



Short communication

Improvements in gold ore cyanidation by pre-oxidation with hydrogen peroxide



Thiago Oliveira Nunan^a, Isabella Lima Viana^a, Guilherme C. Peixoto^a, Herbert Ernesto^a, Daniel Martin Verster^b, Jose Henrique Pereira^c, Jose M. Bonfatti^c, Luiz Alberto Cesar Teixeira^{c,d,*}

^a Mineração Serra Grande (Anglo Gold Ashanti), Brazil

^b Postnet Suite 250, Private Bag H607, Boschfontein, Heidelberg, Gauteng 1438, South Africa

^c Peroxidos do Brasil Ltda (Solvay Group), Brazil

^d Pontifícia Universidade Católica do Rio de Janeiro, Departamento de Eng. Química e de Materiais, Rua Marques de Sao Vicente, 225 – sala L 501, CEP 22451-000 Rio de Janeiro, RJ, Brazil

ARTICLE INFO

Article history:

Received 29 September 2016

Revised 5 January 2017

Accepted 17 January 2017

Keywords:

Pre-oxidation in gold cyanidation

Gold recovery

Cyanide consumption

Hydrogen peroxide

ABSTRACT

It is known that the presence of sulphidic minerals in the cyanidation of gold ores may cause significant consumption of oxygen supplied in the injected air. This may result in dissolved oxygen starvation for the oxidative leaching of the gold, and ultimately it will reduce the maximum attainable recovery of gold from the ore. In addition, the presence of sulphides leads to extra consumption of the cyanide-leaching agent, NaCN, due to the formation of thiocyanate, therefore increasing costs. These types of gold sulphidic ores may be pre-treated prior to cyanidation by means of an oxidation step, converting the sulphides into oxides or sulphates. This treatment leads to a reduction in the consumption of dissolved oxygen and of cyanide in the cyanidation step and to an improvement in the metallurgical recovery. In the current work we present the results of a five month full-scale trial carried out in a gold extraction plant in Brazil, which normally operated with three tanks in series carrying out an alkaline pre-oxidation step using compressed air only, followed by a train of fourteen aerated and mechanically-agitated tanks for the cyanidation. The ore feeding the leaching circuit averages 1.70 g Au/t, with about 2.5% of pyrrhotite (FeS) as the main sulphide constituent. The addition of 60 L/h of concentrated hydrogen peroxide, H₂O₂, 50% w/w (density = 1.19 g/mL) for pre-oxidation of a slurry of 60% solids at a rate of 150 t/h (dry ore) resulted in a marked increase in dissolved oxygen (DO). This addition corresponds to a dosing rate of 0.24 kg 100% H₂O₂ per ton of dry ore and increased the dissolved oxygen level from an average of about 1.0 to 7.2 mg/L in the pre-oxidation tanks. It also led to an overall reduction of NaCN consumption from an average of 0.52 to 0.40 kg/t of ore, and an increase in metallurgical Au recovery from an average of 91.3% to 92.5%.

© 2017 Elsevier Ltd. All rights reserved.

1. Introduction

For several years the performance of the hydrometallurgical circuit at AngloGold Ashanti's Serra Grande's gold extraction plant in the state of Goiás, Brazil, indicated that improvements could occur in the recovery of gold, associated with the leaching kinetics.

Additional tanks were installed in 2009 to expand the circuit. But in some of the ores to be leached the residence time in the circuit was not yet sufficiently long to recover all leachable gold from the ore on a regular basis. In previous internal studies it was found that up to 30% of gold reporting in the tailings was still leachable and wasn't being recovered due to process kinetics, specifically due to low concentration of dissolved oxygen in the slurry in the initial tanks of the cyanidation train.

The leaching circuit comprises an initial three-tanks-in-series alkaline pre-oxidation step using only compressed air and lime, followed by a train of fourteen aerated and mechanically-agitated tanks for cyanidation. The ore feeding the leaching circuit averages 1.70 g Au/t and the main oxygen-consuming component is the sulphide mineral pyrrhotite (FeS) at about 2.5% w/w.

* Corresponding author at: Pontifícia Universidade Católica do Rio de Janeiro, Departamento de Eng. Química e de Materiais, Rua Marques de Sao Vicente, 225 – sala L 501, CEP 22451-000 Rio de Janeiro, RJ, Brazil.

E-mail addresses: TONunan@AngloGoldAshanti.com.br (T.O. Nunan), ILViana@AngloGoldAshanti.com.br (I.L. Viana), GCPeixoto@AngloGoldAshanti.com.br (G.C. Peixoto), HErnesto@AngloGoldAshanti.com.br (H. Ernesto), martin.verster01@gmail.com (D.M. Verster), Jose-Henrique.Pereira@solway.com (J.H. Pereira), Jose.Bonfatti@solway.com (J.M. Bonfatti), teixeira@puc-rio.br (L.A. Cesar Teixeira).

Usually the kind of gold ores containing sulphidic minerals – depending on the sulphide content and mineralogy – can be pre-treated by oxidation steps prior to cyanidation, converting the sulphides to oxides or sulphates, in some cases enhancing the opening up of the ore. Experts in the field propose that pre-oxidation is used for two reasons: (i) to oxidize and breakdown sulphide minerals to expose encapsulated gold; and (ii) to passivate the sulphide minerals by oxidizing the surface and thus making them less reactive in the cyanidation process. Pre-oxidation generally comprises the alternatives (Li et al., 2006): bio-oxidation (Amankwah et al., 2005; Ubaldini et al., 2000; Muravyov and Bulaev, 2013); chemical oxidation with O₂ enriched air, high pressure, and/or lead nitrate (Deschênes and Wallingford, 1995; Deschênes et al., 2009); hydrogen peroxide (Karimi et al., 2010); and high temperature roasting. Pre-treatment basically aims at improving oxygenation along the cyanidation circuit, increasing metallurgical recovery and reducing consumption of the cyanide-leaching agent. Each of the pre-treatment process options has its applicability, depending on the efficiency, capital investment and operating costs.

Previous experience in other gold extraction plants indicated the possibility of the use of hydrogen peroxide (H₂O₂) for the purpose of pre-oxidation. AngloGold Ashanti's Siguri plant in Guinea introduced oxygen supplementation via H₂O₂ injection in the cyanidation circuit, and that resulted in an improvement in overall plant gold recovery from ~90% to ~94% (Verster, 2016). In general, the supplementation of dissolved O₂ by injection of pure O₂ could also be considered for this type of situation. This was in fact initially tried in an industrial trial, but results were not as expected.

The strategy for developing the work began with preliminary lab trials (not reported here) with the aim of determining the rate of H₂O₂ consumption that would be necessary to meet the O₂ uptake by the slurry. Once the feed rate of hydrogen peroxide to the continuous process was established, the project moved ahead to the stage of running an industrial scale trial. A dosing system was assembled consisting of a centrifugal pump for delivering hydrogen peroxide diluted with water on a 1–10 ratio, for fast and efficient mixing of the oxidant into the slurry at each of the three pre-oxidation tanks.

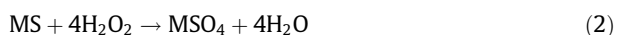
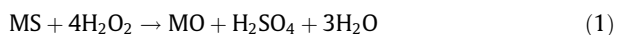
The present work describes the conditions employed and reports the results obtained from the cyanidation, following the pre-oxidation of the gold ore slurry with hydrogen peroxide.

1.1. Hydrogen peroxide for oxidative pre-treatment prior to cyanidation

Hydrogen peroxide (H₂O₂) has been used for many years in gold and silver extraction plants, mainly for: effluent detoxification/neutralization of spent heaps (Botz et al., 2005; Breuer et al., 2010; Kitis et al., 2005)/washing of residual NaCN from waste big-bags; oxidation in intensive cyanidation (Longley et al., 2003); and enhanced oxidation in conventional cyanidation.

H₂O₂ has the following relevant features:

- (1) It is an aqueous liquid oxidant with a standard redox potential ($E_0^H = 1.8$ V), higher than that of O₂ (1.2 V).
- (2) As an oxidant, it is able to oxidize sulphides to form oxides or sulphates, as exemplified in reactions (1) and (2).



- (3) It is a non-persistent chemical in water, wastewater and process solutions – it decomposes spontaneously into water and oxygen:



- (4) Decomposition reaction (3) is catalysed by suspended solids and/or aqueous transition metal ions, such as Fe or Cu.
- (5) For the possible use on pre-oxidation of ore containing sulphides, both the direct oxidation of the sulphides and the reaction driven by the O₂ generated by decomposition of H₂O₂ are useful possible mechanisms.

2. Methodology and pre-industrial trial results

2.1. Survey of process parameters before the H₂O₂ pre-oxidation trial

For a period of 5 days the ore that feeds the leaching circuit was sampled and characterized for mineralogical composition and tested for the determination of the oxygen uptake rate. In addition, measurements of dissolved oxygen (DO) and free cyanide concentration (as NaCN) along the cyanidation train were conducted, and auditing of NaCN consumption was carried out as usual.

Analytical measurements before and during the trial were performed as follows: DO was determined using a Metrohm dissolved oxygen probe; pH was measured by a Hanna pH-meter; Oxygen uptake measurements (for the calculation of the hydrogen peroxide equivalent doses) were carried out with a modified, portable O₂-uptake device assembled by Verster (2016); free cyanide in solution was determined by a portable Mintek Cyanoprobe instrument, as well as by titration with AgNO₃; Au in solution was determined by atomic absorption spectroscopy using Perkin-Elmer equipment. Probes and equipment were used along with ordinary calibration procedures, according to the manufacturer's specifications. It was observed that the addition of H₂O₂ to the pulp caused only a slight reduction in pH at the end of the pre-oxidation time (less than 0.3 pH units). In the industrial trial it was compensated for by a slight increase in lime dosage, to ensure that the pH remained at 10.5.

The results of these analyses led to setting the operating range of the H₂O₂ feed.

2.2. Dissolved oxygen (DO) and [NaCN] profiles

During the five day monitoring of the cyanidation plant parameters, measurements of DO and of the concentration of free cyanide (expressed as NaCN) in each of the tanks of the leaching train were performed. Tanks 1, 2 and 3 are pre-oxidation only tanks, and tanks 4–14 are for cyanidation (with NaCN introduced only in Tank 4). The results indicated that the DO profile could be described as “very low” (fluctuating around 0.5–1.0 ppm in the pre-oxidation tanks 1–3, and 1.4 ppm in the first cyanidation tank (Tank 4)). The free NaCN profile was seen as “normal” (averaging 250–400 ppm in the first cyanidation tank of the train (Tank 4)). The pH of the slurry in tanks 1–3 was controlled by the addition of lime at around 10.5 ± 0.3 pH units. The very low DO values in the pre-oxidation tanks 1, 2 and 3 were all less than 1.0 ppm, well below saturation, indicating insufficient oxidation in these tanks.

2.3. Industrial trial settings

The method of H₂O₂ supply consisted of pumping a 50% hydrogen peroxide solution, diluted 10 times with water, into the alkaline pre-oxidation tanks (tanks 1, 2 and 3), using a dosing skid equipped with a centrifugal pump and a flow meter. Peroxide dilution with water was carried out in the main feed pipe, and it was split equally into the three in-series pre-oxidation tanks.

A schedule was set up for the monitoring of the following parameters, for each shift: flow rate of hydrogen peroxide

Download English Version:

<https://daneshyari.com/en/article/4910198>

Download Persian Version:

<https://daneshyari.com/article/4910198>

[Daneshyari.com](https://daneshyari.com)