Utilization of Acid Mining Waste Water as to Alternative Energy Source with Galvanic Cell

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Abstract. Galvanic cells are cells that produce an electric current, there are three components, namely the anode, cathode, and electrolyte. The electrolyte can be an acid, salt, or amphoteric compound. Acid Mining Water (AAT) is runoff water produced in Mineral or Coal mining areas. The main composition of acid mine drainage is the content of metal sulfates, such as FeSO4, and H2SO4, has a low pH (2–3) and has a high conductivity value, so that this cone has the potential to become an electrolyte solution. The aims of this research are: (1) to find out how to use AAT as an electrolyte solution in Galvanic cells to produce electrical energy, and (2) to compare the amount of AAT as well as the type and number of electrodes and the electrical energy produced. The method used is an experimental method that uses AAT, as the object of research. From the results of the research, Acid Mine (AAT) water can be converted into an electrical energy resource by the electrochemical cell method, from the results of the research the type of electrode has an effect on the magnitude of the electric potential value and the resulting current, so from the results of the study obtained the best electrode in this study, namely Cu-C with a potential value of 2.4 V and a current strength of 1.8 mA, while the number of cells also affects the size of the current and electric potential, from the data it is found that the increase in volume also gives an increase in the value of the electric potential where for the Cu-C electrode the volume of 400mL gives a potential value of 3.0.

Keywords: Acid Mine Drainage · Cell Galvanic · Electrode · electric

1 Introduction

The increasing need for energy and accompanied by the increase in the price of fuel oil (BBM) and gas requires us to immediately switch to cheaper and widely available sources in Indonesia. One of them is coal which is used as fuel to meet energy needs in industries such as power plants, fertilizer industry, cement, textiles, and others [1]. The negative impact of coal mining activities is the formation of acid mine drainage.

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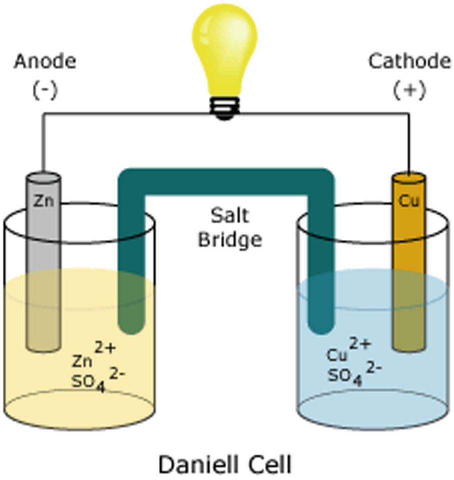

Fig. 1. Galvanic Cell

Acid mine drainage is an environmental problem that must be and must be considered in every mining activity, especially for mines containing sulfide minerals. (PbS and FeS). Acid mine drainage (AAT) or Acid Mine Drainage (AMD) is a term commonly used to describe the occurrence of surface runoff or acidic drainage in mining areas [2].

The formation of acid mine drainage in mining activities in Indonesia is quite large, considering that primary ore or coal mining activities that have been and will operate generally seek sulfide minerals such as pyrite (FeS2). This pyrite will be oxidized by oxygen in the presence of water to form compounds of iron (II) sulfate and sulfuric acid (Stiefel, R.C. 1983). Climatic conditions such as in tropical Indonesia, with high rainfall also affect the rate of formation of acid mine drainage. This issue needs attention from the mining community in Indonesia, because it has the potential to become an environmental problem in the future, in line with the increasing public awareness of the environment and increasingly stringent regulations on national and international environmental management. Characteristics of Acid Mine Water (AAT) is expressed by a low pH (2–3) the presence of metal content (Fe, Mg and Pb), Has a high conductivity (1.7) [3].

1.1 Galvanic Cell

A galvanic cell is a cell in which a chemical reaction between two dissimilar conductors is connected through an electrolyte solution and a salt bridge thereby generating electrical energy. Galvanic cells can also be supported by spontaneous oxidation-reduction reactions. Basically, the electrical energy produced by a galvanic cell is generated by the transfer of electrons in a redox reaction. Electrical energy or current can be sent to a circuit, as in a television or light bulb (Fig. 1).

The electrode of the oxidation half cell is the anode (−), while the electrode of the reduction half cell is the cathode (+). To better remember, we often abbreviate it as “KRAO, or Cathode Reduction, Anode Oxidation” which can be used to help remember that reduction occurs at the cathode and oxidation occurs at the anode.

1.2 Electrolysis Cell

An electrolytic cell is a part of an electrochemical cell that utilizes a source of electrical energy to change the oxidation-reduction process in the cell. In an electrolytic cell, a negative charge means the cathode, while a positive charge means the anode. The arrangement will go through ionization which will become cations & anions. Cations at the cathode will experience a decrease in interaction while at the anode will experience an oxidation cycle. One of the uses of electrolysis cells is in gold metal plating by utilizing an electrolyte arrangement that contains gold (Au) in it. This is done to re-coat gold jewelry whose gold substance has been lost. In the electrolytic response, an event occurs between the disintegration of the electrolyte by direct electric current. The electrolyte used is usually a solution or solution. When an electric current is flowed into the electrolyte, the formation of these particles will occur. Positive particles will be attracted towards the negative axis (cathode) & sent (reduced) into the category of unbiased animals. Negative particles will move towards the positive post (anode) & oxidized to an unbiased species.

1.3 Electrode Potential

In order to transfer a charge starting from one point and then to the next, a possible electrical difference between the two charges is required. Where the potential difference is estimated between the two cathodes, in particular the estimation terminal & the reference anode. Hydrogen ($H + \mid H2$) is used as the correlation terminal. This potential contrast will be communicated as electromotive force (DGL). The standard hydrogen electrode potential is rated as = 0 V ($E^\circ = 0$ V). How much electricity is generated from the two anodes is not entirely regulated in the rock by determining the ability of the Al & Cu cathodes.

1.4 Electrolyte

An electrolyte is a substance that decomposes or decays into its ionic structure. The electrolyte used in this study is corrosive mining waste with a $pH < 4$. Substances that are available in smaller quantities in the composition mean dissolved or dissolved substances.solute, whereas a substance that is more diverse than a substance that differs in composition means the solvent or solvent. The solute & solute chunks in the answer are communicated in order groupings, while the most common way of combining solute & solute to frame the answer means dissolving or dissolving. Electrolytes can turn into salts, corrosive mixtures or amphoteric. Electrolyte also strengthens which is enriched between polar particles & covalent bonds.

1.5 Acid Mine Water

The formation of acid mine drainage at the mining site is characterized by a very low effluent pH ($pH < 3$). This low pH condition affects both the mining environment and the mining equipment itself, because with low pH conditions it can dissolve the metal where the waste is located. The three main components that cause acid mine drainage are:

a). sulfide minerals such as pyrite, marcasite and pyrrhotite
b). oxygen
c). Liquid

In addition to the chemical factors above, there are factors that also determine the rate of formation of acid mine drainage, namely: pH, temperature, Fe3 + activity, surface area of exposed sulfide minerals, and degree of water saturation (Sengupta, 1993).

The reactions that may occur in the formation of acid mine drainage are as follows:

$$2FeS2 + 7O2 + 2H_2O_2 \quad Fe2 + +4SO22 - +4H+ \tag{1}$$

$$4Fe2 + +10H2O + O2 \quad 4Fe(OH)3 + 8H+ \tag{2}$$

$$2Fe3 + +O2 + 2H + 2Fe3 + +H2O \tag{3}$$

$$FeS2 + 14Fe3 + +8H2O \quad 15Fe2 + +2SO42 - +16H+ \tag{4}$$

The reaction rate for the formation of acid mine drainage is a heterogeneous reaction kinetics in which the reaction consists of several phases, namely: solid, liquid and gas phases. Hofman et al. stated that the reaction for the formation of acid mine drainage was an order 1 reaction [4]. The reaction rate of acid mine water formation can be expressed from the rate:

a) decrease in FeS2 in rock
b) increased sulfate ion formation
c) increased formation of iron (II) and ions solution acidity

As for the properties of acid mine drainage, the results of the analysis in several locations where acid mine water occurs can be seen in Table 1. This data is taken from data analysis of AAT sources in the Bukit Asam Coal Mining Company.

2 Research Methodology

See Fig. 2.

Table 1. Properties Acid Mine Darinage Coal Mining of PTBA Tanjung Enim

Parameters (mg/l)	LOCATION			
	Stocfile	Waste soil	Burden	Tailing
pH	2.3	2.6	2.6	2.0
Keasaman	3.180	1.600	3.800	14.600
TS	6.170	4.180	–	–
Fe^{2+}	280	960	1.310	1.750
Fe^{3+}	780	960	1.310	1.450
$SO_4{}^{2-}$	2.800	2.280	4.050	7.440

Source [5]

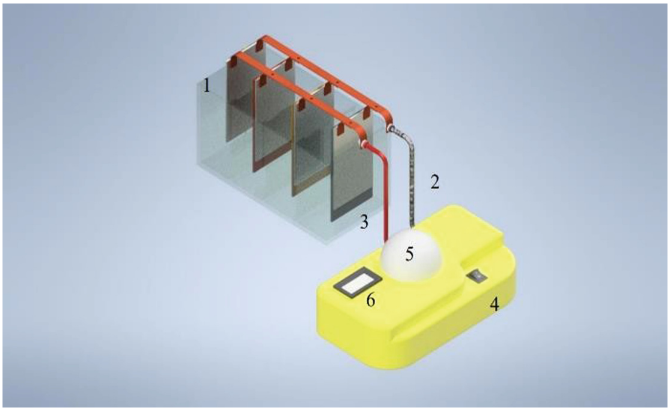

Fig. 2. Design galvanic Cell

Description:

1. Electrode
   Copper+Aluminum
   Carbon+Aluminum
   Metal+Aluminum
   Tin+Aluminum
2. Connector –
3. Connector +
4. Turn on/off
5. DC Lamp
6. digital voltage

3 Results and Discussion

3.1 Results of the Effect of Electrode Type on Electric Potential and Electric Current

See Tables 2 and 3.

Table 2. Results of the Effect of Electrode Type on Electric Potential and electric Current

Type of Electrode	Composition Electrolite AAT/NaCl	Number of Cell	Volume (ml)	Current (mA)	Voltage (V)
Cu + C	3:2	1	100	2.1	2.5
		2	100	2	2
		3	100	2.1	2.2
		4	100	2.2	2.2
	4:2	1	100	2.4	2
		2	100	2.2	1.9
		3	100	2.4	2
		4	100	2.6	2
Al + Cu	3:2	1	100	1.9	1,8
		2	100	1.8	1.8
		3	100	1.8	1.8
		4	100	1.9	1.85
	4:2	1	100	2	1
		2	100	2.2	1.2
		3	100	2	1.1
		4	100	2.4	1.2
Al + Zn	3:2	1	100	2.4	1
		2	100	2.6	1.2
		3	100	2.4	1
		4	100	2.4	1
	4:2	1	100	2.6	1.2
		2	100	2.8	1.2
		3	100	2.6	1.2
		4	100	2.6	1.2

Table 3. Effect of number of cell and electrode type on Electric Potential and electric Current

Type of Electrode	Composition Electrolite AAT/NaCl	Number of Cell	Volume (ml)	Current (mA)	Voltage (V)
Cu + C	3:2	1	100	2.1	2.5
		2	200	2	3.2
		3	300	2.1	3.5
		4	400	2.2	3.7
	4:2	1	100	2.4	2
		2	200	2.2	2.2
		3	300	2.4	2.4
		4	400	2.6	2.8
Al + Cu	3:2	1	100	1.9	1,8
		2	200	1,8	2
		3	300	1.8	2.1
		4	400	1.9	2.3
	4:2	1	100	2	1
		2	200	2.2	1.4
		3	300	2	1.6
		4	400	2.4	2
Al + Zn	3:2	1	100	2.4	1
		2	200	2.6	1.4
		3	300	2.4	1.6
		4	400	2.4	1.7
	4:2	1	100	2.6	1.2
		2	200	2.8	1.4
		3	300	2.6	1.7
		4	400	2.6	1.8

3.2 Discussion

3.2.1 Effect of Electrode Type on Electric Potential Value

The analysis of the electric potential value resulting from the electrochemical process of acid mine water (AAT) in an electrochemical cell with various types of electrodes can be seen in Fig. 3.

The Cu-C electrode gives a high value to the current strength and electric potential this is due to the presence of Fe, Al, Zn and Cu elements in AAT and it can be said that

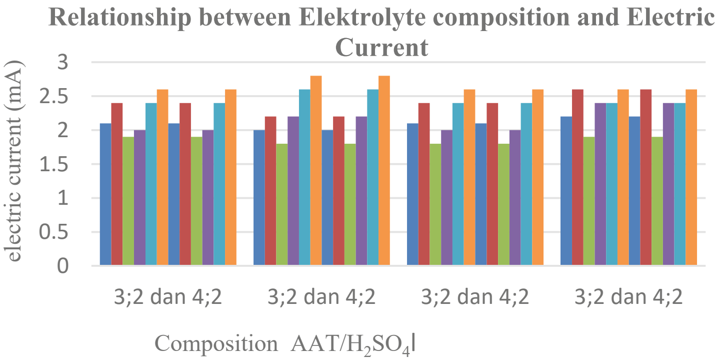

Fig. 3. Grafic of relationships compostitions electrolyte and Electric Current

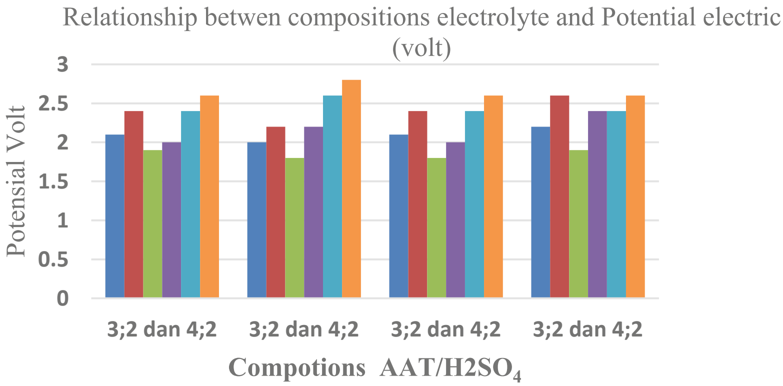

Fig. 4. Grafik Relationships between Compotions Electrolite and potential Electric (volt)

the rate of oxidation and reduction reactions in electrochemical cells gives a significant value.

3.2.2 Analysis of the Type of Electrode and the Number of Cells on the Strength of Electric Current and Potential

Analysis of the results of electrolysis on electrochemical cells with variations in the type of electrode and composition and number of cells can be observed from Figs. 5 and 6.

From Figs. 4 and 5 it can be analyzed that the number of cells indicated by the number of electrolyte volumes has an effect on the value of the electrical potential of the electrochemical cell where the more cells the greater the potential value, it can be analyzed that the more the number of cells, the greater the electrolysis rate, so in each type potential electrode also increases the value of the electric potential. Meanwhile, for the type of electrode that gives a large value for the electrolyte derived from AAT waste, the Cu-C electrode which has a high value is for an electrolyte volume of 400 mL and a composition of 3.2 is 3 V and a composition of 4:2 is 2.8 V.

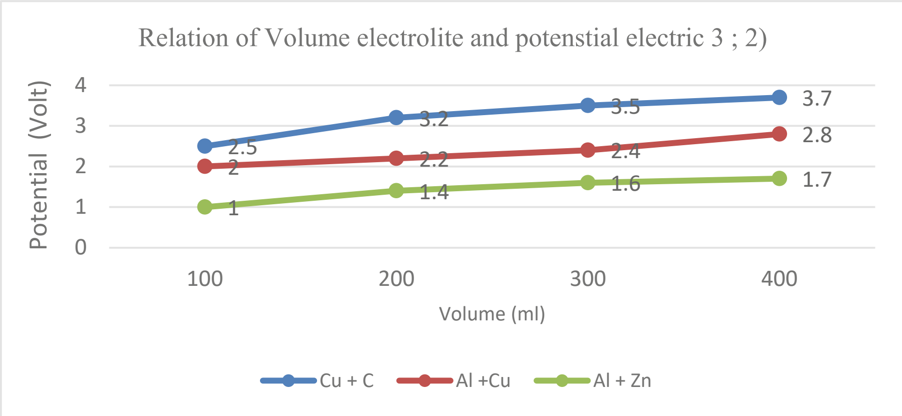

Fig. 5. Grafic Relationships between Volume electrolye and Potential Electric with Compositions 3:2

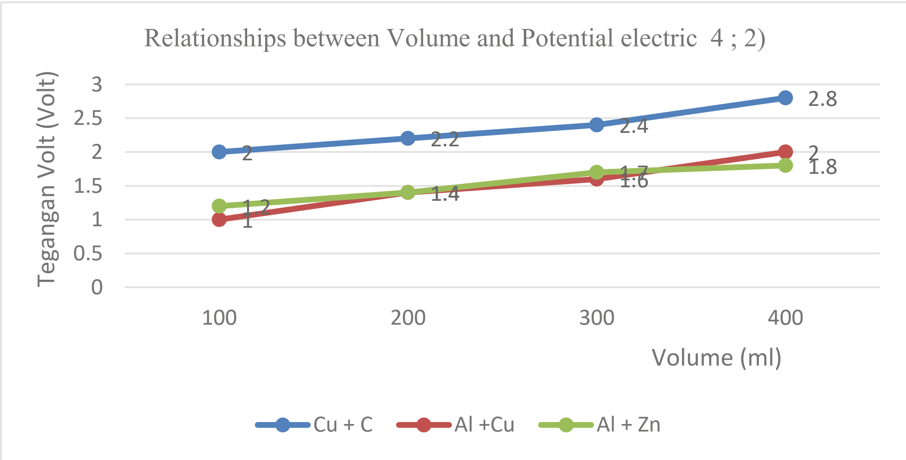

Fig. 6. Grafic Realtionships Between Volume Electrolite and Potentiali electric with Compositions 4:2

4 Conclusion

Based on the results of exploration & perception that have been carried out, it tends to be suspected that from this test, we obtained an electrochemical cell device with an electrolyte composition of Acid Mine Water by changing the type of electrode used, especially aluminum, carbon, copper, tin & brass.

The size of the electric potential and the flow produced by an electrochemical cell depends on the number of cells in the electrochemical cell. This is because the more cells there are in the cell, the greater the number of accumulated electrons.

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