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STUDIES ON ASH REDUCTION OF A NON-COKING COAL SAMPLE BY FROTH FLOTATION

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Abstract

Coal is a vital energy fuel world over, statistically contribution upto 55-60% and it plays a major role in the economic development of the country. In general Indian coals are poor in quality with high ash content and they need beneficiation prior to their utilization. CSIR-NML is pursuing dry beneficiation of non-coking coal for application in DRI, cement and thermal power plant. However, during the crushing of coal for dry separation, some amounts of ultrafines are generated. There are limitations in treating ultrafine particles by dry separation methods. To maximise the overall combustible recovery an attempt was made for ash reduction in a typical non-coking sample from Rajmahal by froth flotation with an initial target of 25% ash in the product. Kerosene and diesel oil were used as collectors for coal flotation. The coal sample was characterised thoroughly in terms of petrography characteristics, size analysis and proximate analysis. Proximate analysis indicated that the coal contains 34.8% ash, 23.52% VM, 6.86% moisture and 34.82% FC. The coal sample of -150µm was taken for flotation studies. The effect of important variables such as collector dosage, frother dosage and pH level are investigated for arriving the optimum value of yield/combustible recovery. Use of dispersant/depressant with diesel oil as collector was found to give better yield with an ash content of 25% with a combustible recovery of 72%. Efforts are put in to further reduce ash content in clean coal for metallurgical application.

Keywords: Non-coking coal, Flotation, Ash reduction

1. Introduction

Coal is a fossil fuel. It is a combustible, sedimentary, organic rock, which is composed mainly of carbon, oxygen and hydrogen (Babatunde and Adeleke, 2014). Coal finds application in different areas like steel making, electricity generation, cement making and some other processes as liquid fuel (Francis and Peters, 2009). The quality of coal depends upon its origin, if it is formed by drift origin it contains high ash naturally whereas if it is formed by in-situ origin the ash content will be lower. Most of the Indian coals belong to drift origin. Out of two different types of coal , the availability of coking coal is limited in India.

Indian non-coking coals, in general, are poor in quality with high ash forming minerals throughout the mineral matrix. The total coal reserves are estimated to be 276 BT out of which nearly 85% is non-coking coal with 40-45% ash. However so far beneficiation of non-coking coal in India has been limited. But considering the scarcity of coking coal and the rise of new technologies of steel making utilising non-coking coal, complete beneficiation of same is required. The Indian coals have difficult washability characteristics due to close mixing of a quite large part of the dirt and mineral matters in most of the coal seams (Singh and Singh, 2002). Coal and coal products play an important role in fulfilling the energy needs of the country.

Coal fines are generally processed using froth flotation technique. It utilizes the difference in the surface properties of coal and minerals to affect the separation. The coal fines are generally hydrophobic in nature and the mineral matter are hydrophilic (Rao and Bandopadhyay, 1980). However, if coal surface is oxidized, hydrophobic nature of it will decrease and it becomes very difficult to float even at high concentration of collector (Jena et al 2004). Flotation of fine non-coking coals is attempted to achieve a high yield or combustible recovery with normal oily collectors, such as kerosene and diesel oil. In the present study the effect of variables such as collector dosage, frother dosage and pH level are investigated on the flotation characteristics of the coal fines. The effect of presence of dispersant in the flotation of oxidized coal is also investigated. The objective of this investigation is to explore the flotation performance of the non-coking coal in a mechanical flotation cell at a targeted ash level of 25% as the demand of the low ash clean coal is increasing. The recovered clean coal can be used for various metallurgical and other industrial purposes.

2. Materials and Methods

2.1. Materials

The non-coking coal sample was collected from Rajmahal, Jharkhand, India. The coal sample of -150µm was taken for flotation studies. The proximate analysis of this fraction was done as per standard procedure. The coal sample on an average analyzed 6.86% Moisture, 23.52% VM, 34.8% ash and 34.82% FC. A representative sample was taken from this size fraction (-150µm) and size analysis was carried out. The size and size-wise ash analysis of the coal sample are shown in Table 1.

Table 1. Size analysis of coal sample.

Size(µm)	Wt%	Ash%
-150+100	9.8	31.6
-100+75	11.6	31.4
-75+63	13.4	30.8
-63+53	11.7	33.9
-53+25	9.6	35.1
-25	43.9	37.8
	100	34.8

Through petrographic investigation it was observed that percentage of Vitrinite (33.3%), Inertinite (33.3%) and Mineral Matter (32.2%) are almost same. Inertinites are mainly represented by fusinite and semifusinites, Liptinite macerals mainly resinite and sporinite contribute 1.1%. Mineral matter mainly represented by argillites, some carbonate minerals, which occur as cavity fillings or in disseminated form.

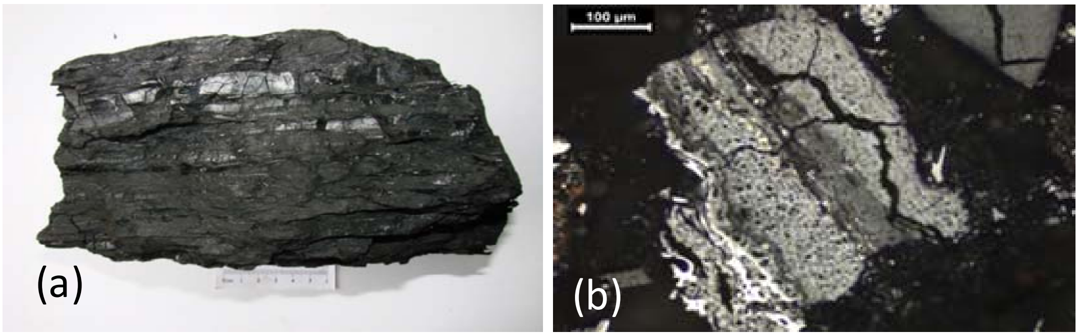


Fig. 1: Photograph showing (a) banding & (b) Vitrinite (grey), Inertinite (white) and Mineral Matter (black) in Rajmahal coal

2.2. Reagents

Commercial grade diesel oil and kerosene were used as collector while sodium silicate and pine oil were used as dispersant/depressant and frother respectively. LR grade HCl and NaOH were used as pH regulator for flotation study.

2.3. Methods

In the present investigation, all flotation tests were conducted using a laboratory Denver 12, sub-aeration flotation cell of 2.5 liters capacity. Flotation tests were carried out using 250 gm of coal of with pulp density 33% during conditioning and 10% during flotation. In each flotation test, the pulp was first agitated thoroughly in the flotation cell for 3 minutes wetting the sample, after which the collector was added and the pulp was further conditioned for 2 minutes. Frother was then added and the pulp was further conditioned for 1 minute. The impeller speed & air flow rate of the flotation machine were kept constant for all experiments. The aeration was started by opening the air valve and the concentrate coming as froth was collected. Froth collection time was 3 minutes; the concentrate and tailing were filtered, dried and weighed. The ash content of the products were determined.

3. Results & Discussion

3.1. Selection of Collector

Two collectors namely diesel oil and kerosene were used at different dosages. The results are presented in Fig. 2 from which we can observe very clearly that the diesel oil gives better yield than kerosene with lesser ash% in the clean coal. Hence diesel oil is continued as collector throughout the tests conducted at different operating conditions

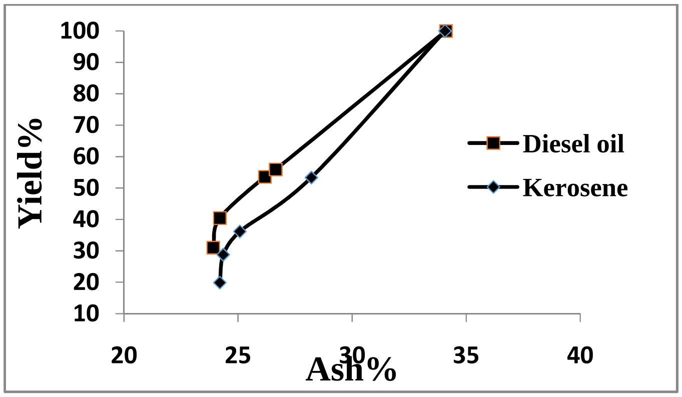


Fig.2: Flotation results using diesel oil and kerosene as collectors

3.2. Effect of Reagent Dosage

3.2.1. Effect of Collector dosage:

The results shown in Fig. 3. indicate that the yield increases with an increase in the collector dosage (diesel oil) from 1.7 to 2.6kg/t. However, a small decrease in the yield is observed at the higher dosage of collector at 3.5kg/t with more ash% in the product from which we can note that the selectivity of the collector is decreased at higher dosages floating non combustible particles. The optimum dosage of collector decided is 2.6 kg/t where a yield of 40% is achieved with 23.8% ash in the products.

3.2.2. Effect of Frother dosage:

In the present study pine oil is used as frother and which is tested at different dosages to find out the optimum dosage. The dosage is varied at three different levels from 0.5kg/t to 1.2kg/t. The results given in the Fig.4. indicate that the yield of clean coal increases with increasing the dosage from 0.5- 0.8 kg/t whereas ash in clean coal was found to decrease initially with increase in frother dosage but at higher dosage ash content in clean coal also increases. However, a sharp increase in the yield is observed at higher dosage of frother resulting a high ash clean coal. Hence the optimum dosage of frother could be easily selected as 0.8 kg/t which found best w.r.t both yield and ash%.

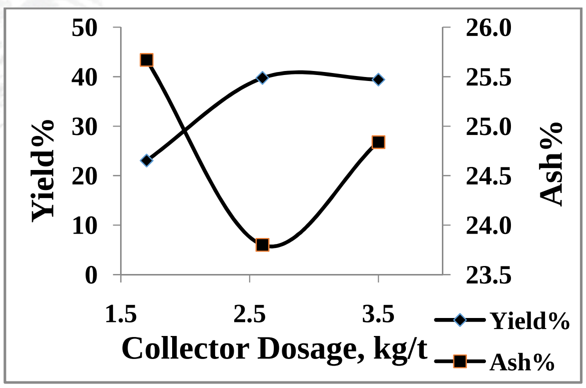


Fig. 3: Effect of collector dosages (diesel oil)

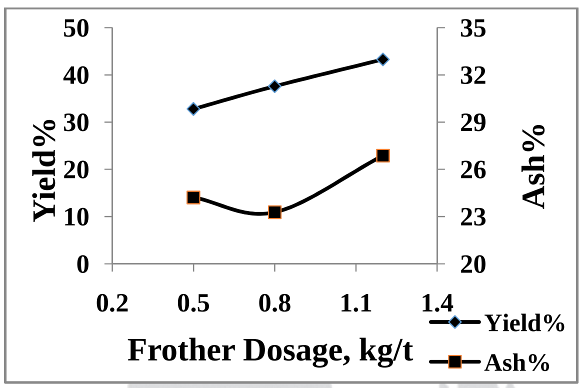


Fig. 4: Effect of frother dosages

3.3. Effect of pH:

The pH of the pulp controls the action of the flotation reagents. In the present study, the effect of pH on yield and ash% of the clean coal was tested by varying the pH of the pulp at four levels. The results are presented in the Fig-5 from which it is observed that at acidic pH, yield is increasing with very little decrease in the ash% whereas at basic pH yield is found to be decreasing with increasing ash%. It is found that neutral pH results in better yield with less ash% in the clean coal product.

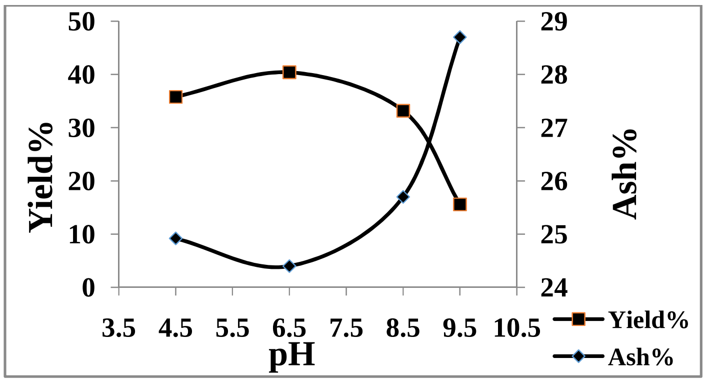
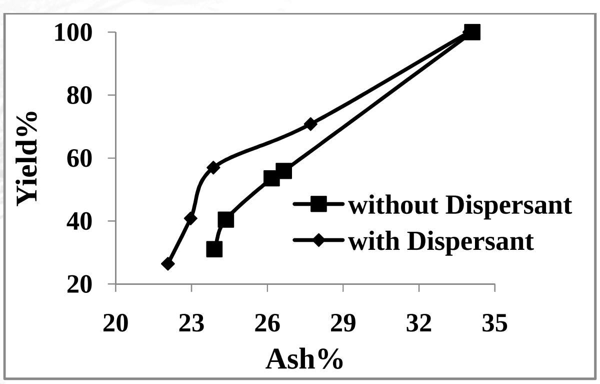


Fig. 5: Effect of pH on flotation of coal

3.4. Effect of dispersant/depressant:

The main function of use of sodium silicate as dispersant is to remove the slimes which coat the surface of the coal particles and help in depression of quartz and silicates. Slimes affect the action of the collector adversely while flotation of quartz and silicates affect the product quality. Hence the effect of dispersant/depressant on the flotation performance is investigated. Two tests were conducted, with and without dispersant. The results are presented in the Fig-6. and from which we can notice that presence of dispersant/depressant gave better results of yield and ash% than the test without dispersant. Use of dispersant/depressant has helped in dispersion of slime and depression of silicates leading to overall better metallurgical performance. This indicates that the slime coating on the coal particles was removed by the facilitating better adsorption of the collector on the surface of the clean coal particles.



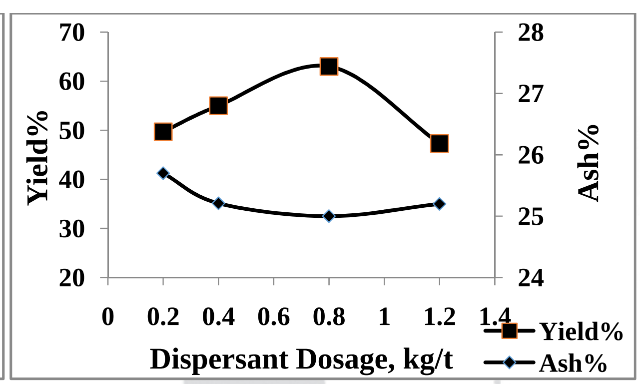


Fig.6: Flotation results with/without dispersant **Fig.7:** Effect of dispersant dosage on flotation results

With initial encouraging results tests were conducted to find the optimum dosage of the dispersant. The dosage of sodium silicate was varied from 0.2kg/t to 1.2kg/t and the results are presented in the Fig-7. The results indicate that the yield increases with increasing dispersant dosage from 0.2 to 0.8 kg/t with gradual decrease in ash% of the product. But yield and ash% found to decrease at higher dosage of dispersant i.e. 1.2 kg/t. Hence the optimum condition can be taken is 0.8kg/t. At this level combustible recovery goes upto 72%.

4. Conclusions

Studies were carried out on ash reduction in anon-coking coal sample by froth flotation under varying reagents and their dosages. Following conclusion are drawn from the study:

- Among the two collectors used diesel oil proved better in terms of yield and low ash in the product.
- Optimized dosage of diesel oil was 2.6 kg/t giving 42% yield with 25% ash.
- Optimized dosage of pine oil was found to be 0.8 kg/t.
- Natural pH condition was found to give better results at optimized dosages of collector and frother.
- Finally, the presence of dispersant/depressant improved the flotation performance than without dispersant.
- Hence from this study is concluded that 63% clean coal can be produced at 25% ash level recovering 72% of the combustibles in the clean coal product.

5. Acknowledgement

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