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Water quality effects on flotation: Impacts and control of residual xanthates

Ishamael Muzinda[a,*], Nóra Schreithofer[b]

[a] Department of Chemical and Metallurgical Engineering, School of Chemical Engineering, Aalto University, P.O. Box. 16300, 00076 Aalto, Finland
[b] Department of Bioproducts and Biosystems, School of Chemical Engineering, Aalto University, P.O. Box. 16300, 00076 Aalto, Finland

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ABSTRACT

For increasing the sustainability and cost effectiveness of their operations Boliden Kevitsa Mining Oy in collaboration with academic research partners aims to develop a holistic approach to water management in its mineral processing operation. This paper describes one of the first steps taken in this process, namely the monitoring and control of residual collectors in their flotation circuits.

Boliden Kevitsa Mining Oy, a Cu-Ni-PGE concentrator recycles 90–95% of its water for use in the plant. The quality of recycled water tends to deteriorate as various elements and compounds such as Ca, Na, Mg, K, SO_4^{2-} and residual reagents accumulate. The accumulation shows seasonal cyclic variation that has an impact on flotation performance.

UV/VIS Spectrophotometry was employed to measure residual xanthates in key process streams and process return water from the Tailings Storage Facility. This allowed the implementation of dosage monitoring and control strategy with the objective of performance control and optimization throughout the seasonal changes during the year.

1. Introduction

Conservation and management of freshwater resources is one of the major challenges facing humanity in this century. The mining and mineral processing industries use water in all of their operations, from exploration, through mining and processing to closure. Limited availability of freshwater resources, government regulations, civil actions as well as the corporate sustainability policies and goals, put serious pressure on the mining industry. Therefore some minerals processing operations started evaluating and implementing water recycling to reduce fresh-water intake already in 1970s (Bailey, 1970; Pickett and Joe, 1974), bringing benefits both from cost effectiveness and sustainability points of view.

The quality of the water plays an important role in determining the performance of the flotation process. This has led to significant amount of research initiatives dealing with the impact of water re-use and water quality on flotation. Summaries of the findings have been published by Rao and Finch (1989), Johnson (2003), Liu et al., (2013). There is now a strong push for this aspect to be included in plant design as well.

The quality of water that is reused by recycling it back into the process tends to deteriorate as various inorganic and organic species accumulate in it altering the chemistry of the system. The accumulation of different species can have positive and negative effects as well. Pickett and Joe (1974) have found that water recycling in monometallic or bulk flotation circuits such as the nickel-copper mills in Sudbury area does not cause serious problems. However, this is not the case for multistage circuits where selective flotation needs to be achieved. Residual collectors, such as xanthates and their oxidation products, activators or depressants can cause activation or depression when not desired.

Alkali metal ions such as Ca^{2+} can activate gangue minerals. Sulphate and thiosulphate generated during grinding can increase froth stability and decrease the grade of the concentrate (Biçak et al., 2012; Forssberg and Hallin, 1989; Johnson, 2003; Levay and Schumann, 2006; Rao and Finch, 1989).

Recycling of reagents can lower reagent consumption and therefore costs, however it can also have negative effect causing loss of selectivity between minerals. For example, the oxidation and degradation products of residual xanthates can be surface active, thus their adsorption in mineral surfaces could lead to loss of selectivity between minerals. The kinetics and mechanism of degradation is dependent on the pH and the temperature of the system as well as the residence time and the amount of UV light penetrating the liquid phase (Dautzenberg et al., 1984; Mustafa et al., 2004; Rao and Finch, 1989; Shen et al., 2016).

Research efforts are now focused on developing protocols for conserving water through reuse and recycling (Bridging North to South, 2016; ITERAMS, 2017) without suffering from the negative impacts of such practices whilst amplifying the positive aspects. These efforts

* Corresponding author at: Kalumbila Minerals Limited, Plot 3805, PO Box 230022, Zambia Road, Industrial Area, Ndola, Zambia.
E-mail addresses: ishmael.muzinda@fqml.com (I. Muzinda), nora.schreithofer@aalto.fi (N. Schreithofer).

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amongst others, attempt to tackle the issues related accumulation of inorganic and organic species such flotation reagents that interfere with the optimal operation of the process.

This paper describes the approach we used at the Boliden Kevitsa mine for the monitoring and control of collector concentrations to improve the process performance.

2. Operational and environmental factors affecting process water quality at kevitsa operation

Boliden Kevitsa Mine treats low grade Cu-Ni-PGM ore in a sequential operation, with copper being floated first followed by nickel to produce two concentrates.

At the Boliden Kevitsa plant, water from precipitation, seepage groundwater and raw water from the water dam enters the site water inventory requiring some portion of the inventory to be treated and discharged to maintain the site water balance.

Notable elements that have been observed to accumulate in Kevitsa process water in a seasonal cyclic manner are Ca, Na, Mg, K and SO_4^{2-} and residual reagents i.e. frother and xanthate collectors. The seasonal variation in the water quality is clearly illustrated by the variation in the conductivity of the process water as shown in Fig. 1.

As it can be seen on the graph, the highest conductivity values are always detected in February-March, followed by a sharp decrease in the late spring and summer months. Nevertheless, the graph also shows an overall increase in conductivity values due to the accumulation of ionic constituents over time.

Seasonal variations with extreme winter conditions that prevail in winter have a direct impact on process water quality used at Kevitsa. Process water is reclaimed from the decant pond that forms at the centre of the Tailings Storage Facility (TSF). Inorganic substances and residual reagents are at their lowest in the spring and summer months because of dilution and decomposition especially for xanthate collectors. In summer with abundant sunlight from the long days, higher temperatures and significant water inventory (1.7 Million cubic metres) decomposition of residual xanthate is complete as the residence time in the tailings pond is longer, and the sunlight provides the UV light and elevated temperatures that speed up the decomposition reactions.

In winter, sub-zero temperatures prevail for 5–6 months during which an ice cap forms on the decant pond. Elevated levels of residual reagents are observed in these months due to the formation of an ice cap on the process water pond which locks a significant amount of the decant pond inventory into the ice thus short circuiting the freshly deposited water to the decant pumps. With reduced residence time, lack of UV light and low temperatures in the dark and cold winter months to aid decomposition, more reagents and unsettled tailings are recycled back into the process with the water, which affects the flotation circuit performance. Additional to lack of UV, xanthate decomposition rate reduces with increase in pH and reduction in temperature (Mustafa et al., 2004). With final tails deposited at the Tailings Storage Facility (TSF) averaging pH 9.5 and sub-zero temperatures in the winter, xanthate decomposition in the TSF decant pond is severely inhibited.

Therefore the need to control the xanthate concentrations in the process was recognised earlier, however the systematic monitoring, evaluation and adjustment of xanthate dosages to suit the particular ore blend was only introduced in early 2017.

3. Water recirculation and process performance

Kevitsa water recycling rate ranges from 86% to 97% and the variation is driven by the amount of fresh raw water entering the site inventory for treatment to provide potable water and for mill motor cooling system heat exchangers. With potable water consumption being constant, the mill cooling water is the main variant and thus the recycling rate is dependent on this.

For purposes of evaluating circuit performance KPIs and operational conditions' relation to the amount of recycling taking place, the 'Water Intensity' parameter was derived. Water intensity in this case is simply the amount of fresh water taken into the inventory per day divided by the milled tonnage for that day, in other words, higher water intensity means more freshwater intake into the process. Plotting recycling rate against water intensity gave a linear relationship as shown in Fig. 2.

The period following commissioning and achievement of commercial production, the flotation performance of the plant varied significantly with changes in seasons. The circuit being a sequential Cu-Ni flotation requires limiting the flotation of Ni into the Cu concentrate. This is achieved by using a Cu selective collector (Aerophine) and high pH in the final cleaning stage. In winter recycling rates are at their

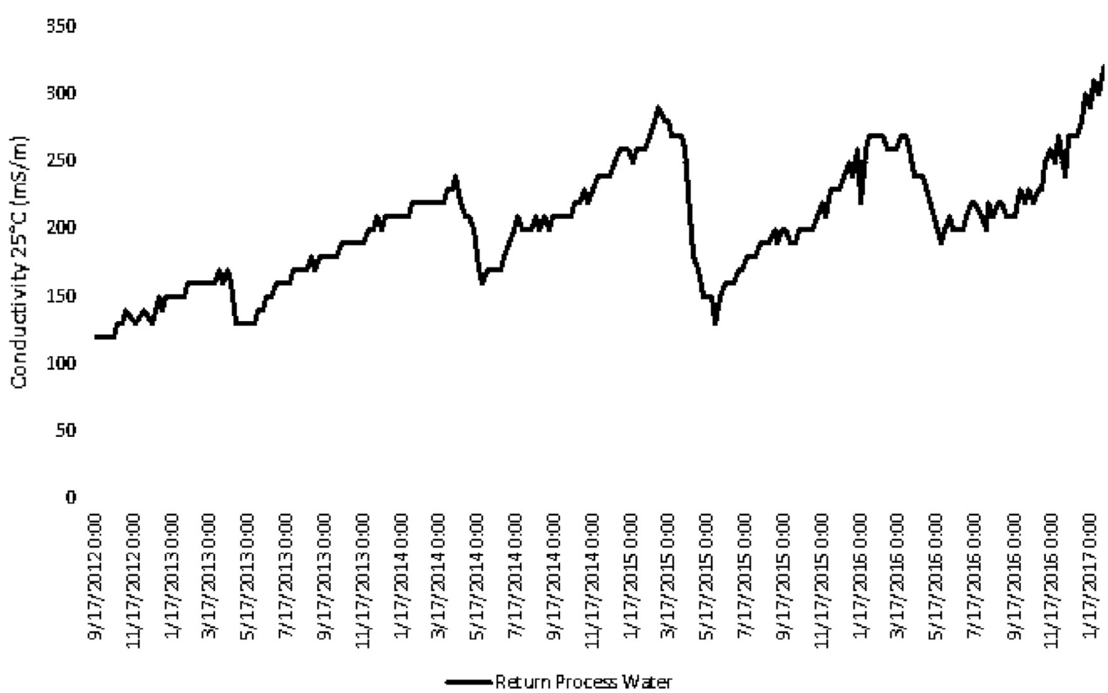

Fig. 1. Seasonal variation in Kevitsa process water conductivity between 2012 and 2017.