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HYDROGEN DRY CELL GENERATOR FOR HYDROGEN PRODUCTION BY SPLITING WATER

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ABSTRACT

The needs energy for fossil fuels continues to increase in people's lives and industry. Fossil energy that cannot be renewed and has an impact on environmental damage needs to be sought alternatives from renewable energy, one of which is hydrogen because it is more environmentally friendly and does not cause air pollution. Hydrogen production through water electrolysis is a processof equicurity of water molecules into hydrogen and oxygen gases using electric current. In this study aims to determine the optimum condition of hydrogen gas produced, which is influenced by electrolyte concentration, time and number of electrode plates with the method used that is electrolysis. Hydrogen gas concentrations are used by MQ-8 gas sensors and dry cell generators as gas production reactors. In this study, Cu/Al electrode plate was used because it has good electrical conductivity as electrode and $NaNO_3$ is used as electrolyte. The current and voltage used in this electrolysis process remained at 0.6 ampere and 2 volts for 1 hour. The results of the measurement of optimum conditions using the RSM program obtained the optimum concentration of hydrogen gas at the number of plates 3/3 (Cu/Al) namely at the concentration of $NaNO_3$ 1 M and time 60 minutes with a hydrogen gas concentration of 75.8907 ppm and the result verification of 76 ppm, while on the number of plates 4/4 (Cu/Al) obtained hydrogen gas concentration of 129,841 ppm and verification of 130 ppm at $NaNO_3$ concentration 1 M and time 60 minutes. Based on the data shows the prediction of optimum solution suggested by RSM program is good enough.

Keywords: Hydrogen, Electrolysis, Cu/Al, electrolytes, RSM

1. INTRODUCTION

The continuous use of fossil fuels (natural gas, coal, oil, etc) results in the depletion of fossil fuel reserves.[1][2] As much as 80% of human needs depend on fossil fuels, this results in the depletion of fossil energy reserves that have limited properties.[23][27] Hydrogen as renewable energy was chosen because it has environmentally friendly properties.[22][25] The use of this alternative energy will save the use of fossil fuels and can gradually reduce dependence on fossil energy sources.[20][21][28]

Compared to the fossil fuels that we commonly use during this time, namely gasoline and diesel, the use of hydrogen as a fuel is much more effective in combustion.[3][30] In comparison 1 kg of gasoline burned at 25°C and pressure 1 atm will produce heat between 44.5 kJ/kg to 47.5 kJ/kg, while 1 kg of diesel can produce heat between 42.5 kJ/kg to 44.8 kJ/kg.[5][6] Hydrogen it self is in the same condition (25°C and pressure 1 atm) of the same weight is capable of generate heat of 119.93

kJ/kg to 141.86 kJ/kg, which means almost 3 times the heat that can be generated by gasoline and diesel combustion.[7][8]

Chemical enginering magazine issue of August 6, 2020, lowered the special news about hydrogen energy technology in several countries.[4][9] Power innovations (American Fork,Utah) and microsoft successfully used hydrogen as fuel for a series of data center servers for 48 hours non-stop and (Guildford, U.K.) with China National Offshore Oil Corporations (CNOOC) jointly developed the hydrogen energy industry in China.[24][29] Hydrogen is seen as one of the promising energies and is able to take a pioneering role in this transition period.[26]

2. LITERATURE REVIEW

Based on literature searches using *endnotes,* there are about 385 researches on hydrogen renewable fuels that have been developed in the world. Electrolysis cells are the most widely used method for hydrogen gas production at the moment, which is the method of electricity use in containers containing water.[16][17] The breakdown of water molecules in order to be ionized requires a large amount of energy, only about 4% of hydrogen can be obtained if using ordinary electrolysis.[10][11] Therefore, an electrolyte is needed as a break-up of water molecules.[12][13] Design of dry cell generator reactors using electric current to disperse hydrogen and oxygen gases in water molecules.[14][15]

The purpose of this study was to determine the maximum concentration of hydrogen gas concentrations instigated through the electrolysis process and to use dry cell generators and MQ-8 gas sensors as hydrogen gas detection devices.[18][19]

3. EXPERIMENTAL

2.1. Tools and materials

The tools and materials used in this study are arduino uno, Power Supply, Aluminum (0.7 mm thick), copper (0.4 mm thick), acrylic, socket, bolt 13, saw, drill, tube, gasket (2 mm), hose, MQ-8 sensor, Glassware, $NaNO_3$, aquades.

2.2. Procedures

Electrode preparation

Copper plate (0.4 mm) and aluminum plate (0.7 mm) in the form of sheets cut with a width of 10 cm and a length of 10 cm as much as 8 sheets and arranged sandwiches as shown in figure 1.

Then the electrodes are limited by gasket and arranged with a plate count of 3/3 (Cu/Al) and 4/4 (Cu/Al).

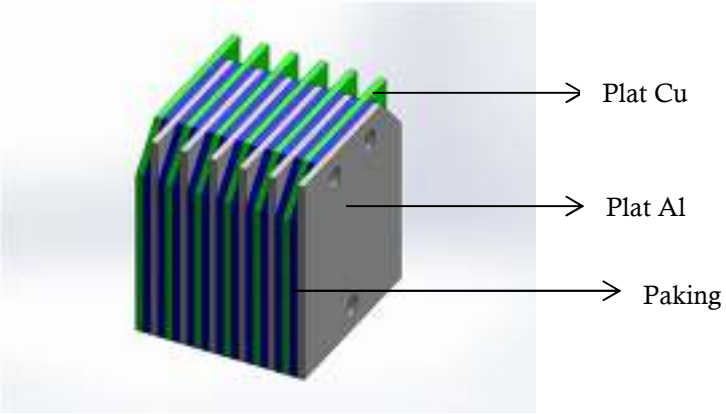

Figure 1. Electrode Sandwich Model

Tools in the form of reactors, electrodes, sensors MQ-8, Arduino Uno and PC arranged like figure 2. Then, *the power supply* is already paired plug cables and cables with clamps. Next, prepare a solution of NaNO3 with various concentrations alternately (0.25 M, 0.5 M, 0.75 M, and 1 M). Prepare the MQ-8 sensor as a measurement of hydrogen gas concentration. Connect the hose from the reactor to the sensor detector. Furthermore, the tube that already contains electrolyte solution is given DC electric current to react the solution so that water decomposition becomes hydrogen and oxygen gas. Measure for 1 hour, it will be able to final concentration than the reading of arduino uno software, Do on each variation of concentration and number of plates to be tested.

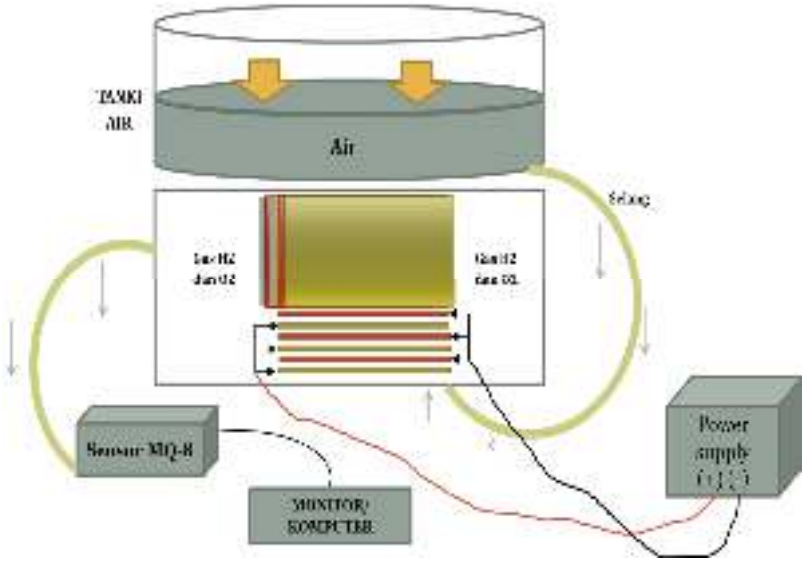

Figure 2. Dry cell Generator Work Scheme

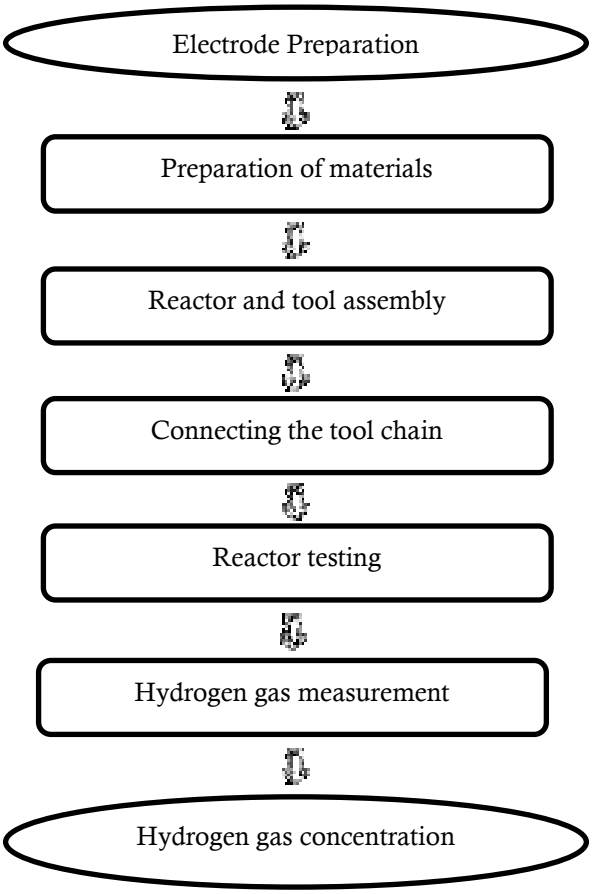

Figure 3. Hydrogen Gas Measurement Flow Chart

4. RESULTS AND DISCUSSION

At the time of measurement of hydrogen concentration as shown in figure 2, it must be ensured that the plates are not connected to each other. This is due to the impaired function in producing hydrogen gas as well as the electric current flowed. The plates used in this test are Cu with a thickness of 0.4 mm and al plate with a thickness of 0.7 mm. Al plate use is thicker than Cu because at the time of electrolysis process occurs Al plate that undergoes oxidation, with the reaction:

$$Al_{(s)} \rightarrow Al^{3+}_{(aq)} + 3e^{-}$$

Which causes a lack of weight of aluminum plate during the electrolysis process, therefore so that the ability of Al does not decrease then the weight is made thicker than Cu.

The maximum concentration of hydrogen gas is obtained at a concentration of $NaNO_3$ 0.75 M and a time of 60 minutes and decreased at a concentration of $NaNO_3$ 1 M (Figure 4), This is because at the concentration of $NaNO_3$ 1 M electrolyte solution t of anions and cations results in reduced electrolyte power, resulting in less concentration of hydrogen gas.

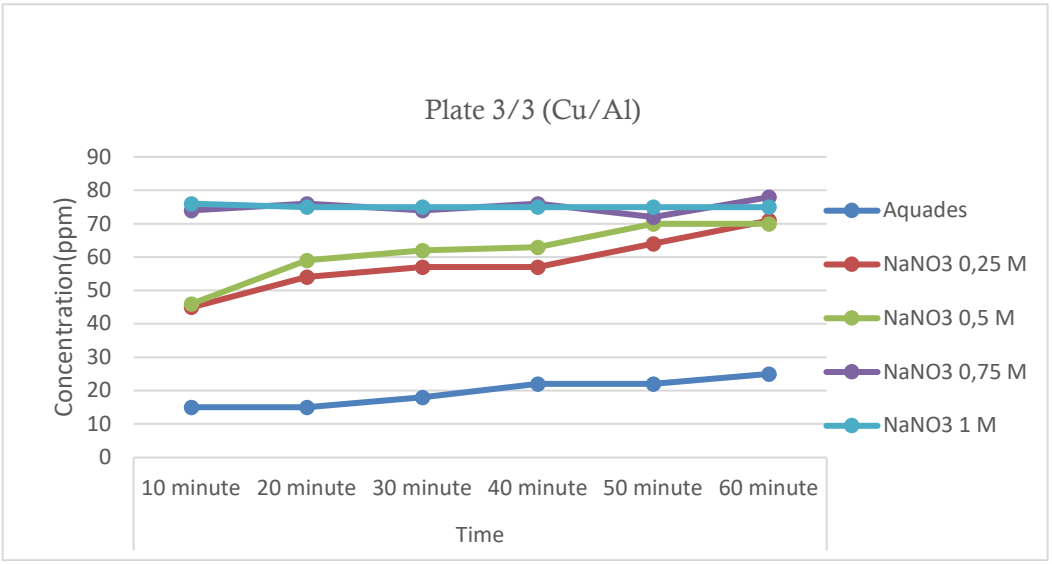

Figure 5. Graph of H_2 concentration measurement results using MQ-8 sensor

The graph above shows that hydrogen gas concentrations will increase with increased $nano_3$ concentrations and time. The decrease in the value of hydrogen gas concentration at electrolyte concentration of 1 M is estimated to occur because the concentration of $NaNO_3$ is increasingly saturated so that the movement of anions and cati in electrolyte solution becomes limited and electrodes are not strong in electrolysis for a long time.

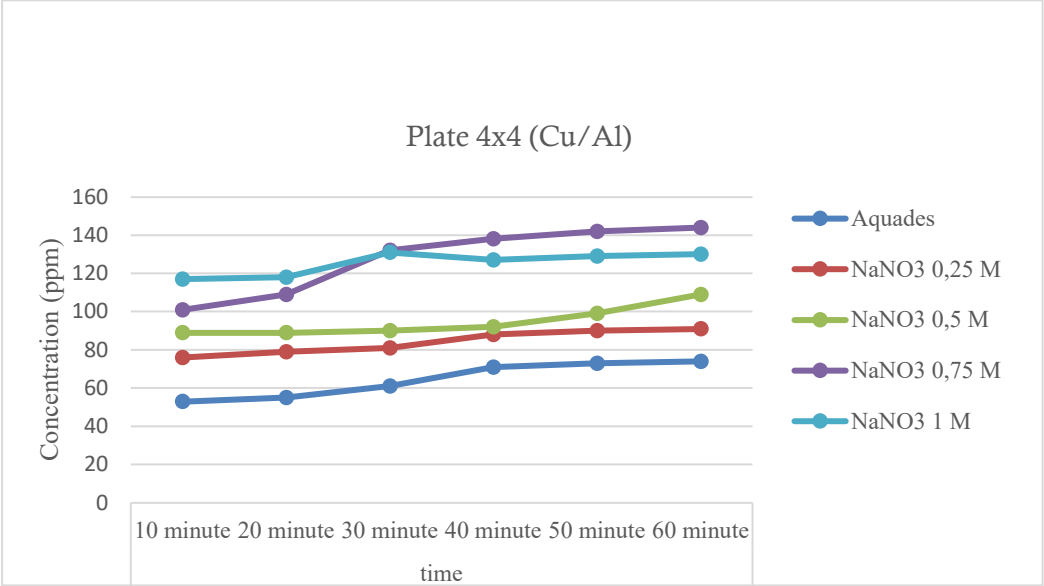

Figure 6. Graph of H_2 concentration measurement results using MQ-8 sensor

In the measurement of hydrogen gas concentration using a variation of plate 4/4 (Cu/Al) obtained maximum H_2 concentration at electrolyte concentration of 0.75 M and time of 60 minutes of 144 ppm, while in the measurement of hydrogen gas concentration on the plate variation 3/3 (Cu/Al) obtained maximum H_2 concentration at electrolyte concentration of 0.75 M and time of 60 minutes as

much as 78 ppm, this indicates that the increasing number of electrodes then the concentration of hydrogen gas produced is also more and more.

Figure 6 shows that the time and concentration of $NaNO_3$ is directly proportional to the concentration of hydrogen gas produced. The high concentration of electrolytes has the ability to accelerate the reduction of resistance in electrolytes resulting in faster electron transfer of electrolysis. While the increase in temperature during the electrolysis time also causes the faster movement of electrons to decompose water molecules into forming elements so that the hydrogen gas obtained is more maximal.

From the picture above, it can be noted that the increasing and increasing electrolyte concentration and time, the greater the concentration of hydrogen gas produced, which indicates that the concentration of $NaNO_3$ and time is directly proportional to the concentration of hydrogen gas produced. According to research conducted by (1), adding electrolytes during the electrolysis process can affect the production of hydrogen gas. This is because the electrolyte solution that acts as an electric transmission decomposes into positive ions and negative ions become more so that the distance between ions will be shorter which has an impact on the amount of electric current flowing and the reaction of water molecule breakdown becomes fast and more hydrogen gas is formed (13).

Figure 7. Sandwich Model Electrodes after electrolysis

In this study, 3/3 plate (Cu/Al) and 4/4 plate (Cu/Al) with an electrode model was arranged sandwichically, with a gap of 2 mm. Short distances can lead to low resistance to transport ions that can produce hydrogen gas quite well. The shorter the cathode distance to the anode also causes the faster movement of electrons, causing friction between electrons that occur faster (14). The use of the number of electrodes 4/4 (Cu/Al) refers to research (15) with currents and voltages used respectively 0.6 A and 2 V, because if the current and voltage or number of plates used is too large or increased then it can decrease the performance of the generator used so that the hydrogen gas produced is less than the maximum.

Calculations to determine the weight of Al and Cu are lost or increased when the electrolysis process can be used formula:

$Q = I \times t$
Notes:
Q = Electricity (Coulomb)
I = Current (Ampere)
T = Time (Second)

The weight of Al lost during the electrolysis process as much as 0.1979 grams. While the weight of Cu electrodes increased by 0.6985 grams. Changes in the weight of the electrodes used indicate that both electrodes experienced oxidation reactions in Al and reduction reactions in Cu**.**

5. CONCLUSION

The addition of concentration and time can increase the concentration of hydrogen gas produced in the electrolysis process. The maximum concentration of hydrogen gas obtained by MQ-8 sensor measurements is at a variation of 3/3 plate (Cu/Al) occurring at $NaNO_3$ concentrations of 1 M and a time of 60 minutes with a hydrogen gas concentration of 78 ppm. while the maximum concentration of hydrogen gas in the plate variation of 4/4 (Cu/Al) was obtained at 144 ppm at a concentration of $NaNO_3$ 0.75 M and a time of 60 minutes. The weight of the metal Al lost during the electrolysis process amounted to 0.1979 grams and the weight of Cu electrodes increased by 0.6985 grams.

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