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A Study on Hydrogen Fuel Technology

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Abstract: *The study of hydrogen fuel cell technology represents the fact that energy can be generated sustainably from a simple apparatus as in our paper without involving any rotating devices. The variation of cell voltage with temperature was measured for different mediums. The efficiencies of each medium were calculated in order to note the performance of the fuel cell.The results obtained proved our hypothesis to be correct. It is observed that the electricity produced was used to charge the multi meter.*

I. Introduction:

In this study, a basic simple fuel cell was built up using salt water, batteries and wire. The glass was filled with water, and charged it through the wires. Then, after a certain period of time, the batteries were disconnected from the water and connected them to a multi meter, and measured the voltage from multi meter of the water and the discharge time it took for the electricity to discharge.

II. Hypothesis:

In the project, the electrical charges were applied to water solution. By which the simplest fuel cell was created that will store the electric charge.

Variables which are dependent:

Output voltage in water solution

Charge dissipation

Independent variables

Water solution,

Applied charge voltage

Anode and Cathode Material

III. Literature Review:

There are several key points and terms that may be helpful in understanding this study of fuel cell.

Fuel cell: An electrochemical cell involving the energy of a reaction between a fuel, such as liquid hydrogen, and an oxidant, such as liquid oxygen. It is electrochemical device which converts the chemical energy of fuel directly into the electrical energy. It operation is fully dependent on the storing the electrical charge.

Cathode: It is the part of a voltaic battery. Here, the electric current leaves substances through which it passes, or we can say that the surface at which the electric current passes out from the electrolyte. It is the negative pole, which is in opposed to the anode.

Anode: It is the negatively charged terminal of a primary cell or can be called of a storage battery that is supplying current.

Electrolyte: A chemical compound in liquid state that ionizes when it is dissolved or molten in order to produce an electrically conductive medium to generate electricity.

Catalyst: A substance used in chemical processes, usually in small quantity relative to the amount of reactants, that either increases or decreases the rate of a reaction without being consumed in the chemical process. It modifies the rate of reaction.

Alkaline: There are various soluble mineral salts, those found in natural water and arid soils are alkaline.

Hydrogen: It is colorless in nature, highly flammable gaseous element in gases, the lightest of all the gases and it is the most abundant element in the whole of the universe, it is used in the production of synthetic ammonia and methanol, also in petroleum refining, in the hydrogenation of organic materials, as a reducing atmosphere, in oxy hydrogen torches, and in rocket fuels.

Fuel cells, however they are considered as a fairly new concept, have been around for years but are very sound in its operation. Earlier in the 1800's, scientists were experimenting with electricity from fuel cells. Fuel cell consists of a chemical reaction that creates an electric charge, that helps to produce electricity. They consist of one positive electrode and one negative one: the cathode and the anode. There are three basic components of fuel cell. These are components which produces the energy. The fuel cells also contain an electrolyte, which is a medium to carry the electrons. This carries the charged particles from electrode to electrode, and also a catalyst.

The way fuel cells work is very simple. It works through a chemical reaction. In this example, the element used will be hydrogen which is helping to produce the electricity, seeing as it is the most commonly used concept. Basically, what happens is that the hydrogen is put to flow through an electrolyte as a medium. The positive side of fuel cell is split from the electrons negative side. These electrons used to produce an electrical current, and power whatever is being used. Then it was found that when the positive and negative side of the hydrogen gets reunited, they get mixed with oxygen, and end up as water, completing the circuit. Here, the water is the by-product of the process.

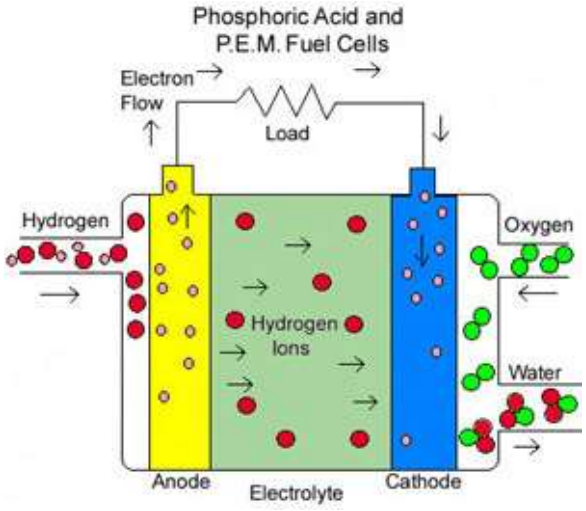

Figure 1 Phosphoric Acid Fuel Cell

Back in 1839 year, Sir William Grove (who is known as the father of fuel cells) noted that it was possible to generate the electricity from water. However, it was found that earlier that it was not generating enough energy for it to be practical or useful at all. About 50 years later, around in 1889, two scientists were working on this technology by the names of Ludwig Mond and Charles Langer gave the fuel cell its name. In another 50 years, Francis Bacon another scientists stepped up to the plate. His finding in fuel cells changed the old ones in many ways. Like before, they used platinum electrodes but then Bacon managed to use alkaline compound as an electrolyte, and nickel to be used as an electrode. This variation was found to be much cheaper than the earlier one. This variation was also more efficient than the older one. They were able to operate under pressures as high as 3000 psi.

There are many different classifications of fuel cells based on electrolyte. A few of them are alkali fuel cells, molten carbonate fuel cells, and PEM fuel cells. Alkali is the most common one of all the cells, it involves using hydrogen and hydroxyl ions for creating the electricity, and end up giving with potable water. This trait makes it very useful aboard space vessels.

The next classification is molten carbonate. The electrolyte used here in this one is carbonate salts. However, these tend to be slightly inefficient because they are needed to be melted before they can be used. Having a liquid electrolyte in its state can be slightly difficult to handle sometimes, and that is time-consuming also. It is, however, useful, seeing as it refreshes the electrolyte through every cycle.

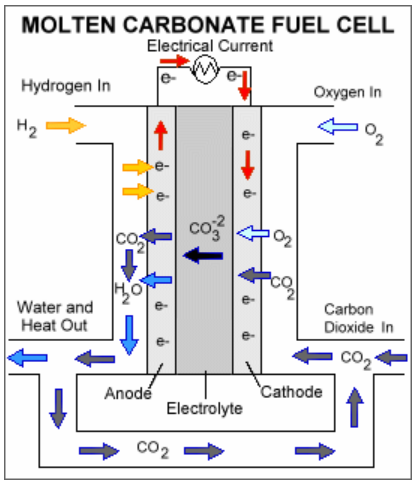

Figure 2 Molten Carbonate Fuel Cell

Finally, there is one of classification which is the PEM (Proton Exchange Membrane) fuel cell. The electrolyte for this type of fuel cell is a polymer sheet which is very thin. Unfortunately, this type can be somewhat expensive in terms of costs. A platinum catalyst must be used for this fuel cell. Also, a temperature of 80^0 C is needed. Once again it is found that this fuel cell requires hydrogen atoms, which are stripped from their electrons at the anode. These electrons passes through an exterior circuit, which creates electricity, and meet back at the end, combine with the air, and create water.

IV. Materials required:

The materials requirement list should be firstly prepared, so that it will help to perform experimentation in a mannered way. The following things were found to be useful tools to set up our experiment:

- Stop watch for measuring time
- 300ml Glass for electrolyte
- Tap Water as electrolyte
- Table Salt(sodium chloride)
- Four 9 volts dc Batteries
- 4 sets battery connectors
- 1 multi meter, 1-5 v dc
- 2 alligator clips for attaching
- 2 (100mm lengths) of .7mm dia. platinum wire as an electrode
- 2 (100mm lengths) of .7 mm diameter copper wire as an electrode.

V. Experimental Setup

After the initial connection of the battery to the platinum wires, the wires immediately started to collect and discharge bubbles of clear gas. The gas began to form and bubble up from all along the cathode and anode wires, but there was a greater frequency and amount of bubbles from the positive anode wire.

After three minutes, quickly disconnected the battery and connected the multi meter. The meter registered a voltage from the water fuel cell of approx. 2 volts and the charge dissipated rapidly for the first 30 seconds and then more slowly. The water fuel cell registered no voltage after approx. 4 minutes.

When repeated the experiment over 1 and 5 minute time periods, received very similar results. The time periods of 1, 3 and 5 minutes using simple water, acidic medium and alkaline medium respectively. Acid used is phosphoric acid and for

alkaline medium potassium hydroxide is used.It appeared that the fuel cell would charge up very quickly and discharge at almost the same rate regardless of how long the batteries were initially applied.

When repeated the experiment with four 9 volts batteries connected in parallel but the results were very similar to those above. The fuel cell would still not charge up to more than 2.1 v. Interestingly however, the fuel cell in this example took longer to discharge.

When repeated the experiment with two 9 volts batteries in series, i.e. 18 volts dc, the results again were the same as with the original results from the batteries in parallel.

The change came when repeated the experiment with increased salt concentration in the fuel cell water. The maximum charge was diminished and the rate of discharge was much faster.

When tried the tests again with dirty water from my fish tank, there were similar results to the first test with little salt.

When tried the test with only fresh water, there was no charge to the battery and could not measure the results.

Finally, it is tried to change the anode and cathode to copper to test the results. There was the same initial bubbling of gas from both the cathode and anode, but the smell of the gas was very strong. The test results were not as strong as with the platinum wires but it was measurable. Interestingly, the water turned green after several trials.

REACTION INVOLVED:

$2H_2 + O_2 \rightarrow 2H_2O$

Anode: $2H_2 \rightarrow 4H^+ + 4e^-$

Cathode: $O_2 + 4e^- + 4H^+ \rightarrow 2H_20$

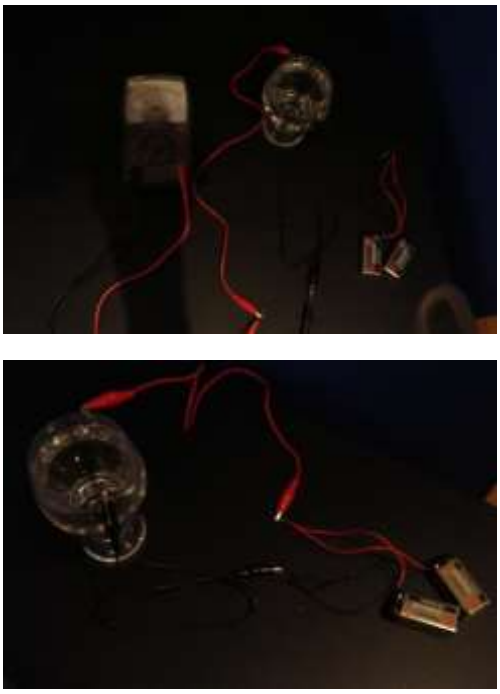

Figure 3 Set Up of Experiment

VI. Experimental Results:

The experiment is performed in the various sets. The variation of cell voltage with discharge time is done to know the performance of the fuel cell system. The time up to which the cell remains get charged. The variation of temperature on efficiency for the different medium like alkaline, acid, neutral and hot salty water is measured. The influence of temperature on cell voltage is analysed. The results and plot obtained after doing the experimentation are as follows:

6.1 The variations of Cell Voltage with Discharge Time:

Figure 4 shows the variations of cell voltage with the discharge time. It has been found that as the discharge time increases the voltage of the fuel cell decreases exponentially, this is due to the increasing time. As with time the electricity gets utilized.

This is the parameter which is significant in providing the time range of the fuel cell till it remains charged. This is the key parameter to judge the productivity of the fuel cell technology.

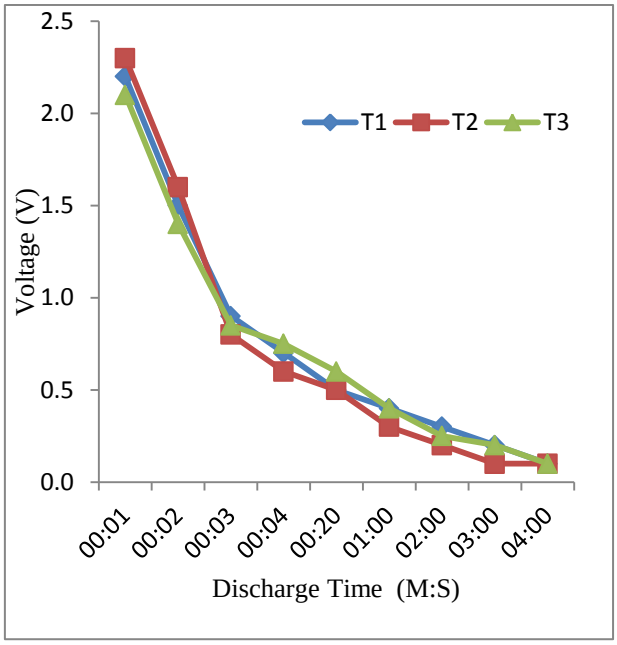

Figure 4 The variations of Cell Voltage with Discharge Time.

6.2 The variations of Cell Voltage with Temperature of different fuel Cells:

Figure 5 shows the variations of cell voltage with temperature of different fuel cells. The experimentation predicts the voltage and temperature characteristics for the Acid medium, alkaline medium, neutral medium and the hot salty water. The obtained results are as follows:

- In case of alkaline medium the variation is almost a linearly decreasing. It is obtained that initially starting from 300 K to 310 K the cell voltage is decreasing and further on increasing the temperature to 320 K the cell voltage decreases linearly.
- In case of Phosphoric acid it's two straight lines with a middle critical point. Initially at the temperature 300 K to 310 K the cell voltage decreases and on increase in the temperature to 320 K the cell voltage increases.
- It has been found for the neutral that variation of the cell voltage and temperature is little bit curvy. Initially from temperature 300 K to 310 K the cell voltage increases to a critical point. Then on increasing the temperature to 320 K the cell voltage decreases.
- The variation of the cell voltage is decreasing slightly exponentially with increase in temperature for hot salty water.

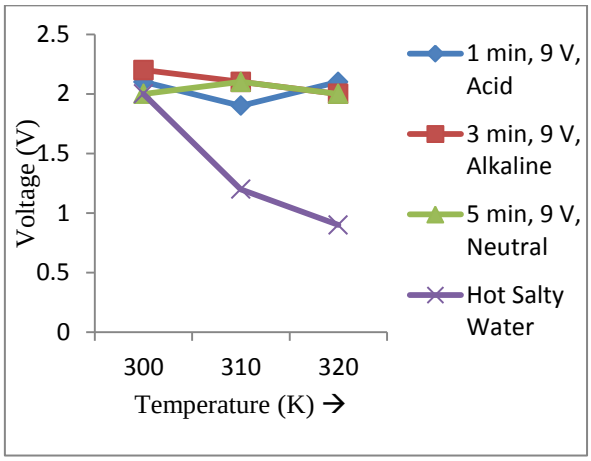

Figure5 The variations of Cell Voltage with Temperature of different fuel Cells

6.3 The variations of efficiency with Temperature for alkaline medium:

Figure 6 shows the efficiency variations with the temperature for alkaline medium. Initially it is a straight line i.e. the efficiency is linearly varying with the increase in temperature from 300 K to 310 K then it gets constant if further increase in temperature to 320 K is made.This is due to the fact that as temperature is increased the electron gets utilized faster and its alkaline medium in which the rate of reaction decreases with temperature due to which the variations are decreasing.

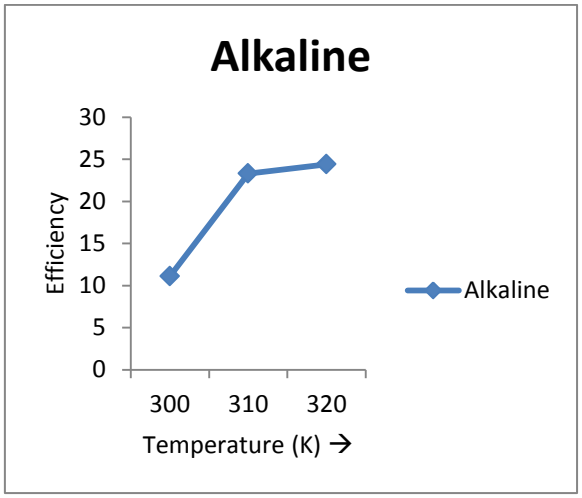

Figure 6The variations of efficiency with Temperature for alkaline medium

6.4 The variations of efficiency with Temperature for acid medium:

Figure 7 shows the variations of efficiency with Temperaturefor Acid medium.For the case of acid initially on increasing the temperature the efficiency decreases to a certain critical point at 310 K then after by increasing the temperature to 320 K the efficiency increases. This is due to the fact that in acidic medium initially the reaction is faster and gradually with increase in temperature the electrons gets consumed faster.

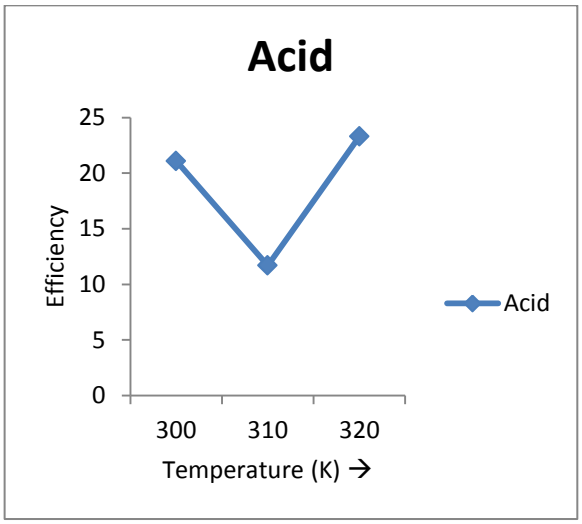

Figure 7The variations of efficiency with Temperaturefor Acid medium

6.5 The variations of efficiency with Temperature for neutral medium:

Figure 8 shows the variations of efficiency with temperature for Neutral medium.The efficiency for the neutral medium firstly increases up to a certain critical point of temperature 310 K then after if temperature is increased the efficiency decreases. When its neutral medium the electrons moment increases so the cell voltage increases with the increase in temperature up to a certain extent then after wards the utilization of electrons is gradually takes place. Then afterwards the cell voltage decreases with the increase in temperature.

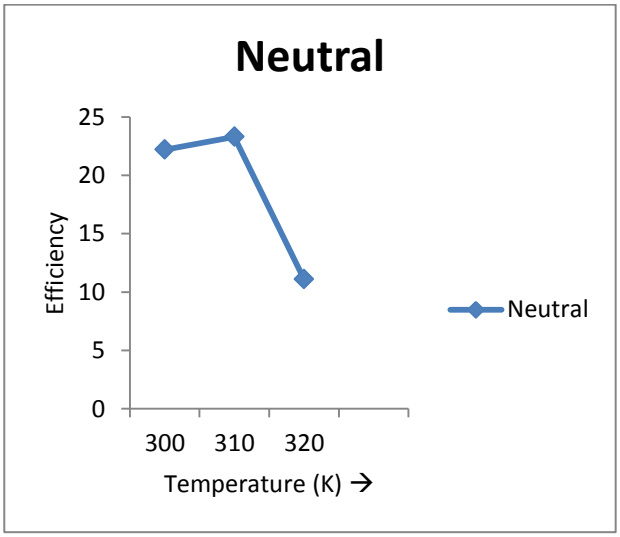

Figure 8 The variations of efficiency with Temperature for Neutral medium

6.6 The variations of efficiency with Temperature for hot salty water:

Figure 9 shows the variations of efficiency with temperaturefor hot salty water.When the hot salty water was used the efficiency decreases with the increase in temperature. If further the temperature is increased the efficiency keeps on decreasing with increase in the temperature. As its salty water initially the moment of electrons happens faster and then gradually decreases.

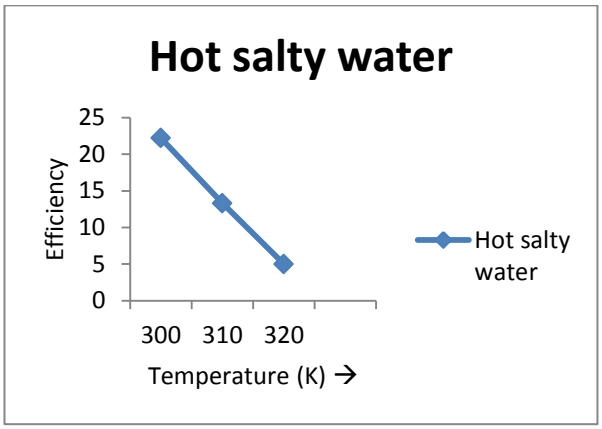

Figure 9The variations of efficiency with Temperaturefor Hot salty water

VII. Conclusion

The analysis of the discharge time and voltage will help the technology to build more systems which can provide power for more time. The discharge time ideally should be more as possible one can keep.

The different types of medium can be analysed with many number of variations such that technology can be build up the way that we can get the range of highest possible cell voltage with the variations of parameters like temperature and type of electrolyte. There can be n number of ways of using the electrolytes and electrodes combination.

This technology is marketed fully based on the efficiency factor. Many variations of electrolyte, electrodes and catalysts can be used in order to produce a fuel cell which can give the highest efficiency possible.

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