Design of Generator HHO Dry Cell Type and Application on 110 Cc Engined Vehicles Towards Gas Emissions

Indah Puspitasari¹*, Noorsakti Wahyudi², Yoga Ahdhat Fakhrudi³, Galih Priyo Wicaksono⁴

Automotive Engineering Department, The State Polytechnic of Madiun, 84 Serayu Street, Madiun, East Java, INA

Email: indahpuspitasari@pnm.ac.id¹*, noorsakti@pnm.ac.id², yoga_sumonggo@yahoo.com³, galihwicaksono1997@gmail.com⁴

Abstract. The HHO generator is a tool that works on the principle of water electrolysis to produce HHO gas, which is a gas consisting of 2 hydrogen molecules and 1 oxygen molecule where the gas can be used as fuel. The number of holes on the plate electrodes affects the amount of discharge and the efficiency of the HHO generator. Therefore, a study was conducted regarding the number of holes on the electrode plate. The parameters measured were voltage, electric current, electrolyte temperature in the reservoir tank, electrolyte temperature in the HHO gas cylinder, and the HHO gas discharge. Whereas what is calculated is the power required for the HHO generator, the production rate, and the efficiency of the HHO generator. Furthermore, the HHO generator was applied to a 110cc vehicle to measure the level of exhaust emissions. Based on the results of the study, the best variation of HHO generators is found in the hole plate electrode 2 with the required power of 180.78 watts and an efficiency of 63.8%. The lowest CO emission levels were in the 2 holes variation, namely 4.01%, and the lowest HC emission levels were in the 4 holes variation, namely 892 ppm.

1. Introduction

Alternative energy is energy that comes from natural elements that are available in large quantities such as wind, water, sun, plants and geothermal. Alternative energy is used to overcome people's dependence on using fossil fuels which are used more and more, while their current availability is increasingly limited on earth [1], [2]. One of the economical and widely available alternative energies is water, various kinds of use of water as alternative energy, namely, PLTA, PLTU, and HHO Generator. Electrolysis is a process of converting water into alternative fuels through electrolysis reactions [3]. Water electrolysis is the process of forming H2 (hydrogen) and O2 (oxygen) gases by flowing electrical energy to the cathode (negative pole) and anode (positive pole) which are immersed in water. The gas produced from the electrolysis process is called Brown's Gas or oxyhydrogen (HHO). Brown's Gas is the patent name for a mixture of H2 and O2 gas which is the result of the electrolysis of natural water by Brown in 1974. Brown's Gas production can be increased by adding a catalyst in the form of a base, acid or electrolyte [4].

The HHO generator consists of two main components, namely the HHO (HHO Cell) generator tube and a source of electrical energy. The HHO generator works with the principle of water electrolysis, namely by flowing an electric current (DC) through the electrolyte with an electrode as an intermediary. This causes a change in electrical energy into chemical energy which is called a redox

*Corresponding author.
reaction. This reaction causes the water molecules to break down and form hydrogen and oxygen gas. HHO generators are classified into two types, namely the wet type and the dry type [5].

The Dry Cell type HHO generator is an HHO generator where some of the electrodes are not immersed in electrolytes and the electrolyte only fills in the gaps between the electrodes themselves [6]. The area of the circle on the electrode plate that is submerged in water is the area where electrolysis occurs to produce HHO gas, while the other parts of the area are not submerged in water and the plate is in dry conditions. The electrolyzed area is about 60% and is sufficiently limited by o-ring or seal.

In the research, Susanto et al stated that the effect of variations in the surface area of the electrode plate and the concentration of KOH solution on the gas discharge from water electrolysis. The effect is that the larger the surface area of the electrode plate and the greater the concentration of the KOH solution, the greater the gas discharge resulting from electrolysis [7].

HHO in gasoline-fueled vehicles can increase efficiency by up to 14% to 18%. Apart from being a mixture, HHO can still be developed into a clean main fuel. To produce HHO, electrical energy is needed, so it is necessary to study the characteristics of the HHO generator, one of which is the modification using a perforated plate electrode [8] [5] [9].

The dry cell type HHO generator is an HHO generator where some of the electrodes are not immersed in electrolytes and the electrolyte only fills in the gaps between the electrodes themselves. The advantages of dry cell type HHO generators are: the water that is electrolyzed is only necessary, that is, only water is trapped between the cell plates; the heat generated is relatively small, because there is always a circulation between hot and cold water in the reservoir tank; the electric current used is relatively smaller, because less power is converted into heat [6].

Based on the above background, further research will be carried out, namely regarding the use of perforated plate electrodes, this research was conducted to determine the impact of using perforated plate electrodes on the performance of the HHO generator produced.

2. Research Method

In general, the HHO generator consists of two main components, the HHO generator tube (HHO cell) and electrical energy. The HHO generator works on the principle of water electrolysis, by flowing an electric current (DC) through the electrolyte with an electrode as an intermediary. This causes a change in electrical energy into chemical energy which is called a redox reaction [7]. This reaction causes the water molecules to break down and form hydrogen and oxygen gas. Perforated plate electrode variations: 2 holes, 4 holes, and 9 holes. Testing the performance of the dry cell type HHO gas generator, namely about power, HHO gas production rate, and efficiency with a variety of perforated plate electrodes. The test was carried out on a 110cc engine using a mixture of HHO gas fuel at the State Polytechnic of Madiun Fuel and Combustion Technology Laboratory.

| Table 1. Generator specifications |
|----------------------------------|
| **Model** | **Unit** | **Specifications** |
| Generator type | - | Dry cell |
| Electrodes | - | SS316L |
| Electrodes arrangement | - | P-Ne-N-Ne- P-Ne-N-Ne-P-Ne-N |
| Plate dimensions | mm | 80 x 80 x 1 |
| O-Ring gasket thickness | mm | 3 |
| Mains voltage (DC) | volt | 12 |
| Catalyst electrolyte | - | KOH |

2.1. Generator Manufacturing Process

Manufacturing steps:

a. Prepare 3 sets of HHO generator electrodes. A set of HHO generator electrodes consists of 3 positive plates, 3 negative plates, 5 neutral plates. Then perforate the plates according to the design with the variants of holes: 2 holes, 4 holes, 9 holes with a diameter in each hole of 12 mm.
b. Prepare 6 Acrylics, punched 6 Acrylics with a distance of 75 mm from the bottom and 6 Acrylics with a hole 75 mm from the top. Then perforate 6 pieces of Acrylic in each corner with a diameter of 6 mm as bolt holes.

c. Assemble a Dry Cell type HHO generator using the electrodes that have been prepared. The assembly begins with placing the acrylic on the front, then placing the electrodes in the P-Ne-N-Ne-P-Ne-N-Ne-P-Ne-N arrangement and ending with acrylic. Description of electrode arrangement: Positive (P), Neutral (Ne), Negative (N). Between the plates, an O-Ring gasket is installed as the distance between the electrodes and the acrylic.

![Fig. 1. Design of Dry Cell Type HHO Generator Arrangement](image)

Generator Testing Test steps:

a. Stringing the electricity to the HHO generator
b. Stringing hoses on all HHO generator lines
c. Connect the positive and negative currents of the battery to the HHO generator circuit
d. Measuring the amount of electric voltage using the avometer and measuring each variation of the perforated plate
e. Measuring the amount of electric current using a DC clam ammeter and measuring each variation of the perforated plate
f. Measuring the rate of HHO gas using an air flowmeter measuring LPM (liter / minute)
g. Take temperature measurements using a thermometer on the HHO generator electrolyte and the HHO gas temperature
h. Turning off the current in the HHO generator circuit after all the data are met

![Fig. 2. Testing the dry cell type HHO generator](image)
2.2. Research Parameters

Power needed for an HHO Generator (PHHO)

\[
P = V \times I \quad (1)
\]

Where: \( P \), the power required for the HHO generator (watts); \( V \), potential / voltage difference (volts); \( I \), Electric current (ampere)

\[
\dot{m} = Q \times \rho \quad (2)
\]

Where: \( \dot{m} \), HHO gas production rate (kg / s); \( Q \), HHO gas production discharge (m³ / s); \( \rho \), Density HHO (kg / m³)

HHO gas production discharge:

\[
Q = \frac{V}{t} \quad (3)
\]

Where: \( V \), the measured gas volume (m³); \( Q \), HHO gas production discharge (m³ / s); \( t \), HHO gas production time (s)

\[
\eta_{gen} = \frac{(\Delta hf \times \dot{n})}{V \times I} \quad (4)
\]

Where: \( \eta_{gen} \), generator efficiency (%); \( \Delta hf \), the energy required to break down the H2O molecule (285.84x10³ J / mol); \( \dot{n} \), molarity of the compound (mol / s); \( V \), the voltage required for the generator (V); \( I \), the current required for the generator (A).

\[
\dot{n} = \frac{(P \times \hat{V})}{(\bar{R} \times T)} \quad (5)
\]

Where: \( P \), the ideal gas pressure is 1 atm; \( \hat{V} \), the measured gas volume per time (L / s); \( \bar{R} \), universal gas constant (0.08206 L.atm / Mol.K); \( T \), temperature (K).

3. Result and Analysis

From the research results, it is obtained the power required for dry cell type HHO generator. The more holes, the greater the power needed to produce HHO gas. Because the more holes in the area of concentration of voltage and electrolysis, the bigger and wider, the more power required. Conversely,
if there are fewer holes, the area of center concentration and electrolysis will also be smaller and the power required will also be lower. [3]

![Fig. 4. HHO gas production rate against time](image)

The graph above shows the production rate of dry cell type HHO gas. Many holes affect the concentration area of the voltage so that it speeds up the rate of HHO gas formation. The holes in the generator function as poles, so the more holes the more poles serve as electrolysis. [10], [11]

![Figure 5. The efficiency of the HHO generator](image)

The number of holes on the plate electrodes affects the amount of discharge and efficiency of the wet cell type HHO generator. The more holes in the plate the greater the area of stress concentration, thereby accelerating the rate of HHO formation. [8] The results above show the graph of the efficiency of the dry cell type HHO generator. The more holes, the greater the resulting efficiency. Because there are more holes, the electrolysis process is formed faster and the gas produced is higher. [12]

### 3.1. Exhaust Gas Emissions

The following is the result of exhaust gas emission testing. The measured exhaust emissions include CO and HC, the test results data with plate variations of 2 holes, 4 holes and 9 holes on vehicles with 110 cc engines with idle engine speed conditions are as follows:

|          | 9 holes | 4 holes | 2 holes |
|----------|---------|---------|---------|
| CO (%)   | 5.17    | 5.52    | 4.40    |
| HC (ppm) | 1138    | 929     | 1402    |

Table 2 shows that the exhaust gas concentration of CO in the variation of hole plate 9 is 5.17%, while in the variation of hole plate 4 it is 5.52%, and for the variation of hole plate 2 it is 4.40%. Table
4.7 also shows the concentration of HC exhaust gas in the variation of hole plate 9 of 1138 ppm, while in the variation of hole plate 4 it is 929 ppm, and for variation of hole plate 2 it is 1402 ppm.

![Fig. 6. CO and HC emissions at various plate holes](image)

Based on Figure 6, it can be seen that the lowest CO emission is in the variation of hole plate 2, namely 4.40%. This is due to the addition of HHO gas to make combustion more perfect. Meanwhile, the lowest HC emission is in the variation of hole plate 4, which is 929 ppm. This is because there is the addition of oxygen from HHO so that the mixing of fuel and air occurs premixes making the mixture a stochiometric. [13], [14].

4. Conclusion

Based on the research that has been done, it can be concluded that:

a. The effect of electrodes with a variation of 2 holes, 4 holes and 9 holes on power performance, production rate, and efficiency of dry cell type HHO generators, namely:
   1. The dry cell type HHO generator with perforated plate electrodes has different power consumption in each variation, the power consumption tends to increase from the initial minutes to the peak and begins to decrease as the testing time increases and the temperature in the generator electrolyte increases. And the more power holes needed, the more it is needed.
   2. The more holes the greater the production rate that is generated. Due to the more holes, the larger the area of concentration of the voltage so that it speeds up the rate of HHO gas formation.
   3. The more holes, the greater the efficiency produced and the higher the gas produced.

b. The lowest CO emission is in the variation of hole plate 2, namely 4.40%. Meanwhile, the lowest HC emission is in the variation of hole plate 4, which is 929 ppm.

Acknowledgments

We would like to express our gratitude to Madiun State Polytechnic who has provided the opportunity and fully funded lecturers to conduct research so that they can apply their knowledge.

References

[1] Dwi Heru Puspitasari, Indah, “Studi Komparasi Performa Motor Yamaha Jupiter Mx 2010 Berbahan Bakar Biopremium Dengan Pertamax,” vol. 02, 2013.

[2] K. Winangun, “Uji Emisi Penggunaan Bioetanol Dari Tetes Tebu Sebagai Campuran Premium Dengan Oktan Booster Pada Sepeda Motor Yamaha Vega ZR 2009,” J. Pendidik. Tek. Mesin, vol. 19, no. 1, pp. 25–31, 2009, doi: 10.2964/jsik.19-25.

[3] D. Seto, S. Dan, and B. Sudarmanta, “Aplikasi Penggunaan Generator Gas HHO Tipe Dry Cell Menggunakan Plat Titanium Terhadap Performa Dan Emisi Gas Buang Honda Megapro 150 cc,” vol. 4, no. 1, 2015.
[4] H. Kusumaningsih, N. Hamidi, and E. Prayitno, “PENGARUH PENAMBAHAN PELAT TERHADAP PRODUKSI BROWN’S GAS PADA GENERATOR HHO TIPE DRY CELL,” no. Snttm Xv, pp. 5–6, 2016.

[5] B. Abdul, “Karacterisasi Unjuk Kerja Generator Gas HHO Tipe Dry Cell dengan Elektroda Titanium dan Penambahan PWM,” Jur. Tek. Mesin, no. January 2016, 2017, [Online]. Available: https://www.researchgate.net/publication/316241672.

[6] G. H. H. O. Hi, “Studi Karakteristik Generator HHO dengan Penambahan Pelat,” vol. 2, no. 2, 2013.

[7] B. Agustinus Susanto Gatut Rubiono, “PENGARUH VARIASI LUAS PERMUKAAN PLAT ELEKTRODA DAN KONSISTENSI Jurnal Prodi Teknik Mesin Universitas PGRI Banyuwangi Jurnal Prodi Teknik Mesin Universitas PGRI Banyuwangi,” vol. 1, pp. 1–6, 2016.

[8] A. Fahruddin and U. M. Sidoajro, “Studi Eksperimen Karakteristik Generator HHO Model Wet Cell dengan Elektroda Pelat Berlubang (Characteristics Experimental Study of Wet Cells HHO Generator with Perforated Plate ... Studi Eksperimen Karakteristik Generator HHO Model Wet Cell dengan Pl),” vol. 400, no. October, pp. 1–6, 2015, doi: 10.21070/jeee-u.v1i1.25.

[9] L. Bruno, “Peningkatan Unjuk Kerja Generator Set 4 Tak Kapasitas 1100 Watt Dengan Penambahan Gas Hho (Hydrogen Hydrogen Oxygen) Sebagai Campuran Bahan Bakar,” J. Chem. Inf. Model., vol. 53, no. 9, pp. 1689–1699, 2019, doi: 10.1017/CBO9781107415324.004.

[10] I. Puspitasari and D. S. Kawano, “STUDI KOMPARASI DISTRIBUSI TEMPERATUR NYALA API PADA BLOW TORCH KEROSIN DAN MIXING KEROSIN + GAS HHO,” pp. 978–979, 2015.

[11] I. Puspitasari, P. Magister, B. Kehlin, R. Konversi, J. T. Mesin, and F. T. Industri, “STUDI KOMPARASI DISTRIBUSI TEMPERATUR NYALA API BLOW TORCH KEROSIN DAN MIXING KEROSIN + GAS HHO COMPARISON STUDY OF TEMPERATURE DISTRIBUTION IN BLOW TORCH FLAME KEROSENE FUELED AND MIXTURE OF KEROSENE + HHO GAS,” 2015.

[12] I. Puspitasari, “Modifikasi Cylinder Head Dan Injeksi Gas Hho Terhadap Performa Mesin 4 Langkah 1 Silinder,” JTT (Jurnal Teknol. Terpadu), vol. 8, no. 1, pp. 1–6, 2020, doi: 10.32487/jtt.v8i1.753.

[13] H. E. G. Prasetya, J. Pratilastiarso, A. G. Safitra, R. Amalia, and H. Ubudiayah, “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, no. 2018, 2018, doi: 10.1063/1.5043026.

[14] A. Sudrajat, I. Nugroho, K. R. Lestari, and V. V. R. Repi, “Pengaruh Penambahan Gas HHO pada Mesin Bensin Terhadap Emisi dan Konsumsi Bahan Bakar,” vol. 23, no. 1, pp. 8–19, 2020.