analysis

AISI 316L Stainless Steel Welded Tubes x .035" thick wall, price per foot.

1/4" OD = \$3.77

3/8" OD = \$3.79

1/2" OD = \$3.10

5/8" OD = \$7.51

3/4" OD = \$9.38

1" OD = \$7.80

Stainless pipes	\$ 135.00
PVC tubes	\$ 40.00
Electrical wires	\$ 60.00
Hoses	\$ 80.00
Solenoid	\$ 35.00
Fuses	\$ 5.00
Amp-meter	\$ 30.00
Reservoir tank	\$ 60.00
Switch	\$ 15.00
Accessories	\$ 70.00
Total	\$ 530.00

Cost may vary depending on the final design. Our team will have to test and diagnose the different size of tubes through the simulation software that will give us the design with the most efficiency.

Prototype System Description

For our design we are going to implement a Wet Cell System. The stainless steel tubes with a negative charge will be connected to the negative pole of the battery and the positive will be connected to a relay, this will give us an on/off control of the system while we drive.

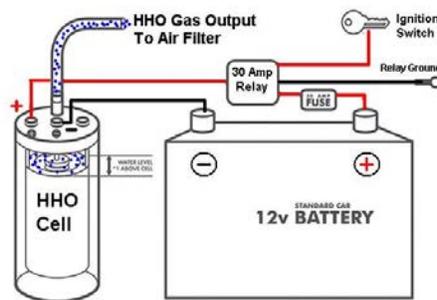


Figure 5 Diagram

For these connections we are using 4 gage cables to reduce electric resistance. To avoid all possible losses the vessel should be placed close to the car battery. An amp meter, as well as a fuse are part of the system, this will help us to monitor and for the system safety respectively. All connections are shown in detail in the next figure.

Plan for Test on Prototype

The prototype is small-scale hydrogen generator. In the device, each plate is assigned to a cathode and an anode. Using electrolysis on water the cathode node will produce hydrogen gas (H_2), and anode node will produce Oxygen gas (O_2). To make sure the generator is working we will use a regular car battery of twelve volts. The prototype has already been implemented Alejandro Paya's car. We are currently testing our prototype fuel cell in order to obtain basic estimations of how fuel consumption can be reduced. The prototype has 17 plates, and the water is mixed with potassium which acts as an electrolyte for better reaction. However, our research shows that the best design for the cell are the circular pipes shown in Figure XX

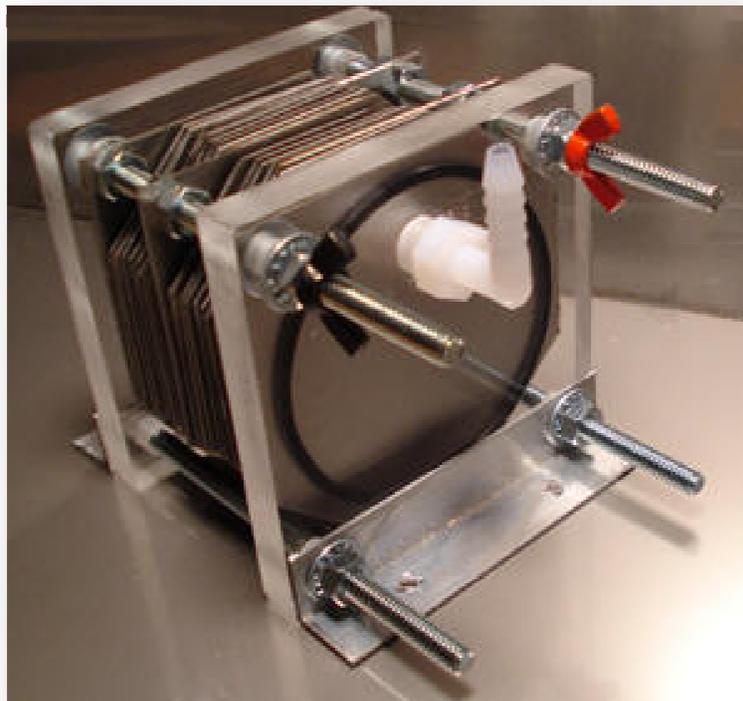


Figure 8 Cell

Conclusion

In the design of our hydrogen generator we are trying to increase fuel efficiency while providing additional power. The hydrogen cell produces oxygen and hydrogen from water through electrolysis. We are trying to minimize the cost by using widely available materials. However, the cost may go up based on the results of different tests and the goal that we want to reach.

Our project will benefit the environment and society. Since implementing the hydrogen generator will produce less carbon dioxide to the atmosphere. Therefor it will reduce greenhouse gasses. Hence, less effect on global warming on the long run. Moreover, since implementing a hydrogen generator will provide more fuel efficiency, it will save money for people who will use our product.

Currently, our main objective is to do more research on which hydrogen generator design will provide maximum fuel efficiency while maintaining minimizing costs for the project. We are still choosing a final design using Solidworks simulations. The final design and model are not yet complete. However, we conclude that we will be able to provide the final design and model base on our progress, teamwork, and our research.

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