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Application of Froth Flotation Technique to Reduce Sulfur from Lakhra Coal Using Froth Flotation

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Abstract. Pakistan is considered in one of those countries with large deposits of coal found in Thar, Lakhra, Salt range, Duki etc. Unfortunately this vast reserve of coal has not been exploited because of the high sulfur contents present in coal. This study discusses the ways to reduce sulfur from coal. Different experiments were conducted to study the effect of frothing agents and particle size for the reduction of ash as well as sulfur content in Lakhra coal. Results showed that the application of diesel being a frothing agent and a particle size of 180 um decreases ash and sulfur content of coal significantly.

Keywords: Ash, coal, froth flotation, sulfur

1. Introduction

Coal is an organic sedimentary rock containing varying percentages of carbon, nitrogen, oxygen, and sulfur alongwith traces of other elements including mineral content. It has been declared that there could be about 909 billion tons of coal reserves in the entire world. This reserve shows that the world has sufficient coal to last for about 155 years [1]. Coal can be found on every continent, USA, Russia, China and India have the biggest reserves in the world. Coal has number of applications in different areas of lives, it can be used domestically as well as industrially [2]. The common application of coal are its uses in electricity generation, steel production, cement manufacturing, production of activated carbon and other processes and also as a liquid fuel [3]. Sulfur present in coal restricts its application for industrial use because of some serious issues related to environment and also to technical. Sulfur could be found in three forms: pyrite, organic, and sulfate. The presence of organic sulfur could be observed in the coal as a bounded structure. Pyritic sulfur (FeS_2) could be found in mineral form as pyrite and marcasite crystal agglomerates. The sulfate is found in the forms of iron sulfates and calcium sulfates. Silica has been observed to be present mainly in the form of quartz, crystobalite. Cay minerals such as kaolinite, illite carbonates such as calsite, dolomite, siderite, sulfate and sulfides, etc., give rise to formation of ash forming minerals in coal [4].

However, coals having high sulfur could be made better by using desulphurization through physical, chemical and biotechnological processes. Froth flotation is considered to be a very likable physico-chemical method to eliminate pyritic sulfur from coal [5]. It has been observed to a be an efficient particle separation process. The process works due to the difference in surface rophobicity of com ponents present in any mixture. Usually, the technique of froth flotation is applied for the range of coal particles which are less than 0.5 mm. In froth flotation, the separation efficiency of fine coal particles depend on the variations in the wetting capacity of the coal and particles rich in mineral content in an aqueous solution [6], [7]. In this process, a stable situation is established between air bubbles and the surface of coal. The stability of this condition depends upon different physical and chemical factors [8]. Flotation is found to be very efficient for

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cleaning the coal as it is naturally rophobic and minerals present are rophilic. The other merits of using this technique in coal processing include requirement of low initial investment and floor space. In addition, relatively high rate of efficiency is achieved for a wider range of operating parameters [9] There are three main aims behind the use of this conventional froth flotation technique to the coal namely: (1) to produce a product having less sulfur as well as ash content by coal recovery in slime, (2) to meet environmental standards by treating the process water, which is commonly referred to as black water. It is the outcome of coal processing plants. (3) to meet the producion of coke by separation of macerals from the coal.

Lakhra coal could be used for various purposes, but presence of sulfur contents restricts its use for industrial applications. Pyrite has the major component share as inorganic sulfur in the coal. The research was conducted to study the application of the physical method for coal cleaning process using froth flotation. Laboratory experiments were conducted order to study the the effect of various frothing agents and different particle size on coal cleaning. The efficiency of the process was determined by measuring the percentage removal of ash and sulfur.

Fig. 1: Rig used for froth flotation

2. Materials and Methods

Coal is the basic material used in this work which is obtained from Lakhra Coal Mines, Sindh, Pakistan. Coal sample obtained was subjected to Proximate Analysis, Ultimate Analysis and Particle Analysis. The methodology is described below:

Particle Size Analysis: First the lumps of coal were crushed with the help of jaw crusher. Then the grinding was done with the help of grinding machine. A sieve analysis was done to assess the particle size distribution. The sample of coal (63um) size was selected for the investigation.

Washing: The sample of coal (63um) size was washed with different frothing agents (Gasoline, Diesel, Hexane and Kerosene). The total experiment time for each sample was 30 minutes. Apparatus/Rig used for froth flotation is shown in Fig. 1.

Proximate Analysis: After Froth flotation, Proximate analysis was caried out in which following procedure was opted. First the pressure of Oxygen and Nitrogen gas was set at 35 Psi and the pressure of pneumatic air was adjusted at 45 psi. Then TGA was turned ON and was allowed to warm for 30 minutes. Later the required method was selected. The sample on each crucible was allotted a name. The crucibles were placed on the plate of the TGA analyzer containing holes. Then TGA was allowed to locate the position of the crucibles. .The given sample of Coal was placed on each crucible. The sample weight should not be less than 0.72 gm and should not be more than 1 gm. After that TGA cover closed au tomatically for analysis. First the temperature of the TGA went to 107◦C for Moisture analysis. After placing crucible cover, TGA cover closed au tomatically for analysis. The temperature of the TGA went to 950◦C for Volatile matter analysis. It is necessary to mention here that Nitrogen flow starts automatically for the analysis of Volatile matter. After Volatile matter analysis, TGA cover opened automatically and a message was shown to remove the crucible cover. After the removal of cover from crucible, TGA cover closed automatically for analysis. The temperature of the TGA lowered to 750◦ C for Ash analysis.

Ultimate Analysis: After the proximate analysis of coal ,ultimate analysis was conducted to observe the impact of different frothers on ash removal. The procedure opted was : First the pressure of Oxygen gas was set at 40 Psi then the sulfur analyzer was switched ON and allow the furnace to gain a temperature of 1350◦ C. After that, with the help of weighing machine, samples were weighed (not more than 0.35 gm). The samples were then fed in the boat and were finally placed in the sulfur analyzer for sulfur test.

3. Results and Discussions

In the first series of the experiments, different frothing agents (Hexane, Gasoline, Kerosene and Diesel) were used and their impact on the removal of ash on 63um was observed as shown in Table I. The results show that by the use of Diesel as frothing agent the ash contents reduce from 7.74 to 6.08 as shown in Fig. 2.

Table I: Proximate Analvsis of Coal Sample

Sr. No.	Type of Fuel	Weight %age			
		Fixed Carbon	Moisture	Volatile	Ash
1	Sample	28.38	1.7	39.52	7.74
2	Hexane	38.86	4.5	50.69	6.5
3	Gasoline	37.95	1.16	54.52	6.92
4	Kerosene	37.73	1.72	54.25	6.84
5	Diesel	32.96	1.73	59.71	6.08

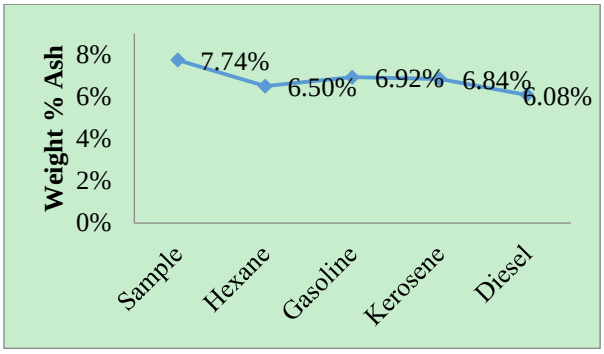

Fig. 2: Impact of different frothing agents on ash removal

This is the lowest value of the ash contents being achieved. Furthermore, volatile matters are also increased from 39.52 to 59.71. This is the highest value of volatile matters being achieved among different frothing agents. It is therefore suggested that by the use of diesel as frothing agent, there would be a better chance to reduce ash contents from coal and also to increase volatile matters too. In the same series of the experiments as shown in Table II, results also show that by the use of diesel as frothing agent the sulfur contents reduce from 4.40 to3.60 as shown in Fig. 3.

Table II: Ultimate Analysis of Coal Sample

		Weight %age
Sr. No.	Type of Fuel	Sulfur
1	Sample	4.40
2	Hexane	3.85
3	Gasoline	3.77
4	Kerosene	3.79
5	Diesel	3.60

It is therefore suggested that by the use of diesel as frothing agent, there would be a better chance to settle ash contents from coal and a better option for the removal of sulfur from the sample. In the second series of the experiments, different particle size of coal (63um, 125um, 180um and 250um) were selected and their impact on the removal of ash was observed using diesel as a frothing agent as shown in Table III. The results show that the particle size of 180um is the most suitable size as it reduces ash contents in the float from 7.07 to 5.48 as shown in Fig. 4.

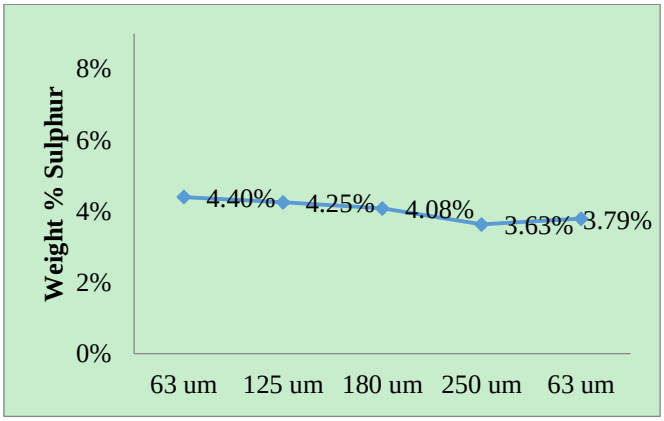

Fig. 3: Impact of different frothing agents on sulfur removal

Table III: Proximate Analysis of Coal Sample

Sr. No.	Sample	Weight %age			
	Size	Fixed Carbon	Moisture	Volatile	Ash
1	63 um	39.93	2.18	50.73	7.74
2	125 um	39.24	2.22	51.77	7.34
3	180 um	38.51	2.21	52.77	7.07
4	250 um	38.75	2.1	53.32	6.39
5	63 um	38.75	2.59	53	6.39
6	125 um	38.31	2.71	53.03	6.5
7	180 um	38.13	3.27	53.62	5.48
8	250 um	37.67	10.54	46.85	5.54

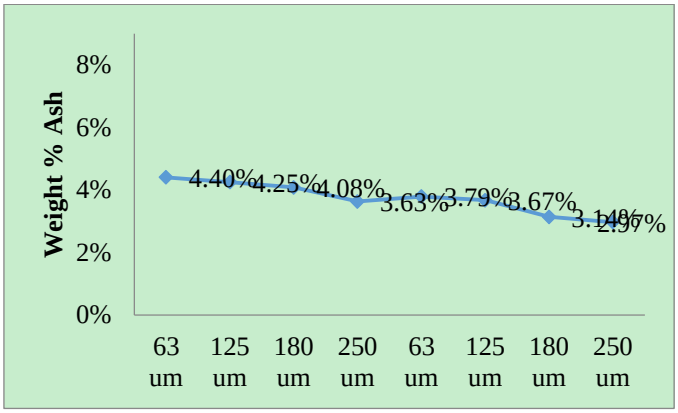

Fig. 4: Effect of particle size on ash removal

Furthermore by the use of this particle size, volatile matters were also increased from 52.77 to 53.62. This is the highest value being achieved among different particle sizes. It is therefore suggested that by the use of particle size of 180um, there would be a better chance to reduce ash contents from coal and also to increase volatile matters. In the same series of the experiments as shown in Table IV, results also show that by the use of 180um, the sulfur contents decreased from 4.08 to 3.14 as shown in Fig. 5.

It is therefore suggested that by the use of diesel as frothing agent, there would be a better chance to settle ash contents from coal and a better option for the removal of sulfur from the sample.

Table IV: Ultimate Analysis of Coal Sample

Sr. No.	Weight %age	
	Sample Size	Sulfur
1	63 um	4.40
2	125 um	4.25
3	180 um	4.08
4	250 um	3.63
5	63 um	3.79
6	125 um	3.67
7	180 um	3.14
8	250 um	2.97

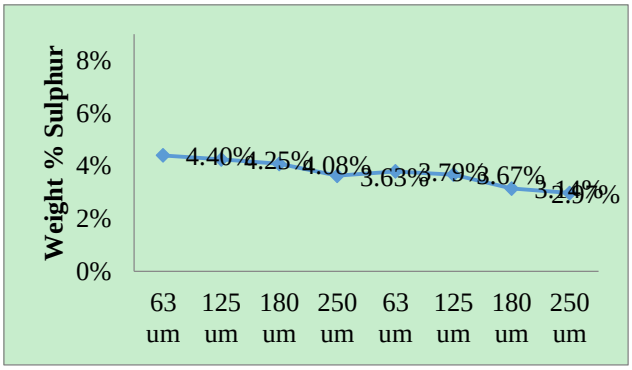

Fig. 5: Effect of particle size on Sulphur removal

4. Conclusion

From the experiments conducted, it could be observed that the froth flotation was carried out at a fixed Mesh number for different frothing agents. From the results, it was concluded that all the frothing agents have almost same affect on impurities removal as the frothing agents used are hydrocarbon oils and all have almost same impact on ash and sulfur removal. By comparing diesel with other frothing agents, it could be inferred that it is more suitable frothing agent than others. In the second series of the experiments, the froth flotation was carried out using Diesel as a frothing agent for different particle sizes. From the results, it could also concluded that a remarkable difference was observed in the ash removal which suggests that particle size plays a vital role in removing ash and sulfur from coal. It is therefore, recommended that depressants and activators could be used to enhance the froth flotation performance and these could play a vital role in removing impurities from coal.

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