ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY

CENTER FOR ETHIO-MINES DEVELOPMENT

FLOTATION RESPONSE OF THE KINDO DIDAYE COAL DEPOSIT, WOLAITA ZONE

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A PROJECT WORK SUBMITTED TO ADDIS ABABA UNIVERSITY, CENTER FOR ETHIO-MINES DEVELOPMENT PRESENTED IN FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF ENGINEERING DEGREE IN MINERAL ENGINEERING.

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Declaration

I declare that the work which is being presented in this project paper entitled "**Flotation Response of the Kindo Didaye Coal Deposit, Wolaita Zone**" is my graduate paper work and has not been presented for a degree in any other university and that all sources of material used for the project have been duly acknowledged.

Temesgen Ayisa

Signature……………………

Statement of certification

This is to certify that Temesgen Ayisa has carried out his research work on the topic entitled **“Flotation Response of the Kindo Didaye Coal Deposit, Wolaita Zone”.** The project paper is suitable for submission for the award of Master of Engineering Degree in Mineral Engineering.

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Abstract

The main objective of the project was to investigate the optimum flotation behavior of the coal.Flotation is an important process, which involves removing ash, and other impurities from coal to improve its quality for energy and industrial use. Froth flotation is a widely used method for coal cleaning, which relies on the difference in surface properties between the coal particles and the mineral matter.However, the efficiency of froth flotation is greatly affected by the size of coal particles. The bulk sample from jaw crusher was milled by cross-bitter miller and coal sample was ready for separation in arranged sieve shakers based on their size. Then,fine powder coal samples were prepared by using different size of sieve shaker arranged as and measured the mass of the feeds of each particle size before the starting of flotation processes.In this study, four different sizes range of coal particles (-500 to +250 µm, -250 to +150 µm,-150 to +125 µm,-125µm to +75µm and -75 µm) were tested for their ability to float in the froth flotation process. Because of natural hydrophobicity of coal, there are a range of chemicals used to further enhance the floatability of coal particles.Results showed that the optimum flotation was highest for particle size und.75µm, while particles above +250µm showed the poorest performance and the same result was seen by the increase of kerosene amount at the same particle size. The results suggest that particle size and the over use of reagents are critical factors in the success of flotation response. The findings of this study will help in optimizing the coal cleaning by flotation increasing the heat value of the coal by avoiding the impurities. So in this flotation experiment the calorific value increases.

Key words:-

Coal, Flotation response,chemical reagents,particle size

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Contents

List of Abbreviations

ASTM …………………………..American society for testing and materials

Btu/lb……………………………British thermal unit per-pound

IM………………………………. inorganic matter

OM………………………………organic matter

ROM…………………………..…….Run-of-mine

SNNPRS…………………………South nation nationalities and peoples regional state

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Chapter One

Introduction

1. 1 Background of the study

To achieve the right product quality in terms of particle size and ash, sulfur, and moisture content, run-of-mine (ROM) coal must be processed using certain technology. A combination of coal preparation technologies must be used in order to create coal with the highest economic value. ROM coal's physical and chemical qualities, such as rank (intrinsic ash and sulfur content) and particle size, determine which coal preparation procedures are used. Technologies for gravity separation are frequently employed to treat coarse coal. However, successful coal cleaning of coarser particles (-1 mm) has also been demonstrated (Polat et al., 2003),but efficient coal cleaning of coarser particles (-1 mm) have also been reported in literature (Brozek et al.,2013). According to (Laskowski et al.,2010) the maximum particle size the feed coal can have to be considered highly floatable is about 28mesh (0.589 mm). According to Lynch et al. (2007), some of the earliest laboratory experiments showing the use of froth flotation to clean coal date back to 1915. While the first coal preparation facility in the USA to employ flotation was built in 1930, the first coal flotation circuit was created and put into use in the United Kingdom in 1920 (Aplan et al.,1999).Nowadays, flotation process is widely applied in many different countries, such as China, USA, Australia, Canada, and India (Aksoy et al., 2016).

Froth flotation is one of the processes used in coal preparation to remove a large proportion of ash forming minerals from coal since coal particles are naturally hydrophobic whereas clays, pyrite and other associated minerals are hydrophilic. However coal and its components behave in different manner during flotation (M.Ramudzwagi et al.,2020). This process has probably the greatest potential of any fine cleaning devices for treating all of the fine fractions from 28mesh (0.5 mm) to particles (Aplan, F.F.,1979). In Turkey about 14-18 percent of raw bituminous coal coming to washery (a place at which a coal is freed from impurities or dust by washing) is treated by flotation (M.Ramudzwagi et al.,2020). In the past, a common approach to treating coal fines (slimes) was to discard and direct them to the refuse ponds. According to a study conducted by the USA's National Research Council, over 70 to 90 million tons of coal fines were deposited in refuses ponds in the USA annually (NATIONAL RESEARCH COUNCIL (NRC), 2002.Coal waste impoundments, National Academy Press, Washington DC). Froth flotation is considered to be one of the rare commercially available technologies for cleaning and recovering of coal fines (Yoon et al.,1999).

1.2 Statement of problem

The availability of coal resource is high in the country, but it is characterized by poor quality due to the high ash, low fixed carbon and low calorific value, which needs more treatment before utilization. So in Ethiopia energy demand is not counterbalanced with the supply, because of expanding industrial zones and improved living standard. This limitation of energy resources is shown in all parts of the country. Therefore, the local industries like cement and other industries are forced to use an imported coal.To fill this gap of high demand-supply and to substitute the imported coal, treating/cleaning coal-using flotation is the solution to use the locally available coal. The main reason for selecting froth floatation method is that the technique requires low capital and operating cost, highly efficient and effective (Barma et al.,2019). And till now no coal separation methods takes place to enhance the quality and quantity of coal in the selected place.

1.3 Objective of the project work

1.3.1 Main objective

The main objective of this paper was to determine the optimum behavior of the flotation of the coal deposit of the study area.

1.3.2. Specific objective

- To know factors those affect the flotation response.
- To separate coal from the impurity.
- To determine the calorific value.
- To compare the calorific value of treated and untreated coal.

1.4 Scope of the study

The scope of this research was more focused on flotation response of Kindo Didaye coal deposit, which is found in SNNPRS, Wolaita zone.

1.5 Significance Of the Project

The significance of this project is to study the floatation in order to understand the flotation behavior of coal deposit in Kindo Didaye area of Wolaita zone and it will provide important information for the coal processing plant and it will also be used as a reference to conduct for further researchers.

Chapter Two

Literature Review

2.1 Factors influencing floatation performance

The flotation performance of low-rank coal is usually affected by different operating factors such as pulp density, reagent dosage, air bubble,flow rate and particle size. But these all working parameters are dependent on the types of floatation cell used.

2.1.2 Particle size

Particle size is an important parameter of the flotation process because it affects bubble size distribution, gas bubble mineralization, the stability of bubble-particle aggregates through particle attachment and detachment rates. But the coarse particle size has a buoyancy of bubble particle aggregate may decrease and increasing particle sizes that may result in longer induction time and proportionate the deterioration in floatability (Sokolovic J.et al.,2018).

2.1.2 Reagent dosages

Reagent dosages are the most influencing parameters for floatation of coal by reacting with the mineral surface or coat to make water repellent and attachment of particle on air bubbles. The importance of reagents in floatation is to minimize the bubble size and stabilize the mobility of froth phases (Kaya O.et al.,2019).

Chapter Three

Material and Methodology

3.1 Materials

3.1.1. Instruments

Instruments used in this study are; Jaw crusher, Cross-bitter mill, Sieve Shaker and flotation cell at Addis Ababa Institute of Technology (Mechanical operation lab).

Figure 3. 1:Instuments those were used for study

3.1.2 Chemicals and Reagents

The chemical reagents used in this study were kerosene as a scavenger and he N-octanol as a foaming agent.

3.2 Method

3.2.1 Sampling Techniques

During sampling, the conditions such as recording the location and the thickness of the seams were taken into consideration. The representative samples from the study area were collected in plastic bags with an amount of 5 kg. Finally, the sample was transported from Kindo Didaye to Addis Ababa University Institute of Technology for processes.

3.2.2 Crushing and size reduction the sample

For treatment, the run-of-mine coal must be crushed to an acceptable top size by using jaw crusher and cross bitter mills.

Figure 3. 2:Crushing and size reduction

3.2. 3 Experimental Design

The whole experimental procedures that were carried out in the present study included the sample collection and preparation methods to the final stage of analysis with instrumental characterizations.

This experimental procedure was designed for both raw and floated samples.

Collecting samples from the study area

↓

Preparing samples for flotation

↓

By crushing using jaw crusher and cross bitter miller

↓

Sieving the samples up to the suitabale grain size by using sieve shaker

↓

Flotation response according to their particle size

↓

Determining the flotation response by increasing the dosage of kerosene

***Figure 3. 3*:Experimental design of the study**

Chapter Four

Results and Discussions

4.1 Coal sample preparation

The bulk sample from jaw crusher was milled by cross-bitter miller and coal sample was ready for separation in arranged sieve shakers based on their size. Then, finally fine powder coal samples were prepared by using different size of sieve shaker arranged as (-500 to +250 µm, -250 to +150 µm , -150 to +125 µm,-125µm to +75µm and -75 µm) and measured the mass of the feeds of each particle size before the starting of flotation processes.

4.2 Factor affects the efficiency of the froth flotation process

4.2.1 Particle size:-

Coarse to fine grain size: Increased flotation concentration and decreased tailings. Therefore, in my flotation process, I have five particle sizes: -500 µm to +250 µm, -250 µm to +150 µm, -150 µm to +125 µm, -125 µm to +75 µm, and -75 µm.

Table 4. 1:-Flotation response of particle size

<table>
<tr><th>particle size</th><th>m of feed</th><th>conc.</th><th>Tailing</th><th colspan="2">Amount of chemical reagents used</th></tr>
<tr><td>-500+250µm</td><td>94</td><td>32.4</td><td>61.6</td><td rowspan="5">Kerosene

5ml</td><td rowspan="5">n-ocanon

2ml</td></tr>
<tr><td>-250+150µm</td><td>94</td><td>35.2</td><td>58.8</td></tr>
<tr><td>-150+125µm</td><td>94</td><td>37.3</td><td>56.7</td></tr>
<tr><td>-125+75µm</td><td>94</td><td>38.9</td><td>55.1</td></tr>
<tr><td>und.75µm</td><td>94</td><td>41.4</td><td>52.6</td></tr>
</table>

Source: Survey 2023

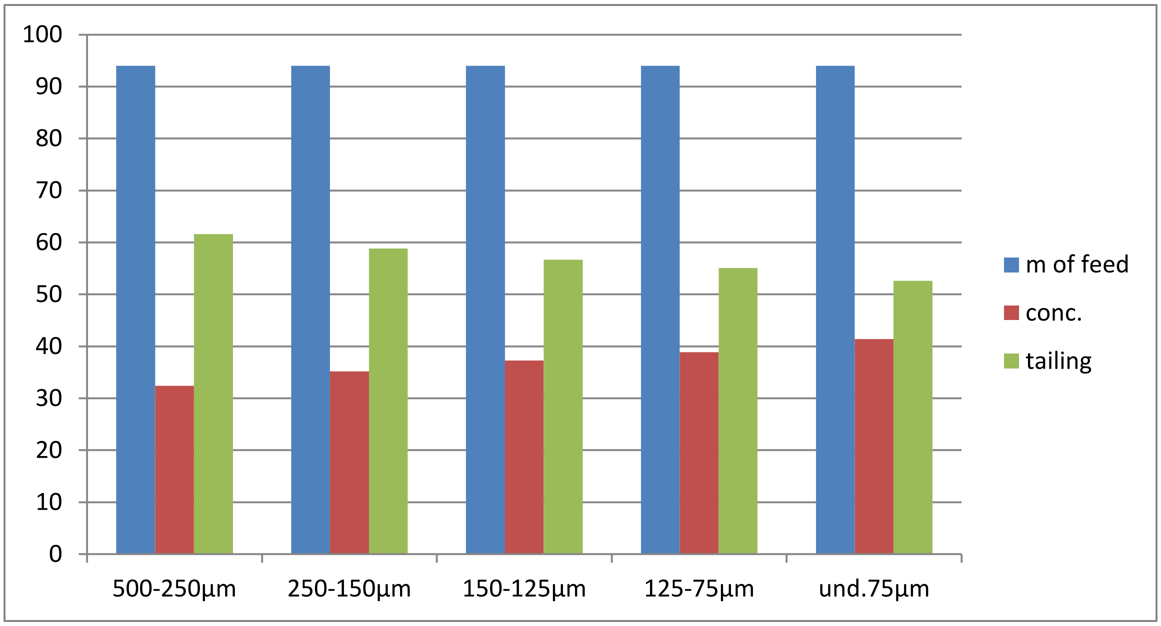

Figure 4.0 1:-The effects of particle size on flotation response

4.2.2 The dosage of reagent

If the amount of reagent added is insufficient, the purpose of ore flotation cannot be achieved, and the separation of useful minerals becomes difficult. Too much reagent dosage results in reactions, poor concentrate quality, loss of selectivity, as well as reagent waste and increased mineral processing costs. Therefore, 5 ml of kerosene as a collector and 2 ml of n-octanol as a whisk were used for each feed mass of 94 g.

Effects of kerosene on concentrate

Table 4. 2:-Effects of kerosene on flotation response

particle size	m of feed	conc.	Tailing	Amount of chemical reagents used	
500-250µm	94	38.6	55.4	Krosene 8ml	n-ocanon 2ml
250-150µm	94	43.4	50.6		
150-125µm	94	45.7	48.3		
125-75µm	94	47.2	46.8		
und.75µm	94	49.8	44.2		

Source: Survey 2023

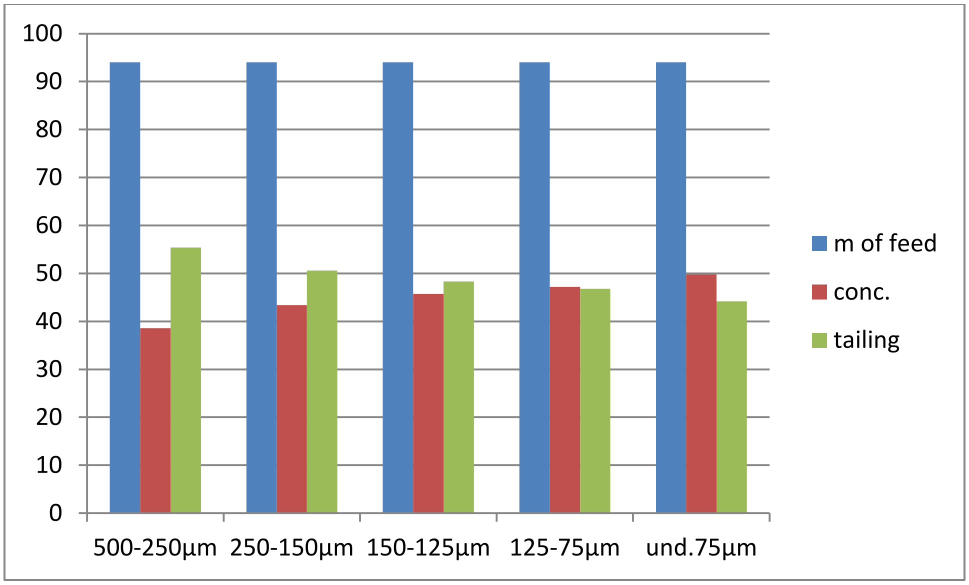

Figure 4.0 2: Effects of kerosene on flotation response

4.3 Proximate Analysis of Raw and treated sample

4.3.1 Moisture Content

The obtained results of moisture content for raw coal was 1.1% and the moisture content of (treated) floated coal was 5.26%. The highest moisture content implies that the coal possesses fewer carbon contents that lead to lower heating value and higher costs for transportation and storage.

The fluid materials of coal matter include gas, gas-liquid and moisture that consist of both solid inorganic matter (IM) and organic matter (OM) [Behera SK.et al.,2018).The higher moisture content decreases the calorific value of coal and increases the heat losses, due to high evaporation and superheating (Xia Y.et al.,2019).

4.3.2 Volatile Matter

The experimental result was obtained from volatile matter for raw coal sample which was collected from the study area was 23.84%. But the volatile matter for the treated sample was 25.63 %. The coal of my study area has the high volatile matter with both raw and floated sample. The higher amount of the volatile matter in coal specifies that the lower rank of the coal and increasing volatile matter also increased the quantities of combustible gases, which directly decreases the amount of fixed carbon and consequently decreases the heating value of the coal.

4.3.3 Ash Content

As Ethiopian geological survey laboratory result,the ash content that was determined by using the ash dry methods in the furnace and the obtained results of ash content for raw coal sample is 40.34%. The outcomes of increasing the amounts of ash content in coal decreasing quality or rank because the volume of high impurity reduces the coal efficiency. The ash content of the treated coal sample was reduced to 39.3%. This confirms that the ash content of the study area was reduced after treatment that possessed relatively high fixed carbon and calorific value.

4.3.4 Fixed Carbon Content

The Fixed carbon tells a rough estimation of the heating value of the coal. The amount of fixed carbon content for raw coal that was obtained from the experimental result was 34.73%. The lowering amount of fixed carbon was due to the fact that the coal contains high amounts of ash, volatile matter, and moisture content. The amount of fixed carbon for treated coal sample was 29.81%. Increasing the fixed carbon increase of heating value and decrease the ash contents, while decreasing the fixed carbon decrease of heating value and increase the ash content.

4.3.5 Calorific Value

The experimental value of calorific value for both raw and floated coal samples is determined by using the Adiabatic Bomb calorimeter in the central laboratory of the Geological Survey of Ethiopia. The obtained result of the calorific value for the raw sample is 8614Btu/lb,but after the treatment, the calorific value is 8750 Btu/lb. This shows that the beneficiation by the froth flotation method is an appropriate approach to increase the calorific value of the study area.Both the treated and untreated coal of the study area has a heat value between 8300 to 11500 Btu/lb that is sub bituminous coal types.

Chapter Five

Conclusions and Recommendations

5.1. Conclusions

The purpose of this study was to investigate the optimum behavior of the flotation of the study area according to its flotation responses, the effect of particle size,the effects of over use of chemical reagents and comparing the energy values of treated and untreated coal sample. For this work different methods were applied,those were Collecting samples from the study area, Preparing samples for flotation ,by crushing using jaw crusher and cross bitter miller and sieving the samples up to the suitabale grain size by using sieve shaker.The coal samples were prepared by using different size of sieve shaker arranged as and measured the mass of the feeds of each particle size before the starting of flotation processes.In this study, four different sizes range of coal particles (-500 to +250 µm, -250 to +150 µm,-150 to +125 µm,-125µm to +75µm and -75 µm) were tested for their ability to float in the froth flotation process.

Results showed that the optimum flotation was highest for particle size und.75µm, while particles above +250µm showed the poorest performance and the same result was seen by the increase of kerosene amount at the same particle size. The results suggest that particle size and the over use of reagents are critical factors in the success of flotation response. The findings of this study will help in optimizing the coal cleaning by flotation increasing the heat value of the coal by avoiding the impurities.

In general the particle size,flotation time,air flowrate and the dosage of reagents have a significant impact on the flotation response of froth flotation for coal cleaning. Proper optimization of the particle size range can help in achieving maximum coal recovery and cost-effect for the coal cleaning process. Therefore, further studies on this topic are necessary to improve the overall efficiency of the coal cleaning process.

5.2 Recommendations

- Studying the detailed physico-chemical beneficiation may provide detailed information on the impurity and the quality of the coal of the study area.
- The results of this study provided useful information for designing and optimizing the coal flotation process.
- The optimum particle size range and the amounts of reagents to get more concentrates and less tailings for efficient coal cleaning by froth flotation should be carefully selected based on the balance between the product quality and the production cost.

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