Minerals Engineering xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Minerals Engineering

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

Comparison of flash and column flotation performance in an industrial sulphide rougher application

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ARTICLE INFO

Article history:
Received 24 November 2015
Revised 20 February 2016
Accepted 6 March 2016
Available online xxxx

Keywords:
Froth flotation
Kinetics
Sulphide ores
Gold ores
Flotation machines
Modelling

ABSTRACT

A survey has been conducted on a refractory gold (pyrite) concentrator which utilises flash flotation on the cyclone underflow stream and a flotation column on the cyclone overflow stream. Both cells are considered to be performing a first rougher operation on their respective streams. A comparison of the size and nature of the target mineral for flotation (pyrite) in the concentrates from both these unit operations has shown that they both recover predominantly liberated pyrite in the fine and intermediate size classes (−150 μm). The flash flotation machine on this particular circuit recovers fast floating well liberated particles, with a minimal froth depth and short residence time; while the rougher column has a very deep froth and long residence time. To date no comparison of a flash flotation cell and a column cell has been published in the literature and the results presented here are the first of their kind to the best of the authors' knowledge.

Analysis of the liberated pyrite recovery data has culminated in the development of a mathematical relationship which takes the form: $k_{fi}^2 \propto k_{ci} * m_{Ri}$. This relates the first order rate constants for liberated pyrite in the flash flotation machine (k_f) and the rougher flotation column (k_c) for each size class (i) in the floatable size range (+38/−150 μm), using the mass recovery (m_R) of each size class within the flash flotation machine. To account for the considerable differences in both feed properties and operating strategy of the two flotation machines, the rate constant data was normalised using the mass recovery of the total solids to concentrate by the flash flotation machine, allowing a relationship to be developed.

The ability to relate these two very different unit operations via particle specific properties provides impetus for further investigation into the methods used to analyse flotation data. The similarities of both the properties of the recovered pyrite particles and the rate constants of both machines for the size range +38/−106 μm are also of interest for the possibility of mill discharge (cyclone feed) flotation. The rougher column receives the fine split of the cyclone feed, while the flash flotation machine receives the coarse split, if a single machine could be used to recover all these particles in a single stage it would result in considerable cost savings to the industry via decreased plant footprint and operating costs, most notably via reduced water and reagent consumption.

1. Introduction

Experimental work for this paper was conducted at Kanowna Belle (KB) Gold Mine, which is located approximately 20 km north–east of Kalgoorlie in the eastern gold-fields of Western Australia. The processing facilities at KB utilise an integrated flowsheet that allows parts of the circuit to be switched on or off, depending on the nature of the ore feed material. There are two primary classifications of ore treated by these facilities, these being broadly classified as either oxide ores (generally from open cut mines) or refractory sulphide ores (from an underground mine). When oxide ores are being processed the circuit utilises a gravity and cyanide leaching (CIP) flowsheet; whilst when refractory sulphide ores are being processed a flotation circuit is used, followed by a CIP leach on the flotation tailings. Concentrates produced from the flotation circuit are further processed through a roaster with calcine leach to extract refractory Au from the pyrite. The processing route utilised for sulphide ores is depicted in Fig. 1 and will be the focus of this paper. The various configurations of this plant have been discussed in detail elsewhere (Newcombe and Semini, 2014; Newcombe et al., 2013) and the reader is directed to those publications if further information is required.

When discussing the data obtained from this concentrator three circuits are identified within the total flotation plant, these are:

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http://dx.doi.org/10.1016/j.mineng.2016.03.009
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Nomenclature

k	first order rate constant
R	recovery (%)
τ	residence time
i	size class
m_R	total mass recovery of the flash flotation cell
k_f	first order rate constant for the flash flotation machine
k_c	first order rate constant for the flotation column

1. Flash flotation circuit.
   The flash flotation circuit consists of a 500 tph flash (SkimAir®) cell, followed by two cleaner cells in serries. The flash flotation cell is fed a fixed portion of cyclone underflow material, flash tails report directly to the ball mill feed chute, whilst the flash concentrate reports to the first cleaner cell as shown in Fig. 1 (flash circuit is within the circle on Fig. 1). The combined concentrates from the two flash cleaner cells report directly to final concentrate, whilst the tails from these two cells are directed to the mill discharge (cyclone feed) hopper.
2. Rougher column circuit.
   Cyclone overflow material from the grinding circuit is directed through two conditioning tanks in serries before reaching the rougher column. Concentrate from the rougher column is cleaned in a single cleaner cell, whilst rougher tailings is directed to another conditioning tank prior to entering the conventional flotation circuit. Rougher column cleaner tails are returned to the column feed, whilst concentrate is directed to final concentrate.
3. Conventional circuit.
   The conventional flotation circuit utilises both forced air and self-aspirated cells and employs two stages of cleaning. This is broadly depicted in the flow sheet of Fig. 2. The combined recleaner concentrate is directed to final concentrate, whilst the 'Scavenger 8 Tail' is the final tails from the flotation circuit, which is directed to the flotation tails leaching plant for further processing.

Final concentrates from each circuit are combined and sent to a roasting plant for gold extraction.

A flotation plant survey has been conducted incorporating mineral liberation analysis (MLA) of key processing streams to determine the nature of the particles being recovered at various points around the flotation circuit. This paper presents the findings of tracking the liberated pyrite within the floatable size classes within the flash flotation and rougher column circuits, focussing on the flash flotation cell concentrate and the rougher column concentrate.

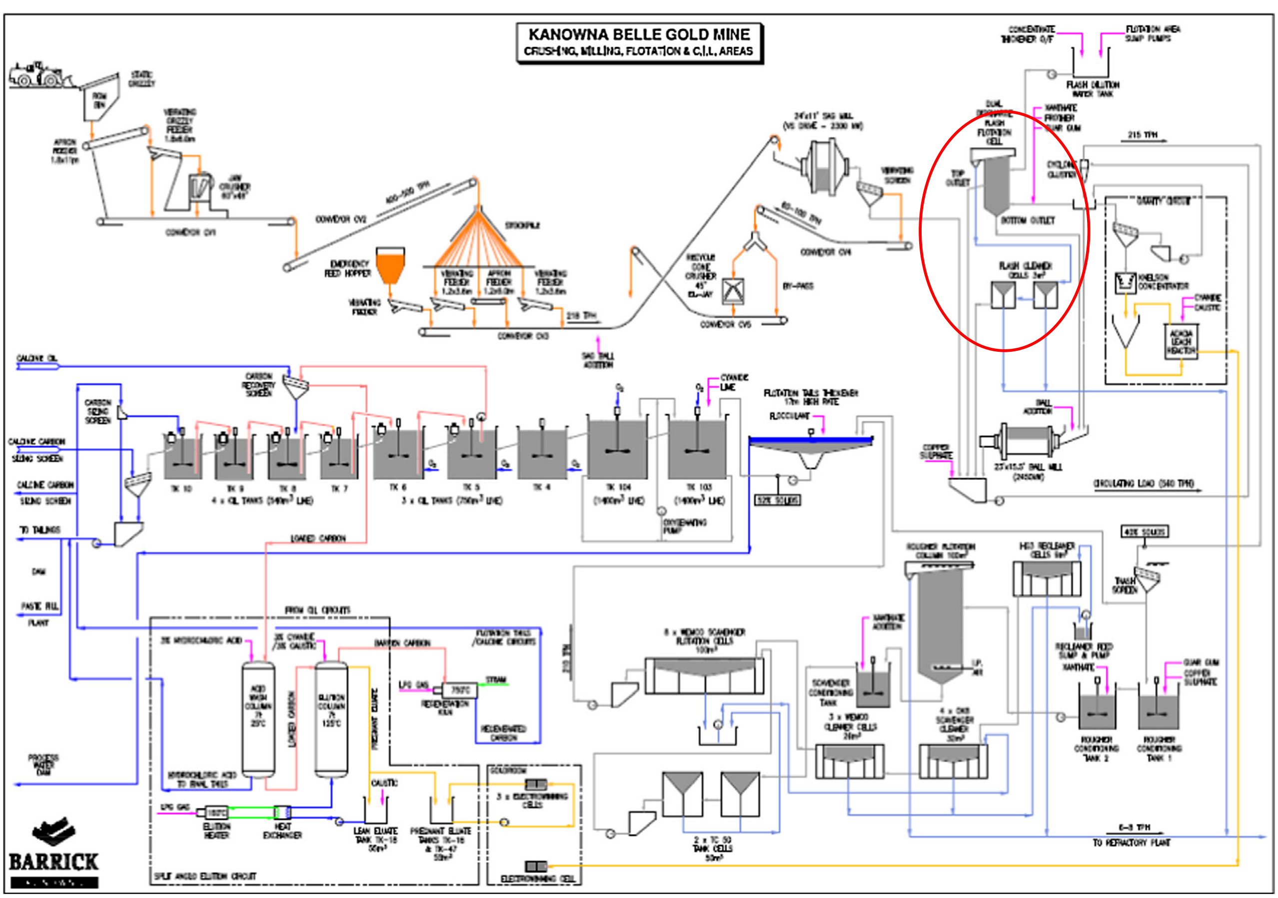

Fig. 1. Kanowna Belle circuit flowsheet (Newcombe, 2014a).