To Recycle Zinc (Zn) from Used Zinc-Carbon Battery as Biogas Desulfurizer

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***Abstract*—Biogas should be purified before further application as a fuel for engine. Hydrogen Sulfide (H_2S) is one the gas impurities that rising problem for the engine since will caused acidity to lubricant and corrosive to metal part of the engine. In this research, zinc obtained from used battery is utilized as desulfurizer. Two methods are introduced in this article for processing zinc as desulfurizer. First by immersing in the salt water to produce zinc oxide (ZnO) and secondly by galvanic coupling with iron in order to obtain ion Zn^{2+}. It is found that both processing techniques having optimum result in reducing H_2S impurity in the biogas.**

***Index Terms*—zing, used battery, recycle, desulfurizer, hydrogen sulfide, biogas**

I. Introduction

In developed country such as Japan [1] and Switzerland [2], the battery waste is well managed. The Japanese government takes care of establishing a system to transport and treat them. Similarly in Switzerland there is an action to treatment of the unrecoverable waste in an environmentally safe manner.

Zinc is in a limited amount on the earth. The world resource of zinc is in the range 20-40 year [3]. Therefore recycle of the zinc should be promoted

The zinc-carbon battery consist of zinc case as a container and negative terminal, carbon road as positive terminal and mixture of MnO_2, graphite powder and ammonium chloride as electrolyte as can be seen in Fig. 1. After used or spent, the used battery still contains zinc case that possible to be recycled again.

In order to use biogas as fuel of the engine, the removal of hydrogen sulfide (H_2S) is particularly crucial because it can cause corrosion to metal parts of the engine [4]. Several techniques of H_2S removal from biogas are available in several publications. In situ removal of H_2S from biogas during anaerobic digestion process [5] for example, this technique using $FeCl_3$ dosing which is quite problem for local farmer in developing country to obtain it.

The next generation of desulfurizer was introduced by Tippayawong and Thanompongchart [6] which involved column reactor. This technique using external energy for circulating aqueous solution countercurrent flow so that not appropriate for small portable or mobile type of biogas system because consume quite large space. By using just activate carbon (AC) as demonstrated by Mescia *et al*. [7] resulting in low selectivity of activated carbon towards the adsorption of only sulfur species. Finally it was informed recently [8] that ZnO is powerful for desulfurization of biogas.

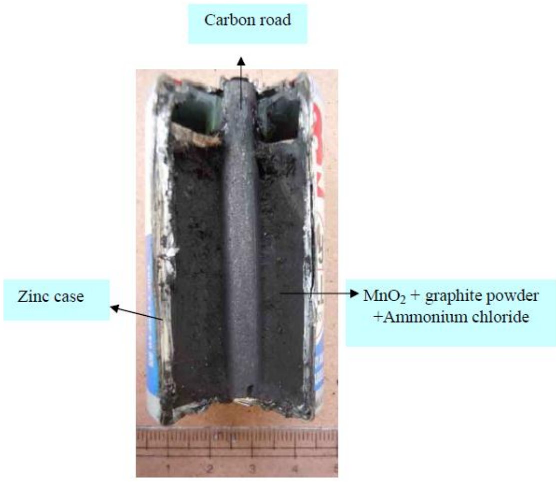

Figure 1. Section view of zinc-carbon battery

It is the purpose of this research to utilize zinc from used zinc-carbon battery as desulfurizer. The process will be developed for this purpose in order problem of waste battery could be overcome simultaneous with elimination of H_2S impurities in the biogas. The technique involved galvanic coupling between zinc and iron that can release ion Zn^{2+} which is reactive to H_2S. Galvanic coupling is a potential difference that usually exists between two dissimilar metals when they are immersed in conductive solution. This potential difference produce electron flow between them and metal ion will be released from one of the coupling [9]. The metal ion is hoped will react with H_2S so that process of desulfurization to occur.

II. Experimental

The zinc case from the used battery was taken out and cut to become small pieces as depicted in Fig. 2 and iron

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chips as can bee seen in Fig. 3 was prepared for galvanic coupling. The iron chips were come from waste of metal manufacturing process. Five compositions were prepared namely: 100% Zn, 75% Zn +25% Fe, 50% Zn+50% Fe, and 25% Zn+75% Fe and 100% Fe. The total mass of each composition were 100gram.

Figure 2. The zinc waste from used battery was cut in small pieces

Figure 3. The zinc waste from used battery was cut in small pieces

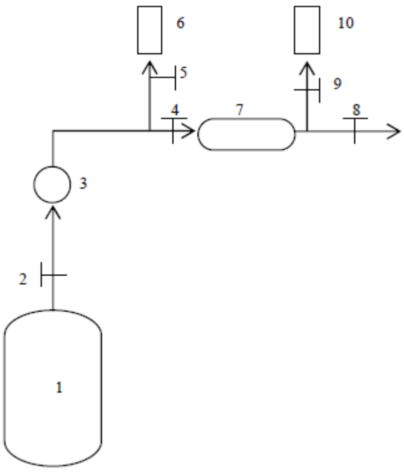

Figure 4. Schematic of experiment for desulfurizer test performance: 1. biogas container, 2. valve, 3. flow rate indicator, 4. valve, 5. valve, 6. H_2S gas sensor, 7. desulfurizer, 8. valve, 9. valve, 10. H_2S gas sensor

Each composition was immersed in to the salt water solution (2500 grams salt+20 liters water) for 2 days in order corrosion to occur and resulting corrosion product that could be reactive to H_2S.

The desulfurizer then was installed in the biogas pipe line system. The system was arranged with flow rate about 3 liters/minute. The performance of desulfurizer was evaluated by measuring the H_2S contents in the biogas before and after passing the desulfurizer as can be seen in Fig. 4. The biogas was let flow from gas container 1 with flow rate was controlled by using valve 2. The flow rate was checked by using flow rate indicator 3. To measure the H_2S contents in the biogas before entering desulfurizer, the valve 4 was closed and the valve 5 was opened and let the biogas flowed to the H_2S gas sensor 6. If the desulfurizer working well, then the H_2S contents in the biogas will decrease and can be measured by closing valve 8 and open the valve 9 and let the biogas flow to the H_2S gas sensor 10. The performance of desulfurizer then can be calculated by using equation (1). The performance of desulfurizer was measured for every 5 liters of biogas that passed the desulfurizer and was stopped until reach 50 liters. The averages of desulfurizer performance for total 50 liters then will be calculated and presented in form of graph for analyzed.

$$\frac{H_2S \text{ before desulfurizer} - H_2S \text{ after desulfurizer}}{H_2S \text{ before desulfurizer}} \times 100\% \qquad (1)$$

III. Result and Disccusion

Positive result is obtained from the composition of 100% zinc as can be seen in Fig. 5. The performance of desulfurizer is found optimal to reach 100%. This is caused by during immersion in the salt water, the zinc is corroded and form product of corrosion of ZnO [10]. The ZnO is very reactive to H_2S according chemical reaction as written in the equation (2) [11].

$$ZnO + H_2S \rightarrow ZnS + H_2O \qquad (2)$$

As can be seen in Fig. 5. The performance of desulfurizer made from 100% Zn is much better that desulfurizer made from 100% Fe. The iron (Fe) also reactive to H_2S because during immersion in to the salt water will yield the iron oxide ($Fe(OH)_3$). This type of iron oxide is reactive to H_2S according reaction from the equation (3) [12], [13].

$$2Fe(OH)_3 + 3H_2S \rightarrow Fe_2S_3 + 6\,H_2O \qquad (3)$$

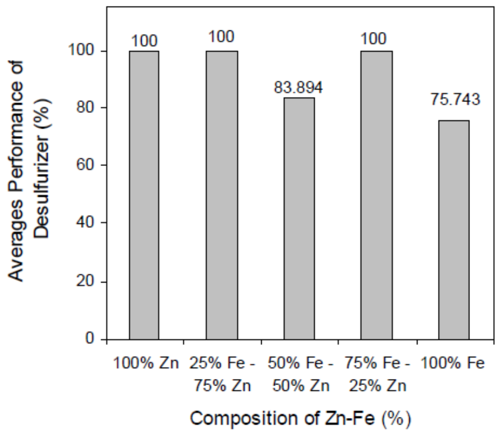

Figure 5. The Averages performance of desulfurizer

An interesting result is obtained for mixture of 75% Zn +25% Fe as desulfurizer which is resulting also optimum performance. This result is appear due to three reactions with H_2S to occur: primarily is reaction beween ZnO and H_2S (equation (2)) and small amount reaction between $Fe(OH)_3$ with H_2S (equation (3)). Since galvanic coupling between Zn and Fe, the coupling will release ion Zn^{2+}

that will react with H_2S as can be explained in Fig 6. Since the number of Zn mass is smaller that Fe in the mixture then the galvanic coupling is not so active in releasing Zn^{2+}.

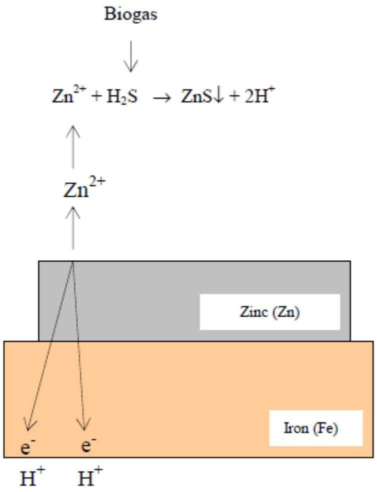

Figure 6. Scematic of galvanic coupling between Zn and Fe which can yield ion Zn^{2+} that will react with H_2S

In contrary, if the contains of Zn and Iron in the mixture is equal as in the mixture of 50% Zn+50% Fe, the performance of desulfurizer become decrease to the level of 83.894% as depicted in Fig. 5. The galvanic coupling is not effective to release Zn^{2+} since the coupling is in the same quantity and further more the fraction of ZnO that more reactive then $Fe(OH)_3$ is reduced make composition of 50% Zn+50% Fe is not appropriate as desulfurizer.

It is important to note that the mixture with composition 25% Zn +75% Fe also resulting an optimum performance as desulfurizer which is reach 100%. Even though contains small amount of Zn that make reaction of ZnO and H_2S not as main part of desulfurization process but reaction of Zn^{2+} with H_2S become main reaction of desulfurization since quantity of Zn is lower than Fe in the mixture that make galvanic coupling effective to release Zn^{2+} and react with H_2S impurity in the biogas.

IV. CONCLUSON

The used zinc-carbon type of battery contains Zn case that can be recycled as desulfurizer. By process of immersing in the salt water, the zinc is ready to be used as desulfurizer. Other technique is by mixing with Fe with not in equal quantity for examples 75% Zn+25% Fe or 25% Zn+75% Fe respectively and immersing it in the salt water.

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