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The Influence of the Mass Fraction of Catalyst for Oxy-Hydrogen (HHO) Production on the Dry Cell Type of HHO Generator

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ABSTRACT

One alternative energy that can e developed in the future is water. The water can produce future fuels, namely hydrogen and oxy-hydrogen, through the electrolysis of water. Electrolysis of water is one way to produce hydrogen into electrical and thermal energy conversion of hydrogen and oxygen. This study used a dry cell type HHO generator to produce Oxy-hydrogen. Oxy-hydrogen consists of two hydrogens and one oxygen or Oxy-hydrogen (HHO). Carried out to determine the optimal performance of the mass fraction of the catalyst on the productivity of Oxy-hydrogen by mixing 2500 ml of air and NaHCO3 as a catalyst. The observed mass catalyst fractions were 0.69, 1.38, 1.77, 2.15, 5 7.5, 10, and 15%. The results showed that the best Oxy-hydrogen production performance using a catalyst was 10% catalyst mass fraction with a production rate of 0.02250 l/s with an efficiency of 36.98%.

Keywords: Mass fraction of catalyst, Oxy-Hydrogen (HHO), water electrolysis, HHO Generator dry cell type

Introduction

Currently, most energy consumption is fossil fuels, whereas fossil fuels are finite resources. Besides that, the resulting use of fossil fuels is toxic and unhealthy for the environment and could contribute to climate change (Höök, 2013). Energy cannot be created or destroyed, but it can transform into another form, a process known as energy conversion.

On the other hand, fossil fuels meet most of the world's energy needs. The availability of fossil fuels, which are running out and contributing to air pollution, has also created problems. In all spheres of life, there is considerable dependence on fossil fuels as an energy source. The availability of energy sources found in nature does not equal the demand for fossil fuels, which will increase due to this problem. A rise in greenhouse gases is one of the environmental pollutions that can result from the overuse of fossil fuels.

The issues above promote the development of environmentally friendly and sustainable alternative energy. Water is one alternative energy source; it covers nearly 70% of the earth's surface. Furthermore, the result of water evaporation is harmless and environmentally friendly. Water is a naturally occurring compound, and water (H_2O) is composed of hydrogen (H_2) and oxygen (O_2), both of which can be burned and can aid in the combustion process (Hidayatulloh, 2015). Water contains hydrogen, an energy carrier because hydrogen cannot be obtained directly but only through water electrolysis (U.S Department of Energy, 2014).

Water molecules are split apart by the HHO generator using electrolysis. Hydrogen and oxygen atoms, or H_2O, are combustible when split apart and produce a clean-burning gas instead of a liquid. Through the air intake lines of our engines, this gas—consisting of hydrogen and oxygen atoms that have been separated—is introduced, which is then mixed with our fuel. There

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are two types of electrolysis processes: those that use a separator and those that do not (Kurniawan et al., 2015). If a separator is used in the electrolysis process, the resulting gas is hydrogen and oxygen gas separated from each other. Meanwhile, if no separator is used during the electrolysis process, the gas produced is a mixture of hydrogen gas and oxygen gas, also known as Oxy-hydrogen.

Internal combustion engines can benefit from oxy-hydrogen (Ursua et al., 2012). An HHO generator is used to create Oxy-hydrogen. This study employs a dry cell HHO gas generator typically housed in a plate (square cell). The electrodes are only partially immersed in water through the plate's holes and gaps. The benefits of this type are its less expensive and simpler design, faster production time, low current, and less water used because it only focuses on the plate gap. Eq. (1) describes the reactions on each plate of the HHO gas generator (Mang et al., 2013).

$$\begin{aligned} &\text{The reaction of Oxidation (+)} && : 2H_2O_{(l)} \rightarrow O_{2(g)} + 4\,H^+_{(aq)} + 4e^- \\ &\text{The reaction of Reduction (-)} && : 2H_2O_{(l)} + 2e^- \rightarrow H_{2(g)} + OH^-_{(aq)} \qquad (1) \\ &\text{Overall reaction} && : 2H_2O_{(l)} \rightarrow 2H_{2(g)} + O_{2\,(g)} \end{aligned}$$

Past studies on the productivity of Oxy-hydrogen have been widely conducted, including studies examining the productivity of Oxy-hydrogen in dry cell electrolyzers using direct and indirect photovoltaic voltages. According to the research findings, using an indirect photovoltaic system will occasionally increase the productivity of Oxy-hydrogen over a direct photovoltaic system (Imam et al., 2013). Another study is looking into the characteristics of solar-powered oxy-hydrogen production. This study discovered that using a direct solar system necessitates a higher average power than using an indirect system (Widhiyanuriyawan et al., 2013).

Using pure water without a catalyst results in low electrical conductivity and Oxy-hydrogen production. As a result, using an electrolyte solution, a mixture of water and a catalyst, will increase conductivity, resulting in increased Oxy-hydrogen production (Chakrapani et al., 2011). This study aimed to see how the configuration of the electrode gap distance used as an electrode plate and a neutral plate affected the amount of Brown gas produced during the electrolysis of water using a dry cell.

Material and Methods

The research method used in this research is experimental, namely experimental method, by carrying out direct observations of the cause and effect of a process. In this study, the object observed was the effect of the mass fraction of the catalyst on the productivity of Oxy-hydrogen in dry cell type water electrolysis. Figure 1 shows the HHO generator dry cell type with ten plates of electrodes: one plate of the cathode, one plate of the anode, and eight plates of neutral.

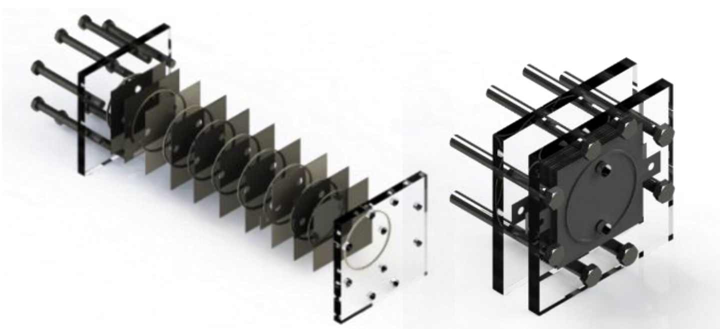
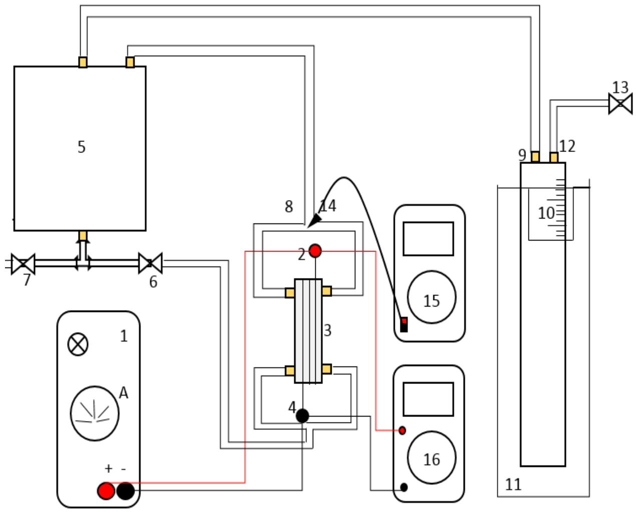


Figure 1. The HHO generator dry cell type

This study used the mass fraction of catalyst as the free variable (independent), that is, 0.69, 1.38, 1.77, 2.15, 5, 7.5, 10, and 15%. Meanwhile, the volume of water in the solution is 2.5 litres or 2500 ml, the thickness of the plates is 1 mm, the percentage of the mass fraction of the $NaHCO_3$ catalyst used is 1.77% (45 grams), and the current of amperes is 10 A. The ambient temperature is kept constant during the study. The dry cell electrolyzer used is O-Ring insulation with a diameter of 56 mm, an electrode plate, and a neutral plate with 304L Stainless Steel material. The dry cell electrolyzer construction used in this study is shown in Figure 1.



Description:

1. Dry cell electrolyzer
2. Inverter (Power supply)
3. Bubbler box
4. Voltmeter
5. Thermocouple
6. Exhaust valve (electrolyte solution)
7. Inlet valve (electrolyte solution)
8. Exhaust valve (Oxy-hydrogen)
9. Measuring tube

Figure 2. The installation of experiment

Data retrieval is done by looking at the measurement parameters read, namely the voltage, temperature and volume of oxy-hydrogen. The oxy-hydrogen volume measurement method uses the manometer principle by looking at the change in height (Δt) of the air in the tube and the air outside the tube at a pressure of 1 atm in a closed tube condition in Figure 2.

Results and Discussion

To get the value of oxy-hydrogen production rate, it must first know the volume of oxy-hydrogen produced. In this study, the volume measurement was carried out simply using the help of a measuring cup installed in Figure 2. The principle of this measurement is to flow oxy-hydrogen through a hose from the electrolyte box to a measuring cup installed upside down and put into a container of water.

The condition of the water in the measuring cup and the container has the same pressure, which is 1 atm, then the surface of the water in the measuring cup and container has the same height as the average water. So oxy-hydrogen that has been produced will continue to fill the measuring cup and push the water in it. The difference between the height of the water in the measuring cup and the outside shows the volume per unit time of oxy-hydrogen, which refers to the manometer principle. So to calculate the rate of gas production, it can be seen from Eq. 2 as follows:

$$Q = \frac{V}{t} \quad (2)$$

Q = The production of oxy-hydrogen (ml/s)
V = The Volume of oxy-hydrogen (ml)
t = time (s)

The increase in volume as a result of the addition of a catalyst following previous research on wet cell type electrolyzers, the addition of a catalyst will increase productivity. However, the more catalyst is added, the more saturated the solution will be, resulting in anions and cations in the solution being more challenging to move to transfer electrons. Oxy-hydrogen most significant gas production was founded at a mass fraction of 1.31%, namely 0.00171 l/s in wet cell electrolysis (Laksono et al., 2013).

Likewise, Figure 3 shows that the productivity of Oxy-hydrogen increases with the addition of the catalyst mass fraction, but there is an optimal point for the productivity of Oxy-hydrogen. The addition of the catalyst mass fraction between 0.69-2.15% still experienced an increase in Oxy-hydrogen production, but at 5-15%, the catalyst mass fraction had an optimal point of Oxy-hydrogen production of 0.02250 l/s at 10% catalyst mass fraction.

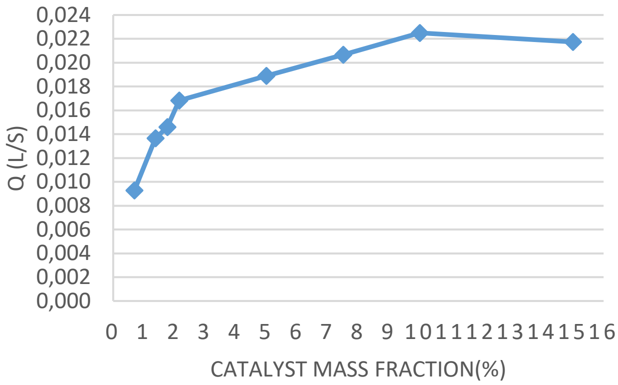


Figure 3. Relationship between productivity and catalyst mass fraction

Adding a catalyst to the wet cell type electrolyzer will increase the production of oxy-hydrogen (El Kady et al., 2020), but adding more catalysts will also increase the saturation of the solution. The above happened because anions and cations in solution will be increasingly difficult to move and transfer electrons. As a result, the most significant production of Oxy-hydrogen was at 1.31% catalyst fraction and 28.13 watts of power, namely 0.00171 l/s. Meanwhile, in dry cell electrolysis with variations of catalyst mass fraction of 0.39, 0.59, 0.79, 0.99, 1.18, 1.38, and 1.58% dissolved in 2500 ml/s aqua dest resulted in the most significant Oxy-hydrogen production of 0.00736 l/s at 1.58% catalyst, productivity can be seen in Figure 3.

Figure 4. Residual catalyst on electrode

A catalyst can help speed up a reaction, but the catalyst does not react with the reaction, and the amount of catalyst will be the same before and before the reaction, as evidenced by the catalyst in Figure 4. Adding a catalyst fraction can speed up the electrolysis reaction because the catalyst can reduce the activation energy. The activation energy is the minimum energy required for reactants to interact and mix. The activation energy is the energy barrier that separates the reactants and products. For the reaction to take place, it needs at least the same energy as the activation energy (Cakrapani et al., 2013).

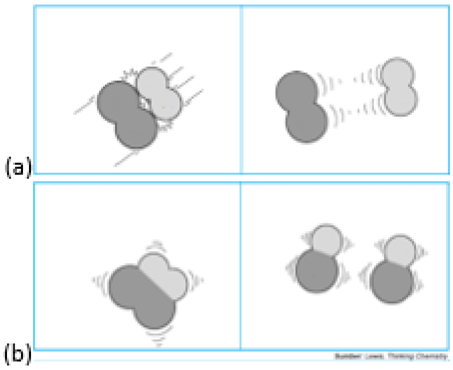


Figure 5. Molecular collision theory (a) Collision failed (b) Collision was successful

Increasing the concentration of reactants can accelerate the reaction rate because the number of particles will increase in that volume and cause collisions between particles to occur more often. With the same energy and many collisions, it is possible to increase the number of successful collisions so that the reaction rate increases. Reactions that can occur due to collisions between molecules assisted with sufficient energy can be seen in Figure 5.

The addition of the mass fraction of $NaHCO_3$ catalyst can affect the productivity of Oxy-hydrogen according to the hypothesis that the more significant the mass fraction of the catalyst will accelerate the reaction rate, so the productivity is excellent. However, the addition of catalyst has a maximum value when the total catalyst concentration reaches the maximum point, mass fraction 10. The solution will experience concentration and saturation, so the movement of anions and cations is inhibited. Another phenomenon occurs in precipitation in the solution, and the solubility of the catalyst in water decreases, so the catalyst function is not optimal, as shown in Figure 6.

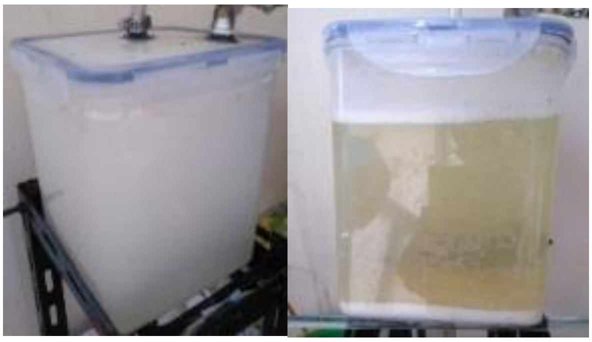


Figure 6. Saturated electrolyte solution and precipitation after electrolysis

Conclusion

The best performance is adding the catalyst mass fraction by 10%. The more catalyst used, the greater the production of Brown's gas, but at the maximum point, the addition of the catalyst will cause saturation of the electrolyte solution.

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