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Design of HHO generators as producers of water fuel (HHO generator product analysis based on electric current and catalyst)

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Design of HHO generators as producers of water fuel (HHO generator product analysis based on electric current and catalyst)

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Abstract. One of the fossil fuels is petroleum fuel. Petroleum is a non-renewable natural resource. Various aspects of life have felt its effects, where fuel oil has begun to experience scarcity. The higher price of fuel oil should make us realize that the amount of oil reserves has begun to run low. The purpose of this study was to determine the effect of electrodes, current strength, and concentration of NaHCO3 on the HHO gas generator output. HHO electrode generator material made of aluminum and brass. The electrode's shape is rectangular with a size of 250 mm x 400 mm, with a gasket seal. The test begins with the HHO gas pressure test. The independent variable used is aluminum and brass electrode variations. The electric current given is 20A, 30A, 40A, and the amount of 5-25% NaHCO3 catalyst. Then proceed with analyzing the pressure obtained on the HHO gas flow rate. To test the HHO gas flow rate carried out with a duration of 1 to 3 minutes in each treatment, the measurement of the discharge using a gas regulator to determine the flow rate of H2 and O2 produced. The results showed that the lowest gas discharge value was on aluminum electrodes with a current of 20A, i.e., 0,00033554 m3/s, while the highest discharge value on brass electrodes with a current of 50A was 0,001657 m3/s. It shows that the better the metal element contained in the electrodes and the higher the current applied, the greater the flow of H2 and O2 gas flow.

1. Introduction

The biggest energy needs that occur in Indonesia today is the use of fossil fuels. One of the fossil fuels is petroleum fuel. Petroleum is a non-renewable natural resource. Various aspects of life have felt its effects, where petroleum fuels have begun to experience scarcity. The higher price of fuel oil should e able to make us realize that the amount of oil reserves has begun to run low. The purpose is that efforts need to be made, such as finding and developing alternative energy sources [1]–[5]. One alternative energy is the use of hydrogen gas (H_2), which is environmentally friendly and can save the use of fuel oil in vehicles [6].

Hydrogen is an element that is widely available in nature, but not in the form of gas but in the form of compounds, for example, in water and coal. The purpose is to get hydrogen gas that is not available in a free state, and it can be done by industrial production so that the final price of the hydrogen depends on the production results that have been used. To obtain or produce hydrogen can be done by the water electrolysis method [2,6–8]. The hydrogen is different from energy from fossils. Fossil energy is very abundant in nature. Besides abundant existence, fossil energy can also be mined. It is very different from hydrogen, which must be produced first using electrolysis of water [3,9,10].

Hydrogen gas is an alternative energy source that is environmentally friendly so that it can be used as a fuel mixture for motor vehicles. The use of hydrogen for motor fuel oil is still rarely done [8,11, 12]. The use of hydrogen as an alternative to motor fuel oil can be used to conserve fossil fuels. Hydrogen can be used in fuel cells and has advantages, among others, can provide high energy efficiency, does not have soot particles that can harm humans, and has a low noise level. Gupta and Pant [13], Susilo and Anis [14], and Sudrajat et al. [15], states that the use of hydrogen for motor vehicle fuel oil can reduce harmful exhaust emissions such as CO_2, which has decreased by 59.93%. This figure is high enough for hydrogen to be said to be an excellent material to replace or serve as a mixture of motor vehicle fuel.

2. Theory

Colli et al [16] and Susilo et al [17] researched the electrodes dimensions, which stated in his research that the production of HHO gas by wet type HHO generators using the water electrolysis method produces the best generators at 1 mm electrode thickness. The electrodes used are stainless steel with $NaHCO_3$ (Sodium Bicarbonate) catalyst in the electrolyte solution. The HHO power used was 59.11 Watt resulting in an HHO gas production of 0,00054 kg/s, and the efficiency value of the HHO generator was 9.42%. Tranggono et al [18] and Morse [19] also stated in his research in making electrolyzer that only uses two variations of the electrode area, namely the front and rear surfaces only so that the level of accuracy and current flow is hampered. This shows that further research is needed on the effect of the extent of the electrodes that are directly in contact with the electrolysis system so that the hydrogen gas product produced matches the energy expended [20].

One way to save energy is to produce hydrogen, which can be obtained using the electrolysis method or through HHO technology. Production of HHO gas as much as possible is expected to reduce fuel prices and scarcity. This is supported by the discovery of Stanley Meyer, which is about fuel made from water used in his VW frog so it can go at speeds of up to 160 km/h using only 3 liters of water [21,22]. Previous research conducted only focused on the catalyst, shape, and extent of the electrodes on the production of hydrogen gas produced without analyzing the HHO generator made. Nylund et al [23] and Praveen and Sethumadhavan [24] state the hydrogen is not available to free in the earth, it is produced from an industrial production process so that the final price is determined by the production process used. 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. In the study using stainless steel log, a modification was made to the electrodes used in the form of the addition of catalytic metals such as Fe, Co, and Ni because they have similar properties and sizes with stainless steel metals. Hydrogen production can also be done by steam reforming of hydrocarbons [26–28]. In addition, hydrogen can be produced from the reaction of metals and water with the help of a catalyst. One of them is hydrogen produced from aluminum metal, which is reacted with water using a NaOH catalyst [29,30].

This generator has a working principle of water electrolysis, which is to flow DC through an electrolyte using an electrode. It can cause changes in electrical energy into chemical energy (redox reactions), causing water molecules to break down into hydrogen and oxygen. HHO Generators have two types: wet type and dry type [31].

3. Experimental methods

The object of research, is the HHO generator, several variables given in the experimental study include variations of aluminum and brass electrode materials, electric current 20A, 30A, 40A, and the amount of 5-25% NaHCO3 catalyst mixed into the solution, and the dependent variable, i.e., the discharge is converted from the HHO gas flow pressure. From the HHO generator testing process, HHO gas pressure data can be obtained and then converted to HHO gas discharge. Acetylene regulator is used to measuring the value of the resulting gas pressure. On the aluminum electrode, 15 times of research were carried out using a catalyst variation of 5% (200 g), 10%, (400 g) 15% (600 g), 20% (800 g) and 25% (1000 g) catalyst used is $NaHCO_3$. Pressure data obtained will be processed into discharge (m ^ 3 / s).

3.1. HHO generator design

The generator design in this study was a prototype HHO generator with dimensions of 250 mm x 400 mm with electrodes made of aluminum and brass, it show figure 1. While the experimental setup show figure 2.

Figure 1. HHO generator design.

3.2. Experimental setup

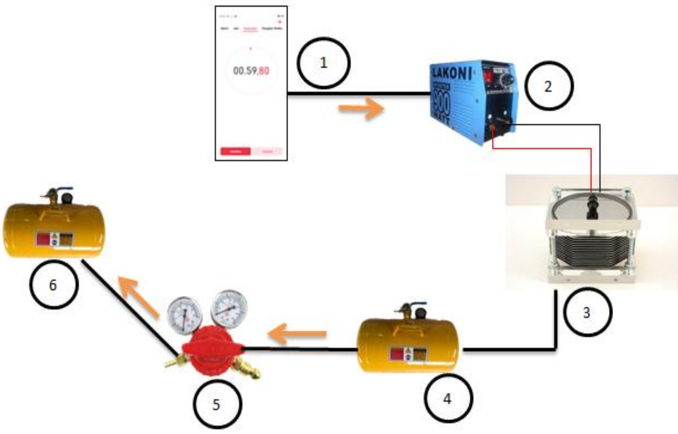

Figure 2. Research scheme.

Where: 1. Stopwatch, 2. DC inverter, 3. HHO Generators 4. HHO Gas Cylinders 1, 5. Asetylin Regulators, 6. HHO Gas Cylinders 2.

4. Results and discussion

4.1. HHO gas discharge with 5% NaHCO3

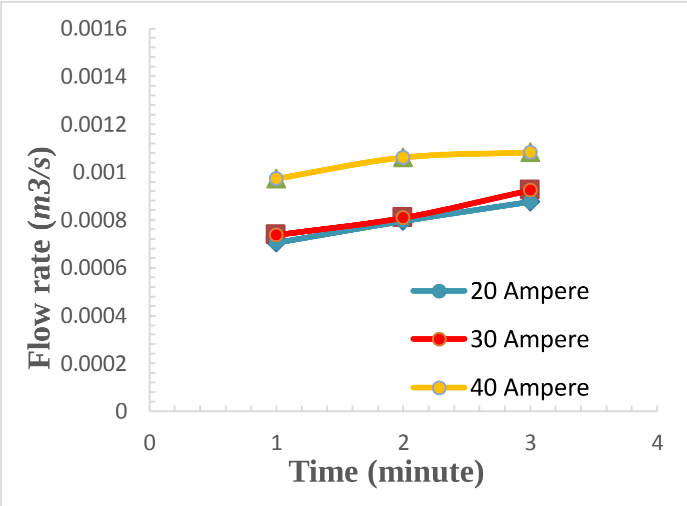

Figure 3. HHO gas discharge with 5% NaHCO3.

Figure 3 shows an increase in HHO gas discharge when the HHO generator is given a voltage source with a current of 40 Amperes with a time of 1 minute, that is, produces a Debit of 0.0009725 (m^3/s) and within 3 minutes the discharge reaches 0.001082 (m^3/s). It shows that the longer the HHO generator gets electricity to supply, the higher the HHO gas produced. The lowest HHO gas discharge is obtained at an electric current of 20 Amperes with a time of 1 minute that is equal to 0.0007038 m^3/s. With 5% NaHCO3 content, the maximum HHO gas discharge on electric current is 40 Amperes. Thus, the time and electric current are very influential on the amount of HHO gas production, because the longer and the higher the current is given to the HHO generator, the reduction and oxidation reaction (redox) will run more optimally. In this research, sodium bicarbonate ($NaHCO_3$) acts to accelerate the reaction. When sodium bicarbonate is added to water, it separates sodium cations (positively charged) and hydroxide anions (negatively charged oxygen and hydrogen). Sodium bicarbonate is easily soluble in water and will produce heat (exothermic). From the results of the above study, it can be concluded that the best electric current to produce the amount of HHO gas discharge is an electric current of 40 amperes. It is because the greater the source of electric current, the faster the reaction process is carried out. The results of testing the measurement of discharge from HHO generators using variations in the electrode material, the amount of $NaHCO_3$, and the electric current are given to the HHO generator showed a significant effect on the rate of HHO gas production. The better the electrode material used, the higher the HHO gas discharge generated. The more amount of $NaHCO_3$ given, the higher the HHO gas discharge generated. Furthermore, the higher the electric current used, the rate of HHO gas production will be even higher. Thus providing variations in the electrode material, the amount of $NaHCO_3$, and electric current influences the rate of HHO gas production (discharge), but the amount of $NaHCO_3$ has a significant effect on the amount of HHO gas production rate when HHO gas is given a power source for 3 minutes, while for electrode material and the electric current influences the speed of the H_2O electrolysis process, the better the metal content of the electrodes and the higher the current is given, the faster the electrolysis process carried out by the HHO generator.

4.2. HHO gas discharge with NaHCO3 10%

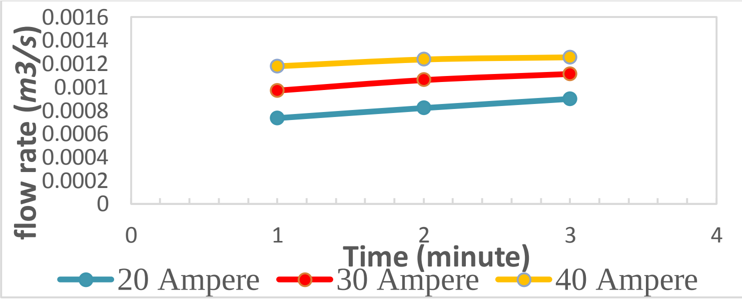

Figure 4. HHO gas discharge with NaHCO3 10%.

Figure 4 shows the increase in each current given for 1 minute to 3 minutes. The largest increase in HHO gas discharge within 3 minutes occurred at a current of 20 Amperes in the amount of 0.0001649 m^3/s. The largest HHO gas discharge is obtained at a current of 40 Amperes with a time of 3 minutes of 0.001255 m^3/s, the lowest HHO gas discharge produced is at a current of 20 Amperes with a flow of 0.0007351 m^3/s. It shows that the higher the electric current is given to provide electricity to the HHO generator, the greater the HHO gas produced. With 10% NaHCO3 content, the maximum HHO gas discharge when using a current of 40 Amperes. Thus it can be said that the time and electric current affect the amount of HHO gas production, because the longer and the greater the current given to the HHO generator, the reduction and oxidation reaction will run more optimally, and the more $NaHCO_3$ levels are given, the reaction reduction and oxidation will proceed quickly too. From the results of the above study, it can be concluded that the best electric current to produce the amount of HHO gas discharge is an electric current of 40 amperes. It is because the greater the source of electric current, the faster the reaction process is carried out. The results of testing the measurement of discharge from HHO generators using variations in the electrode material, the amount of NaHCO3, and the electric current are given to the HHO generator showed a significant effect on the rate of HHO gas production. The better the electrode material used, the higher the HHO gas discharge generated. The more amount of $NaHCO_3$ given, the higher the HHO gas discharge generated. Furthermore, the higher the electric current used, the rate of HHO gas production will be even higher. Thus providing variations in the electrode material, the amount of $NaHCO_3$, and electric current influences the rate of HHO gas production (discharge), but the amount of $NaHCO_3$ has a significant effect on the amount of HHO gas production rate when HHO gas is given a power source for 3 minutes, while for electrode material and the electric current influences the speed of the H_2O electrolysis process, the better the metal content of the electrodes and the higher the current is given, the faster the electrolysis process carried out by the HHO generator.

4.3. HHO gas discharge 20 amperes brass electrodes

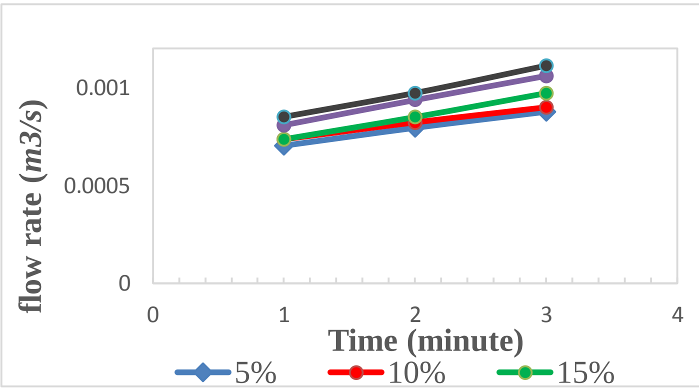

Figure 5. HHO gas discharge with $NaHCO_3$ 10%.

Figure 5 shows the increase in each current given for 1 minute to 3 minutes. The largest increase in HHO gas discharge within 3 minutes occurred at a current of 20 Amperes in the amount of 0.0001649 m^3/s. The largest HHO gas discharge is obtained at a current of 40 Amperes with a time of 3 minutes of 0.001255 m^3/s, the lowest HHO gas discharge produced is at a current of 20 Amperes with a flow of 0.0007351 m^3/s. It shows that the higher the electric current is given to provide electricity to the HHO generator, the greater the HHO gas produced. With 10% $NaHCO_3$ content, the maximum HHO gas discharge when using a current of 40 Amperes. Thus it can be said that the time and electric current affect the amount of HHO gas production, because the longer and the greater the current given to the HHO generator, the reduction and oxidation reaction (redox) will run more optimally, and the more NaHCO3 levels are given, the reaction reduction and oxidation (redox) will proceed quickly too. From the results of the above study, it can be concluded that the best electric current to produce the amount of HHO gas discharge is an electric current of 40 amperes. It is because the greater the source of electric current, the faster the reaction process is carried out. The results of testing the measurement of discharge from HHO generators using variations in the electrode material, the amount of $NaHCO_3$, and the electric current are given to the HHO generator showed a significant effect on the rate of HHO gas production. The better the electrode material used, the higher the HHO gas discharge generated. The more amount of $NaHCO_3$ given, the higher the HHO gas discharge generated. Furthermore, the higher the electric current used, the rate of HHO gas production will be even higher. Thus providing variations in the electrode material, the amount of $NaHCO_3$, and electric current influences the rate of HHO gas production (discharge), but the amount of $NaHCO_3$ has a significant effect on the amount of HHO gas production rate when HHO gas is given a power source for 3 minutes, while for electrode material and the electric current influences the speed of the H_2O electrolysis process, the better the metal content of the electrodes and the higher the current is given, the faster the electrolysis process carried out by the HHO generator.

4.4. HHO gas discharge 20 amperes brass electrodes

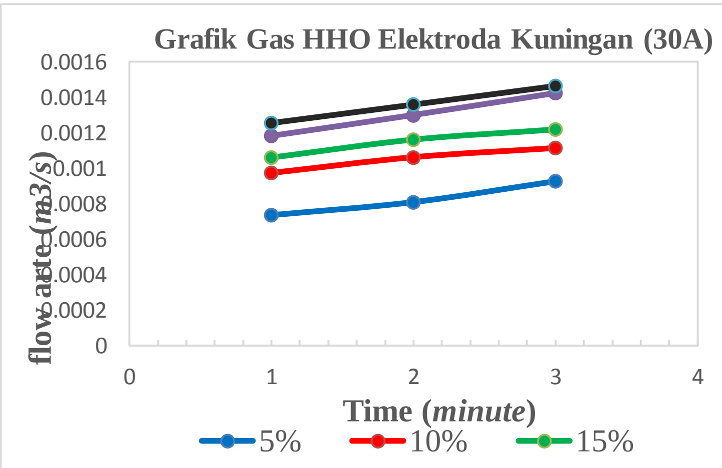

Figure 6. HHO gas discharge 30 ampere brass electrodes.

Figure 6 shows an increase in HHO gas discharge within 3 minutes for each given $NaHCO_3$ level ranging from 5-25% on the brass electrode. The addition of $NaHCO_3$ by 5% within 3 minutes produced a gas discharge of 0.000925 m^3/s. It shows an increase in HHO gas discharge from time to time and from each addition of NaHCO3, unlike the aluminum electrodes. The lowest HHO gas discharge was obtained with a 5% $NaHCO_3$ level in 1 minute of 0.000735 m^3/s. On the addition of 25%, $NaHCO_3$ debit gas produced large enough to reach 0.001462 m^3/s within 3 minutes. From the graph above, it can be concluded that the addition of 25% $NaHCO_3$ with 30A electrical current to the brass electrode is still better in terms of the amount of discharge generated, in addition to the addition of $NaHCO_3$ will accelerate the electrolysis process. Based on these data, the gas discharge produced in the H2O electrolysis process is best shown by the addition of $NaHCO_3$ at 25% (1000gr). The results of testing the measurement of discharge from HHO generators using variations in the electrode material, the amount of $NaHCO_3$, and the electric current are given to the HHO generator showed a significant effect on the rate of HHO gas production. The better the electrode material used, the higher the HHO gas discharge generated. The more amount of $NaHCO_3$ given, the higher the HHO gas discharge generated. Furthermore, the higher the electric current used, the rate of HHO gas production will be even higher. Thus providing variations in the electrode material, the amount of $NaHCO_3$, and electric current influences the rate of HHO gas production (discharge), but the amount of $NaHCO_3$ has a significant effect on the amount of HHO gas production rate when HHO gas is given a power source for 3 minutes, while for electrode material and the electric current influences the speed of the H_2O electrolysis process, the better the metal content of the electrodes and the higher the current is given, the faster the electrolysis process carried out by the HHO generator.

4.5. Discharge Gas HHO 40 amperes Brass Electrodes

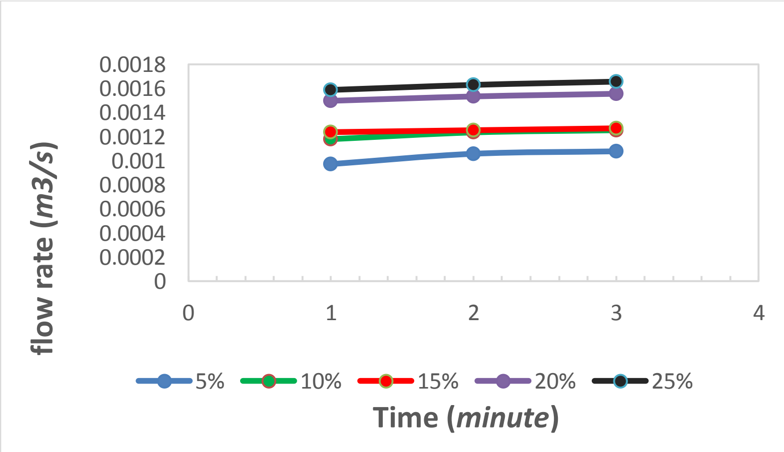

Figure 7. HHO gas discharge 40 ampere brass electrodes.

Figure 7 shows an increase in HHO gas discharge within 3 minutes for each given $NaHCO_3$ level starting from 5-25% on the brass electrode. The addition of $NaHCO_3$ by 5% within 3 minutes resulted in a gas discharge of 0.001082 m^3/s. It shows an increase in HHO gas discharge from time to time, as well as from each addition of $NaHCO_3$, unlike the aluminum electrodes. The lowest HHO gas discharge was obtained with 5% $NaHCO_3$ levels in 1 minute of 0.000972 m^3/s. The addition of 25% $NaHCO_3$ debit gas produced is large enough to reach 0.001657 m^3/s within 3 minutes. However, 10% and 15% $NaHCO_3$ only slightly increased HHO gas discharge by 0.000018 m^3/s. From the graph above, it can be concluded that the addition of 25% $NaHCO_3$ with 40A electric current on the brass electrode is still better in terms of the amount of discharge generated, and the addition of NaHCO3 will accelerate the electrolysis process. Based on these data, the gas discharge produced in the H_2O electrolysis process is best shown by the addition of NaHCO3 at 25% (1000gr). The results of testing the measurement of discharge from HHO generators using variations in the electrode material, the amount of $NaHCO_3$, and the electric current are given to the HHO generator showed a significant effect on the rate of HHO gas production. The better the electrode material used, the higher the HHO gas discharge generated. The more amount of $NaHCO_3$ given, the higher the HHO gas discharge generated. Moreover, the greater the electric current used, the rate of HHO gas production will be even higher. Thus providing variations in the electrode material, the amount of $NaHCO_3$, and electric current influences the rate of HHO gas production (discharge), but the amount of $NaHCO_3$ has a significant effect on the amount of HHO gas production rate when HHO gas is given a power source for 3 minutes, while for electrode material and the electric current influences the speed of the H_2O electrolysis process, the better the metal content of the electrodes and the higher the current is given, the faster the electrolysis process carried out by the HHO generator.

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5. Conclusion

Based on the results, the following conclusions can be drawn.

- Giving variations of electric current 20 amperes and 30 amperes has a significant influence on the discharge of HHO gas produced, especially on the most significant current. The provision of massive electrical currents makes the HHO gas discharge faster, but too large currents also make the generator heat up quickly when using poor electrode materials such as aluminum.
- The variation in the amount of $NaHCO_3$ has not had a significant effect on the discharge of HHO gas produced, especially on aluminum electrodes. However, the largest HHO gas discharge was obtained from the research conducted at the amount of 25% $NaHCO_3$ (1000gr).
- The most gas flow rate or HHO gas discharge can be produced from brass electrodes with 25% $NaHCO_3$ (1000gr) with a 40-ampere electric current source equal to 0.001657 (m^3/s).

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