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Performance of the electrical generator cell by the ferrous alloys of printed circuit board scrap and Iron Metal 1020

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Abstract. Galvani cell is one of thealternative energy. This cell can be used as an electric resources. In this research, the generator cell was designed and builds to generate the electric. The generator cell consisted of the iron metal 1020 were used as anode, the ferrous alloys of printed circuit board scrapwas then used as chatode, and NaCl solution as an electrolyte. The aim of this research is to estimate the performance of this generator cell by using variation of NaCl concentration (i.e.1%, 3%, 5%, 7%, and 9%) with the electrodes pair (1 and 8 pairs). The performance of the cell was measured with a multi tester equipment and a LED bulb (5-watt 3Volt). The Results shown that the generator cell can produce the electric power of 3.679 Volt maximally by using NaCl 9% and 8 electrode pairs applied for this condition.

1. Introduction

Recently, some researchhave been done to create several things from the electronic good scraps, such as an alternative energy in order to overcome energy crisis issues in the future [1, 2, 3, 4, 5, 6 & 7]. One of them isto use electronic goods scraps such as jengkol transistors scraps as a power generator. By utilizing the power of the transistor jengkol 2N3055, the jengkol can produce a voltage of 0.3-0.6 Volt [8]. With the voltage of one transistor, then it arranged in parallel position as many as transistors to get the desired voltage and to increase the current by parallel the number of transistors to increase the electrical current.

In this research, development of the electrical generator cell has been designed. This generator cell can generate electric power based on the electrochemical reaction spontaneously of the cell. Basically, the generator cell consisted of two electrodes, the iron metal 1020 as an anode, the ferrous alloys of printed circuit board scraps as a cathode, and NaCl solution as an electrolyte solution.

Electrolyte compound is dissolved in water, then the electrolyte is dissociated into positively and negatively charged electric particles called ions (positive ions and negative ions). The amount of positive ion charge will equal to the amount of negative ion charge, so the charge of ions in the solution is neutral. These ionic functions to be as an electric current media. The solution transferred an electric current is called electrolyte [11, 12]. This solution gives a symptom of flashing a lamp or the incidence of a gas bubble in solution.

NaCI solution is solved in H_2O, it can be ionization as Na^+ and Cl^-ionics [9-12]. These ionics function as a electron transfer media from one electrode to another one. Because there is electron current between two electrodes, the reduction and oxidation reactions has been appeared spontaneously, as a result there is electric current produced of the generator cell [11-14]. The portable electrical generator cell was

determined using variation concentration of NaC lwith the amount of electrode pair in the generator cell. The multitester equipment was used for estimating performance of the generator cell.

The objectives of this study are: (i) to study the influence of the variation concentration of NaCl solution to the performance of the generator cell (ii) study the reaction of the generator cell, iii) to determinethe efficiency of the generator cell.

2. Materials and methods

2.1. Metal material and supporting tools

Some material used such as sodium chloride p.a (Merck), aquadest DM, analytical balance, glasses, the multitester equipment, LED bulb (5 watt 3volt), the ferrous alloys of printed circuit board scrap and the iron metal 1020, and the generator cell with probes.

2.2. Design and built of the electrical generator cell

The following procedure were chosen the ferrous alloys, the iron metal is put in the generator cell as well. One unit of cell consisted of the ferrous alloys of printed circuit board scrap as a cathode (5 cm width x 10 cm length) and the iron metal 1020 as a anode (5 cm width x 10 cm length) (Figure 1). Then, a certain number of the unit of cell were put in the box, one unit of cell connected to other unit of cells in parallel position. Finally, NaCl solution filled into the generator cell, and this generator cell was connected to a LED bulb and the multitester equipment in order to estimate the electric power of the generator cell performance.

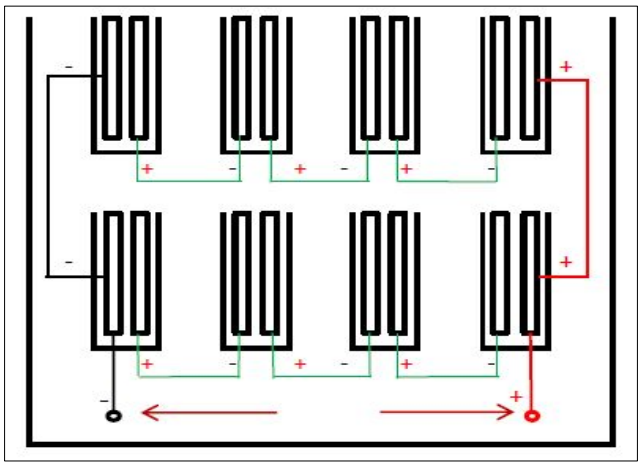

Figure 1. Circuit electron current of the generator cell which is consist of 8 electrode pairs.

The generator cell is consisted of several things, such as two Electrodes, the cell, the multitester equipment, terminal slot, LED bulb, Probe positive and Probe negative, also the electrolyte solution. The electrolyte solution is made from a solid mixture of NaCl with water (H_2O). Separator, between positive and negative plates, separator serves to separate or seal the positive and negative plates. The generator cell is a box containing liquid NaCl, plate positive and negative and separator.

Part of the generator cell consists of a box, it can be used as a house or container of its main components such as positive electrode (Fe_2O_3) and negative electrode (Fe) with electrolyte NaCl solution. The box lid above serves as the electrolyte filling hole cover, so the electrolyte solution is not easily spilled. The holeventilation serves to separate hydrogen gas from NaCl as well as a water evaporation channel. The metal plate is made of the ferrous alloys of printed circuit board scrap, while the negative plate is made using the iron metal 1020 (iron pure or Fe metal).

2.3. Determine performance of the electrical generator cell

Innitially, the ferrous alloys of printed circuit board scrap are put in the cell, then the iron metal is put in the generator cell as well. One unit of the cell consist of the ferrous alloys of printed circuit board scrap as a chatode and the iron metal 1020 as a anode (Figure 2). Then, a certain number of the unit of cell were put in the box, one unit of cell connected to other unit of cells in parallel position. Finally, NaCl solution filled into the generator cell, and this generator cell was connected to a LED bulb and the multitester equipment in order to estimate the electric power of the generator cell performance.

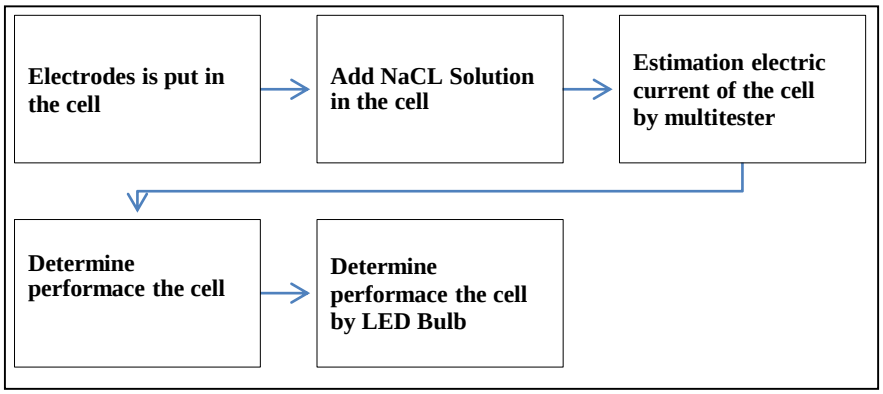

Figure 2. Diagram operation of the generator cell.

3. Results and discussion

3.1. Effect of variation concentration of NaCl solution to performance of the generator cell

This electrical generator cell is generated an electric power based on electrochemistry same as Galvani cell [12. 13, 14]. The effect of thevariation concentration of NaCl solution to the performance of the generator cell is presented in Table 1 and Figure 3.

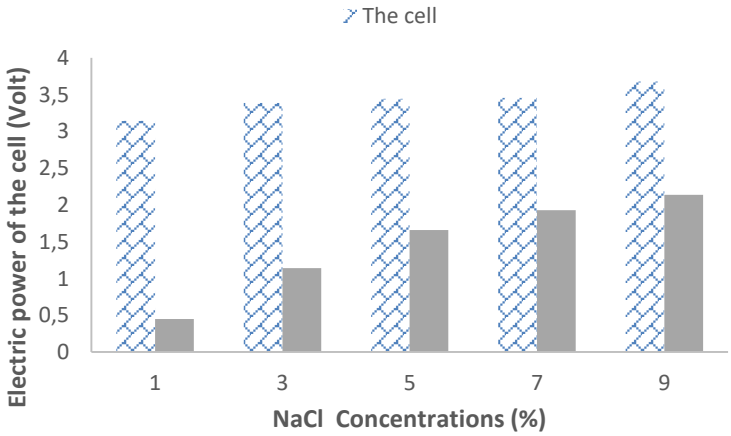

Figure 3. Influence of NaCl concentration variation to electric power of the cell.

Overall, the treatment of the variation NaCl concentration is affected to the performance of the generator cell. The highest of the NaCl concentration will be decreasing the electrical current significantly. There are a lot of wires used for connecting one unit of the cell to other unit of the cell in this generator cell. Another reason, exhoterm reaction is occured in this generator cell because of the differences enthalpi between ferro hydroxide (-925 kJ/mol) and NaCl (-411,153 kJ/mol) too high [10, 15].

Table 1. Performance of the generator cell over concentration variation of NaCl solution

NaCl Concentration (%)	Performace of the cell (Volt)	Performace of the cell by LED bulb (Volt)	Eficiency (%)
1	3.141	0.406	13.533
3	3.386	1.148	38.267
5	3.443	1.654	55.133
7	3.457	1.963	65.433
9	3.679	2.128	70.933

There were potential different of both electrodes, as can been seen on multitester equipment. This generator cell generated electric power around 3.679 Volt maximally under condition and it also unconnected with LED bulb and at 9 % NaCl solution applied. The generator cell produced an electric power 2.218 Volt under condition the generator cell connected by LED bulb at 9 % of NaCl solution. The cell was produced the lowest electrical power of 3.141 Volt at 1% of NaCl solution. It indicated tthat there was electrical current in the electricity generator cell.

The longest time LED bulb of 4 hours under condition at 9 % of NaCl solution and 8 pair of electrodes were applied. After 4 hours, LED bulb will suddenlyoff, because surface of both electrodes i.e, surface of ferrous metal 1020 was corrupted by reaction and the ferrous alloys of the printed circuit board scrap was covered by white solid residue, so there is no reaction and also there are no electron current among both of electrodes. In addition, from 1% until 3% of NaCl electrolyte solution the LED bulb was not on.

3.2. Study the reaction of the electrical generator cell

In the electrical generator cell designed and made electrochemical reactions occur. In the electrolyte solution used, each molecule of sodium chloride (NaCl) breaks into one positively charged sodium ion (Na^+) and a negatively charged chloride ion (Cl^-).

$$NaCl + H_2O \rightarrow Na^+ + Cl^- + H^+ + OH^-$$

Each ion Cl^- located near the iron metal (Ferrous 1020) or a pure iron plate will unite with one pure iron atom (Fe) into ferrous chloride compound ($FeCl_3$) while releasing three electrons.

$$Fe + 3\,Cl^- \rightarrow FeCl_3 + 3\,e^-$$

The ion hydrogen from the decomposition of the NaCl solution in water will be drawn by a ferrous oxide plate (Fe_2O_3), receiving three electrons and uniting with one oxygen atom to form a water molecule (H_20).

$$H^+ + 3e + O_2 \rightarrow H_2O$$

In this process, there is an electron capture of Fe_2O_3 compound (so it becomes positive) and gives the electron on the pure Fe plate (so it becomes negative), this process results in an electric potential difference between the two poles of the electrode. The process occurs simultaneously, the chemical reaction is expressed as follows:

$$4\ Fe + 4\ H^{+} + \ 3e \ + 4\ O_2 \rightarrow 2\ Fe_2O_3 \ + 2H_2O$$

During the discharging process of $FeCl_3$, this will be reducing the reactivity of the NaCl electrolyte liquid. The resistance between the poles is very weak for practical use. In the chemical process during charging occurs after the battery is weak (unable to supply the current when the vehicle is started).

The battery condition can be restored to its original state by providing an electric current in the opposite direction of the current that occurs during discharging [14]. In this process, the water molecule decomposed and ions of the hydrogen pairs close to the negative plate unit with Cl^- ions on the negative plate to form hydrochloric acid molecules HCl. The free oxygen ion with each Fe atom on the positive plate formed Fe_2O_3. The chemical reactions that occur are;

$$2\ Fe + \ 8\ Cl^- + 4\ H_2O \rightarrow \ Fe_2O_3 + Na_2O + 8\ HCl$$

3.3. Determine efficiency of the generator cell

Efficiency of the electrical generator cell was calculatedusing this equation;

$$Unit\ \ eficiency = \frac{b}{a} \mathrm{X}\ 100\%$$

where, b is electric power produced by the generator cell, and a is LED bulb's voltage.

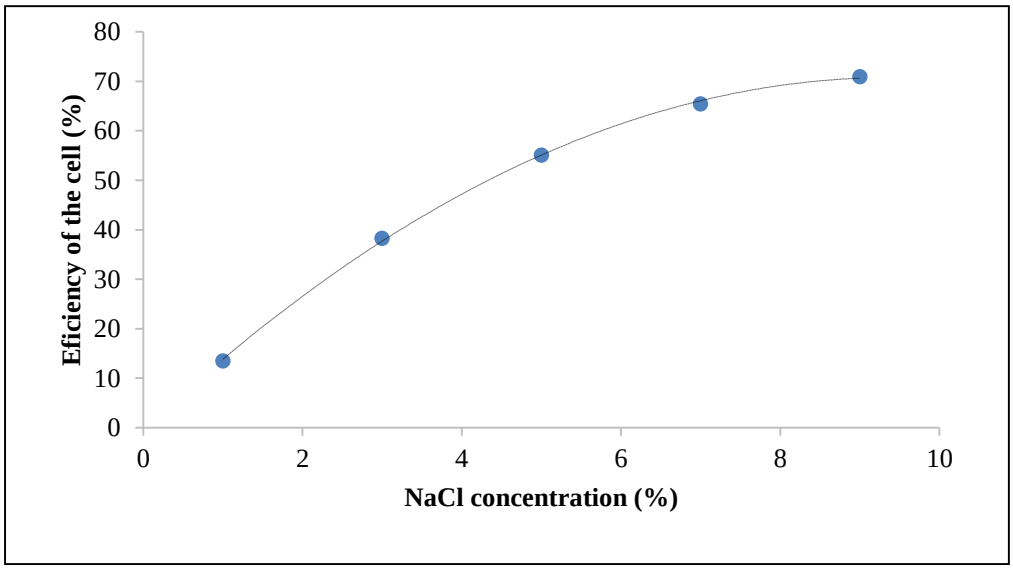

Figure 4. Efficiency of the generator cell by using LED bulb.

Overall, the increasing of NaCl content were appliedto the efficiency of the generator cell, it depicted in Figure 4. The most efficiency of the generator cell was 71 % under the system carried out by 9 % of NaCl solution. If the system operates with NaCl content over 9 %, it will be predicted that LED bulb still on. This trend is the same as the electrical power generator cell had been designed and built by Amri et. al (2015). They have been designed and built a portable electrochemical cell-based power cell which is consisted of three main components: magnesium AZ91 as an anode, MAB5A cell as a cathode, and NaCl solution as electrolyte [17]. Their cell produces an electrical power of 15.47 Volts using 10 %

of NaCl electrolyte solution. However, both electrodes are used to decay the surface rapidly due to their interaction with NaCl solution.

Corrosion is a natural process. The whole process will naturally move toward the lower energy [11, 12. 13, 14, 16, 17]. So iron and steel have a tendency to join elements or other chemicals to move to the lower energy. The principal disadvantage of many ferrous alloys is their susceptibility to corrosion [15, 16, 17]. For example, iron and steel will often bind to oxygen to form FeO or Fe_2O_3 iron oxide compounds called rust iron. Rust on iron and steel have the same chemical arrangement as iron ore FeO or Fe_2O_3 [20].

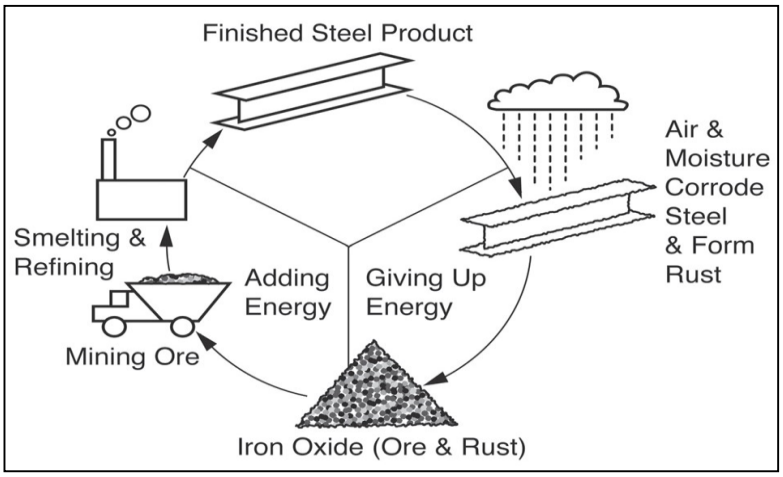

Figure 5. Corrosion Cycle on iron and steel (Adopted from Jenkins, 2005 [20])

Figure 5 illustrates the cycle of corrosion refining of iron and steel [20]. Metals and other alloys under high-energy conditions, they formed metal resistant to corrosion formed passive layer (usually oxide) on the surface. Stainless steel, aluminum alloys and titanium are metals with high-energy conditions. However, the passive layer form on its surface causes the relative resistance to corrosion. Especially in the case of stainless steel and aluminum alloys this layer is not immune to the entire natural environment and can be damaged in one or more special environments. Passive layer damage often progresses is very quickly, localized corrosion is caused by electrochemical activity part of the surface that remains passive.

4. Conclusions

The performance of the electrical generator cell is affected by variation concentration of NaCl solution. The performance of this generator cell was determinedusing the multitester equipment and Light Emitting Diode (LED) bulb. LED bulb was light on for 4 hours by using 9 % of NaCl solution and 8 electrode pairs were applied in this condition. This generator cell was produced the electric power of 3.141 – 3.679 Volt. The most efficiency of the electricity generator cell (71 %) is the system carried out by 9 % of NaCl electrolyte solution.

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