Contents lists available at ScienceDirect

Int. J. Miner. Process.

journal homepage: www.elsevier.com/locate/ijminpro

Influence of chemical parameters on selectivity and recovery of fine coal through flotation

Ashiwani Kumar Gupta [a,*], P.K. Banerjee [a,1], Arun Mishra [b]

[a] Research and Development, Tata Steel, Jamshedpur, 831001, Jharkhand, India
[b] West Bokaro Washery, Tata Steel, Jamshedpur, 831001, Jharkhand, India

ARTICLE INFO

Article history:
Received 12 July 2006
Received in revised form 25 May 2007
Accepted 1 February 2009
Available online 11 February 2009

Keywords:
Blended frother
Frother concentration
Selectivity
Surface tension
Flotation kinetics
Synergistic effect

ABSTRACT

This paper summarizes how the chemical parameters (collector concentration, frother concentration and different mixed frothers) affect the selectivity, kinetics and size wise flotation performance. Three different mixed frothers have been taken for this study. Frother 'x' is composed of alcohol and ketone. Frother 'y' consists of alcohol and aldehyde group chemicals. Frother 'z' is a blended product of alcohol and polyglycol ether. Flotation performance of different mixed chemical systems is correlated with affinity of frothers with air–water interface. Blended frothing molecules of short chain alcohol and polyglycol ether have shown a dramatic impact on the surface activity and flotation performance in term of ash reduction and improvement in coal yield.

1. Introduction

Froth flotation, as a process in which fine coal particles are separated selectively from associated minerals in water slurries, by attachment to rising air bubbles, has a long history in coal beneficiation history. There are three dispersed phases that constitute flotation pulp: coal particles, water and air bubbles. Several parameters affect the different sub processes. These parameters are divided into four groups as illustrated in Fig. 1. Theses are material, chemical, and operational and equipment parameters (Sis et al., 2003; Bazin and Proulx, 2001; Vanangamudi et al., 1981; Blake and Ralston, 1985; Harris and Jia, 2000; Jia et al., 2000, 2002). The parameters that might fluctuate and need adjustment on a regular basis (e.g. daily) are referred to as level I parameters. Those that are set during the design stage or after a major renovation are referred to as level II parameters. Some parameters are not controlled due to inherent material characteristics and practical limitations, and they are referred to as the level III parameters (Polat et al., 2003; Hadler et al., 2005). Some examples of these parameters are listed in Fig. 1.

The type and concentration of frother and collector are the key chemical factors in determining the performance parameters, the combustible solid recovery and purity (grade) of the concentrate. To qualitatively summarize the role of the frother in industrial flotation process it can be said from direct visual observation that the presence of a surface-active agent (frother) leads to the following: an enhance formation of a froth; an increase in the dispersion of air in the flotation cell; a reduction in the rate at which the bubbles rise to the surface (which effectively increases the residence time of bubble contact with particles); and a reduction in the coalescence of individual bubbles within the flotation pulp (Cho and Laskowski, 2002a,b; Laskowski et al., 2003a,b; Grau et al., 2005). According to Leja–Schulman's penetration theory (Leja and Schulman, 1954; Leja, 1956/57), frothers accumulate preferentially at the air/water interface and interact with collector molecules adsorbed onto solid particles in the particle-to-bubble collision and attachment. Putting all of these factors has the net effect of significantly increasing the probability of particle–bubble contact and therefore the overall rate of valuable material recovery and upgrading by removal of the upper levels of the froth phase as it is formed in flotation cells.

The surface tension of a solution is an indication of the activity of a frother. Frothers that strongly lower the surface tension produce more stable froths (Klimpel and Hansen, 1988). While the above conceptual picture is qualitatively correct, the use of surface tension measurements alone to screen frothers for application in flotation is limited. The difficulties inherent in giving a comprehensive scientific analysis of flotation frothers were already recognized 50 year ago (Wrobel, 1953). This situation is not very different today and the terms "powerful" or "selective", which are used to characterize frothers, have intuitive rather than scientific meaning. In practice, the frothers

* Corresponding author. Tel.: +91 657 2147460/2147466; fax: +91 657 2271510.
E-mail addresses: ashiwani.gupta@tatasteel.com (A.K. Gupta), pkbanerjee@tatasteel.com (P.K. Banerjee), arun.mishra@tatasteel.com (A. Mishra).
[1] Tel.: +91 657 2147460/2147466; fax: +91 657 2271510.

0301-7516/$ – see front matter © 2009 Published by Elsevier B.V.
doi:10.1016/j.minpro.2009.02.001

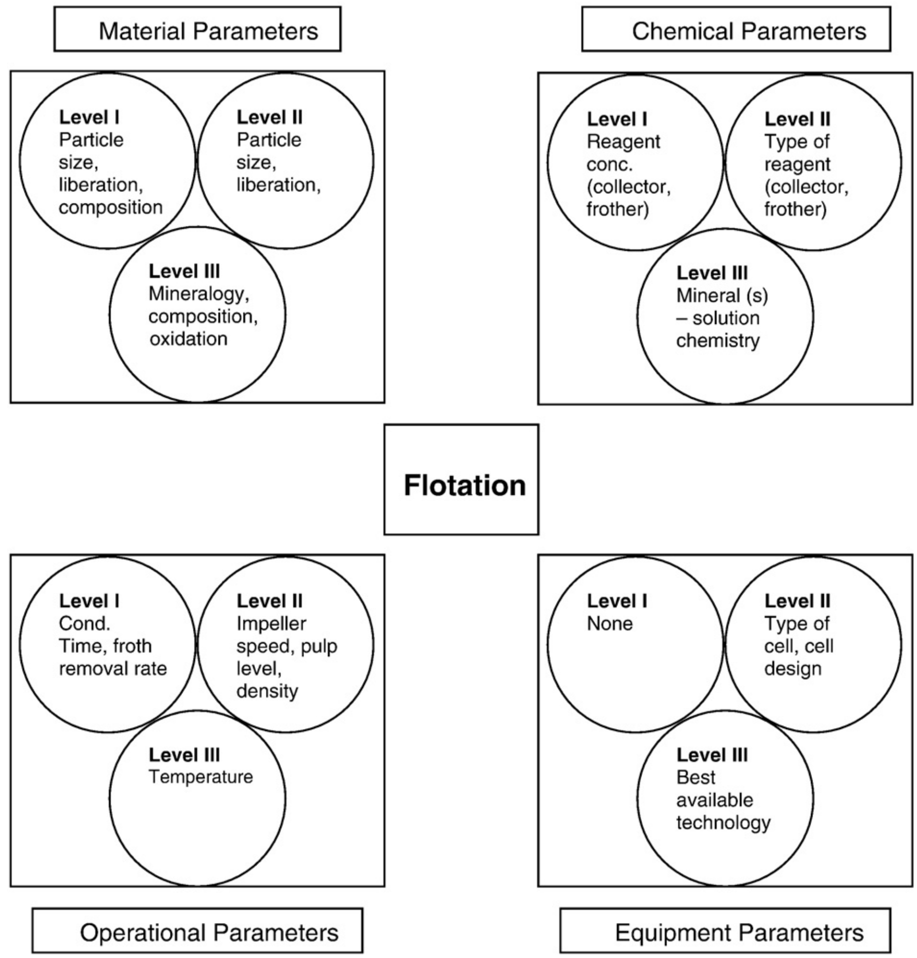

Fig. 1. Different process parameters in flotation (Polat et al., 2003).

are screened under general guidelines and verification by laboratory and/or plant flotation data (Klimpel and Isherwood, 1991; Comley et al., 2002).

Based on the laboratory experience and literature findings broadly emerge that frothers belonging to alcohol and ketone family are selective for ultrafine particle size fraction and ploy glycol frother and aldehyde are effective to float coarse fraction. Branched and water soluble alcohol and ketone molecule produce mono and finer bubbles size which enhance the separation efficiency of finer particle size fraction (Laskowski, 2003; Melo and Laskowski, 2006). Ploy glycol ether and aldehyde molecule are more surfaces active and produce more stable and viscous froth compared to alcohol frothers, which leads the recovery of coarse particle size fraction of flotation feed. It is difficult to use a single frother that will effectively give good overall flotation performance for wide particle size distributed flotation feed (Xu and Liu, 2006; Fuerstenau et al., 2006).

A research program is started to determine the effects of the reagent and frother mixture on the froth flotation performance and froth structure for wide size distributed coal flotation feed. The performance was evaluated in terms of selectivity, kinetics and size wise flotation performance. Three mixed frother systems are designed based on the optimum performing permutation and combination of alcohol, ketone and aldehyde and polyglycol ether frothing molecules. Frother 'x' is composed of alcohol and ketone. Frother 'y' consists of alcohol and aldehyde group chemicals. Frother 'z' is a blended product of alcohol and polyglycol ether. Synergistic effect in flotation with mixed frothing molecules is studied. Flotation performance of different mixed chemical systems is correlated with affinity of frothers with air–water interface.

2. Experimental

2.1. Materials: coal and reagents

A representative minus 0.5 mm size semi bituminous flotation feed coal sample, namely V-A seam (from West Bokaro, Tata Steel, India), was taken in this investigation. Nature of coal sample is difficult to float. The samples were first allowed to settle, decanted and then dried at 60 °C. Ash analysis were carried out according to ASTM D 3174-73 standard showed that the sample contains 24.0% ash. Streaming

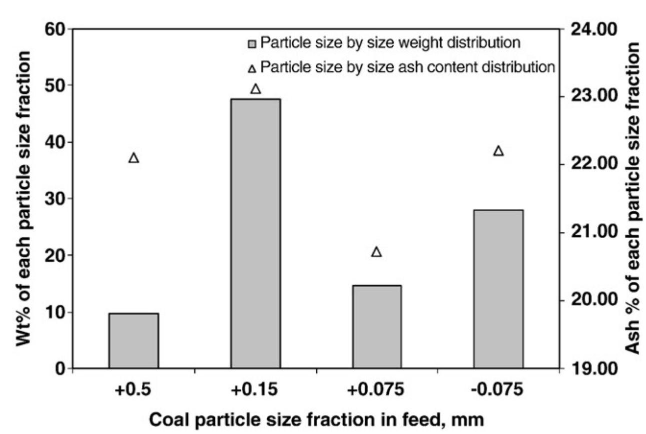

Fig. 2. Total weight and mineral matter (ash) distribution among different particle size fractions of flotation feed sample.