EFFECT OF SURFACE ROUGHNESS ON HYDROGEN GAS PRODUCTION RATE IN ALKALINE ELECTROLYSER

AHMAD SABRI BIN ZAHARI

B041110171

BMCT

Email: ahmadsabri.1234@yahoo.com

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Supervisor: ENGR. MUHAMMAD ZULFATTAH BIN ZAKARIA

Faculty of Mechanical Engineering

Universiti Teknikal Malaysia Melaka

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DECLARATION

"I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledged."

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ABSTRACT

Hydrogen gas is commonly used to reduce the effect of greenhouse gases such as carbon dioxide and carbon monoxide .It is one of energy resource in vehicle combustion engine. Water electrolysis is the most common way to produce hydrogen gas. The review of surface roughness based on alkaline electrolysis may play important role in investigating the factor of hydrogen rate production. The possible method is by scratching the plate so that the surface area of the plate increases as well as the rate of electrolysis. The hydrogen emission reaction was studied to reveal and to compare the activities of the electrode plate based on percentage line scratching of surface roughness produce. the experiment show that plate with 50% area of scratching has the highest rate of reaction compare to the plate with 0% and 100% area of scratching. Furthermore, the rate of hydrogen production for plate with 50% area of scratching also gave the optimum value compare to the other two plate. Several factor need to be considered that affected the rate of reaction and rate of hydrogen production as the plate with 100% area of scratching was expected to has the highest rate of reaction and volume of gas production but the result from graph shown the vice versa. The temperature at the cable, size of the wire, the presence of contaminants with formation oil layer and leakage at the container play important role that affect the whole result of rate ampere, power produce and hydrogen production in experiment. So the several precaution needs to be considered to handle this all problem that so that it cannot occur again for repeating the same experiment in the future

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ABSTRAK

Gas hidrogen biasanya digunakan untuk mengurangkan kesan gas rumah hijau seperti karbon dioksida dan karbon monoksida .Ia adalah salah satu sumber tenaga dalam proses pembakaran bahan api enjin dalam kenderaan . Elektrolisis air adalah kaedah yang paling mudah untuk menghasilkan gas hidrogen. Kajian mengenai kekasaran permukaan berdasarkan proses elektrolisis alkali boleh memainkan peranan yang penting dalam menyiasat faktor pengeluaran kadar hydrogen gas. Kaedah yang sesuai untuk menghasilkan permukaan kasar adalah dengan mencalarkan plat supaya kawasan permukaan plat bertambah serta kadar elektrolisis meningkat. Reaksi pelepasan hidrogen telah dikaji untuk mendedahkan dan untuk membandingkan aktiviti plat elektrod berdasarkan peratusan calaran kepada plat hasil kekasaran di permukaan plat. Eksperimen menunjukkan bahawa plat dengan kawasan 50% calaran menghasilkan paling banyak tindak balas berbanding dengan plat dengan 0% dan 100% luas plat calaran. Tambahan pula, kadar pengeluaran hidrogen untuk plat dengan luas 50% calaran juga memberi nilai yang optimum berbanding dengan dua plat yang lain. Beberapa faktor perlu dipertimbangkan yang mempengaruhi kadar tindak balas dan kadar pengeluaran hidrogen di plat dengan luas kawasan calaran 100% dijangka mempunyai kadar tindak balas dan jumlah pengeluaran gas yang tinggi tetapi graf menunjukkan sebaliknya . Suhu pada kabel, saiz wayar, kehadiran bahan cemar dengan lapisan minyak serta pembentukan dan kebocoran pada bekas memainkan peranan penting yang memberi kesan kepada hasil keseluruhan kadar ampere,kuasa dan pengeluaran hidrogen dalam eksperimen. Jadi beberapa langkah berjaga-jaga perlu dipertimbangkan untuk menangani masalah ini supaya ia tidak boleh berlaku lagi untuk sesiapa yang mengulangi eksperimen yang sama pada masa akan datang

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CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

Hydrogen is the most abundant element in the universe. Energy researchers see a logical progression from wood, coal, oil and to hydrogen as standard of living and technologies improve. Hydrogen gas is one of the energy resource in vehicle combustion engine (Gao, 2011). Water electrolysis may play an important role in this system as it produces hydrogen using renewable energy as a fuel gas for heating applications and as energy storage. This process involves the use of an electrode dipped in an electrolyte which is then connected to an external power source (Zoulias, Varkaraki, Lymberopoulos, Christodoulou, & Karagiorgis, 1978). The reaction between ions within the electrolytes breaks down components according to its reactivity series such as water into its basic ions releasing hydrogen and oxygen. This is the basic concept of how hydrogen is extracted.

The factor that affects the emission of hydrogen gas may be considered to investigate the hydrogen gas production rate in alkaline electrolyte. One of the factors is surface roughness of electrode plate. Based on this factor, the possible method is by scratching the plate of stainless steel 304 so that it will increase the surface area and increase rate of electrolysis. The hydrogen emission reaction was studied to reveal and to compare the activities of the electrode plate based on percentage line scratching of surface roughness produce.

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1.2 OBJECTIVE

The objective of this study is to investigate the effect of different surface roughness to hydrogen gas production rate in an alkaline electrolyser.

1.3 SCOPE

The scope of this research is to produce line scratching to the plate with the same grit size of sand paper, same speed and same pressure along the electrode plate. In the beginning, three scratching percentages will be implemented which are 100%, 50% and 0% to obtain the reaction characteristic.

1.4 PROBLEM STATEMENT

The factor that affects the production rate of hydrogen gas is surface roughness. The line scratching method is done to the electrode plate manually, so the consistent roughness is hard to obtain. So the few precaution needs to be considered to achieve the good surface finish quality.

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CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The hydrogen emission reaction was studied to reveal and to compare the activities of the electrode plate based on percentage of area scratching of surface roughness produce. By scratching the plate, the surface area will increase and thus increase the rate of electrolysis. There are 3 types of different percentage of scratching area that is 0%,50% and 100% for surface roughness produce .There several methods to produce surface roughness including chemical etching, laser cutting and the using of sandpaper of non-metal and metal type. Among all this method, the method chosen to produce surface roughness must fulfill by good scratching scratching criteria. The method is also compared based on several properties like advantage and disadvantage, easy to produce, and the surface finish quality.

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2.2 METHOD OF SCRATCHING

Table 2.1: Type of Method

No.	Type of Method	Properties	
		Easy to Produce	**Surface Finish Quality**
1	Chemical etching	Yes	Good
2	Laser Cutting	Yes	Medium
3	Sandpaper metal	Yes	Hard
4	Sandpaper non metal	Yes	Hard

Surface roughness will be measured by a scratching test machine and flow of hydrogen also will be measured. The method of scratching by non-metal sandpaper is chosen to produce the surface roughness a consistent surface roughness by line scratching method compared to the other method.

Based on table 1, the method of scratching by using sandpaper is more appropriate even though the surface finish quality is hard to predict. This due to the manual way is easier to construct the line of scratching. Basically, there are two types of sandpaper that are sandpaper of metal and sandpaper of non–metal. Closed-coat sandpaper can used to scratch stainless steel because the particles of swarf produce are much smaller. It is also much denser size of grain that a more appropriate to scratch steel compare to open-coat categories of non-metal sandpaper.

Aluminum oxide can be used for all types of woodworking abrasive. It is a sandpaper with sharp and a blocky mineral with only abrasive mineral that can resist under the high heat and pressure generated by sanding wood. This characteristic is called brittle and this is mostly required in sanding the wood. Aluminum oxide can be described as a relatively tough abrasive sandpaper because the edges of scratching side would not dwell much before they fragment (Nurbaş & Atabay Durul, 2012). Aluminum oxide is brittle and tough that makes it the longest lasting and the most economical mineral for sandpaper. The use of sandpaper of aluminum oxide to the steel can renew

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the cutting edges of plate which will sharpen and cutting longer compare to the other minerals.

Silicon carbide characteristic is black colored and hard shaped type of metal sandpaper. Compare to aluminum oxide, there is only one type of silicon carbide which is the abrasive grain is harder and sharper than most aluminum oxides making it the better choice for scratching hard materials such as stainless steel and other metal. Usually, silicon carbide sandpapers are available in any hardware store. Silicon carbide sandpapers for woodworking are almost always on waterproof paper and intended for sanding finishes (Brydges, Hall, Nicolson, Holmes, & Hall, 2012). Although silicon carbide is a brittle mineral, it is so hard that sanding wood will not cause it to fragment and renew its cutting edges. Although silicon carbide will sand faster at first, it will dull more quickly than aluminum oxide. Aluminum oxide does not leave as nice of a finish . The use of non-metal type sandpaper like silicon carbide will produce better surface finish compared to metal type sandpaper like aluminums oxide (Benny Hendarto, Dr. Ebrahim Shayan, 2002). Compare to sandpaper of metal, sandpaper of non-metal have more abrasive grains and the spaces between the abrasive grains that serve an important role. They work like the way gullets on saw-blades that is sandpaper give the shavings a place to go. The silicon carbide sandpaper characteristic is harder and sharper than most aluminums oxide sandpaper making it the better choice for scratching hard material like stainless steel. Moreover, aluminum oxide does not leave as nice of surface finish.

For the laser cutting method, the surface finish cannot be easily predicted due to the dynamic nature of the laser cutting process which uses oxygen as an assisting gas to produce the oxidation process. Generally, when laser beam focused on the cutting area, the cut surface can expose two zones that are the laser beam entrance and the area of the laser beam exit side. Oxygen produced is used as a cutting gas mainly for non-alloyed and low-alloyed steels. The jet of cutting gas oxidizes the material melted by the laser beam and blows away the melt and slag from the cutting groove(Miroslav RADOVANOVIC, 2006). Oxidization is an exothermic reaction which release energy or

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heat and generates extra heat. This can speeds up the cutting process and enables the laser to cut thicker materials

The layer formed during the laser cutting process manifests itself as a loosely adhering scale that easily chips and cracks from the metal surface upon impact. Therefore, its removal is necessary before painting. Otherwise, for adhesion failure the customer complaints and warranty claims will result. The oxidation reactions with iron and other alloying elements produce the heat and material removal occurs at two moving and often interacting fronts which is the oxidation front and the laser beam front. This oxidation reaction could damage the surface finish.

For chemical etching, the process producing the surface roughness could create undetected resist bubble which will disturb surface finish quality(Kulkarni & Erk, 2000). During the etching process the researcher uses a bird feather or similar item to wave away bubbles and detritus produced by the dissolving process from the surface of the plate or the plate may be periodically lifted from the acid bath. If a bubble is allowed to remain on the plate then it will stop the acid biting into the plate where the bubble touches it (Wile, 1895). The waste or debris is powdery dissolved metal that fills the etched grooves and can also block the acid from penetrate to the exposed plate surfaces. The method to remove this waste of metal cutting from a plate is to place the plate to be etched face down within the acid upon plasticize balls or marbles but the negative effect of this technique is the exposure to bubbles and the inability to remove them readily. The problem of chemical etching is more pronounced near cutting edge, the surface finish produce cannot be easily expected as there some gases produced are quite toxic and corrosive as well as deposition of non-volatile compound (Jency & Mathew, 2013). This method also need for specialized expensive equipment.

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Overview

Surface roughness also can be measured by using stylus measurement head with loading system and scan mechanism used in Veeco/Sloan Dektakprofilers (Kwok, 2001). It used a sensor to analyze surface roughness produce. The analog signal of the sensor consists of capacitance sensor output that is digitized and displayed in a surface roughness map.

For producing surface roughness of same consistency level, the constant pressure and velocity level when we scratch using sandpaper to the plate. Besides that, there also must be one sandpaper for one plate to get the same surface roughness finish for each plate.

The sanding technique only works on plain or uncoated stainless steel panels. If we use our fingerprints easily, the result is not consistent surface roughness produc

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CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

The methodology is a method that to be concerned. It is used to ensure that the methodology used is suitable with the variables during the research. Research methodology guided the researchers during the research implementations. The good arrangement of methodology will show the smooth experimental activities that will be conducted.

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3.2 THE MAKING OF SURFACE ROUGHNESS

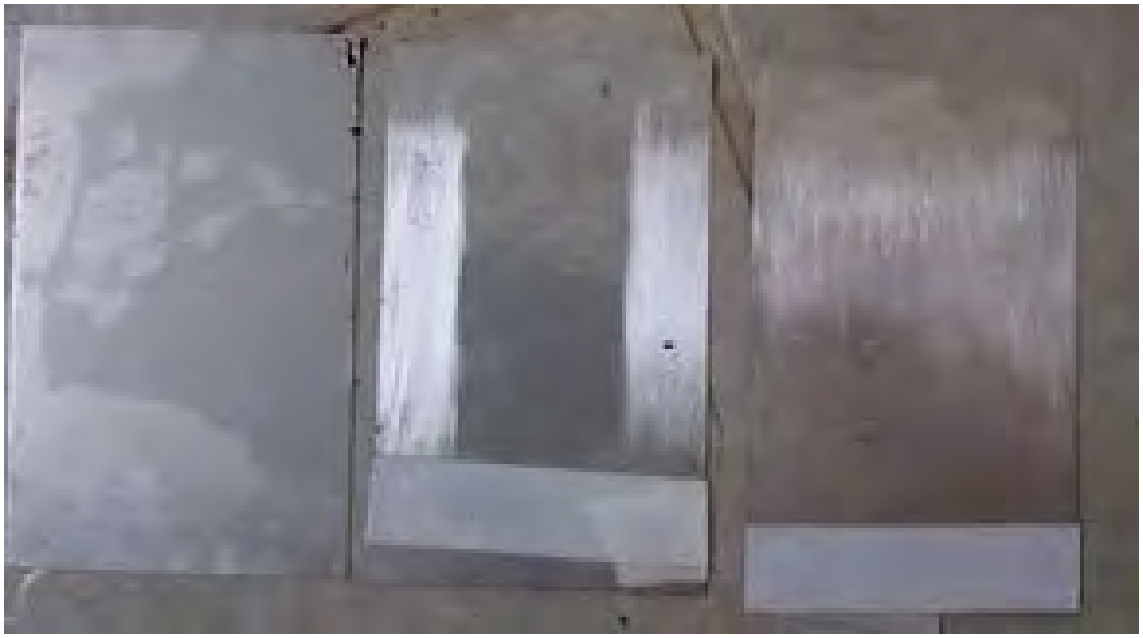

Figure 3.1: Plates with different percentage area of scratching

0% (Left), 50% (Centre), 100%(Right)

Based on Figure 4.1, the by using sandpaper block, the surface roughness for stainless steel plate was produced by using percentage area of scratching. Before scratching process, the controlled area of 10 cm x 10 cm scratching was selected for area of scratching based on 15 cm x 10 cm of plate. So the unselected area will be sealed by using cellotape to prevent scratching unwanted area.

The percentage area of surface roughness was produce by scratching all area of 10 cm x 10 cm area for both side of plate to produce 100% area of scratching and scratching half of the plate of area of 10 cm x 10 cm for both side of plate to produce 50% percentage of surface scratching

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3.2.1 SANDPAPER BLOCK

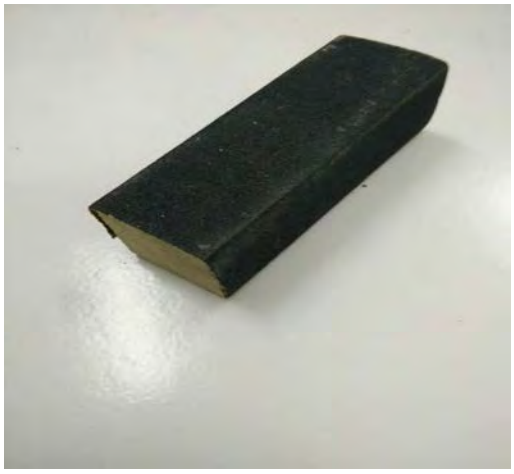

Figure 3.2: Sandpaper wooden block

First, the plate was planned to be scratched by using the grinder but unfortunately the tip of the grinder cannot reach at the center of plate because the tips of grinder is too short so that the inconsistent surface roughness was produce. Because of that reason, the method of scratching needs to be changed in order to produce the best consistent result of surface roughness. The using of sandpaper block is the most suitable way to scratch because sandpaper block can reach all area of plate.

Furthermore, the plate needs to be scratched by using sandpaper of same grit type to ensure the same roughness produce. The sandpaper is used to wrap the wooden block. The sandpaper needs to use only ones at a time of scratching. The motion of the sandpaper block also needs to be controlled with one motion without repeated. The sandpaper has variety of grain sizes. As the grain size of the sandpaper increases, the roughness also increases. There are also two categories of sandpaper to scratch the steel that is closed coat and open coat sandpaper. The sandpaper designed for wood is called an open coat where only 40% to 70% of the backing is covered with abrasive. The spaces in an open coat are hard to see in fine grits but are very clear in coarse grades. Closed-coat sandpaper, where the backing is fully covered with abrasive is appropriate for sanding the steel because the swarf has no place to go and clogs the paper.

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3.2.2 NON METAL SANDPAPER

The non-metal sandpaper made of black silicon carbides is suitable for grinding of metal and non-metal materials of low tensile strength such as gray cast iron, brass, aluminum, stone materials, leather and rubber. Adhesive back of metal sandpaper is easier to use by peeling off the back and sticking on a backer pad. Stainless steel is a great look but if we scratch it will looks awful. By using a wooden block, the sandpaper will be wrapped around wooden block **.** The plate can be scratched with non-metal sandpaper 600 grit (Bera, Guptha, Dasan, & Natarajan, 2012) for sanding the block, an abrasive pad, and rubbing any compound material.

3.3 PASSIVATION PROCESS

Figure 3.3 : Passivation Process

Based on Figure 4.2, Passivation process includes the process of soaking the plate in the lime water. This process is to prevent corrosion to the plate during experiment. The plate must be soaked for a day before running the experiment so that the process of corrosion cannot happen due to expose of plates to oxygen in air which is called as reduction process.

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3.4 ELECTROLYSIS

The working principle of alkaline water electrolysis to produce hydrogen gas for generator can be describe by observation and analysis .Firstly, the two plate of electrode will be dipped into alkaline electrolyte. The tube holder is used to hold the plate so that the plate will not collapse in water. The stainless steel electrode plate is put in vertical position to make sure the electrolysis process occur with the most efficient way. The alkaline water solution will be separated by using separator cell. After that, one plate will be connected to the positive terminal of battery and the another plate will be connected to negative terminal . The voltage needed to apply for electrolysis process to be carried out is 1.23V (Mazloomi, Sulaiman, & Moayedi, 2012). Increasing the voltage input would increase the rate of hydrogen output. Rather than connecting the rig directly to a battery, the battery is connected to a voltage regulator to control the voltage to a desired value This is return controls the rate of current input for all the plates thus giving us a constant voltage to be used for all the experiments later on. By this method we are keeping the voltage at a constant level to make sure the voltage produce as constant variable.

Hydrogen gas which produced from water electrolysis process is the result of discharge of positive ion to the negative terminal (cathode). The transparent tube for collecting hydrogen will be placed onto the cathode because at this positive terminal is where hydrogen gas will be formed after the connection is made.

The flow of hydrogen gas then will be observed at the cathode which is the negative terminal of electrode plate.

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3.4.1 PRODUCTION OF ALKALINE ELECTROLYTE

The production of alkaline water as the electrolyte is by using KOH pellets that put in water to produce KOH solution. At first starting the experiment, the technique used to determine the alkaline solution is by using pH metre. Unfortunately, the pH meter cannot be used if the concentration of electrolyte is higher than pH 14 because the reading maximum reading only to pH 14.So by using the mass of KOH pellets, the number of mole was calculated to determine the concentration of alkaline electrolyte. To produce the KOH solution with 0.1 mol concentration is by using formula:

$$n = m \div M \qquad [3]$$

where n = number of mol

m = mass of KOH pellets (g)

M=Molar mass of KOH pellets (g/mol)

So by using 38 number of KOH pellets, the 0.1 mol of KOH solution was produced for 1.4 Liter water solution.

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3.5 HYDROGEN GAS PRODUCTION

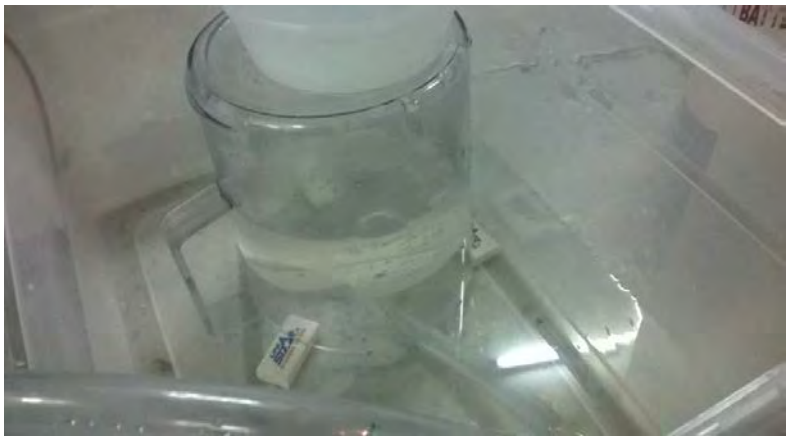

Figure 3.4 : Hydrogen gas production

The measurement of hydrogen gas is by using measuring beaker that put on the tube that connected to the container of electrolyte during the experiment. The level of gas produced (oxygen +hydrogen) was marked on beaker as indicator to measure the volume of gas displaced. The initial and final level of gas produce was marked when the volume of gas displaced for every 2 minutes

The measurements of current (ampere) also was taken when Voltage was sets constant with.7 V.The experiment was repeated for 3 times to get the average time of volume hydrogen displaced for every 2 minutes. By this we can determine how each steel plate reacts and rate of production of hydrogen by half reaction :

$$\text{Cathode (reduction): } 2\,H_2O\,(l) + 2e^- \rightarrow H_2\,(g) + 2\,OH^-\,(aq) \qquad [1]$$

$$\text{Anode (oxidation): } 4\,OH^-\,(aq) \rightarrow O_2\,(g) + 2\,H_2O\,(l) + 4\,e^- \qquad [2]$$

Combining the two of half reaction yields the same overall decomposition of water into oxygen and hydrogen:

$$\text{Overall reaction: } 2\,H2O(l) \rightarrow 2\,H2(g) + O2(g) \qquad [3]$$

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which means that the total gas produce consist two molecules of hydrogen and 1 molecules of oxygen.So to calculate the value of hydrogen gas produced is by equation

$$\text{Hydrogen gas }, H_2 = \frac{\text{Total volume of gas produced}}{3} \times 2 \qquad [4]$$

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