Research Inventy: International Journal of Engineering And Science
Vol.10, Issue 4 (April 2020), PP 04-09
Issn (e): 2278-4721, Issn (p):2319-6483, www.researchinventy.com

Effect of Electrodes, Electric Currents, And Nahco$_3$ Concentration Against Hho Pressure Generator

Sugeng Hadi Susilo[1], Zahratul Jannah[2], Kasijanto[3], Gumono[4]
[1,2,3,4]Department of Mechanical Engineering, State Polytechnic of Malang-Indonesia
Corresponding Author: Sugeng Hadi Susilo

Abstract:*The paper discusses the factors that influence the gas pressure of an HHO generator product. The purpose of this research is to study the effect of electrodes, electric current, and $NaHCO_3$ concentration on HHO gas pressure. Using pure experimental methods, the electrode material is made of aluminum and brass. rectangular shape with a size of 250 mm x 400 mm, with a gasket bulkhead. To produce HHO gas using electric current 20A, 30A, 40A, and 50A. and $NaHCO_3$ catalyst concentrations of (5%, 10%, 15%, 20% and 25%). Gas pressure measurement using acetylene gas regulator. The results showed the greater the electric current, the higher the gas pressure. The pressure produced at 20A is 0.297 Bar while the electric current of 50A is 0.458 bar. Whereas for copper electrodes, at an electric current of 20A produces a pressure of 0.539 Bar while at an electric current of 50A, a pressure of 1.588 bar. This shows that the gas pressure generated from the HHO generator also depends on the energy used to carry out the electrolysis process and the electrode material used. The greater percentage of $NaHCO_3$ catalyst causes an increase in HHO generator gas pressure. This is indicated by the percentage catalyst of 5% with aluminum electrodes which produces a gas pressure of 0.325 bar while the catalyst percentage of 25% produces a gas pressure of 0.458 bar. While copper electrodes increased dramatically, a 5% catalyst percentage produced a gas pressure of 0.411 bar while a catalyst percentage of 25% produced a gas pressure of 1,588 bar.*

Keywords:*Electrodes, Electric current, catalyst, HHO Generator.*

Date of Submission: 02-06-2020 Date of Acceptance: 16-06-2020

I. INTRODUCTION

Petroleum is a non-renewable natural resource. in the last few decades, fuel oil production has begun to decline. The higher the price of fuel oil should be able to make us realize that the number of oil reserves has begun to run low. To overcome this problem, it is necessary to develop alternative energy sources[1]–[3]. One alternative energy is the use of hydrogen fuel (H_2) which is environmentally friendly. The development of technology in the field of alternative energy is currently being developed to replace increasingly limited fuel oil, in this study will discuss alternative energy about HHO gas or better known as Brown's Gas. To get HHO gas water electrolysis can be done with the chemical $NaHCO_3$ (Sodium Bicarbonate) as a catalyst. This water electrolysis process is by separating H_2O water molecules into HHO gas $2H_2$ and O_2 using direct electric current. Various methods are used to produce hydrogen gas. One way is to break the bonds of compounds.[4]–[7]states that to get hydrogen gas (H_2) one must first separate hydrogen gas in water or called electrolysis of water. Electrolysis is the process of decomposition or separation of water molecules (H_2O) into hydrogen (H_2) and oxygen (O_2) using electrical energy [5], [8], [9].

[3], [10]said that hydrogen energy is different from fossil energy. Fossil energy is abundant in nature and can also be mined. This is very different from hydrogen, which must be produced first by electrolysis of water.

[11] stated that the use of hydrogen as a vehicle fuel can reduce harmful exhaust emissions, such as CO_2 which has decreased by 59.93%.

The electrolysis process occurs when two electrodes are placed in water and electrified (DC). Electrodes consisting of a cathode and anode. The cathode is the electrode connected to the negatively charged pole, while the anode is the electrode connected to the positively charged pole[6], [8]. Hydrogen gas forms at the cathode while oxygen forms at the anode.

[12]states that HHO gas generator H_2 production reaches a maximum product at an electrode thickness of 1 mm. The electrodes used are stainless steel with $NaHCO_3$ (Sodium Bicarbonate) catalyst. The power used is 59.11 Watt which produces H_2 and O_2 gas production 0,00054 kg / s.

[9], [13], [14] states that the hydrogen contained in it is not available in a free state. This hydrogen is produced from industrial production processes. To get or produce hydrogen gas can be done using the water electrolysis method. Stainless steel metal has a fairly good corrosion resistance because it has a chromium oxide

(CrO) content. Besides hydrogen production can also be done by steam reforming hydrocarbons[15].[16] using NaOH catalysts with aluminum electrodes to produce H_2 and O_2 gas in water electrolysis.

II. THEORY

2.1 HHO Generators

Water is a renewable natural resource that can be used as alternative energy, one of which is to produce hydrogen gas and oxygen through the water electrolysis method. Yull Brown researches electrolysis of water which can produce H_2 and O_2 gas and is called Brown's Gas (HHO gas). This generator has a working principle of electrolysis of water, which is to flow DC through an electrolyte using an electrode. This can cause changes in electrical energy into chemical energy (redox reactions) which can cause water molecules to break down into hydrogen and oxygen. HHO generators have two types, namely wet cell, and dry cell [17].

The amount of power used for the hydrogen gas production process is determined by the amount of voltage and electric current used. The formula used to measure the amount of power needed by the HHO generator [18], as shown in equation 1.

$$P = V.I \quad 1)$$

Where: P = Power (Watt), V = Voltage (Volt), I = Electric current (Ampere)

2.2 HHO gas reaction rate

Water electrolysis process products using HHO generators are H_2 and O_2 gas. So we know the performance of the HHO generator, and how much HHO gas is produced by the HHO generator. Equation 2 shows the mass flow rate of HHO gas.

$$\dot{m} = Q \times \rho \quad 2)$$

Where: m = HHO Gas Production Rate (Flow Rate) (kg⁄s), Q = HHO Gas Discharge (m^3⁄s), ρ = HHO density (kg⁄m^3). While equation 3 shows the amount of HHO gas discharge.

$$Q_{HHO} = \frac{v_{HHOgas}}{t} \quad 3)$$

Where: Q_{HHO} = HHO gas production rate (ml/s), $V_{HHO\ gas}$ = HHO gas volume (ml), t = The time required to produce HHO gas (s).

2.3 Electrode

Electrodes are conductors through which electric current passes from one medium to another. Electrodes have several different forms, including wire, plate, or rod. Electrodes are made of metals, such as copper, silver, lead, zinc, aluminum, brass.

The electrodes are separated by a solution containing ions. Negative electrodes undergo chemical reactions that give excess electrons. Positive electrodes undergo chemical reactions that eliminate electrons. When two electrodes are connected by an external electrical circuit, excess electrons will flow from the negative to the positive electrode. The electricity source moves electrons to one electrode and pulls electrons from the other, causing current to flow through the media [19].

In the electrochemical process, the anode undergoes oxidation. The movement of anions and cations towards or away from the anode depends on the type of electrochemical cell. In the anode galvanic cell is a negative pole, oxidation reactions occur spontaneously. Because it continuously releases electrons, the anode tends to be positively charged and pulls the anion from the electrolyte solution. The cathode is the negative pole of an electrolyte cell.

Positive electrodes (+) are called anodes and negative electrodes (-) are called cathodes. The type of electrode can affect the electrolysis process because each electrode has conductor properties. If a voltage is applied to a conductor, there is a transfer of electrical charge, and an electric current arises [20], [21].

2.4 Water electrolysis

Water electrolysis is the process of decomposing water molecules (H_2O) into hydrogen (H_2) and oxygen (O_2) using electrical energy. The electrolysis process occurs when two electrodes are in solution and both electrodes are electrified with direct current. The type and extent of the cathode are very influential in the production of gas produced.

Hydrogen gas and oxygen produced from the electrolysis of water form bubbles on the electrodes [22]–[24]. The principle is utilized to form as much hydrogen as possible which can be used as hydrogen fuel. In the electrolysis process, the electric voltage that flows between the anode and the cathode ionizes the water molecules into positive and negative ions. Positive ions at the cathode will absorb electrons to produce H2, while negative ions will move towards the anode to produce O_2[25], [26].

The catalyst used in the process of electrolysis of water is an electrolyte solution. The electrolyte solution functions as an electrical conductor [27]. Electrolytes used in the electrolysis process are very diverse, one of which is Sodium Bicarbonate ($NaHCO_3$). Electrolytes are compounds that can dissociate when dissolved in water and form ions (anions and cations) and can conduct electricity [28].

III. EXPERIMENTAL METHODS

To study the effect of electrodes, electric currents, and catalyst concentrations on gas pressure in HHO generators, this study uses an experimental method to determine the gas products produced by HHO generators.

3.1 Materials and Methods

In the study, the HHO generator design is shown in Fig. 2, and the design of the HHO geometry generator is shown in Table 1.

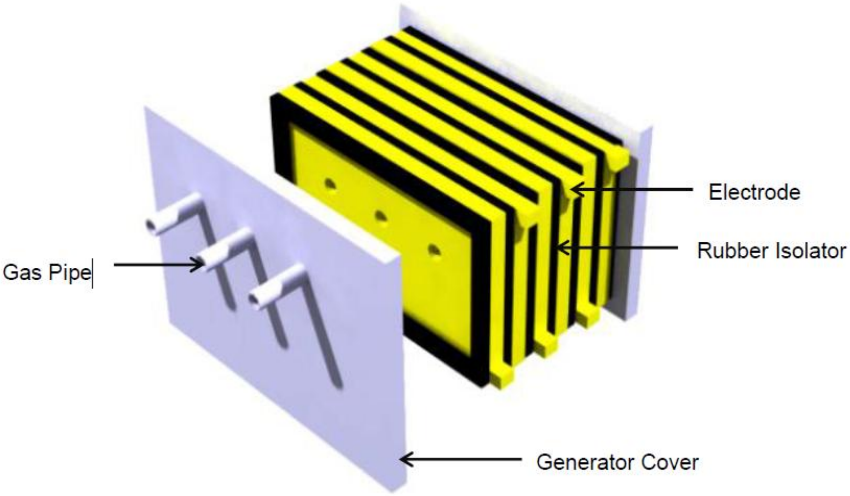

Figure 2. HHO Generator Design.

Table 1. Microchannel Geometric Parameters Used For Testing

Electrode	Alumunium	Copper
Tebal electrode	3mm	3mm
Rubber isolator	0,4mm	0,4mm
Cover	5mm	5mm
Gas pipe	Ø63mm	Ø63mm

3.2 Experimental Setup

This experiment used a variation of electrode material, electric current, and the concentration of $NaHCO_3$ catalyst. The setup consists of three main components: material of electrode (aluminum and copper), electric current (10A-50A) and $NaHCO_3$ catalyst concentration (5% -25%). To get gas pressure data use the Asetyline regulator. This regulator is installed before and after the HHO gas cylinder storage. This is intended to maintain the stability of the resulting gas flow. HHO gas pressure testing was carried out with a duration of 5 minutes for each treatment. Research scheme as shown in Figure 3.

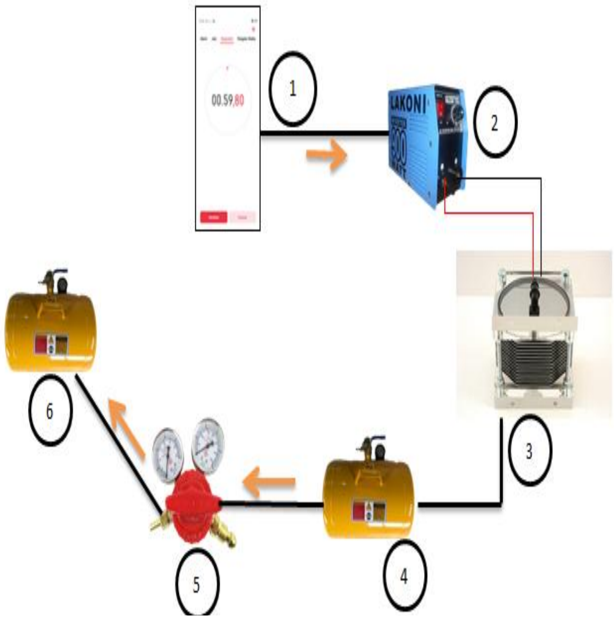

Fig. 2 Scheme of experiment setup

Where, 1. Stopwatch, 2. Trafo Las (inverter dc), 3. Generator HHO, 4.Tabung Gas HHO 1, 5. Regulator Asetylin, dan 6. Tabung Gas HHO 2.

4. Result and Discussion

4.1 Effect of electric current and electrode material and on the gas pressure of the HHO generator product

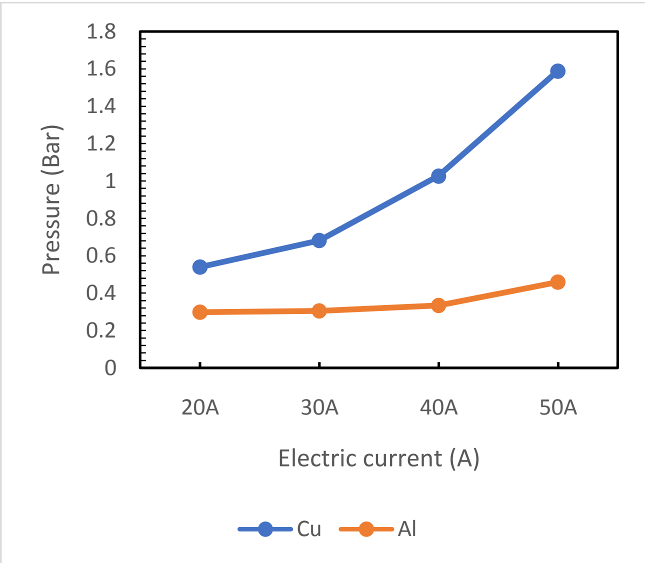

Figure 4. The relationship of electric current to the pressure of a gas generator HHO on a copper (Cu) and Aluminum (Al) electrode with a 25% NaHCO3 catalyst.

Figure 4. shows the increase in pressure of the HHO gas produced on both the copper and aluminum electrodes, with an increase in electric current. The two electrodes show that the increase in copper gas pressure is greater than that of the aluminum electrode. For aluminum electrodes, the resulting increase in gas pressure is linear, whereas the copper electrode increases in exponential gas pressure.

The amount of energy needed in the electrolysis process for the reduction-oxidation reaction of water molecules (H_2O) to occur depends on the amount of electric current. The greater the electric current, the higher the productivity. Figure 4 shows that the aluminum electrode varies in electric current ranging from 20A to 50A, using a 25% $NaHCO_3$ catalyst. the resulting pressure changes are not significant. It can be seen that the pressure generated at 20A is 0.297 Bar while the 50A electric current is 0.458 bar. But in contrast to using a copper electrode, at an electric current of 20A produces a pressure of 0.539 Bar while at an electric current of 50A, the resulting change in pressure is very significant, which is 1.588 bar. This shows that the gas pressure generated from the HHO generator depends also on the energy used to carry out the electrolysis process and the electrode material used. the amount of energy used is much changed to heat and not used to release the bonds of water so that more energy is wasted and its efficiency will decrease. This includes evidence that the higher the current the more energy will turn into heat and increase the temperature of the electrolyte.

4.2 Effect of catalyst concentration and electrode material on the gas pressure of the HHO generator product.

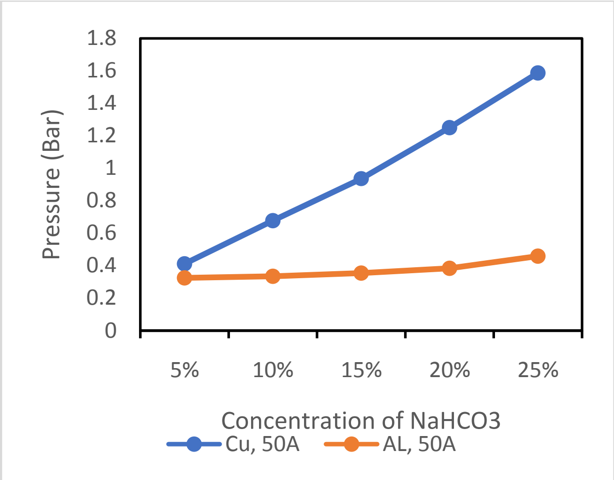

Figure 5. Relationship of NaHCO3 catalyst concentration to the HHO generator gas pressure on copper (Cu) and Aluminum (Al) electrodes with an electric current of 50A.

Figure 5 shows that the greater percentage of the $NaHCO_3$ catalyst causes an increase in the HHO generator gas pressure. This is shown by the percentage catalyst of 5% with an aluminum electrode producing a gas pressure of 0.325 bar while the catalyst percentage of 25% produces a gas pressure of 0.458 bar. While the copper electrode increases dramatically, the percentage of catalyst 5% produces a gas pressure of 0.411 bar while the percentage of catalyst 25% produces a gas pressure of 1.588 bar. This is because the more the amount of $NaHCO_3$ catalyst, the greater the HHO gas pressure. the more $NaHCO_3$ content, the greater the conductance of electricity. Because $NaHCO_3$ dissolved in water will break down into Na + anions and HCO_3- cations, these anions, and cations will conduct electric current in the water. This is due to the greater amount of catalyst which is faster in helping the process of splitting H_2O water molecules into HHO gas, and at high concentrations, this catalyst will not affect the equilibrium of the electrolyte solution so that the ions from the H_2O compound are completely split by the electrolysis process. Another cause is that the more ions in the solution the greater the conductance of electricity and the more electrical energy that can be used to carry out the electrolysis process. So many water molecules are broken down so that the HHO gas produced will increase. the greater the percentage of $NaHCO_3$ in the electrolyte solution can cause the solution to become more saturated, so the ions in the electrolyte solution will be more difficult to move when delivering an electric current. So the conductivity also becomes low and makes the electrolysis process not optimal, and makes the gas pressure decrease.

IV. CONCLUSION

The results of the study can be summarized as follows:

1. The amount of energy needed in the electrolysis process for the reduction-oxidation reaction of water molecules (H_2O) to occur depends on the amount of electric current. The greater the electric current, the higher the productivity. for aluminum electrodes with variations in electric current ranging from 20A to 50A, using a 25% $NaHCO_3$ catalyst. the resulting pressure changes are not significant. It can be seen that the pressure generated at 20A is 0.297 Bar while the 50A electric current is 0.458 bar. But in contrast to using a copper electrode, at an electric current of 20A produces a pressure of 0.539 Bar while at an electric current of 50A, the resulting change in pressure is very significant, which is 1.588 bar. This shows that the gas pressure generated from the HHO generator depends also on the energy used to carry out the electrolysis process and the electrode material used.
2. The greater the percentage of $NaHCO_3$ catalyst causes an increase in the HHO generator gas pressure. This is shown by the percentage catalyst of 5% with an aluminum electrode producing a gas pressure of 0.325 bar while the catalyst percentage of 25% produces a gas pressure of 0.458 bar. While the copper electrode

increases dramatically, the percentage of catalyst 5% produces a gas pressure of 0.411 bar while the percentage of catalyst 25% produces a gas pressure of 1.588 bar. This is because the more the amount of $NaHCO_3$ catalyst, the greater the HHO gas pressure. the more $NaHCO_3$ content, the greater the conductance of electricity. Because $NaHCO_3$ dissolved in water will break down into Na + anions and HCO3- cations, these anions, and cations will conduct electric current in the water.

ACKNOWLEDGEMENT

This research activity is supported by state polytechnics of Malang for Applied Research Dipa Swadana Research No. 023.18.2.677606/2020, with assignment letter No: 5214 / PL2.1 / HK / 2020.

REFERENCES

[1] H. L. Tuller, “Solar to fuels conversion technologies: A perspective,” Mater. Renew. Sustain. Energy, vol. 6, no. 1, pp. 1–16, 2017, doi: 10.1007/s40243-017-0088-2.
[2] B. S. Schwartz, C. L. Parker, J. Hess, and H. Frumkin, “Public health and medicine in an age of energy scarcity: The case of petroleum,” Am. J. Public Health, vol. 101, no. 9, pp. 1560–1567, 2011, doi: 10.2105/AJPH.2010.205187.
[3] J. Blázquez, R. Fuentes-Bracamontes, and B. Manzano-Gonzalez, “A road map to navigate the energy transition,” Oxford Inst. Enery Stud., no. October, 2019.
[4] F. M. Sapountzi, J. M. Gracia, C. J. (Kee. J. Weststrate, H. O. A. Fredriksson, and J. W. (Hans. Niemantsverdriet, “Electrocatalysts for the generation of hydrogen, oxygen and synthesis gas,” Prog. Energy Combust. Sci., vol. 58, pp. 1–35, 2017, doi: 10.1016/j.pecs.2016.09.001.
[5] S. Shiva Kumar and V. Himabindu, “Hydrogen production by PEM water electrolysis – A review,” Mater. Sci. Energy Technol., vol. 2, no. 3, pp. 442–454, 2019, doi: 10.1016/j.mset.2019.03.002.
[6] Rusdianasari, Y. Bow, and T. Dewi, “HHO Gas Generation in Hydrogen Generator using Electrolysis,” IOP Conf. Ser. Earth Environ. Sci., vol. 258, no. 1, 2019, doi: 10.1088/1755-1315/258/1/012007.
[7] U. Bossel and B. Eliasson, “Energy and Hydrogen Economy,” Eur. Fuel Cell Forum, Lucerne, p. 36, 2002.
[8] N. A. Kelly, Hydrogen production by water electrolysis. Woodhead Publishing Limited, 2014.
[9] A. Sudrajat, E. Mayfa Handayani, N. Tamaldin, and A. Kamal Mat Yamin, “Principle of generator HHO hybrid multistack type production technologies to increase HHO gas volume,” SHS Web Conf., vol. 49, p. 02016, 2018, doi: 10.1051/shsconf/20184902016.
[10] IRENA, Hydrogen : a Renewable, no. September. 2019.
[11] N. R. Udengaard, “Hydrogen production by steam reforming of hydrocarbons,” ACS Natl. Meet. B. Abstr., vol. 228, no. 1, pp. 906–907, 2004.
[12] R. A. Rozendal, Hydrogen Production through Biocatalyzed Electrolysis, vol. PhD disser. 2007.
[13] N. A. Ashford, Reducing Physical Hazards: Encouraging Inherently Safer Production, no. July. 2012.
[14] C. N. Yee, C. H. Raymond Ooi, L. P. Tan, M. Misran, and N. T. Tang, “Large-scale structure formation in ionic solution and its role in electrolysis and conductivity,” PLoS One, vol. 14, no. 3, pp. 1–17, 2019, doi: 10.1371/journal.pone.0213697.
[15] P. Chandran, S. Bakshi, and D. Chatterjee, “Study on the characteristics of hydrogen bubble formation and its transport during electrolysis of water,” Chem. Eng. Sci., vol. 138, pp. 99–109, 2015, doi: 10.1016/j.ces.2015.07.041.
[16] L. Weger, A. Abánades, and T. Butler, “Methane cracking as a bridge technology to the hydrogen economy,” Int. J. Hydrogen Energy, vol. 42, no. 1, pp. 720–731, 2017, doi: 10.1016/j.ijhydene.2016.11.029.
[17] A. Tristán et al., “Renewable Smart Hydrogen for a Sustainable Future,” 2018.
[18] L. Trisnaliani, S. S. Polytechnic, I. Purnamasari, and S. S. Polytechnic, “the Effectiveness of Separation Hydrogen By Electromagnetic Forces To Efficiency Electrolysis of Water Combustion of the Effectiveness of Separation Hydrogen By Electromagnetic Forces To Efficiency Electrolysis,” no. July 2017, pp. 13–18, 2016.
[19] F. Scheepers et al., “Improving the efficiency of PEM electrolyzers through membrane-specific pressure optimization,” Energies, vol. 13, no. 3, 2020, doi: 10.3390/en13030612.
[20] T. S. De Silva, L. Senevirathne, T. D. Warnasooriya, and D. Silva, “HHO Generator – An Approach to Increase Fuel Efficiency in Spark Ignition Engines TS,” Eur. J. Adv. Eng. Technol., vol. 2, no. 4, pp. 1–7, 2015.
[21] I. Staffell et al., “The role of hydrogen and fuel cells in the global energy system,” Energy Environ. Sci., vol. 12, no. 2, pp. 463–491, 2019, doi: 10.1039/c8ee01157e.
[22] S. Haryati, D. Susanto, and V. Fujiyama, “(1) Effects of Electrical Current, pH, and Electrolyte Addition on Hydrogen Production by Water Electrolysis | Welly Welly - Academia.edu,” 2014.
[23] M. R. Aczel, “Hydrogen storage technology: materials and applications, by L. Klebanoff,” Contemp. Phys., vol. 59, no. 1, pp. 99–99, 2018, doi: 10.1080/00107514.2017.1403482.
[24] P. Straka, “Institute of Rock Structure and Mechanics, Academy of Sciences of the Czech Republic, V Holešovi č kách 41, 182 09 Praha 8 * Corresponding author e-mail:,” vol. 1, no. 4, pp. 23–27, 2004.
[25] T. Younus, A. Anwer, Z. Asim, and M. S. Surahio, “Production of hydrogen by steam methane reformation process,” E3S Web Conf., vol. 51, pp. 1–5, 2018, doi: 10.1051/e3sconf/20185103003.
[26] K. Praveen and M. Sethumadhavan, “On the extension of XOR step construction for optimal contrast grey level visual cryptography,” 2017 Int. Conf. Adv. Comput. Commun. Informatics, ICACCI 2017, vol. 2017-Janua, no. 8, pp. 219–222, 2017, doi: 10.1109/ICACCI.2017.8125843.
[27] H. E. G. Prasetya, J. Pratilastiarso, A. G. Safitra, R. Amalia, and H. Ubudiyah, “The experimental study of wet cell HHO generator type with Ba (OH)2 catalyst on performance and exhaust gaseous emissions of 4 stroke engine 120 cc,” AIP Conf. Proc., vol. 1977, 2018, doi: 10.1063/1.5043026.
[28] M. Nagashima, Japan’s Hydrogen strategy and its economic and geopolitical implications études de l’Ifri monica nagasHima Centre for Energy, no. October. 2018.

Sugeng Hadi Susilo, et. al. " Effect of Electrodes, Electric Currents, And Nahco3 Concentration Against Hho Pressure Generator." International Journal of Engineering And Science, vol. 10, no. 04, 2020, pp. 04-09.