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ANALYSIS OF ACID MINE DRAINAGE TREARMENT USING COAL FLY ASH WITH AERATION AND STIRRING METHODS (JAR TEST)

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ABSTRACT

Acid mine drainage is an important environmental impact of mining activities, both ore and coal mining which are oxidized with sulfide minerals. In addition to low pH, acid mine water also contains heavy metal ions such as Cu, Si, Mg, Al, Mn, Fe and others. Materials used in the processing of acid mine drainage are materials that have alkalinity such as coal fly ash has the potential to have alkalinity levels and so far has only been considered a B3 waste. In this study, fly ash is used as the main ingredients for treatment in order to meet river water quality standards is by neutralizing the pH, reducing the content of dissolved solids (TDS) and reducing the electrical conductivity (EC) of acid mine drainage using coal fly ash. Various variables used in this study; including the independent variable in the form of variations in the dose of coal fly ash (20 - 60 gr) on acid mine drainage and jar test-stirring speed (100 - 300 rpm).The dependent variables examined were pH, TDS and EC. This research conducted by the aim of studying the effect of coal fly ash on research parameters. The results obtained show that coal fly ash can increase the pH value by increasing percentage by 67,56 – 105,41%, increasing TDS value by increasing percentage by 8,49 – 202,58% and increasing EC value by increasing percentage by 11,68 – 187,23%. The affixing of coal fly ash with a dose 20 gr at a stirring speed of 300 rpm is the optimum condition with results that meet the quality standards of wastewater from coal mining activities and environmental quality standards.

Keywords:*Acid Main Drainage*,*Fly Ash*, pH, TDS, EC.

PRELIMINARY

Acid mine drain is a general term used to describe leachate, seepage or flow (*drainage)* which have been affected by the natural oxidation of sulphide minerals contained in the rocks exposed during the activity mining. Rock that containing sulphide minerals exposed to the surface due to land clearing or rock removal during mining. Oxidized sulphide minerals form oxide compounds when in contact with water (rainwater or groundwater) to form iron (II) sulphate and sulphuric acid. If the acidic water not neutralized, it flows into the surrounding environment and can cause environmental pollution. Acid mine drainage can occur in open pit and underground mines. Moreover, it can also come from material hoarding and processing activities. In general, this situation occurs because the sulphur contained in rock oxidizes naturally. Furthermore, the rainfall condition is high enough to cause the formation of acid mine drainage [1]. The rise of mining activities, especially in South Sumatra, will have implications for environmental damage, especially waters. The company such as limestone certainly has an impact cost that must issue the use of large amounts of chemicals. On the other hand, acid mine drainage is not only produced by coal mining companies but also the metal mining industry, for example tin and nickel. For this reason, efforts to neutralize acid mine drainage without chemicals gave more improved so not cause new problems to the environment [2].

Referring to this background, the problem formulation is: how is the processtreatment acid mine use coal flu ash as a raw material using the stirring method so that the acid mine drainage produced can meet the quality standards of mining activity waste water and meet the river water quality standards.

The research objective refers to the formulation of the problem, namely knowing how the change pH, TDS and EC of acid mine drainage from the treatment process using coal fly ash, knowing the effect of the dose and stirring speed to changes in acid mine water pH, knowing how far the ability coal fly ash affects changes in pH, TDS and EC in the process treatment acid mine drainage and knowing the optimum dose conditions and the speed of mixing used in the process *treatment* acidmine drainage.

The method or technology used for processing acid mine drainage can be done withtwo ways, namely (active treatment and passivetreatment.Actively acid mine water treatment generally useschemicalscontain lime, can be in the form of $CaCO_3$, $Ca(OH)_2$ or addition of caustic soda (NaOH) and ammonia (NH_3) whereas passive acid mining water treatment generally imitates wetland systems orother natural processes with modifications directed for special processing purposes [3].

Coal fly ash is a material that produced from the burning process of coal in a power plant so that all of its properties are also determined by the composition and properties of impurity minerals in coal and the combustion process. In the process of burning coal, the melting point of coal ash is higher than the combustion temperature. In addition, this condition produces ash, which has a very fine grain texture. The type of coal that burned and the technique of storage and handling influence chemical properties of fly ash coal [4]. Based on components *fly ash*the coal is contained in PP No.85 of 1999 concerning amendments to Government Regulation No.18 of 1999 concerning the Treatment of Toxic Hazardous Waste Materials. Coal fly ash was categorized B3 waste because there are heavy metal oxide content that will pollute the environment [5].

Utilization coal fly ash was carried out increase its economic value as well as reduce the adverse impact on the environment. Coal fly ash has various uses including [6]:

1. Constructing concrete for roads and dams
2. Ex-mining land hoarders
3. Recovery magnetite, cenosphere and carbon
4. Raw materials for ceramics and, glass and, coal and refractories
5. Polisher / polishing agent
6. Filler asphalt, plastic and paper Substitute of
7. Cement raw materials Additives in waste
8. Treatment Conversion into zeolites and
9. Adsorbents

Coal fly ash that converted to adsorbents is an example of theeffective utilization of *fly ash.* Profit from coal fly ash as an adsorbent is low cost due to fly ash in the form of waste that generated continuously. In addition, this adsorbent can be used both waste gas and liquid waste treatment. Also, use this adsorbent in the removal of heavy metals, waste of hazardous coloured substances, organic compounds in sewage treatment, pollutant gases and organic gases [7].When the adsorbent material isused is coal waste and generated by the industry itself, the process carried out by the industry itself. However, it will be interesting to develop.Coal fly ash can tooconverted to neutralizing agent due to the content of free soluble alkalis (CaO and MgO) is easily dissolved in acid mine drainage so that it can increase the pH value [8].

Based on previous studies,coal fly ash used as an adsorbent and neutralizing agent in the acid mine water treatment process. In Madzivire's [9] study to reduce sulphate levels in acid mine drainage depending on the final pH reached during the treatment process, the dose*fly ash*coal used and the presence of Fe and Al in acid mine drainage. This processing uses a ratio of acid mine water and dose ratio *fly ash*coal 5: 1, 4: 1, 3: 1 and 2: 1 resulted in a reduction in sulphate percentages of 55, 60, 70 and 71% and a change in pH to 8.98, 9.88, 10.98 and 12.35.

In the research of Subriyer Nasir et al. [10] *fly*coal ash is an effective adsorbent in raising pH and reducing EC and metal ions from synthetic acid mine drainage. The percentage increase in pH is97.40%, the percentage reduction in EC value of 96.71% and the highest percentage reduction of manganese, iron, and sulphate metal ions were 99.1%, 98.4%, 99.7% respectively, and the percentage of water recovery (WRP) was 75%.

In the research of Chairul Wahyu Adha et al. [11] to analyse the effectiveness of two chemicals namely quicklime and zeolite in neutralizing acid mine drainage and calculating the amount of chemical needed to be applied in the field. The research conducted on a laboratory scale using the jar test method by applying several independent variables such as dose variations, variations in particle size, and variations in stirring speed. Based on the final valuesof pH, Fe and Cu produced, quicklime is the most common chemical. Effective at an optimal dose of 0.4 gram/litre on a laboratory scale. The results of the correlation analysis also showed that the three independent variables applied to quicklime had a very strong influence on the final pH, Fe and Cu values produced.

RESEARCH METHODS

When the research was conducted on September 20, 2019 and ended on December 10, 2019, the study was conducted within ± 3 (three) months. The activities carried out in this study started from the sampling stage of acid mine drainage and coal fly ash sample in the first week. Then in the second week it was continued with the experimental stages of research on *fly ash* coal with the research subject (acid mine drainage) so there is no strict control of the research variables. The pH, TDS and EC tests of acid mine drainage were carried out in the third and fourth weeks of the study. The testing process for pH, TDS and EC must be in accordance with laboratory procedures that refer to

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SNI. The data that been obtained are then processed and analysed. Data processing and analysis in the fifth and sixth week of the study. After the data was processed and analysed, the report preparation stage carried out in the seventh and eighth week of the study. The location of the research at the Laboratory of Energy Engineering and WasteManagement, Faculty of Engineering, Sriwijaya University.

The equipment used in research to assist in obtaining research data are as follows:
1. PH meter
2. Digital TDS-EC meter
3. Analytical balance
4. Beaker Glass
5. Filter paper
6. Glass Funnel
7. Erlenmeyer
8. Jar Test
9. Vaporizer cup

Meanwhile, the research material used in this research is acid mine drainage sumpPit 3 Timur Banko Barat PT Bukit Asam, Tbk, (Figure 1) and *fly ash* coal from the combustion of PLTU Bukit Energi Servis Terpadu(Figure 2).

Figure 1. The location of acid mine drainage

Figure 2. Pick up location *fly ash* coal

The research procedure starts from mass weighing coal fly ash, measuring the volume of acid mine drainage, processing using a stirring tool (jar test),filtering, and testing of pH, TDS and EC of acid mine drainage.

The research method used in this study starts from the stage of literature study, primary and secondary data collection, data processing, data analysis, and research flowcharts.

Literature studies carried out by searching for literature studies that can be used as supporting reading material for research in libraries and related agencies (laboratories), libraries (literature), journals, websites and so on.

The primary data needs in this final project are categorized into two, namely data on pH, TDS, EC in situ acid mining water and data on pH, TDS, EC of acid mine drainage after the treatment process. The secondary data is composition coal fly ash.

Interpretation results regarding the foundation theory, study of literature and the field data obtained, and then data processing carried out. Processing of field data is done through Microsoft excel softwarein order to get the percentage increase in researchparameters which are then processed using tabulations and diagrams.

The calculation of the percentage rate of increase in research parameters calculated by the formula:

$$E = \frac{Ce - Ca}{Ca} \times 100\% \quad (1)$$

Information:
E = Percent Increase (%)
Ce = pH, TDS and EC test results *treatment*
Ca = pH, TDS and EC test values

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The research flowchart contains the stages to achieve the objectives of the research manifested in the form of a chart or scheme that guides how the data required for the process carried out, so that the research objectives achieved and become the conclusion of the study (Figure 3).

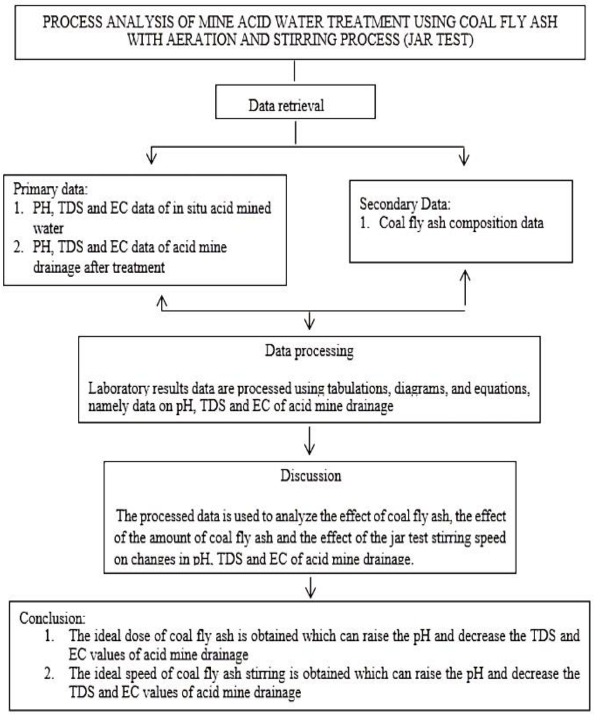

Figure 3. The research flowchart

RESULTS AND DISCUSSION

In research using coal fly ash for acid mine drainage process was carried out by passively without the addition of chemicals which is divided into three columns of stirring experiments at stirring speeds of 100, 200, 300 rpm with doses coal fly ash 20 gr, 30 gr, 40 gr, 50 gr, 60 gr then put into acid mine water with 400 ml of volume and stirred in beaker glass, measuring 1000 ml using a mixer for 10 minutes then allowed to settle for 10 minutes. After that, it is filtered to separate coal fly ash that been mixed with acid mine drainage, then after being filtered, the acid mine water sample is observed.

1. Influence Coal Fly Ash as Raw Material Treatment Process

This study shows the results that coal fly ash can be used as a raw material for the process *treatment* acid mine water due to coal fly ashaffects the change in pH value, TDSin acid mine drainage.

In each column of the stirring experiment there was an increase in the pH of acid mine water, namely the initial pH of each stirring experiment column of3.7 to 7.1 for experiment column A, the pH in experimental column B became 7.3 and the pH in experiment column C became 7.6 (Figure 4).

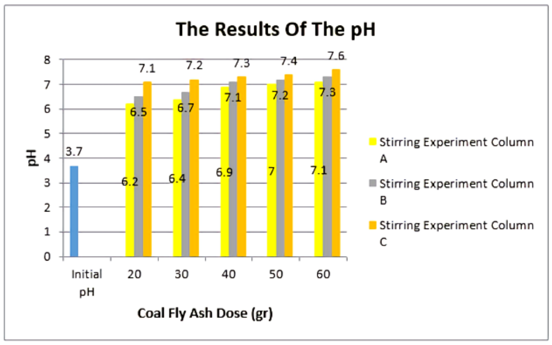

Figure 4. pHResults Test

In the stirring experiment column A resulted in an increase in pH with a susceptibility of 6.2 - 7.1 and the stirring experiment column B resulted in an increase in pH with a susceptibility of 6.5 - 7.3, then in the stirring experiment column C resulted in an increase in pH with a susceptibility of 7.1 - 7.6. The results of this study indicate that the pH of each experimental column has met the quality standard requirements for coal mining activity wastewater, namely with a pH value of6.0 - 9.0.

The increase in the pH value of acid mine drainage in each experimental column was due to coal fly ash contains calcium, magnesium, silicate compounds which in their oxidation form react with OH + ions to form hydroxide compounds whichthen dissolves in acid mine drainage and will increase the pH value of acid mine water.

The chemical reactions for the formation of hydrolysis compounds that occur are as follows:

$$CaO + H_2O \rightarrow Ca^{2+} + 2OH^- \quad (2)$$

$$MgO + H_2O \rightarrow Mg^{2+} + 2OH^- \quad (3)$$

$$SiO_2 + 2H_2O \rightarrow Si^{4+} + 2OH^- \quad (4)$$

Based on the results of the calculation of the percentage increase in the optimum pH of acid mine drainage in the stirring experiment column A was 91.81%, the stirring experiment column B was 97.30% and the stirring experiment column C was 105.41%.

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The percentage increase in the optimum pH of acid mine drainage in experiment column C is higher than experiment column A and B. This happens because, in experiment column C treated using a stirring speed of 300 rpm so affects the mixing time *fly ash* coal with acid mining water becomes faster than results in faster reaction times for calcium, magnesium, silicates with OH + ions to form hydroxide compounds which will increase the pH of acid mine water.

In each column of the stirring experiment, there was a significant increase in the TDS value of acid mine drainage after stirring. The initial TDS value in each stirring experiment column was 271 mg/L and an increase to 722 mg/L for the stirring experiment column A, and the TDS value in the stirring experiment column B became 744 mg/L, then the TDS value in the stirring experiment column C to 820 mg/L (Figure 5).

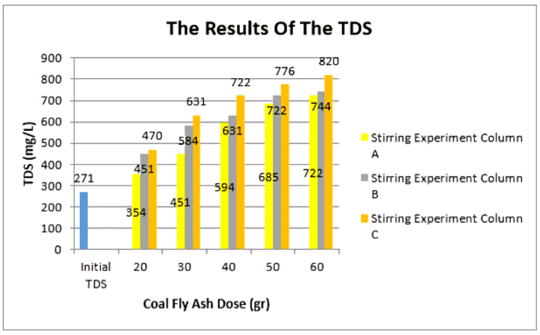

Figure 5. TDS Results Test

The initial EC value for each stirring experiment column was 0.548 mS/cm and there was an increase to 1.444 mS /cm for the stirring experiment column A, and the EC value in the stirring experiment column B became 1.552 mS/cm then the EC value in the experimental column C to 1.574 mS/cm (Figure 6).

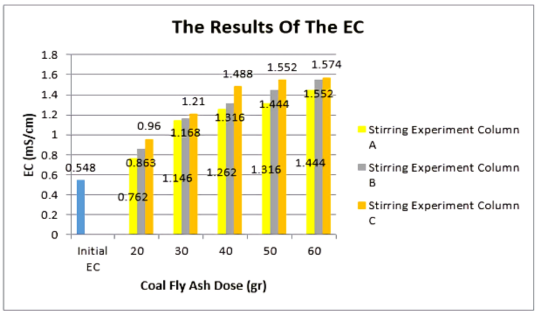

Figure 6. EC Results Test

In the stirring experiment column A resulted in an increase in the TDS value with susceptibility of 354 - 722 mg/L and the stirring experiment column B resulted with a susceptibility of 490 - 744 mg/L then in the stirring experiment column C there was an increase in the TDS value with susceptibility 470 - 820 mg/L.

The increase in the TDS value of acid mine drainage in each stirring experiment column was due to coal fly ash has a high metal content such as calcium, magnesium, silicates which are in their oxides form, which is also due to the lack of preparation. Coal fly ash used in the process treatment that aims toreduce the content of impurities in coal fly ash. This also occurs due to the lack of waiting time for settling before filtering coal fly ashthat functions as an adsorbent of dissolved solid particles in water becomes impurity due to the lack of waiting time for settling before filtering.

As for the results of testing the EC value, there was an increase in each of the stirring experiment columns. In the experiment column stirring A resulted in an increase in the EC value with a susceptibility of 0.762-1,444 mS/cm and stirring experiment column B resulting EC value with a vulnerable 0.960 - 1,552 mS/cm then in the stirring experiment column C there was an increase in the EC value with a susceptibility of 0.980 - 1,574 mS /cm.

The increase in the EC value of acid mine drainage in each stirring experiment column is directly proportional to the increase in the TDS value of acid mine drainage in the previous TDS test results. This increase in EC value occurs due to the high amount of minerals in coal fly ash is ionic ally bonded during the stirring process. Based on the results of the calculation of the percentage increase in the TDS value of acid mine drainage in the stirring experiment column A was 166.42%, the stirring experiment column B was 174.54% and the stirring experiment column C was 202.58%. While the results of the calculation of the percentage increase in the EC value of acid mine drainage in the stirring experiment column A were163.50%, in the stirring experiment column B of183.21% and stirring experiment column C of187.23%.

The percentage increase in the TDS value of acid mine drainage in experiment column C was higher than experiment column A and B. This happened because, in experiment column C,coal fly ash is treated using a stirring speed of 300 rpm, resulting in the rupture of the floc formed during the stirring process, to produce another floc from the stirring process, which depends on the coal fly ash doserequired. When affixing coal fly ash used according to the required dose, floc core

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process run well. The increase in the TDS value alsocaused by not doing the preparation coal fly ash used in the process treatment that aims to reduce the content of impurity compounds in coal fly ash. This also occurs due to the lack of waiting time for settling before filtering coal fly ashthat functions as an adsorbent of dissolved solid particles in water becomes impurity due to the lack of waiting time for settling before filtering.

Meanwhile, the percentage increase in the EC value of acid mine drainage in experimental column C was higher than in experimental columns A and B. The percentage increase in the EC value was linear to the increase in the TDS value of acid mine drainage. This happens due to the high amount of minerals in coal fly ash ionic ally bonded during the stirring process.

2. The Effect of the Coal Fly ash Dose and Stirring Speed Jar Test Against Changes the pH of Acid Mine Drainage

Research shows the results of the change in pH value of acid mine drainage due to differences in the coal fly ash dose and jar test-stirring speed. Process shows that a change in the pH of acid main drainage at each coal fly ash dose. Change in pH at 60 gr coal fly ash dose shows maximum results compared to the coal fly ash dose. This applies to all mixing jar test speed. Following the results of measuring the pH of acid main drainage by jar test speed 100 rpm (Table 1) jar test speed 200 rpm (Table 2) and jar test speed 300 rpm (Table 3).

Tabel 1. The results of the pH Measurement by Jar Test Speed 100 rpm

Coal Fly Ash Dose (gr)	pH	Change Of pH	PH value based on environmental quality standards of the ministerial decree. Environment No. 113 of 2003 and the Governor of South Sumatra No. 8 of 2012
20	6,3	0	6-9
30	6,4	0,1	6-9
40	6,9	0,5	6-9
50	7,0	0	6-9
60	7,1	0,1	6-9

Tabel 2. The results of the pH Measurement by Jar Test Speed 200 rpm

Coal Fly Ash Dose (gr)	pH	Change Of pH	PH value based on environmental quality standards of the ministerial decree. Environment No. 113 of 2003 and the Governor of South Sumatra No. 8 of 2012
20	6,5	0	6-9
30	6,7	0,2	6-9
40	7,1	0,4	6-9
50	7,2	0,1	6-9
60	7,3	0,1	6-9

Tabel 3. The results of the pH Measurement by Jar Test Speed 300 rpm

Coal Fly Ash Dose (gr)	pH	Change Of pH	PH value based on environmental quality standards of the ministerial decree. Environment No. 113 of 2003 and the Governor of South Sumatra No. 8 of 2012
20	7,1	0	6-9
30	7,2	0,1	6-9
40	7,3	0,1	6-9
50	7,4	0,1	6-9
60	7,6	0,2	6-9

In each reactor, the initial pH of acid mine drainage did not meet the quality standard requirements for coal mining activity wastewater, which was 3.7. At a dose of 20 gr coal fly ash , acid mine drainage has met the quality standard requirements for coal mining activity waste water at all stirring speeds jar testused in the treatment process. This applies equally to all of coal fly ash dose. This study shows that the higher the coal fly ash dose affixed to acid mine drainage also increases the resulting changein pH. Moreover, the higher the

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stirring speed used for the treatment the higher the pH change that results at the coal fly ash dose the same coal. This means, changes in the pH of acid mine water are carried out is directly proportional to the coal fly ash dose and jar test stirring-speed.

3. Ability Analysis Coal Fly Ash Influencing Changes in pH, TDS and EC

In previous test it was concluded that the percentage increase in pH, TDS and EC values of acid main drainage in the stirring experiment column C was higher than other stirring experiment columns. The test show that the stirring experiment column C is the optimum condition for the treatment process using coal fly ash. In other case, the filtered coal fly ash from the stirring experiment column C are re-tested. The test run three times. The following are the results of measuring change in pH, TDS and EC values in the second test (Table 4) and the third test (Table 5)

Table 4. The Second Test of the Coal Fly Ash

Coal Fly Ash Dose (gr)	pH	TDS (mg/L)	EC (mS/cm)
20	6,6	282	0,568
30	6,8	294	0,580
40	6,9	326	0,637
50	7,1	335	0,652
50	7,3	349	0,670

Table 5. The Third Test of the Coal Fly Ash

Coal Fly Ash Dose (gr)	pH	TDS (mg/L)	EC (mS/cm)
20	6,5	258	0,553
30	6,7	263	0,567
40	6,8	274	0,588
50	7,0	287	0,598
50	7,2	294	0,612

In each test reactor, the change in the values of pH, TDS and EC of acid mine drainage compared to the stirring experiment column C. In the second reactor of the coal fly ash resulting 49.32% in percentage increase of the optimum pH, and for the third reactor resulting 48.61%. In addition, second test reactor produces an optimum TDS percentage increase in acid main drainage of 22.34% and third reactor produces a percentage of 7.82%. Meanwhile, in the second test reactor produces the percentage of optimum EC increase is 18.21% and for the third test reactor is 10.46% (Figure 7).

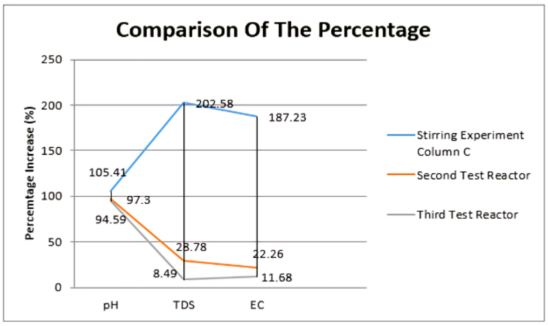

Figure 7. Comparison of the Percentage Increase

This decrease in the percentage of pH, TDS and EC values occurs due to reduced coal fly ash doses after the first and second testing. The decrease in the percentage increase in pH occurs due to the reduction in the amount of compounds such as calcium, magnesium, silicates which in their oxides form play a role in increasing the pH value of acid mine drainage. The results of second and third have met the standard requirements for the quality of wastewater for coal mining activities. The percentage decrease also occurs in the TDS of acid mine drainage due to the reduced amount of metal content that acts as a dissolved solid. This also applies to the percentage decrease in the EC acid mine drain due to the reduced amount of minerals in coal fly ash which can bonded in a manner ionic (contains either a positive charge or a negative charge). Based on this it can be said that fly ash coal has a large capacity as a raw material in the process treatment acid mine drainage so that it can be used up to 3-4 times with results that meet the quality standards for waste water for mining activities and for river water quality standards.

4. Determination of the Optimum Conditions

Coal fly ash dose variations affixed in this study are 20 gr, 30 gr, 40 gr, 50 gr and 60 gr with variations in the stirring speed of 100 rpm, 200 rpm and 300 rpm.

In this study, there was a change in the value of the dependent variable with variations in the speed of stirring after stirring for 10 minutes in a working volume of 400 ml of sour mine water. Following are the results of changes in the pH value of the process (Figure 8), and the result of changes in the TDS value of the process (Figure 9).

STIRING SPEED (rpm)	DOSAGE FA (gr)	PH	SBML	INFORMATION
	20	6.7	6-9	✓
	30	6.9	6-9	✓
100	40	7.0	6-9	✓
	50	7.0	6-9	✓
	60	7.1	6-9	✓
	20	6.2	6-9	✓
	30	6.7	6-9	✓
200	40	7.1	6-9	✓
	50	7.2	6-9	✓
	60	7.3	6-9	✓
	20	7.1	6-9	✓
	30	7.2	6-9	✓
300	40	7.3	6-9	✓
	50	7.4	6-9	✓
	60	7.6	6-9	✓

Information:
Std : Environmental Quality Standards
✓ : Meet the standards
x : Not Meeting Standards

Figure 8. The Results of the Change in pH values

STIRING SPEED (rpm)	DOSAGE FA (gr)	TDS (mg / L)	SBML (mg / L)	INFORMATION
	20	354	500	✓
	30	521	500	x
100	40	594	500	x
	50	685	500	x
	60	722	500	x
	20	490	500	✓
	30	584	500	x
200	40	631	500	x
	50	722	500	x
	60	744	500	x
	20	470	500	✓
	30	631	500	x
300	40	722	500	x
	50	776	500	x
	60	820	500	x

Information:
Std : Environmental Quality Standards
✓ : Meet the standards
x : Not Meeting Standards

Figure 9. The Results of the Change in TDS values

Reactivity between each coal fly ash dose added and the variation of the stirring speed have quite a difference. This shows from the final value of pH, TDS, and EC after acid mine drainage treatment. Coal fly ash thatapplied to laboratory testing results inchanges in the value of the dependent variable. In Figure 8, it is found that the final pH value of acid mine drainage meets environmental quality standards, but in Figure 9 the final TDS value of acid mine drainage meets and does not meet environmental quality standards. Meanwhile, the final value of the EC acid mine drainage has a linear relationship with the final TDS value of acid mine drainage. This happens because the working principle of EC and TDS is the same, and the TDS value is the converted EC value. This also applies to the variation of stirring speed, which is the reactor to accelerate the mixing reaction fly ash coal with acid mine, water. So that in the parameters of changing pH, TDS and EC values, the stirring speed of 300 rpm is the most effective reactor.Selection of the correct dose for this parameter made easier by meeting environmental quality standards for all doses affixed coal. Thus, dosing of 20 g at a stirring speed of 300 rpm used for process treatment acid mine drainage is the optimum condition to obtain the final pH, TDS and EC values of acid mine drainage that meet environmental quality standards.

CONCLUSION

The conclusions drawn based on the results and discussion of the research obtained, namely:

Coal fly ash can get usedto treatmentacidmining water; this indicated by an increase in pH, TDS and EC values in acid mine drainage with an increase in percentage of 67.56 - 105.41% for pH, 8.49 -202.58% for TDS and 11.68 - 187.23% for EC at optimum conditions treatments

Coal fly ash dose of affixing and jar test stirring speed affect changes in the pH value of acid mine drainage. The higher of the coal fly ash dose and the stirring speed, the higher the pH value changes inacid mine drainage.

Coal fly ash can be used up to 3-4 times in succession for the processtreatment acid mine drainage. This shown in the measurementresults of the second and third test reactors that have met the standard requirements for wastewater quality.

Dosing of 20 g at a stirring speed of 300 rpm is used for the treatment acid mine drainage is the optimum condition to obtain the final pH,TDS and EC values of acid mine drainage that meet environmental quality standards.

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