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Development of methodologies to improve the assessment of reagent behaviour in flotation with particular reference to collectors and depressants

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Abstract

Reagents are added to flotation pulps to perform specific roles, however due to the complexity of the sub-processes and the interactions between reagents and these sub processes, it is not always possible to know whether the intentions have been achieved either directly or indirectly. It is also not possible to reliably predict whether the behaviour or trends observed in the laboratory can be scaled up to plant conditions.

This paper seeks to unravel the behaviour of reagents and improve the understanding of the mechanisms on the sub processes which contribute to the resulting overall flotation performance. In particular, to decouple the material reporting to the concentrate by true flotation from that recovered by entrainment and to take into account the froth phase behaviour as well as that of the pulp phase. This makes it possible to get a better indication of how trends will be translated to a larger scale. © 2004 Elsevier Ltd. All rights reserved.

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1. Introduction

Conceptually, the flotation process is relatively simple and is a physico-chemical process based on exploiting the differences in surface properties between the desired, valuable minerals and unwanted gangue. However, in practice, the process is complex and there are many sub processes and interactions that make interpretation of mechanisms or direct assessment of factors difficult. Reagents are added to perform specific roles to manipulate the pulp chemistry and enhance the differences in mineral surface hydrophobicity to facilitate the separation. The reality is not so straightforward and in addition to the

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primary role of a reagent there are various reagent interactions and competing effects. It is necessary to assess the reagent behaviour holistically and evaluate the effects both in the pulp and froth phases as material is recovered by true flotation as well as by entrainment.

This paper focuses on collectors and their role in increasing particle hydrophobicity of valuable minerals and depressants, and their role in decreasing the hydrophobicity of gangue minerals. It discusses the primary roles as well as the competing behaviour and interactions. A case study is presented which investigates; the effect of collector chain length, (sodium ethyl xanthate (SEX) and sodium isobutyl xanthate (SIBX)); the effect of depressant charge (Depramin 186, high charged and Depramin 158, low charged) and dosage 100, 300 and 500 g/t) are discussed in terms of the behaviour of the sulphides (grade and recovery) and gangue recovery

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(floatable and entrained) as well as the effect on froth stability.

2. Background

2.1. Pulp phase

In the pulp phase it is important to create the necessary environment, both physical and chemical, to promote bubble-particle collision, successful attachment of the valuable hydrophobic particles and the transport of these mineral laden bubbles to the froth phase. At the same time, the unwanted gangue minerals should be hydrophilic and remain unattached after collision and therefore not be transported to the froth phase by 'true flotation.' However the rising flux of bubbles causes material to report to the froth phase unselectively by entrainment. Entrainment is a mechanical phenomenon which is not directly affected by changes in mineral surface hydrophobicity, whatever the cause, but is rather affected by particle properties such as size and density.

2.2. Froth phase

The role of the froth zone in flotation is to facilitate the upgrading of the valuable materials reporting to the concentrate without loss of valuable material. The froth structure allows water to drain thereby reducing non-selective recovery of gangue material by entrainment. The recovery of entrained material has been shown to be proportional to water recovery (Englebrecht and Woodburn, 1975) so that reducing water recovery, reduces gangue recovery by entrainment and increases the valuable mineral grade. It follows that factors that affect the froth stability also affect the amount of material recovered by entrainment.

An optimum froth stability is sought, if the froth phase is 'too stable', although there is no valuable recovery loss, the recovery of gangue by entrainment is substantial and the upgrading of the valuable material can be inadequate. On the other hand if the froth phase is 'too unstable', there is good upgrading of the concentrate but this can be accompanied by a loss in recovery. Froth stability is governed primarily by the frother concentration in solution but can also be strongly affected by solid properties.

Studies have consistently shown that increasing particle hydrophobicity increases the stabilising effect of particles up to an intermediate or 'critical' contact angle (Johansson and Pugh, 1992; Schwarz and Grano, 2002). Above this contact angle, the particles were shown to destabilise froths. In another study using high speed photographic techniques, individual highly hydrophobic galena particles speeded up the rupture of films by an order of magnitude (Dippenaar, 1982). This indicates that particle size and shape are also important particle properties with respect to their ability to act as froth breaking agents.

In the lower layers of froth, bubbles with attached hydrophobic species enter the froth with relatively low loads in terms of the solids per unit surface area. Rapid coalescence and drainage increases the solids load per unit surface area as the bubbles become larger. It is expected that this coalescence occurs rapidly until a stabilising layer of solids is formed on the bubble surface. If the concentration of floatable material entering the froth is below the critical level required to achieve a stabilising layer of solids, the highly hydrophobic particles will act as independent froth breakers (Dippenaar, 1982). An increasing concentration of moderately hydrophobic floatable material (typically floatable gangue) in the froth is expected to increase froth stability.

2.3. Role of collectors

Collectors are generally hetero polar molecules containing a polar group that interacts with the mineral surface and a non-polar hydrocarbon chain that induces hydrophobicity. Their primary role is to increase valuable minerals relative to that of the gangue minerals, therefore it is necessary that they are selective and their effectiveness has been shown to be dependent on both the alkyl chain and functional group (King, 1982). Xanthates, first invented and patented in 1925 remain the most widely used collectors and over the years various methods of surface reaction have been proposed and various effects and trends have been noted (de Donato et al., 1979). Increasing collector chain length has long been shown to increase hydrophobicity and recovery (Taggart, 1945; Dimou, 1986; Ackerman et al., 1987).

A secondary effect of the collectors changing hydrophobicity is the influence on froth stability as discussed above. Bradshaw et al. (2004), showed that in microflotation tests with no froth phase, the flotability of galena was increased more by PAX than SEX, indicating increased hydrophobicity. In batch flotation tests, under conditions with no talcaeous minerals present, this situation was reversed indicating that the effect of the increased hydrophobicity obtained with PAX was to destabilise the froth to the extent of reducing valuable recovery. In the case where no depressant was added and froth stabilising talcaeous material was present to counteract the destabilising effect of the highly hydrophobic material, no loss of valuable mineral occurred and similar recoveries were obtained.

2.4. Role of depressants

The function of a depressant is the opposite to that of a collector; it is to inhibit flotation of a given mineral. This is achieved either by (a) preventing collector from Download English Version:

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