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Effect of Electric Current Supply and Number of Electrode Cells on Hydrogen Gas Production as Fuel Cell Energy Source

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ABSTRACT

This study aims to determine the effect of electric current supply and the number of electrode cells on hydrogen gas production through water electrolysis process, and analyze the efficiency of hydrogen gas conversion into electrical energy using PEM fuel cells. The electrolysis process was carried out by varying the supply of electric current (0.5; 1.0; 1.5; 2.0 A) and the number of electrode cells (6, 12, 18 cells) using KOH electrolyte solution. The results showed that the greater the supply of electric current and the number of electrode cells, the more volume of hydrogen gas produced. The highest volume of hydrogen gas was produced at a current supply of 2.0 A with 18 electrode cells, which amounted to 0.0442 mol. The efficiency of hydrogen gas energy conversion into electrical energy in PEM fuel cell reaches an optimal condition of 50% at a current supply of 1.0 A with 18 electrode cells. The data obtained shows that the combination of optimal electric current supply and the appropriate number of electrode cells can maximize hydrogen gas production. These findings have important implications for the development of more efficient fuel cell systems in renewable energy applications.

Keywords: *Electrolysis, Electrode Cells, Hydrogen, Fuel cell, Renewable Energy.*

1. INTRODUCTION

Fuel cell is a promising technology in producing clean and efficient energy, especially as an alternative to conventional energy sources that are more polluting to the environment [1]. One type of fuel cell that is widely researched is the hydrogen fuel cell, which utilizes hydrogen as a fuel to generate electricity. Hydrogen production for fuel cell purposes can be done through the process of water electrolysis, which involves a chemical reaction between water and electric current in an electrode cell [2].

The process of water electrolysis involves splitting water molecules into oxygen and hydrogen with the help of an electric current. In this process, the amount of hydrogen gas produced is greatly influenced by various factors, including the electric current supply and the configuration of the electrode cell [3]. A higher electric current supply can accelerate the electrolysis process and increase the volume of hydrogen gas produced. However, the effect of increasing the electric current on efficiency and hydrogen gas production needs to be investigated further to determine the optimal conditions [4].

In addition to the electric current supply, the number of electrode cells also plays an important role in hydrogen production. The electrode cell serves as a reaction medium that enables the separation of hydrogen and oxygen. Increasing the number of electrode cells can increase the reaction area, potentially increasing hydrogen gas production. However, the effect of the number of electrode cells on hydrogen gas production efficiency is not always linear and can be affected by other factors such as current distribution and system resistance [5].

Previous studies have shown that optimizing operational conditions in the electrolysis process can increase the efficiency and yield of hydrogen production [6]. Research by Erlinawati [7] found that at higher electric current supply, hydrogen production increased significantly, but was also accompanied by greater energy consumption. On the other hand, research by Arifin [8] showed that increasing the number of electrode cells can increase hydrogen production, but also affect the stability and distribution of current in the system.

This study aims to explore in depth the effect of electric current supply and number of electrode cells on hydrogen gas production. By conducting experiments with variations in electric current and number of electrode cells, it is expected to find the optimal combination that can improve the efficiency and yield of hydrogen gas production for fuel cell applications. A better understanding of these parameters will help in the development of more efficient and environmentally friendly fuel cell technology [9].

This research is also relevant given the importance of developing renewable energy technologies to reduce dependence on fossil fuels and address global climate change issues [10]. Hydrogen fuel cells offer a potential solution in the provision of clean and sustainable energy, but challenges in efficient hydrogen production must first be overcome [11]. Therefore, this research aims to contribute to understanding and optimizing the hydrogen production process, so as to support the development of more effective and powerful fuel cell technology.

2. MATERIAL AND METHODS

This study investigated the effect of electric current supply and number of electrode cells on hydrogen gas production as a fuel cell energy source. Preparation and implementation of the research were carried out for five months, starting in March 2024 and ending in July 2024. The output of this research is a concept of hydrogen gas utilization technology using fuel cells as an electrical energy conversion tool that is applied for practical learning purposes at the vocational higher education level and commercial purposes.

2.1 Material and Tools

The raw materials used for this experiment are Aquadest and potassium hydroxide (KOH). The equipment used for this research is a set of electrolysis tools and fuel cells as illustrated in figure 1.

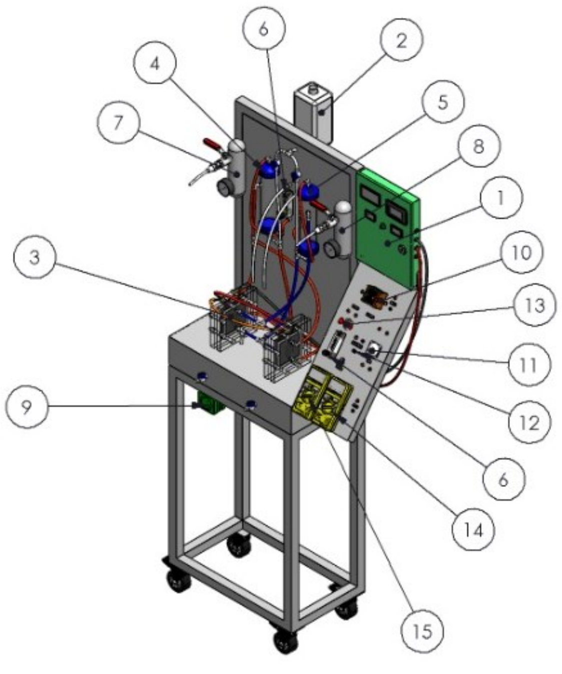

Figure 1. Unit Electrolysis and Fuel Cell

Description:

1. Control Panel
2. Feed Tank
3. Dry Cell Elektrolyzer
4. H_2 Gas Separator
5. O_2 Gas Separator
6. Flow Meter
7. H_2 Storage
8. O_2 Storage
9. Vacuum Pump
10. PEM Fuel Cell
11. Lamp
12. Socket USB
13. Mini Fan Motor
14. Volt Meter
15. Ampere Meter

2.2 Methods

As the object of this research, 300 ml of 0.3 M KOH electrolyte solution was used. The electrolysis process was carried out for 30 minutes. The treatment of electric current supply consisted of four experimental levels, namely 0.5 A; 1.0 A; 1.5A; and 2.0 A. The treatment of the number of electrode cells in the electrolysis process consisted of three experimental levels, namely 6 cell 12 cell and 18 cell. Consists of 3 experimental levels, namely 6 cell 12 cell and 18 cell. Each treatment uses 5.05 g KOH with a concentration of 0.3 M. The process variables that will be measured and observed are temperature, pressure, and power measurements used during the electrolysis process. Raw data from the results of measurements and observations are then compiled in tabular form and analyzed to determine the interaction relationship between variables.

3. RESULTS AND DISCUSSIONS

3.1 Effect of Electric Current Supply and Number of Electrode Cells on Hydrogen Gas Production

This research aims to analyze the effect of electric current supply on the volume of hydrogen gas produced in a fuel cell system. Electric current supply is one of the key factors influencing the efficiency of the electrolysis process, which is a common method for producing hydrogen from water. In the context of fuel cells, a deep understanding of this relationship is important to optimize hydrogen production and, ultimately, improve fuel cell performance [12].

In this experiment, the variable electric current supply was tested at four different levels: 0,5 A; 1,0 A, 1,5 A; and 2,0 A. Observations show that the volume of hydrogen gas produced increases as the electric current supply increases. From the Figure 2, it can be seen the effect of electric current supply on hydrogen gas production in the electrolysis process carried out for 1800 seconds. In Figure 3.1 it can be seen that in 6 electrode cells at an electric current of 0.5 A the amount of gas produced is 0.0113 mol, then the amount of gas increases at 12 and 18 electrode cells by 0.0164 mol and 0.0168 mol.

Similarly, at 6 electrode cells, the production of the amount of hydrogen gas with an electric current supply of 1.0 A, 1.5 A and 2.0 A has increased respectively, namely 0.0309 mol, 0.0429 mol, and 0.0430 mol.

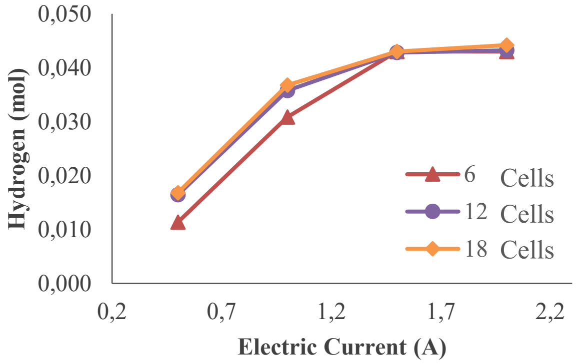

Figure 2. Effect of Electric Current Supply and Number of Electrode Cells on Hydrogen Gas Production

This shows that there is an effect of electric current supply on the amount of hydrogen gas production produced because two water molecules react by capturing 2 electrons at the cathode which is induced into gas (H_2) and hydroxide ions (H-) will be faster. According to Fajri, et al [13] the high and low supply of electric current will affect the amount of gas obtained, the greater the current given, the greater the volume of hydrogen gas produced, and instead, the lower the current, the less volume of hydrogen gas obtained.

This is directly proportional to the sound of Faraday's law I: The amount of substance produced at the electrode is directly proportional to the amount of electric current through electrolysis. So that the most amount of hydrogen gas is found in the supply of electric current 2.0 A and 18 electrode cells which amounted to 0.0442 mol.

3.2 Effect of Electric Current Supply and Electrode Cells on Energy Consumption Used in the Electrolysis Process

This research aims to evaluate the effect of the number of electrode cells on the efficiency of hydrogen gas production in the electrolysis process. The electrode functions as a mediator in the electrolysis reaction which breaks down water molecules into hydrogen and oxygen. By understanding how varying the number of electrode cells affects production efficiency, we can optimize fuel cell system design for better results [14].

In this experiment, the number of electrode cells was varied at three levels: 6 cells, 12 cells, and 18 cells. The observation results show that increasing the number of electrode cells has a significant impact on the volume of hydrogen gas produced.

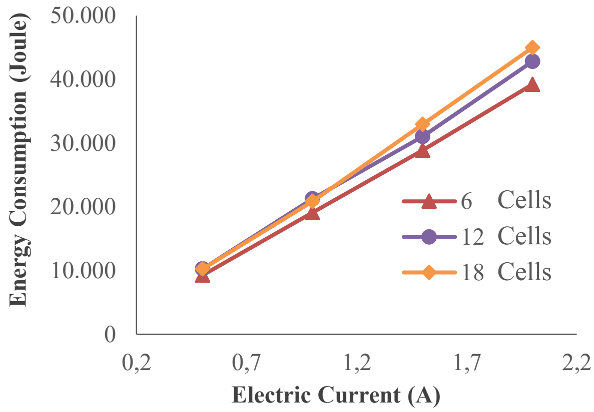

Figure 3. Effect of the Number of Electrode Cells on the Energy Consumption Used in Electrolysis

From the Figure 3. above, it can be seen that increasing the number of electrode cells in the electrolysis process produces an increasing amount of energy at each magnitude of the electric current supply. In Figure 3.2 it can be seen that at 6 electrode cells at a current of 0.5 A the energy produced is 9,270 Joules, then the amount of energy increases at 12 and 18 electrode cells by 10,260 Joules. Similarly, at 2.0 A, the production of the amount of hydrogen gas with 6, 12, and 18 electrode cells experienced an increase in energy consumption of 39,240 Joules, 42,840 Joules, and 45,000 Joules, respectively. This shows that there is an effect of the number of electrodes on the energy consumption used. According to Erlinawati et al [15] the number of electrode cells affects the electric current distributed in each electrode cell, the more the number of electrode cells, the more the current supplied will be divided into each cell. So that the highest energy consumption is obtained in 18 electrode cells with a current supply of 2.0 A, which is 45,000 Joules.

3.3 Effect of Electric Current Supply and Number of Electrode Cells on the Efficiency of Electrolysis Process

In this research, the main focus is to identify optimal operational conditions that can maximize hydrogen gas production in a fuel cell system. Efficient hydrogen production in a fuel cell system is highly dependent on several operational parameters, including electric current supply, number of electrode cells, electrolyte type and concentration, and operational temperature. A deep understanding of how each of these factors affects hydrogen production is very important for developing more effective and efficient fuel cell systems [16].

One of the key parameters in hydrogen production is the electric current supply. Increasing the supply of electric current generally speeds up the electrolysis process, which can increase hydrogen gas production [17]. However, research by Nugroho [18] shows that there is an upper limit beyond which increasing electric current no longer provides a significant increase in hydrogen production. Too much current can cause excessive heating and increased resistance, which in turn can reduce system efficiency. Therefore, identifying the optimal electrical current supply is essential to ensure maximum efficiency without causing damage to the system.

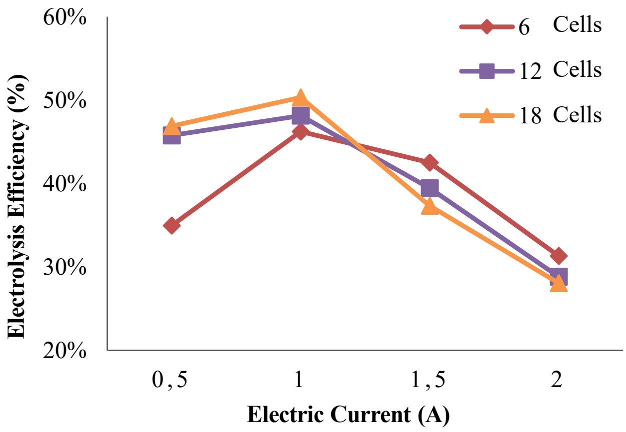

Figure 4. Effect of Electric Current Supply and Number of Electrode Cells on Efficiency in the Electrolysis Process

In the electrolysis process with variations in the supply of electric current and the number of electrode cells, the optimal condition is obtained at 18 electrode cells with an electric current supply of 1.0 A, which is a tool efficiency of 50%. This shows that the use of 18 electrode cells with an electric current supply of 1.0 A produces the most optimal tool efficiency in the electrolysis process. The greater the supply of electric current given, the efficiency of the tool tends to decrease. At a current supply of 2.0 A, the efficiency of the device is only about 28-31% for various numbers of electrode cells. This is because an increase in the supply of electric current leads to an increase in energy consumption in the electrolysis process.

3.4 Utilization of Hydrogen Gas from Electrolysis as an Energy Source for Proton Exchange Membrane (PEM) Fuel Cells

In the electrolysis process with variations in electric current supply of 0.5 A, 1.0 A, 1.5 A, and 2.0 A. and the number of electrode cells 6 cells, 12 cells, and 18 cells, the amount of hydrogen gas is obtained which is then utilized to the PEM fuel cell so that the PEM fuel cell efficiency data is obtained in graphical form, and can be seen in Figure 5.

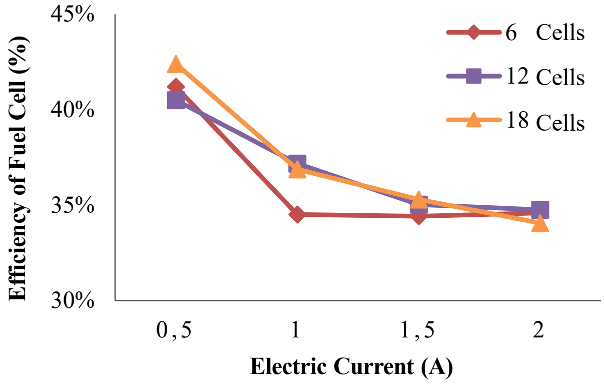

Figure 5. Hydrogen Gas Conversion Results into Electrical Energy in Terms of PEM Fuel Cell Efficiency Using LED Lamp Load

From Figure 5. above shows that the efficiency of PEM fuel cell in converting hydrogen gas into electrical energy is influenced by the supply of electric current and the number of electrode cells in the electrolysis process. Where the conversion of hydrogen gas energy into electrical energy in PEM fuel cell is also influenced by the volume of hydrogen gas. The greater the volume of hydrogen gas, the higher the conversion efficiency. At a current of 0.5 A, the PEM fuel cell efficiency is 41.20% for 6 electrode cells, 40.50% for 12 electrode cells, and 42.40% for 18 electrode cells.

However, the efficiency of PEM fuel cell tends to decrease as the supply current increases. Where at a current supply of 1.0 A, the efficiency of 34-37% is obtained, and continues to decrease to around 34-35% at a current supply of 1.5 A and 2.0 A. This is reinforced by the statement Nordin, et al [19], PEM fuel cell efficiency is influenced by several factors, such as operating conditions (temperature, pressure, humidity), and cell design. At higher supply currents, PEM fuel cell systems tend to experience decreased efficiency due to increased activation polarization, concentration polarization, and internal resistance. In addition, the number of electrode cells also affects the efficiency of PEM fuel cells. The more the number of electrode cells, the efficiency tends to increase. This is because the more hydrogen gas produced, the more electrical energy can be generated by the PEM fuel cell.

4. CONCLUSIONS

This research provides an in-depth understanding of how the supply of electric current and the number of electrode cells affect hydrogen gas production in fuel cell systems. From the results it can be concluded that there is a significant relationship between the supply of electric current and the number of electrode cells to the production of hydrogen gas. The higher the current supplied, the more hydrogen gas produced, with the highest result reaching 0.0442 mol at a current of 2.0 A and 18 electrode cells. In addition, increasing the number of electrode cells also affects the energy consumption used in the electrolysis process, where energy consumption increases with the increase in the number of electrode cells and the supplied current, reaching a peak at 45,000 Joules for 18 cells at a current of 2.0 A. The hydrogen gas produced can also be utilized in PEM fuel cells, where the efficiency is affected by the volume of gas produced and the supply of electric current. Although the efficiency tends to decrease at higher currents, a larger number of electrode cells increases the energy conversion efficiency. Overall, this study shows that optimization of the electric current and the number of electrode cells is essential to improve hydrogen gas production and device efficiency in the electrolysis process.

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