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Comparative study of the performance of conventional and column flotation when treating coking coal fines

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ARTICLE INFO

Article history:
Received 6 February 2008
Received in revised form 12 June 2008
Accepted 30 June 2008

Keywords:
Coking coal
Conventional flotation
Column flotation
Combustible recovery

ABSTRACT

Investigations were carried out on coking coal fines by conventional cell and column flotation techniques. The effects of different operating parameters were evaluated for both conventional and column flotation. The coal fines were collected from Bhojudih washery, India. These coal fines averaged 24.4% ash, 19.8% volatile matter and 53.8% fixed carbon on a dry basis. A commercial grade sodium silicate, light diesel oil and pine oil were used as depressant, collector and frother respectively. The flotation performance was compared with release analysis. The conventional flotation results indicated that a clean coal with 14.4% ash could be obtained at 78.0% yield with 88.4% combustible recovery. The ash of the clean coal could be further reduced to 10.1% at 72.0% yield with 85.6% combustible recovery by using column flotation. The column flotation results were close to those obtained by release analysis.

1. Introduction

Froth flotation is a fine particle separation process that is based on the difference in surface hydrophobicity of different components. Separation of required solids is achieved when the surface properties of a required solid component are such that it preferentially attaches to the air bubbles. At present scenario in India most of the coal fines (–0.5 mm) are treated by froth flotation technique to reduce the ash content to a desired level. In contrast to widely used machines, which resemble continuous stirred reactors, there are flotation machines which are similar to counter-current reactors, popularly known as flotation columns.

Column flotation was developed as an alternative to the conventional, mechanically agitated flotation machines. A flotation column in essence consists of a vertical cylinder in which the reagent conditioned feed slurry is introduced at a height approximately 2/3 of the column height, travels downwards against the rising air bubbles. The rising froth bed above the feed point is washed down by a spray of water and clean froth is collected at the top of the column. These columns are operated to maintain streamline conditions in the flotation zone to avoid back mixing and entrapment of gangue into the froth, a drawback generally observed in mechanically agitated cells. The main advantages of column flotation compared to conventional cells are 1) a better product without sacrificing recovery, 2) a reduction in the number of stages of operation, 3) ability to handle a finer feed, 4) savings in collector requirements, 5) simplicity in design for construction without any moving parts and 6) less floor space requirements. However compared to conventional cells the water requirement per tonne of feed processed and consequently the frother requirement may be more [1].

The major disadvantages of flotation columns are the mixing in the axis of the column, the blockage of spargers (diffusers) and problems posed by the column height in installations. In the last few decades, many alternative column designs have been developed to eliminate these disadvantages and to increase the recovery. Some of these are Leeds column, Packed column, Flotaire column, Hydrochem column, Jameson column, Microcel column, Cyclonic column and Cyclo-microbubble column [2–9]. Earlier studies indicated that some

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doi:10.1016/j.fuproc.2008.06.012

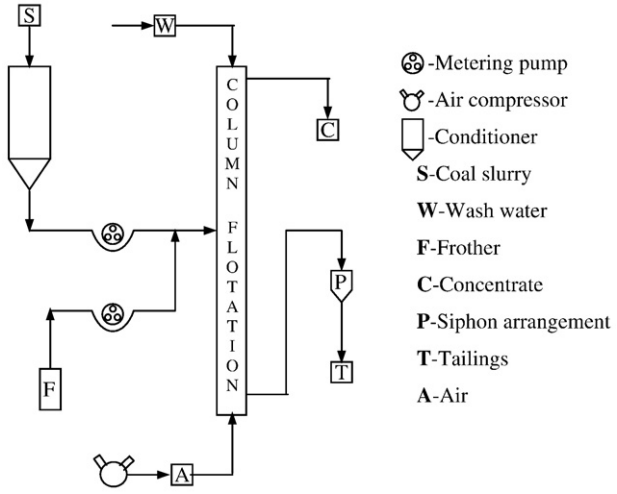

Fig. 1 – Schematic diagram of the flotation column.

parameters, such as the air rate, the feed rate, the wash water rate and the reagent dosage relatively affect the flotation performance. According to many researchers, the recovery increases as the air rate increases to produce the maximum yield [10–13]. Finch and Dobby [10] claimed that when the feed rate increases, the retention time decreases and thus, the recovery increases. However, Goodall and O'Connor [14] have proved that the reverse may be possible. In many of the studies related to wash water, it was established that with the increase in wash water rate the grade increases and the recovery decreases [10,13]. Other studies have shown that despite a rise in the grade, the recovery did not decrease much [10–11,13–14]. The effect of the reagent dosage (collector and frother) on column flotation performance is almost similar to that observed in conventional cells. In other words, it has been mentioned that the reagent dosage has an optimum value in flotation and at that value the recovery reaches the maximum [15–17].

In many studies, it has been claimed that column flotation gives a higher recovery with better grade [1]. In India coking coal is being washed to reduce the ash content. The process consists of size reduction to 25 mm and classified at 13 mm and 0.5 mm. The −25+13 mm is cleaned by dense media bath and −13+0.5 mm is cleaned by dense media cyclone. During the process, 15 to 20% of the raw coal is generated as fines (−0.5 mm), which contain high ash content. Flotation is the well established method to beneficiate these fines. An attempt has been made to evaluate the effects of different operating parameters on the flotation performance of both conventional and column flotation. The results were compared to those from release analysis.

2. Materials and methods

2.1. *Material preparation and analysis*

The coking coal fines generated at Bhojudih coking coal washery in Eastern India were collected and used for this investigation. A representative sample of about 500 kg was collected in the form of wet slurry and the associated water was removed by dewatering. The whole sample was thoroughly mixed and representative samples (by standard coning and quartering) were taken for size and chemical analysis as well as flotation studies.

The proximate analysis of the coking coal fines was carried out by following ASTM standard procedures using a Leco TGA Model 601. The standard BSS (British Standard System) sieves were used for size analysis. Size fractions of +300, −300+210, −210+150, −150+75, −75+45 and −45 μm were generated. Each size fraction was analysed for ash.

2.2. *Flotation tests*

A commercial grade light diesel oil was used as the collector and pine oil was used as the frother. Commercial grade sodium silicate was used as silica depressant as well as dispersant.

In order to determine the floatability of the coking coal fines, the release analysis test developed by Dell was carried out [18]. These studies were carried out in standard laboratory Denver D-12 sub-aeration flotation cell using the standard test procedure.

A standard laboratory Denver D-12 sub-aeration flotation machine with 4-litre cell was used for the batch flotation studies. The coal slurry was prepared at 40% solids by weight with normal tap water and conditioned with required dosage of commercial grade sodium silicate for 5 min at 1500 rpm. The required amount of light diesel oil was added and conditioned for 5 min. The required solids concentration was obtained by adding additional water in the cell. The required amount of pine oil was added and conditioned for one more minute. The required impeller speed was set and monitored by the tachometer. Then the air valve was opened and the froth was collected for 3 min. The experiments were carried out by varying different operating parameters such as collector concentration, frother concentration, depressant concentration, solid concentration and impeller speed. The flotation concentrate and tailings were collected separately for each experiment. The concentrates and tailings were dried, weighed and analysed for ash.

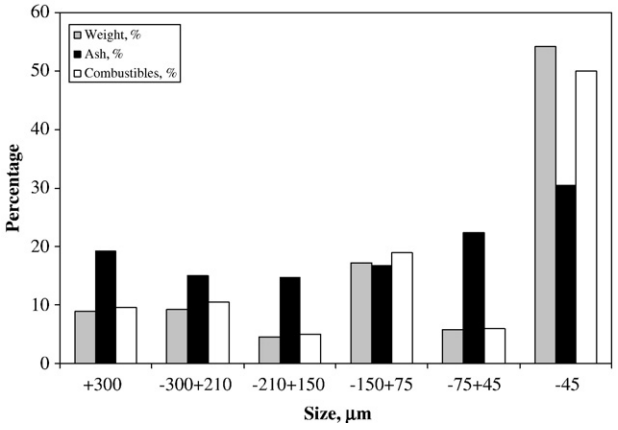

Fig. 2 – The sizewise distribution of weight, ash and combustibles of the coal sample.