

The Effect of Electric Current on the Production of Brown's Gas using Hydrogen Fuel Generator with Seawater Electrolytes

by Dentri Irtas

Submission date: 25-Apr-2023 09:54AM (UTC+0800)

Submission ID: 2074628465

File name: t_of_Electric_Current_on_the_Production_of_Brown_s_Gas_using.pdf (1.33M)

Word count: 4343

Character count: 22244

PAPER • ² OPEN ACCESS

The Effect of Electric Current on the Production of Brown's Gas using Hydrogen Fuel Generator with Seawater Electrolytes

To cite this article: Dentri Irtas *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **709** 012001

View the [article online](#) for updates and enhancements.



240th ECS Meeting ORLANDO, FL

Orange County Convention Center Oct 10-14, 2021

Abstract submission due: April 9

SUBMIT NOW

The Effect of Electric Current on the Production of Brown's Gas using Hydrogen Fuel Generator with Seawater Electrolytes

Dentri Irtas¹, Yohandri Bow², Rusdianasari^{1*}

¹Renewable Energy Engineering Department, Politeknik Negeri Sriwijaya, Jl. Sriwijaya Negara Palembang 30139, Indonesia.

²Energy Engineering Department, Politeknik Negeri Sriwijaya, Jl. Sriwijaya Negara Palembang, 30139, Indonesia

*Corresponding author: rusdianasari@polsri.ac.id

Abstract. The decline in crude oil production in Indonesia is a burden for the Indonesian people. Therefore, Indonesia needs alternative energy or innovation that aims to review the use of petroleum fuels. One alternative energy is the use of hydrogen fuel (H₂). Hydrogen gas can be obtained by breaking air compounds (H₂O) into hydrogen-oxygen hydrogen gas (HHO) which is brown by electrolysis. Water electrolysis is the decomposition of water compounds into oxygen and hydrogen gas by using an electric current through water. The current will conduct electricity to the electrodes so that a reduction reaction will occur at the cathode and form hydrogen gas. To speed up the electrolysis process, we need an electrolyte solution that conducts electricity. In general, the electrolysis process is carried out to produce oxygen gas and hydrogen gas using alkaline solution. Alkaline solution used is sea water-electrolyte. The solution is a strong electrolyte that can conduct electric current well. The electrodes used are stainless steel pipe which is resistant to corrosion with insulating material added cotton fabric that serves as an insulator or barrier zone between the cathode and the anode. By designing a hydrogen fuel generator, hydrogen gas may be generated based on the effect of electric current. Variations of the electrical current used is 3A, 6A, 9A, 12A, 15A, 18A, and 21A. The higher the electrical current supplied to the production of hydrogen gas will be many more. The production of hydrogen gas is the most widely produced on the current 21A with 0.0478 LPM of hydrogen gas and efficiency hydrogen fuel generator at 12.99%.

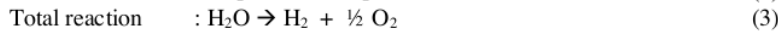
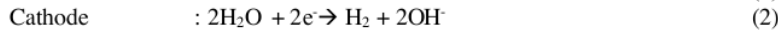
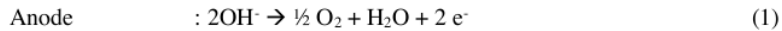
1. Introduction

The decline in production and the increasingly high price of crude oil at this time is a burden for the people of Indonesia. To reduce this burden, the efforts made are to find and develop other energy sources as alternative energy [1]. One alternative energy is the use of hydrogen fuels that are environmentally friendly. To get brown's gas you must first separate brown's gas in water [2]. Water is a natural resource that is very important for life. Water has a very abundant amount, especially salt water in the sea around 1,337 million km³ [3]. Electrolysis is a process of decomposition of water molecules (H₂O) into Hydrogen (H₂) and Oxygen (O₂) with the energy triggering the reaction in the form of electrical energy. This process can take place when two electrodes are placed in water and a direct current is passed between the two electrodes. Hydrogen is formed at the cathode, while oxygen is at the anode. During this time electrolysis is known as the most effective hydrogen production process from water with a high purity level, but limited to small scale [4]. The reaction is as follows:



Content from this work may be used under the terms of the [Creative Commons Attribution 3.0 licence](https://creativecommons.org/licenses/by/3.0/). Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

Published under licence by IOP Publishing Ltd



3

The hydrogen and oxygen gas produced from this reaction form bubbles in the electrodes and can be collected. This principle is then used to produce hydrogen and hydrogen peroxide, which produce hydrogen fuel [5,6]. In the process of electrolysis of water, the catalyst used is an electrolyte solution. Electrolytes can function as electrical conductors, where electric current is carried by the movement of ions [7]. The electrolyte used is seawater because seawater contains sodium chloride (NaCl). Sodium chloride is the most important salt in marine salinity and the extracellular fluid of many multicellular organisms. NaCl is very commonly used as a food spice and preservative. Sodium chloride is a crystal-shaped salt or white powder. NaCl can dissolve in water but not dissolve in alcohol. NaCl is also a sodium compound that is abundant in nature, NaCl contained in the sea is one of the electrolytes that can conduct electricity. NaCl dissolved in H₂O can be broken down into Na⁺ and Cl⁻ ions, in the presence of free charge particles, there is an electric current [8]. The chemical equation of NaCl can be seen in the equation below.



The element NaCl has a degree of ionization of 1, or close to 1, and NaCl includes a strong electrolyte solution and can be fully ionized in water [9]. The energy produced from seawater has many advantages, including environmentally friendly and does not require many funds.

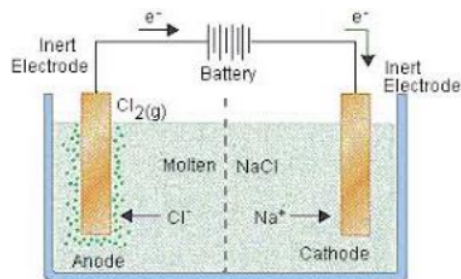


Fig 1. The working principle of electrolysis cells

The flow of electric current is unidirectional, causing the ions in the solution to move toward the electrodes whose charge is the opposite. Positive ions (cations) go to negative electrodes (cathodes) and subsequently undergo a reduction reaction, otherwise negative ions (anions) go to positive electrodes (anodes), which will undergo an oxidation reaction [10]. Electrodes act as a place for the reaction. The reduction reaction takes place at the cathode, while the oxidation reaction takes place at the anode.

Research conducted by Putra in 2010 with the current regulation of 4A-6A, optimal hydrogen gas is produced at a current of 6A. However, the experimental device has the disadvantage that if the current is raised, it will overheat and melt the tube, which is made of mica (plastic). For efficient production of hydrogen gas, tube construction must be replaced with components that are resistant to high currents, which cause overheating. The decomposition of water can be optimized with the use of large currents [11].

2. Materials and Methods

2.1. Functional Design Approach

In this approach, the hydrogen fuel generator design that is made, there is usefulness for each of the feed water tanks located at the top of the tool leading to the reactor below to get the force of gravity so that

it can push feed water into the reactor. In it, an electrolysis reaction takes place between the cathode (-) and the anode (+), which functions to separate the brown's gas contained in water with the help of a catalyst. To separate these compounds, electrode cells are used in the form of stainless steel cylindrical pipes that have been given an electric voltage that is changed to the direction (DC) through the DC Power Supply. The resulting product is brown's gas. Inside this electrode cell, there is an insulating material that can separate the zone between hydrogen gas and oxygen gas that the two gases do not mix. Brown's gas produced is flowed into a water storage tube that serves to bind the water content that is still present in brown's gas. Not all of the gas produced is pure. After that flowed into the absorber tube, which aims to absorb the water content contained in brown's gas, it is expected that with the filter tube brown's gas produced is genuinely pure and can be used as fuel.

2.2. Structural Design Approach

In general, the design of the tool is divided into 4 parts, namely a water storage tank, electrodes, a separation tube consisting of hydrogen and oxygen cylinders, and absorber tubes. The water storage tank (feed) is made with a length of 12 cm, width 7.5 cm, and height 12 cm. The electrode, section consists of stainless steel cylindrical pipes arranged in parallel and with electric current supplied from a DC power supply that aims to process electrolysis of water. The electrode consists of an inner tube, which is a cathode cell (negative pole) and an outer pipe, which is an anode cell (positive pole).

In the inner tube, which is the cell cathode, the insulating material is covered with cotton, which functions to separate the zone between the cathode pole and the anode pole so that hydrogen gas and oxygen gas do not mix. Then at the lower end of the flow is given a residual discharge channel that serves to remove residual from the electrolysis process. At the top of the separation tube, which consists of a hydrogen tube and brown's gas reactor tube, has a diameter of 7 cm and a length of 33 cm. While the filter tube has a diameter of 6 cm and a length of 28 cm placed after the storage tube. The filter tube is made to increase the purity of the gas. Then the brown's gas output pipe from the tube is given a pressure gauge and a valve. At the output of the gas is given a tool called Flashback Arrestor, which serves to dispel the fire to get back into the cylinder. This plays an important role in reducing the potential for an explosion in the gas in the reservoir. The design of the hydrogen fuel generator in Figure 2.

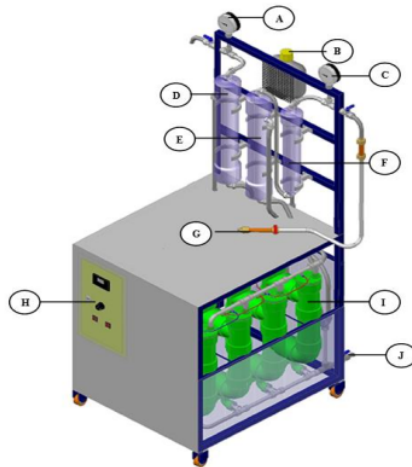


Fig 2. Hydrogen fuel generator design

Where:

- | | | |
|-----------------------------------|---------------------------------|-----------------------------------|
| A = Pressure Gauge O ₂ | B = Feed Storage Tank | C = Pressure Gauge H ₂ |
| D = O ₂ Storage Tank | E = H ₂ Storage Tank | F = H ₂ Filter Tank |
| G = Aerestor Valve | H = Box Panel (Controller) | I = Reactors and Electrodes |
| J = Feedback | | |

The seawater electrolyte solution used is as much as 7.5 liters. This solution is electrolyzed by using a varied supply of electric current, namely 3A, 6A, 9A, 12A, 15A, 18A, and 21A. The research data is directed to be able to see the effect of the supply of electric current on hydrogen gas products that are produced, so this research requires a specific analysis of the gas product produced and the electrical efficiency of the tool.

2.3. Hydrogen Fuel generator Performance parameters

2.3.1. Calculating the Amount of Gas in the Electrolysis Process

In both voltaic cells and electrolysis cells, there is a quantitative relationship between the amount of substance that is rotating and the electric charge involved in a redox reaction. Faraday's Law I states that the mass of a substance produced at an electrode during the electrolysis process is directly proportional to the electric charge used. The amount of electric charge that occurs in a cell is the product of the strength of the current flowed by the length of time of electrolysis. This statement is a basic principle of Faraday's Law which can be explained as follows:

1. In an electrochemical cell, the mass deposited on an electrode is proportional to the amount of electric charge (the flow of electrons) involved in a cell.
2. The equivalent mass of the substance deposited on the electrode will be equivalent to the electric charge flowed into the cell.

The law of faraday I can be formulated as follows:

$$W = \frac{e \cdot i \cdot t}{F} \quad (5)$$

Where:

| | |
|---|------------------------------------|
| W | = mass of substance (gram) |
| e | = equivalent mass/(M/valence) |
| i | = strong current (amperes) |
| t | = time (seconds) |
| F | = Faraday constant (96500 Coulomb) |

The charge of 1 electron mole is equal to $6.02 \times 10^{23} \times 1.6021 \times 10^{-19}$ or equal to 96500 Coulomb. Where an electric charge of 96500 Coulomb is called faraday.

An ideal gas is a theoretical gas consisting of point particles that move randomly and do not interact with each other. The concept of an ideal gas is very useful because it meets the ideal gas law, a simplified state equation, so that it can be analysed with statistical mechanics.

On normal conditions such as standard temperature and pressure, most real gases behave like ideal gases. Many gases such as nitrogen, oxygen, hydrogen, noble gases, and carbon dioxide can be treated as ideal gases with differences that can still be tolerated. In general, gases behave like ideal gases at high temperatures and low pressures, because the action against intermolecular forces becomes much smaller when compared to the kinetic energy of particles, and the size of molecules also becomes much smaller when compared to empty spaces between molecules.

The ideal gas model cannot be used at low temperatures or high pressures, because intermolecular forces and molecular sizes are important. The ideal gas model also cannot be used in heavy gases such as refrigerants or gases with strong intermolecular forces, such as water vapor. At some point, when the temperature is low, and the pressure is high, the real gas will undergo a phase transition to liquid or solid. The ideal gas model cannot explain or allow phase transitions. This can be explained by more complex state equations. The Ideal Gas formula can be explained as follows:

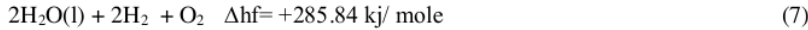
$$PV = nRT \quad (6)$$

Where,

| | | | |
|---|------------------------------|---|--|
| P | = Gas Storage Pressure (atm) | V | = Initial Volume (liters) |
| n | = Mole of H ₂ gas | R | = Gas Constant 0.082 L • atm • K ⁻¹ • mol ⁻¹ |
| T | = Temperature (K) | | |

2.3.2. Calculating HHO Generator Efficiency

Efficiency is the ratio between useful energy and energy given to a system. In the HHO Generator, a useful result is the electrolysis of water in the form of HHO gas obtained in the decomposition reaction of water (H₂O).



Endothermic reactions that produce the enthalpy energy needed to break the H₂O molecules into H₂ and O₂ are positive (+). The enthalpy energy produced is +285.84 kJ/mole. In this study to calculate the efficiency of an electrolysis device can be calculated by the following equation:

$$\text{Hydrogen fuel generator efficiency} = \frac{\text{Theoretical Energy Used}}{\text{Actual Energy Used}} \times 100 \% \quad (8)$$

3. Result and Discussion

In this research, a Hydrogen Fuel Generator has been made which functions to produce brown's gas. The study was conducted using sea water as an electrolyte so that the solution can conduct an electric current. To produce brown's gas, a varied supply of electric current is used to determine how the effect of the electric current on the product of brown's gas produced.

The process of decomposition of water into brown gas occurs in the reactor. Electrolyte solution from the feed tank is channeled to the reactor where the reactor is in the form of electrodes in the form of stainless steel pipes, which serve as a place for the reaction to take place. Reduction reactions occur at the cathode, while oxidation reactions occur at the anode. When given an electric current supply, the negative pole from the current source will lead to the cathode (because it requires electrons), while the positive pole from the current source must lead to the anode [12]. As a result, the cathode is negatively charged and attracts cations that will be reduced to metal deposits. Conversely, the anode is positively charged and attracts anions which will be oxidized to gas. Brown's gas produced from this reaction will form bubbles on the electrodes and flow separately to the hydrogen gas storage tube and oxygen gas storage tube. Gas is flowed again into the gas filter tube to filter or absorb oxygen gas, which is still mixed in hydrogen gas.

3.1. The Effect of Electric Current on Theory's Brown's Gas Production

The effect of current variations on the brown's gas produced increases with the amount of current used in the electrolysis process, besides the increase in the amount of brown's gas produced is affected because the decomposition reaction that occurs at the cathode is greater than the anode. The current is needed for the process of breaking down water molecules into brown's gas. The number of electrodes as many as 4 cells affects the amount of electric current supplied to the reactor, where the electrode serves as a conductor of the current so that the electrolysis process can run well. This can be seen based on the graph between the flow versus brown's gas volumes shown in Figure 3.

Figure 3 shows that theoretically, the current flow of 3A brown's gas is 0.0206 LPM, then the amount of gas has increased at current 6A by 0.0413 LPM, 9A by 0.062 LPM, 12A by 0.0827 LPM, 15A was 0.1034 LPM, 18A was 0.1241 LPM, and the highest gas production in the current 21A was 0.1448 LPM. Where in this condition, the number of electrode plates is not varied (fixed variable) that is equal to 4 cells. In the electrolysis process there is a change in current strength during the production of brown's gas, the results obtained are not linear because it is influenced by the diffusion of ions from the solution to the surface of the electrode, and there is a tensile strength between opposing charge ions so that the current strength is initially low and slowly increase.

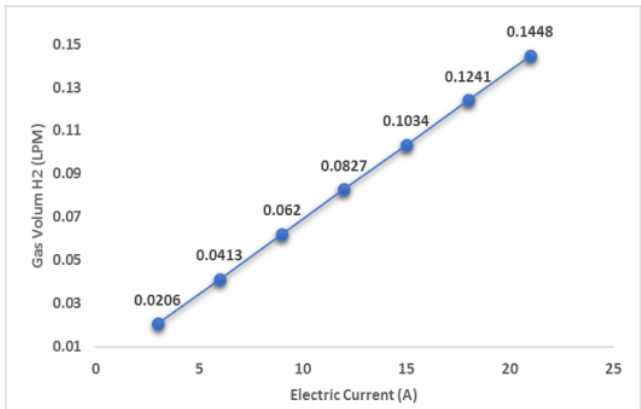


Fig 3. The effect of electric current on theory's brown's gas production

3.2. The Effect of Electric Current On Brown's Gas Production Practically

Electrolysis is a chemical process that converts electrical energy into chemical energy. The process of electrolysis separates water molecules into brown's gas, one of which is by flowing an electric current to the electrodes to place an electrolyte solution of sea water. The electrolysis reaction is classified as a non-spontaneous redox reaction, the reaction can take place due to the influence of electrical energy. To be able to take place, the electrolysis reaction is used as an electric current from outside.

According to Faraday's law, the amount of deposits formed at the cathode is largely determined by the amount of electric current used and the length of electrolysis. The current will conduct electricity to the electrodes so that the reduction reaction will occur at the cathode to form hydrogen gas and the oxidation reaction at the anode to form oxygen gas. The following are the results of calculations that are then converted into a graph in Figure 3, showing the effect of the current on the brown's gas produced.

The production of brown's gas produced is affected due to several factors, including the large or the amount of current used, the number of electrodes, and the type of electrolyte. Electric current is the amount of electric charge caused by the movement of electrons flowing through a point in an electric circuit each time unit. The greater the electric current used, the movement of electrons in the solution will be faster so that the process of splitting water molecules will be faster in producing hydrogen.

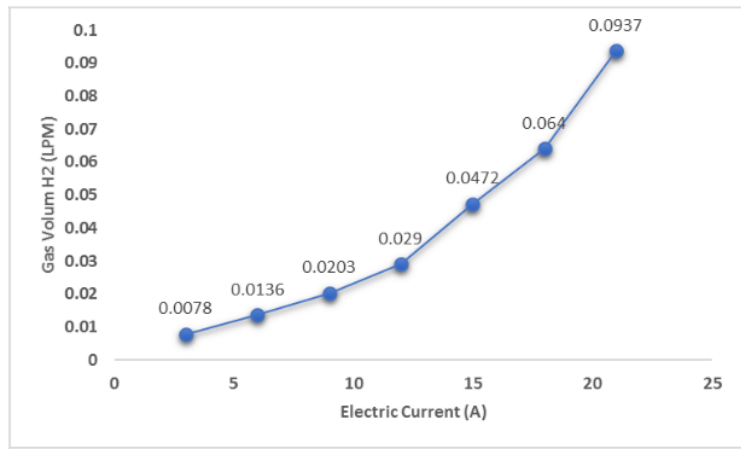


Fig 4. The effect of electric current on brown's gas production practically

In Figure 4, the brown's gas produced increases with the amount of current used in the electrolysis process. It can be seen in Figure 3 that the least gas production in the current 3 A is 0.0078 LPM, and the most brown's gas product produced in the current 21A is 0.0937 LPM. Thus, there is an influence of electric current on the production of brown's gas where the greater the current used is also greater so that the production of brown's gas more and more.

3.3. Effect of Electric Current Against Equipment Efficiency

The working system of a hydrogen generator can be reviewed based on one parameter, namely its efficiency. Efficiency is the optimization of a tool in production. Figure 4 shows the effect of the current on the efficiency of the hydrogen generator tool.

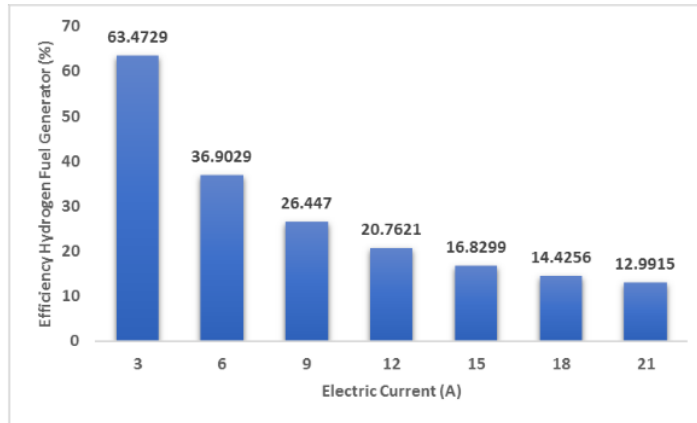


Fig 5. Graph of electric current vs efficiency of hydrogen fuel generator

The efficiency of the hydrogen generator produced decreases with increasing supply of electric current provided. This efficiency is inversely proportional to the results of the amount of hydrogen and oxygen obtained in the electrolysis process. The more the amount of current that is sparked, the efficiency of this tool will decrease. Efficiency is a comparison of theoretical energy with actual energy during the electrolysis process. Efficiency tends to increase with the smaller electric current used. Conversely, the greater the electric current used, the efficiency of the resulting current decreases. The use of small currents shows more compliance with Faraday's law than large currents. The greater the current used, the greater the power consumption used. The decrease in efficiency is caused by the increase in electrical energy used which is greater than the ratio of Brown's Gas energy produced in the electrolysis process.

In this experiment, a high efficiency of 63.47% was generated on the use of 3 Amperes of the electric current and for a low efficiency of 12.99% it was produced at 21 Amperes of the electric current. Thus the current produced will be stable because if the high current generated is high, the efficiency will decrease. The decrease is due to the electric current that occurs affecting the efficiency generated at the electrolyser. The greater the current used, the greater the power consumption used. The decrease in efficiency is caused by an increase in the electrical energy used [13]. Low current efficiency is usually caused by a side reaction that is the formation of hydrogen gas at the cathode or the formation of oxygen at the anode due to the decomposition of water contained in the solution and also related to the current density used. Current density is the current per unit surface area of the electrode, usually expressed in amperes, cm² surface. The use of a large current density at the anode, when compared to the surface area of the anode which is quite small, is unbalanced. The current will pass quickly, causing a rapid reduction reaction at the cathode. The reduction can be seen from the formation of bubbles at the cathode. Because the reduction at the cathode is rapid, the hydrogen at the cathode is quickly formed [14].

4. Conclusions

Hydrogen Fuel Generator can produce Brown's gas as an environmentally friendly alternative energy source. Based on research results, hydrogen gas products produced in the electrolysis process have increased along with the increase in the supply of electric current provided. The most widely produced hydrogen gas product is when there is a current supply of 21 Amperes in the amount of 0.0478 LPM and efficiency at 12.99%. The electric current affects the efficiency of the hydrogen generator tool where the greater the electric current that is supplied, the tool efficiency will be smaller.

Reference

- [1] Kholiq, Iman. 2015. Pemanfaatan Energi Alternatif Sebagai Energi Terbarukan Untuk Mendukung Substitusi BBM. Fakultas Teknik Universitas Wijaya Putra, Surabaya: Jurnal IPTEK Vol. 19 No. 2 (in Indonesian).
- [2] Rusdianasari, Yohandri Bow, Tresna Dewi, and Pola Risma. 2019. Hydrogen Gas Production using Water Electrolyzer as Hydrogen Power. 2019 International Conference on Electrical Engineering and Computer Science (ICECOS), Batam.
- [3] Suryadimal. 2018. Kajian Eksperimental Pengaruh Penambahan Gas Oksihidrogen (HHO) Terhadap Unjuk Kerja Motor Bensin Berbahan Bakar Premium 8. Fakultas Teknologi Industri Universitas Bung Hatta, Padang (in Indonesian).
- [4] Helmenstine A.M. Jumiati. 2001. Chemistry Glossary Definition of Electrolyte. New York. Effect of Catalyst and Electrode Solution Concentration in Electrolysis Process to Produce Brown Gas. *Jurnal Positron* Vol.3(1).
- [5] Rusdianasari, Y. Bow, T. Dewi. 2019. HHO Gas Generation in Hydrogen Generator using Electrolysis. IOP Conf. Ser.:Earth Environ. Sci. 258 012007, doi:10.1088/1755-1315/258/1/012007.
- [6] Sierens. 2005. An Overview of Hydrogen Fueled Internal Combustion Engines. Ghent University, Belgium.
- [7] Gaikwad, K.S. 2004. Development of Solid Electrolyte for Hydrogen Production. Engineering University of South Florida.
- [8] Kai Zeng and Dongke Zhang. 2010. Recent Progress in Alkaline Water Electrolysis for Hydrogen Production and Application". *Progress in Energy and Combustion Science*. Elsevier. Vol. 36(3), pp. 307-326.
- [9] S.A. Grigoriev, V.I. Poremsky, and V.N. Fateev. 2006. Pure Hydrogen Production by PEM Electrolysis for Hydrogen Energy, Elsevier, Vol. 31(2), pp. 171-175.
- [10] Rusdianasari, Yohandri Bow, Tresna Dewi, Ahmad Taqwa, and Lin Prasetyani. 2019. Effect of Sodium Chloride Solution Concentration on Hydrogen Gas Production in Water Electrolyzer Prototype". *International Conference on Technology and Policy in Energy and Electrical Power*, Yogyakarta.
- [11] Putra, A.M. 2010. Hydrogen Gas Productivity Analysis and Oxygen Gas in the Solution Electrolysis of KOH. *Jurnal Neutrino*, Vol. 2(2), Malang
- [12] Frano Barbir, 2005. PEM Electrolysis for Production of Hydrogen from Renewable Energy Source". *Solar Energy*, Elsevier, Vol. 78(5) pp. 661 -669.
- [13] Thien Khanh Tran, Hoang Jyh Leu, and Trong Quyet Vu. 2019. Hydrogen Production from the Tannery Wastewater Treatment by using Agriculture Supports Membrane/adsorbents", *International Journal of Hydrogen Energy*.
- [14] R Ploetz, R, Rusdianasari, E Eviliana. 2016. Renewable Energy Advantages and Disadvantages", *Proceeding Forum in Research, Science and Technology (FIRST)*.

The Effect of Electric Current on the Production of Brown's Gas using Hydrogen Fuel Generator with Seawater Electrolytes

ORIGINALITY REPORT

15%

SIMILARITY INDEX

15%

INTERNET SOURCES

10%

PUBLICATIONS

5%

STUDENT PAPERS

PRIMARY SOURCES

| | | |
|---|--|----|
| 1 | Submitted to Universitas Negeri Surabaya The State University of Surabaya Student Paper | 5% |
| 2 | iopscience.iop.org Internet Source | 4% |
| 3 | eprints.polsri.ac.id Internet Source | 3% |
| 4 | en.wikipedia.org Internet Source | 3% |

Exclude quotes On

Exclude matches < 3%

Exclude bibliography On