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Effect of SS316L Plate's Surface Texture on Hydrogen Production of HHO Generator for Defence Application in Remote Locations

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A B S T R A C T

The research aims to determine if surface texture of HHO generator's electrode plate affect hydrogen production, and which of 4 tested surface textures gives the best performances. Electrolytes used is KOH with variation in concentration of 10, 20, 30, 40, 50, and 60 g/L. Testing is done by running the generator to produce 1 L of hydrogen, with the tested parameter being current, electrolytes temperatures, and time required. Data is measured in 2 waves: the first wave is 30 measurements with the generator always on, and the second wave is 30 measurements with the generator turned off for 10 seconds between measurements. The average, standard deviations, and correlation coefficients is compared to determine the best surface texture.

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INTRODUCTION

Recently, applications of hydrogen fuel cells as alternative to standard diesel fuel for military and defence has gained tractions in multiple countries, especially for use in forward bases or remote locations. Hydrogen fuel cells have multiple advantages in defence applications including being significantly quieter than diesel generator of comparable output (FCW Team, 2025). Recently, multiple energy company has also created fuel cells that not only offer high efficiency but also has good longevity and power density, attributes that are critical in ensuring that personnels have access to reliable power during critical field operations, regardless of the external conditions or logistical constraints. Some of these fuel cells are small and portable, used to power soldiers' electronics devices (h2iq.org, 2024). The electronic devices could also be connected to satellite network for communication. Not only personnel equipment, hydrogen fuel cells could also be applied to Unmanned Aerial Vehicles and balloon systems, and also transports, all combined to allow deeper penetration to conflict area. This is possible because hydrogen fuel cells is reliable energy source with less logistics constraint than diesel, such as requiring less space and lighter than fossil fuel.

To increase the logistic independence even more, important innovations is to be able to produce the hydrogen on the field as well. US Department of Defence's investment in hydrogen fuel cells include H2Rescue, truck carrying hydrogen fuel cells for disaster reliefs. This truck is also equipped with HHO generator powered with solar cell to create the hydrogen from water, allowing quick and easier disaster management (Casey, 2024). Other company has also designed similar vehicle systems where generated hydrogen is stored in gaseous form to be used or distributed as needed, portable by military car or truck, with size smaller than the battery with equivalent energy storage (Temin, 2024).

One way to improve HHO generator production is to apply surface texture etching on the electrodes. Surface texture allows higher surface area to better facilitate electrolysis process. This research aim to investigate the effect of the surface texture pattern to hydrogen production, and determine which pattern has the best performance.

THEORETICAL REVIEW

HHO generator is a device that works by electrolysis process of water molecules to produce hydrogen and oxygen gases. Around anode, a water molecule loses 2 electrons to form O_2 and 4 hydrogen ions. The positive charged hydrogen ions will then be attracted by the negatively charged cathode and accept electrons to become H_2 molecules.

However, as we are performing redox reaction involving steel plate and water, corrosion is inevitable. in the electrolysis process, few iron atom in stainless steel is ionized as well, the resulting iron ions then flow together with H^+ ions towards the cathode. When reduced, H^+ ions will become H_2, but iron ions are reduced into rust particles and precipitate on the surface of the plate. Decreasing the effective surface area of the plate, weakening HHO generator performance.

In electrolytes, when electrified, the following reactions will occur:

$$4\ H_2O\ (l) + 4e^- => 2H_2\ (g) + 4\ OH\ (aq) \quad (1)$$

$$4\ OH^-(aq.) => 2H_2O\ (g) + O_2\ (g) + 4e^- \quad (2)$$

$$2H_2O\ (l) => 2H_2\ (g) + O_2\ (g) \quad (3)$$

The E^0 of the above reaction becomes 1.246 V, so the reaction can proceed spontaneously if given an electric current.(Asmawi et al., 2022)

HHO generators produce hydrogen gas which helps engine performance when injected during the combustion process along with fuel for a more even combustion. (El-Kassaby et al., 2016).

HHO generators are divided into 3 types, namely dry cell, wet cell, and hybrid cell. Hybrid cell generator, where a series of dry cell electrodes is installed in a support frame before being immersed in a vessel containing electrolyte, was chosen for this experiment for the following advantages: Produces a more stable current; Lower temperature for voltage 12 to 14 V; Generator system is more durable, and can be used longer. (Sudrajat et al., 2018)

When the car is initially started, the car's system voltage is at least 12.6 V (because the family car battery consists of 6 cells, each with a voltage of 2.1 V). When the car is running, the alternator will work to supply energy to various systems in the car and charge the car battery; for that, the system voltage will be increased to 13.8 V so that the charge can flow into the battery. Then the HHO generator will be connected to a voltage of 13.8 V during this research (Autobatteries.com, 2021).

To increase the longevity of the generator, we also use stainless-steel plate for electrode and strong base (KOH) as electrolyte. To increase the conductivity, the electrolyte used in the cell must consist of ions with high mobility. Strong base Potassium hydroxide (KOH) is used to avoid corrosion problems caused by acidic electrolytes; KOH is chosen over sodium hydroxide (NaOH) because KOH solution has a smaller standard electrode potential so that it has a higher conductivity. (Santos et al., 2013). In the electrolysis process, the electrolytic cell begins to flow electrons when the voltage exceeds the minimum limit. At still low voltages, increasing the voltage can push more electrons through the cell (Turky, Mohamed., 2018), however, the current density also increases, and as the current density increases, the corrosion rate increases (Bala Srinivasan et al., 2009).

Alloy metal SS316 & SS316L is a steel made of austenite iron and contains molybdenum, which is more resistant to corrosion in general, especially pitting corrosion, even at high current densities (Ilevbare & Burstein, 2001), and also has more resistance to temperature rise. SS316L has lower carbon content, so it is easier to shape. As a result of these properties, SS316L plate has resistance to atmospheric corrosion, polluted marine environmental conditions, and mild redox reaction conditions, exceeding metal plates made of SS304 material (most commonly used stainless steel). (Sandmeyer Steel, 2021).

Hydrogen production will be influenced by the strength and type of electrolyte, the strength of the electric voltage, the timelength of the experiment, the system temperature, the addition of a neutral plate, and the morphology of the plate surface. (Essuman et al., 2019).

Pure water tends to have a more stable equilibrium in the molecular state than in the ionic state; anions with a lower standard electrode potential than hydroxide ions will be oxidized so that they do not produce oxygen gas, while cations with a higher standard electrode potential compared to hydrogen ions will go through a reduction process, so no hydrogen gas will be produced. (Rusdianasari et al., 2019).

KOH is a strong base that can be used as a catalyst in the electrolysis process because it has the property of being able to spontaneously ionize:

$$KOH\ (aq) \Rightarrow K^{+}\ (aq) + OH^{-}\ (aq) \qquad (4)$$

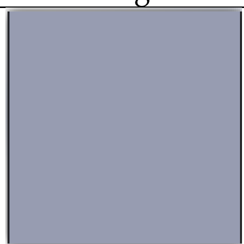
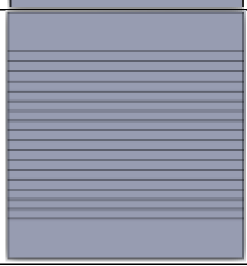
This process increases the concentration of hydroxide ions thereby accelerating the electrolysis reaction. An additional advantage of using KOH as a catalyst is that because it is alkaline, the catalyst will not accelerate the corrosion process as fast as using an acid catalyst (Manabe et al., 2013).

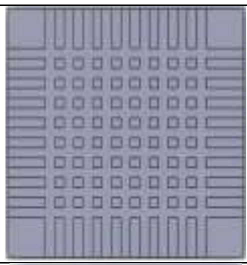
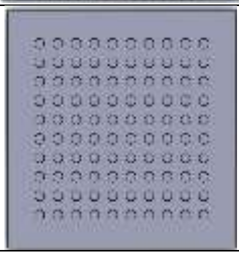
METHODOLOGY

Because the limitation in conducting field experiment, the experiment is done in laboratorium and irregularities are introduced during data collection: 15 data is measured while the generator remaining on, to simulate generator in constant use; 15 datas is measured with the generator turned off for a few seconds between every measurements, to simulate situation when generator is used sporadically.

The surface texture of 10 cm X 10 cm SS316L plate was etched and then used as electrode plate between the cathode and anode in the HHO generator. 21 SS316L plate is prepared, 1 plain plate to be used as control plate and 5 plates for each surface texture (plain, linear, criss-cross, and dotted). The surface texture of the SS316L plates is etched using a computer numerical control machine (CNC Machine). The CAD software used to design the etching is Solidwork, while the surface texture is rendered using a CNC mill machine.

Table 1. Surface Texture as Designed in Solidwork

Texture	Image	Area (cm^2)
Plain		100,00
Linear		101,80

Criss-Cross		102,30
Dotted		101,32

The electrode plates are mounted in plastic spacers support. The 5 etched plates for each textures functions as neutral plate between cathode and anode plate.

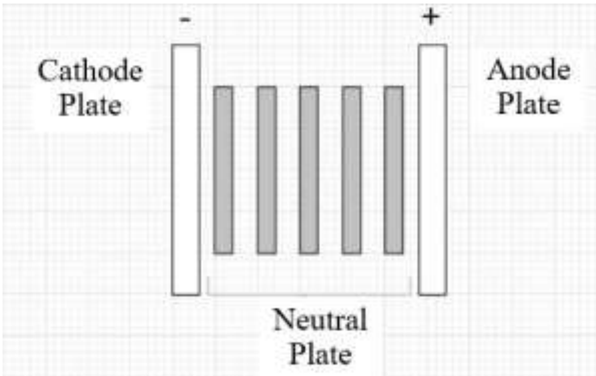


Figure 1. Plate arrangement scheme

The HHO generator schematic used in this study is shown in Figure 2. The power source will provide a voltage of 13.8 V to the 2 terminals at the top of the generator connected to the cathode and anode. Inside the generator, electrolysis process will occur. Hydrogen gas will flows out through the hose, then through the safety bubbler to ensure there is no gas leak (because hydrogen is flammable, colourless, and odourless), before entering the measurement tank. In the experiment, a stop watch was used to calculate the time it took for the measurement tank to be filled with 1 L of gas. After each data collection, the outlet faucet is opened to empty the measuring tank.

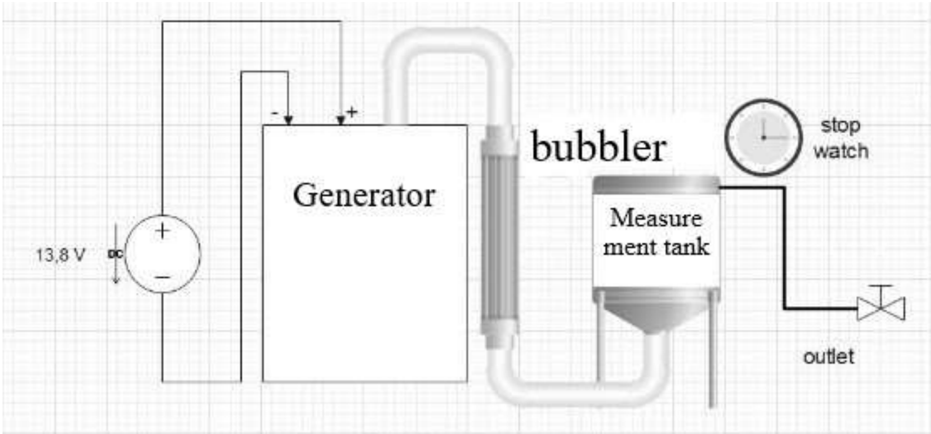


Figure 2. HHO generator schematic

For electrolyte solution, solid KOH granules are dissolved in 1 liter of distilled water. 6 variations of KOH electrolytes are used, from 10 g/L, 20 g/L, 30 g/L, 40 g/L, 50 g/L, to 60 g/L.

Previous research has shown, with only 3 variations of concentrations, that plate texture has effect on hydrogen production ((Ridhwan et al., 2023; Ridwan et al., 2024). This research is done with more variations of concentrations to determine which surface texture has better performance.

The HHO generator is supplied with a constant voltage of 13.8 Volts during the measurement (Autobatteries.com, 2021). The data collected are electrolyte's temperature; current in the system; and the time for generator to produce 1 liter gas. The electric current and temperature recorded are those shown by the measuring instrument right as the generator has produced 1 liter of hydrogen.

The two sets of data for each type of plate are then combined, and have their average and standard deviation calculated. Then individual graphs were made for each parameter in regard to KOH's concentration for each surface texture, as well as a comparison graph of the performance of the 4 surface textures based on the concentration of KOH. For each individual graph, linear regression was performed from each graph to obtain the correlation coefficient of the four parameters to the KOH concentration for each surface texture, then compared. Using the comparison of the average data, standard deviation, and correlation coefficient, it is determined which surface texture has the best performance.

RESULTS

The results of data collection on hydrogen gas production are processed numerically by calculating the average value and standard deviation value for each parameter, as well as the correlation coefficient value for each parameter graphs, to determine the surface texture with the best performance.

In the HHO generator, as the electrical voltage is connected to a series of stainless-steel electrode plates, which have internal resistance, some of the energy is wasted in the form of heat. As a result, the temperature of the electrolyte solution will increase, causing an increase in the rate of the electrolysis reaction (Miles et al., 1976).

Table 2. Comparison of (a) average and (b) standard deviation of current (A)

a)	Average Current			
KOH (g/L)	Plain	Linear	Criss-Cross	Dotted
10	4,77	5,16	5,27	4,90
20	4,25	4,55	4,48	4,63
30	8,16	10,51	7,87	9,81
40	11,39	12,69	12,26	12,81
50	12,24	13,90	13,60	13,46
60	15,43	16,18	16,38	16,40

b)	Current Standard Deviation			
KOH (g/L)	Plain	Linear	Criss-Cross	Dotted
10	0,58	0,39	0,71	0,53
20	0,21	0,26	0,22	0,21
30	0,31	0,51	0,40	0,35
40	0,49	0,26	0,61	0,44
50	0,57	0,41	0,50	0,69
60	0,77	0,43	0,15	0,40

Figure 3 shows a comparison graph of the data in table 2. It can be seen that the measurement results increase with increasing concentration.

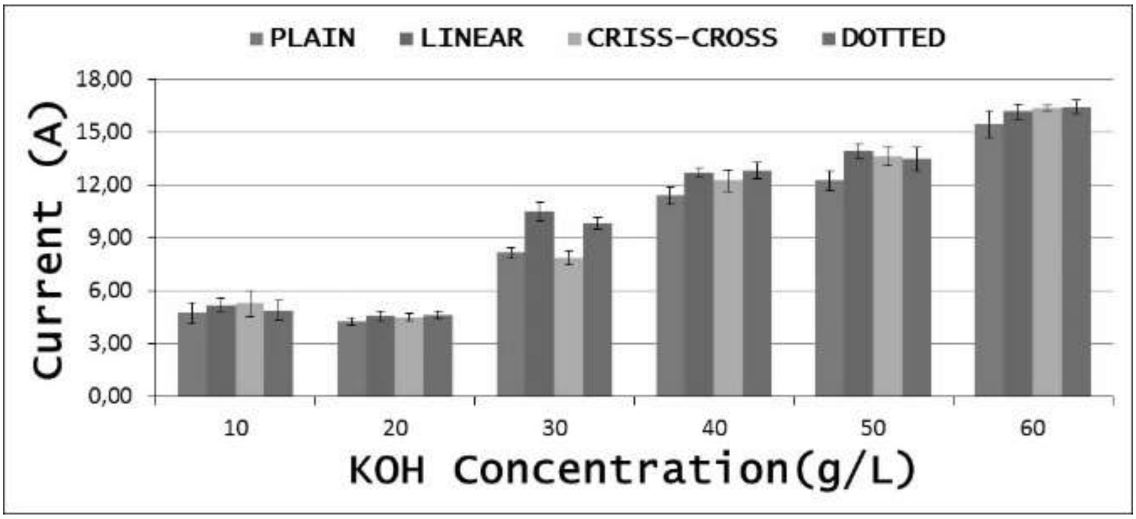


figure 3. Comparison of electric current's average value and standard deviation between 4 textures

In an electrolyte solution, an increase in temperature causes an increase in the ionization rate due to a decrease in the E0 value of these reactions, and the velocity of the ions flowing in the solution from heat convection. Consequently, the conductivity, and thus the current, of the solution increases. (Salek et al., 2020a).

Table 3. Comparison of (a) mean and (b) standard deviation of temperature (^oC)

a)	Average Temperature (^oC)			
KOH (g/L)	Plain	Linear	Criss-Cross	Dotted
10	34,20	32,74	32,58	31,29
20	34,24	29,57	30,07	32,24
30	31,64	33,02	33,75	32,34
40	36,71	37,32	35,92	34,50
50	34,39	34,33	34,55	36,07
60	39,36	40,02	40,80	38,16

b)	Temperature Standard Deviation (^oC)			
KOH (g/L)	Plain	Linear	Criss-Cross	Dotted
10	6,06	2,35	3,02	3,03
20	2,70	2,89	2,27	2,43
30	3,59	3,52	2,58	3,21
40	3,73	2,55	3,79	2,15
50	4,30	4,95	3,61	4,23
60	4,97	0,43	4,15	5,36

Figure 3 shows a comparison graph from table 2. It can be seen that the measurement results have a high deviation at all KOH concentrations, while the average generator temperature only increases slightly following the increase in catalyst concentration, indicating that the temperature is not significantly affected by the electrolyte concentration.

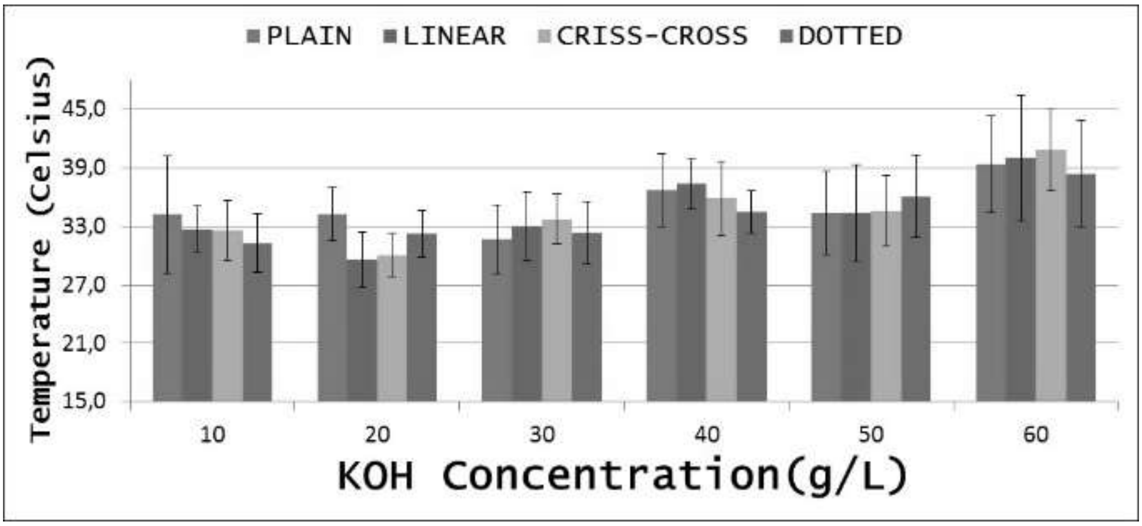


Figure 4. Comparison of temperature's average value and standard deviation between 4 textures

In the HHO generator, due to the heat released by the electrode plates, the rate of ionization and the movement of ions becomes faster, resulting in faster hydrogen gas formation (Salek et al., 2020b). This also reduce the production time.

Table 4. Comparison of (a) mean and (b) standard deviation of of production time (seconds)

a)	Average Time			
KOH (g/L)	Plain	Linear	Criss-Cross	Dotted
10	153,37	113,27	115,23	119,80
20	132,70	122,03	126,70	121,70
30	105,00	54,97	72,20	61,17
40	54,40	46,90	48,30	47,43
50	50,37	43,60	45,57	46,10
60	40,53	35,63	35,03	35,00

b)	Time's Standard Deviation			
KOH (g/L)	Plain	Linear	Criss-Cross	Dotted
10	16,27	23,09	19,14	18,68
20	7,41	10,26	7,24	7,71
30	32,49	3,27	3,69	3,28
40	2,59	1,19	2,89	1,93
50	2,77	1,58	1,82	2,47
60	2,58	3,09	2,29	2,18

Figure 5 shows a comparison graph of the data in table 3. It can be seen that the data decreases as the concentration of KOH increases. The measurement data at the 3 highest concentrations were also more stable than the 3 lowest concentrations. Shown as well that plain plates have very large data variations at low concentrations, which can be considered as unreliable performance.

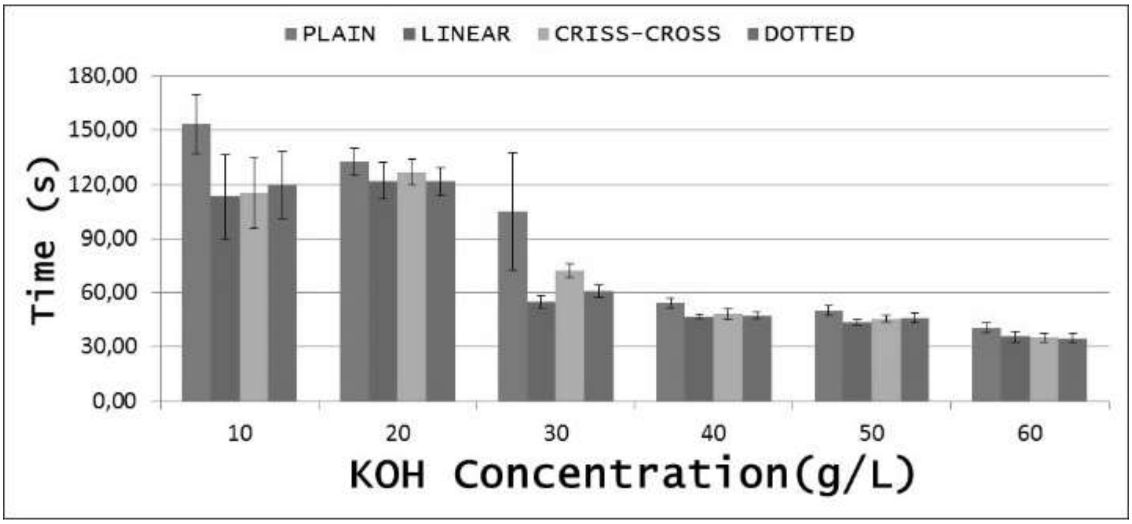


Figure 5. Comparison of time's average value and standard deviation between 4 textures

The data for each plate was then processed into a graph of the average and standard deviation of the values of temperature, current, production time, and production rate of each plate, to the concentration of KOH. Linear regression is then calculated. Shown below in figure 6, the sample of such individual graph. The graph shows the increase of production rate correlated to concentration of catalyst. A linear regression was drawn, with the equation of the linear regression is shown, alongside the value of the determination coefficients. Correlation coefficient is the mean square of determination coefficient.

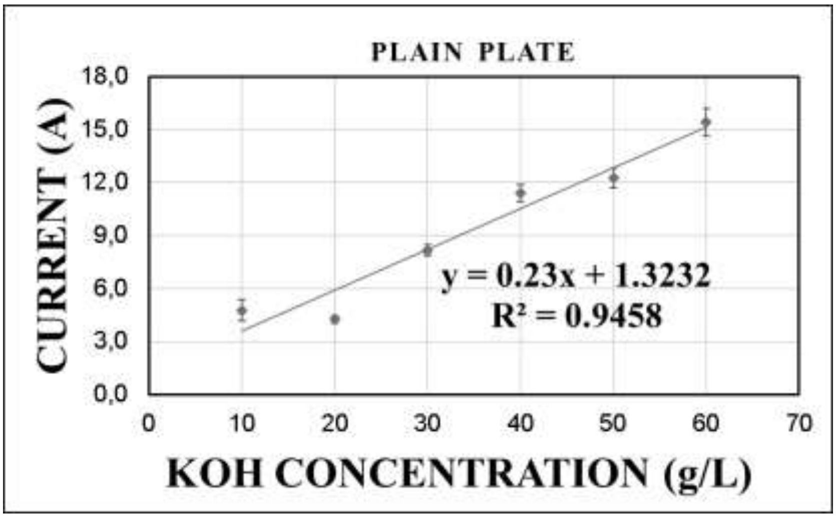


Figure 6. Individual graph of HHO generator's current with plain plate

The value of the coefficient of determination and the correlation coefficient of each plate is shown as follows in table 5. The value of the correlation coefficient shows how big the correlation is between the measured parameters of hydrogen gas production and the concentration of KOH in the electrolyte. Correlation coefficient of 1 or -1 indicated that the data obtained are right on the regression line, while a value of 0 indicates data that is not correlated at all. (Schober & Schwarte, 2018).

Table 5. The coefficient of determination and the correlation coefficient of each parameter for the four types of plate surface textures

Parameter	Texture	Correlation Coefficient (R)
Temperature	Plain	0,635
	Linear	0,797
	Criss-Cross	0,838
	Dotted	0,967
Current	Plain	0,973
	Linear	0,961
	Criss-Cross	0,968
	Dotted	0,969
Time	Plain	-0,967
	Linear	-0,889
	Criss-Cross	-0,924

	Dotted	-0,916

DISCUSSION

Table 2 shows the results of the calculation of the average and standard deviation of the generator current. Since a high electric current will increase the rate of hydrogen gas production and a steady current is required throughout the process, the best surface texture is the one that produces the highest current average and the lowest standard deviation. From the table, dotted plates had the best results at 3 concentrations, followed by linear texture at 2 concentrations. However, the standard deviation of dotted plate is less stable than the linear plate which has the lowest standard deviation at 3 concentrations.

Table 3 shows the results of the calculation of the average and standard deviation of the generator temperature. The best surface texture is the one that produces the lowest average and standard deviation high temperature can damage generator. From the table, dotted plates had the best results at 3 concentrations, followed by linear texture at 2 concentrations. The criss-cross texture has the worst results, but tends to have the most stable standard deviation, meaning that it tends to release the most amount of heat.

Table 4 shows the results of the calculation of the average and standard deviation of the time required to produce 1 L of gas. The best surface texture is the one that produces the lowest average and standard deviation. From the table, linear plates had the best results at 4 concentrations and 3 standard deviations.

Correlation coefficient values that are close to 1 or -1 indicate parameters that are strongly affected by concentration, while data close to 0 have values that are almost not affected. For temperature, a correlation coefficient close to 0 is better. Current and production rate on the other hand, require results that are correlated with increasing concentrations because it is hoped that the increase in concentration will effectively assist hydrogen production. And time requires inversely proportional results (Schober & Schwarte, 2018). From table 5, plain plate has the best characteristics for temperature, current, and production time.

CONCLUSIONS AND RECOMMENDATIONS

From the experimental results, there have been 18 comparisons of mean and 18 comparisons of standard deviation (6 concentrations for 3 parameters), as well as correlation coefficients for 3 parameters. After comparison according to their respective criteria, it was determined that the linear plate had the best results among the 4 types of surface textures, as it regularly show the best or the 2nd best average value of the 3 parameters, while also being very stable, having some of the lowest standard deviations. It was followed by the dotted texture which had a fairly good but unstable production result. The criss-cross plate has the property of releasing the most amount of heat between the 4 textures. Finally, plain plate has the worst performance, with very slow production time and high standard deviations.

FURTHER STUDY

Although this study has determined that the linear texture has the best performance, the determination method could still be improved with more rigorous multi-criteria decision-making analysis, such as TOPSIS method.

After the experiments, depositions occur on the surface of the electrodes, indicating that SS316L is not fully free from corrosion. As corrosion would affect longevity of the generator and deposition affect hydrogen performance by reducing electrode plates effective surface area, testing of the corrosion rates should be done and compared between the 4 textures as it also possible criterion in deciding the best surface texture.

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REFERENCES

Asmawi, A., Bin Mansor, MUHD. R., Tamaldin, N., Repi, V. V. R., & Sudrajat, A. (2022). Pengaruh Penggunaan Pelat Elektroda Tekstur terhadap laju Produksi gas pada Generator HHO. *Jurnal Ilmiah Giga*, *25*(2), 96. https://doi.org/10.47313/jig.v25i2.1974

Autobatteries.com. (2021). *How to Test Your Auto Battery | Battery Testing & Maintenance | Autobatteries.com*. https://www.autobatteries.com/en-us/battery-testing-and-maintenance/car-battery-voltage-and-testing

Bala Srinivasan, P., Liang, J., Blawert, C., Störmer, M., & Dietzel, W. (2009). Effect of current density on the microstructure and corrosion behaviour of plasma electrolytic oxidation treated AM50 magnesium alloy. *Applied Surface Science*, *255*(7), 4212–4218. https://doi.org/10.1016/J.APSUSC.2008.11.008

Casey, T. (2024, July). *Defense Department Eyes Green Hydrogen For Fuel Cell Electric Vehicles - CleanTechnica*. https://cleantechnica.com/2024/07/29/defense-department-eyes-green-hydrogen-for-fuel-cell-electric-vehicles/

El-Kassaby, M. M., Eldrainy, Y. A., Khidr, M. E., & Khidr, K. I. (2016). Effect of hydroxy (HHO) gas addition on gasoline engine performance and emiss ions. *Alexandria Engineering Journal*, *55*(1), 243–251. https://doi.org/10.1016/j.aej.2015.10.016

Essuman, S. P. K., Nyamful, A., Agbodemegbe, V., & Debrah, S. K. (2019). Experimental Studies of the Effect of Electrolyte Strength, Voltage and Time on the Production of Brown's (HHO) Gas Using Oxyhydrogen Generator. *Open Journal of Energy Efficiency*, *08*(02), 64–80. https://doi.org/10.4236/ojee.2019.82005

FCW Team. (2025, January 16). *Estonia's Defense Forces Testing Portable Hydrogen Generators*. https://fuelcellsworks.com/2025/01/15/fuel-cells/estonia-s-defense-forces-testing-portable-hydrogen-generators-for-use-on-battlefield

h2iq.org. (2024, April 7). *Hydrogen Fuel Cells in the US Military - H2 IQ*. https://h2iq.org/hydrogen_fuel-_cells_in_the_us_military/

Ilevbare, G. O., & Burstein, G. T. (2001). The role of alloyed molybdenum in the inhibition of pitting corrosion in stainless steels. *Corrosion Science*, *43*(3), 485–513. https://doi.org/10.1016/S0010-938X(00)00086-X

Manabe, A., Kashiwase, M., Hashimoto, T., Hayashida, T., Kato, A., Hirao, K., Shimomura, I., & Nagashima, I. (2013). Basic study of alkaline water electrolysis. *Electrochimica Acta*, *100*, 249–256. https://doi.org/10.1016/j.electacta.2012.12.105

Miles, M. H., Kissel, G., Lu, P. W. T., Srinivasan, S., Soc, J. E., Miles, M. H., Kissel, G., Lu, P. W. T., & Srinivasan, S. (1976). *Effect of Temperature on Electrode Kinetic Parameters for Hydrogen and Oxygen Evolution Reactions on Nickel Electrodes in Alkaline Solutions Effect of Temperature on Electrode Kinetic Parameters for Hydrogen and Oxygen Evolution Reactions on Nickel Electr*. *123*(3), 332–336. https://doi.org/10.1149/1.2132820

Ridhwan, A. M., Mansor, M. R., Tamaldin, N., Latief, F. H., & Repi, V. V. R. (2023). Effect of KOH Concentration on the Performance of HHO Generator at Varying Plate Surface Textures. *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences*, *106*(2), 116–128. https://doi.org/10.37934/arfmts.106.2.116128

Ridwan, A. M., Mansor, M. R., Tamaldin, N., Latief, F. H., & Repi, V. V. R. (2024). Effects of NaOH Concentration and Plate Surface Texture on the Performance of the HHO Generator. *Pertanika Journal of Science and Technology*, *32*(3), 1123–1139. https://doi.org/10.47836/PJST.32.3.08

Rusdianasari, Bow, Y., & Dewi, T. (2019). HHO Gas Generation in Hydrogen Generator using Electrolysis. *IOP Conference Series: Earth and Environmental Science*, *258*(1). https://doi.org/10.1088/1755-1315/258/1/012007

Salek, F., Zamen, M., & Hosseini, S. V. (2020a). Experimental study, energy assessment and improvement of hydroxy generator coupled with a gasoline engine. *Energy Reports*, *6*, 146–156. https://doi.org/10.1016/j.egyr.2019.12.009

Salek, F., Zamen, M., & Hosseini, S. V. (2020b). Experimental study, energy assessment and improvement of hydroxy generator coupled with a gasoline engine. *Energy Reports*, *6*, 146–156. https://doi.org/10.1016/j.egyr.2019.12.009

Sandmeyer Steel. (2021). *Alloy 316/316L Austenitic Stainless Steel Plate - Sandmeyer Steel*. https://www.sandmeyersteel.com/316-316L.html

Santos, D. M. F., Sequeira, C. A. C., & Figueiredo, J. L. (2013). HYDROGEN PRODUCTION BY ALKALINE WATER ELECTROLYSIS. *Quim. Nova*, *36*(8), 1176–1193.

Schober, P., & Schwarte, L. A. (2018). Correlation Coefficients: Appropriate Use and Interpretation. *Anesthesia and Analgesia*, *126*(5), 1763–1768. https://doi.org/10.1213/ANE.0000000000002864

Sudrajat, A., Handayani, E. M., Tamaldin, N., & Yamin, A. K. M. (2018). Principle of generator HHO hybrid multistack type production technologies to increase HHO gas volume. *SHS Web of Conferences*, *49*, 02016. https://doi.org/10.1051/SHSCONF/20184902016

Temin, T. (2024, September 10). *The Defense Department explores how to make hydrogen fuel on the go*. https://federalnewsnetwork.com/defense-news/2024/09/the-defense-department-explores-how-to-make-hydrogen-fuel-on-the-go/

Turky, M. (2018, May). *How does distance between two electrodes affect reaction rate of electrolysis?* https://www.researchgate.net/post/How-does-distance-between-two-electrodes-affect-reaction-rate-of-electrolysis