International Journal of Mineral Processing 135 (2015) 11–19

Contents lists available at ScienceDirect

International Journal of Mineral Processing

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

Mineralogical interpretation of the collector dosage change on the sphalerite flotation performance

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ARTICLE INFO

Article history:
Received 31 December 2013
Received in revised form 16 September 2014
Accepted 16 December 2014
Available online 17 December 2014

Keywords:
Liberation
Flotation
Collector
Metallurgy
Mineral balance

ABSTRACT

The aim of the paper is to investigate the effect of the collector dosage on the Zn Rougher performance based on the mass balance of the liberated and locked particle types. Two sampling surveys were conducted in different periods of the collector dosage adjustments. In the high and low dosage limits, the feed, tail and bulk concentrates together with each cell concentrate were sampled and sized in narrow size fractions to facilitate quantitative mineralogical analysis. The metallurgy of the existing, high and low dosage cases was calculated using mass balance. Mineral balancing of the liberated and locked particles was also performed around the bank. The sphalerite was lost to the tail, even in liberated form, with over 21.5% of coarse size in low dosage. Increasing the dosage of the collector did not much affect the liberated pyrite and non-sulphide gangue (NSG) particles, except for finer sizes, which indicated the occurrence of recovery by entrainment. Because sphalerite was mostly locked with pyrite, the amount of sphalerite–pyrite binaries was 21 to 28% higher in the size fractions of the high case. Therefore, it was also concluded that increasing the dosage of the collector in the rougher bank was necessary to collect sphalerite locked particles.

1. Introduction

Industrial application of sphalerite flotation has more selectivity problems than the flotation of chalcopyrite and galena due to unintentional activations (Lastra, 2007), process water (Chandra and Gerson, 2009) and other issues. Hence, the relationships between the process parameters (predominantly the dosage of collector) and the Zn separation efficiency have been the subject of many studies (Bazin and Proulx, 2001; Maier et al., 1997; Mehrabani et al., 2010; Lotter and Bradshaw, 2010). However, in all of these studies, the reagent optimisation was evaluated by implementing laboratory studies, statistical techniques and optimisation tests in plants rather than quantitative mineralogy. Unlike such studies, Lotter and Bradshaw (2010) suggested that it is more logical to perform a quantitative mineralogical analysis before designing the appropriate reagent scheme.

The value of quantitative mineralogical data and their effects on the metallurgical performances of plants has been very well documented in many case studies (Lastra, 2007; Frew and Davey, 1993; Lauder et al., 1994). It is known that determining the mineralogical profile of the ore provides a boost to flowsheet development, the designation of the reagent scheme, the performance evaluation and the optimisation of the process (Nice and Brown, 1995; Frew and Davey, 1993; Pyecha et al., 2005). In some studies; the distributions of minerals and metals among the streams in a mill were performed, but generally a metallurgical assessment was performed, based on the liberation classes, which are only grouped into liberated and locked particles (Frew and Peck, 1991; Petruk, 1990; Vedrine et al., 1991). It is well known that the floatability of a composite mineral particle is a function of its particle size, mineralogy and liberation characteristics as well as the chemical environment in the flotation cell and that the floatability of different liberation classes can be different (Manlapig and Franzidis, 2001). Wang and Fornasiero (2010) indicated that the flotation of these composite particles decreases with increasing particle size, but even for the same particle size and liberation class, a composite particle with a complex locking texture has a higher floatability due to the size and distribution of the hydrophobic phases in the particle. Sutherland (1989) also studied the effect of liberation on the flotation rate of products in terms of particle compositions by classifying the particles as liberated and locked binaries; he stated that the coarse particles floated more slowly than the intermediate sizes at the same liberation class and that the flotation rate of the optimum size was higher than that of a fully liberated coarse particle. However, grouping the liberation classes as only liberated and locked would not be adequate in multi-mineral systems because the floatability of each liberation class will be changed due to the amount of relevant mineral in a locked particle.

Although the effects of reagent dosage on the recovery and the grade have been widely researched, it has seldom been elucidated in terms of quantitative mineralogy. The main objective of the study is to use quantitative mineralogical analysis as a tool for interpreting the collector dosage change in terms of the mineral balance rather than a routine

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http://dx.doi.org/10.1016/j.minpro.2014.12.003
0301-7516/

Table 1
The code description of the samples.

	Code	Description
High collector dosage	ZnRghF-H	Zn rougher feed
	ZnRghT-H	Zn rougher tail
	ZnRghC-H	Zn rougher concentrate
	C1-H	Zn rougher cell 1-concentrate
	C2-H	Zn rougher cell 2-concentrate
	C3-H	Zn rougher cell 3-concentrate
	C4-H	Zn rougher cell 4-concentrate
	C5-H	Zn rougher cell 5-concentrate
Low collector dosage	ZnRghF-L	Zn rougher feed
	ZnRghT-L	Zn rougher tail
	ZnRghC-L	Zn rougher concentrate
	C1-L	Zn rougher cell 1-concentrate
	C2-L	Zn rougher cell 2-concentrate
	C3-L	Zn rougher cell 3-concentrate
	C4-L	Zn rougher cell 4-concentrate
	C5-L	Zn rougher cell 5-concentrate

metallurgical performance. Instead of laboratory studies, a plant-scale Zn Rougher Bank was selected to perform surveys because sphalerite flotation is mainly affected by the chemical, operational and physical–mechanical parameters that reflect the real case. It is known that as the life of a mine extends; the mineralogy of the ore becomes more complex relative to the originally designed case. A rougher bank was particularly preferred for sampling because it is the most appropriate place where recovery is designated and where the effect of collector dosage is clearly observed. In general, the recovery is maximised at a rougher bank to collect all the liberated and the locked particles with the relevant mineral; if necessary, regrinding can be implemented prior to the cleaning stages. For this purpose, except for the existing condition, two more sampling surveys were conducted in the period of the different collector dosage conditions applied. A quantitative mineralogical analysis of the feed, concentrates (cell by cell) and tail samples of the Zn Rougher Bank was performed to characterise the liberation classes and particles affected by this change. The distribution of the mineral locking among Zn feed, Zn rougher concentrate and Zn rougher tail were also calculated by performing mineralogical mass balance for both cases.

2. Method

The plant has been processing a typical volcanogenic massive complex copper and zinc sulphide ore with a grade of 3.2% Cu and 8.00% Zn in Cu and Zn circuits. The major sulphide minerals were chalcopyrite, sphalerite, pyrite, chalcocite and bornite. The liberation size for flotation feed was 80% passing 38 μm. In addition to the existing condition, two more sampling surveys were performed at steady-state condition around the Zn rougher bank in a Cu–Zn flotation plant at two different collector dosages. Samples were taken from the feed, tail and the concentrate streams of the bank using periodic sampling every 4 h to adequately represent the conditions. The other operating conditions were similar in all of the surveys. For all conditions, the $CuSO_4$ (activator) and MIBC (frother) dosages were kept constant at a flotation pH of 11.5. Sodium isopropyl xanthate (SIPX) was used as the collector, and the dosage changes were set to be 20% higher and 35% lower than the existing conditions. The Zn rougher bank involves five mechanical cells, each with a 38 m^3 volume, which were used for both high and low collector dosage conditions using cell-by-cell sampling.

The collected samples from the main streams and each cell were weighed wet first, and then dried to determine the percent of solids. Sieving and cyclosizing were used to prepare the samples into narrow ranges of sizes, such as +38 μm (F1), −38 + 20 μm (F2), −20 + 10 μm (F3), and −10 μm fractions for chemical and mineralogical analyses. Each size fraction was assayed for Cu, Zn and Fe to accomplish mass balance on size-by-size basis.

The effects of collector dosage on the flotation performance were also evaluated based on the particle classes. A quantitative mineralogy study was performed on 48 samples of polished sections by using an optical automatic image analysis system called Clemex Vision PE 5.0. The polished samples of +38 μm, −38 + 20 μm, and −20 + 10 μm sizes were prepared and the locking statements of zinc and copper minerals together with pyrite and non-sulphide gangue (NSG) were quantified. The liberation criterion was selected as 95%, which means that if one particle consists of a specific mineral at a ratio of over 95%, then the particle is classified as a free particle. If two minerals, each at a ratio of less than 95%, existed in one particle, then the particle is classified as a binary particle. Liberation criterion of 95% was used to refer mineral liberation in this study, since it is believed that a particle

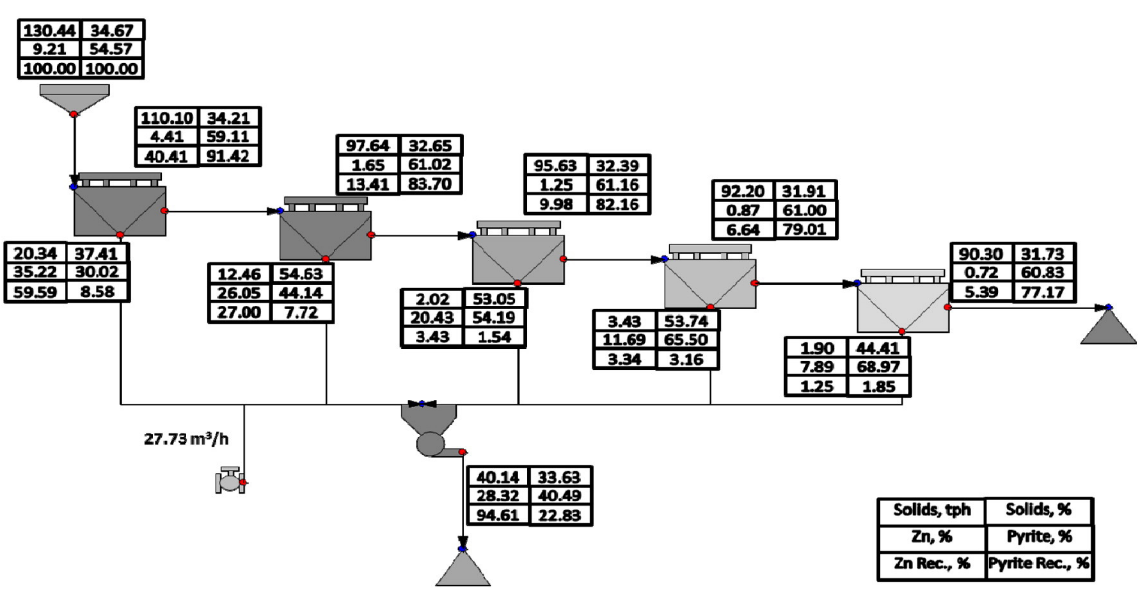

Fig. 1. Metallurgical balance for a high collector dosage.