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The Effect of Cyanide Concentration and Grinding Time in Tailings on %Extraction at PT. Agincourt Resources

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Abstract

This study aims to analyze the effect of cyanide concentration and ore grinding on the extraction of gold and silver. The tests were conducted on three different samples, including samples without grinding and samples with grinding sized untill 75 µm. The results of the Atomic Absorption Spectroscopy (AAS) test showed that gold content decreased in all samples, while silver content tended to increase. For the Grinding Time test used to achieve a P80 particle size (where 80% of particles pass through a sieve at certain size), it was found that the optimal time to reach 75 µm was 18 minutes and 65 seconds. Silver extraction increased with the addition of cyanide concentration up to 1000 ppm and grinding untill 75 µm, while gold extraction remained insignificant (0%). This is likely due to the short duration of the test, which only for 2 hours using the bottle roller test method. For future tests, it is recommended to use a stir leach or magnetic stirrer with longer duration of stirring time and better control of oxygen and pH levels. The test results showed that the percentage of silver extraction was 0,82%, 3,23%, and 3,28%, respectively, while the percentage of gold extraction was 0%. The AAS test revealed that gold content ranged from 0,001 g/t to 0,003 g/t, while silver content ranged from 0,322 g/t to 0,559 g/t. The most influential parameters for increasing silver extraction were ore size reduction and the addition of cyanide concentration.

Keywords: Bottle Roller Test, Gold, % Extraction, Extractive Metallurgy

Introduction

At PT. Agincourt Resources, the gold processing process carried out by the Agitation Leach method. The Agitation Leach process includes selective dissolution of gold and silver using chemical reagents such as sodium cyanide. Agitation Leach is carried out through agitation and air or mechanically using an agitator (Alguacil, 2006). As one of the most important precious metals, gold is not only used as ornaments or currency but also has an important role in electronic devices, computers and aerospace.

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To fulfill the needed of gold, an extraction process is required. Gold is non-toxic, stable in the leaching process, and oxidation resistance (Zhang et al., 2023).

There are many other reagents that can be used in gold extraction apart from cyanide, namely chloride, mercury or sulfur which are generally very aggressive and toxic. Currently, industrial gold recovery is very challenging because high grade gold ore is very rare. So the industry has to use low grade and poor quality ore (Birich et al., 2019). Cyanide consumption in the extraction process is a major economic cost in extracting gold. Disposal of cyanide waste can cause very significant environmental pollution so estimating cyanide consumption is very important (Kianinia et al., 2018).

Cyanide waste or also called tailings which still contain free cyanide can be processed into by-products in metallurgical processes. The cyanide detoxification process is also needed to reduce the tailings to become harmless and non-toxic before being released into the environment (Hou et al., 2020). Cyanidation is the main extraction process in the gold industry and has been applied in more than 80% of gold mines in the world. One of the main factors is also the leaching rate. Generally, gold leaching is an electrochemical process through anodic dissolution and cathode reduction with oxygen (Y. Yang et al., 2019). Gold leach with cyanide often involves increasing cyanide concentrations to produce higher leaching levels but can result in safety risks and increase waste handling costs (Zheng et al., 2023).

Tailings or waste resulting from the leaching process often still contain gold which is difficult to recover. Cyanide waste is residual cyanide that still reacts with sulfide and forms a passivation layer (W. Yang et al., 2023). Factors that influence the level of gold leaching include particle size, cyanide concentration, dissolved oxygen, pH, percent solid, and leaching time. These parameters are very important and must be optimized through laboratory testing (Shi, 2024). Cyanidation of copper-gold ore can result in the loss of soluble gold, the cyanide product is separated by weak acid (WAD) (Oraby & Eksteen, 2015). Although oxygen is needed in leaching gold with cyanide, its low solubility in water can cause drawbacks in its application. Therefore hydrogen peroxide needs to be added(Fungene et al., 2018).

Adsorption tests (CIL/CIP, RIL/RIP) need to be carried out to ensure selective recovery of gold and silver from pregnant leach solutions obtained from high temperature burning or calcination processes (Albert MSUMANGE et al., 2023). The method of leaching gold with cyanide is very dangerous for the environment and also the operator. The leaching methods that are quite environmentally friendly and are still being developed are thiourea leaching, halide leaching and sulfate leaching (Ji et al., 2023). Copper dissolved in cyanide can cause increased cyanide consumption. Significant levels of weak acid separable cyanide (WAD) can be detoxified prior to tailings disposal (Oraby & Eksteen, 2016). Processing high sulfide gold ore has problems because it can consume excess cyanide and reduce the efficiency of gold leaching (Kianinia et al., 2019).

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The cyanidation process has been used in gold production for more than 130 years due to its selectivity and suitability in the mining industry. The gold industry is always adapting its methods to more efficient processes and technology (Medina & Anderson, 2020). A good and correct gold leaching process is adjusted to appropriate mineralogy, chemical requirements, leaching techniques, flow diagrams and environmental management (Sparrow & Woodcock, 1995). Cyanide leaching is the main process for large-scale gold extraction. The use of cyanide has reduced the use of mercury in small-scale and traditional mining (Brüger et al., 2018). In the past, artisan mining used mercury to extract gold with cyanide but the yield percentage was low, namely only 40% (Sabara et al., 2018). Dissolution using mercury to release gold with Hg content produces waste that is very dangerous for the environment, health and operations (Kantarcı & Alp, 2023).

The Au content in the tailings on the lounder after leaching process still has the possibility to be extracted again through certain treatments. The purpose of this test is to determine the effect of cyanide concentration, grinding time, and ore particle size on the percentage of tailings extraction from the leaching process. In conducting several of these tests of course testwork is needed to help obtain data. At PT Agincourt Resources, one of the testworks used is the Bottle Roller Test (BRT).

Research methods

The testing process is carried out by comparing the Au content in each sample with other samples that have been reduced in size to 75µm and using 1000 ppm cyanide concentration. The samples that will be used are extended as is samples which are ordinary samples without any treatment or changes before being continued with the Bottle Roller Test, extended high cyanide 1000 ppm samples, two extended high cyanide 1000 ppm samples that have been re-grind to reach P80, which is 75 µm.

Extended as is generally used as quality control in companies to ensure process efficiency and ensure no wasted gold. The tools that will be used in this test are a small bucket, scoop, bottle roller, filter press, pH meter, scales, and DO meter, while the materials to be used are hydrogen peroxide, lime and also NaCN. The flow of the test process can be seen in Figure 1.

Results and Discussion

Based on the tests that have been carried out, it was found that with the increasing concentration of cyanide, the levels of gold or silver in the solution or solution being tested tend to be different. In the results of AAS testing with three different samples, the gold content decreased both in the test samples without grinding up to 75 µm and with grinding 75 µm. However, in the results of the AAS testing of the three samples, the silver content tended to increase. The results of these tests can be seen in Table 1 and Table 2.

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Figure 1 Research flow diagram

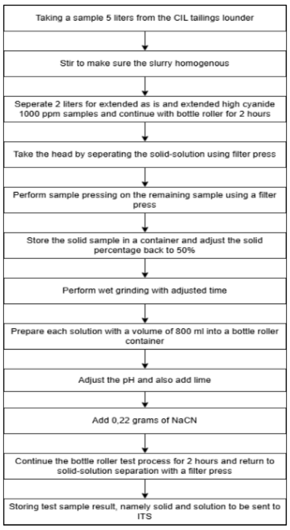

Table 1 AAS Au Test Results

No.	Sample	Au (g/t)
1	as is	0.003
2	CN 1000 ppm	0.002
3	CN 1000 ppm + 75 µm	0.001
4	CN 1000 ppm + 75 µm	0.001

Table 2 AAS Ag Test Results

No.	Sample	Ag (g/t)
1	as is	0.322
2	CN 1000 ppm	0.525
3	CN 1000 ppm + 75 µm	0.559
4	CN 1000 ppm + 75 µm	0.532

In the calculation of Grinding Time, namely to obtain P80 or the number of ore particle sizes where 80% number of samples can pass through a sieve with a certain size, the results obtained where the grinding time required to obtain a size of 75 µm is around 20 minutes, and if viewed directly using the line equation, the most optimal grinding time is 18 minutes 65 seconds. The graph of the relationship between time and % passing 75 µm can be seen in Figure 2.

The calculation of % extraction that has also been obtained shows that the effect of cyanide concentration, grinding time and ore particle size only has a significant effect on increasing % silver extraction and there is no increase at all in % gold extraction. This

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is likely because the time used in the bottle roller test is quite short, which is only 2 hours and for subsequent testing can be done with a magnetic stirrer or stir leach with a longer stirring time. In this test, oxygen and pH can be controlled properly so that it provides more accurate results. The graph of % extraction from all samples that have been tested can be seen in Figure 3.

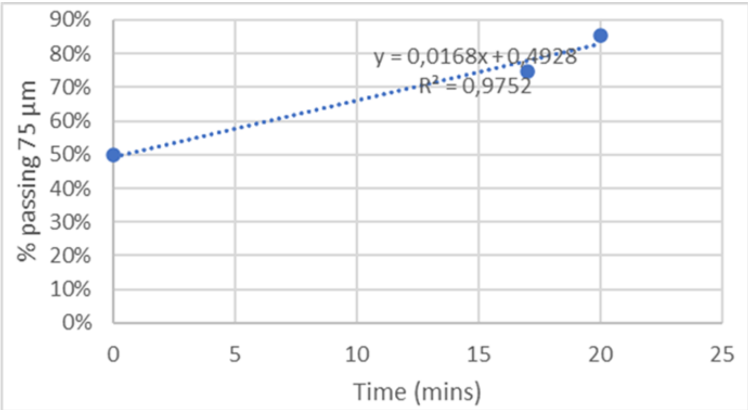

Figure 2 Time vs % passing graph 75 µm

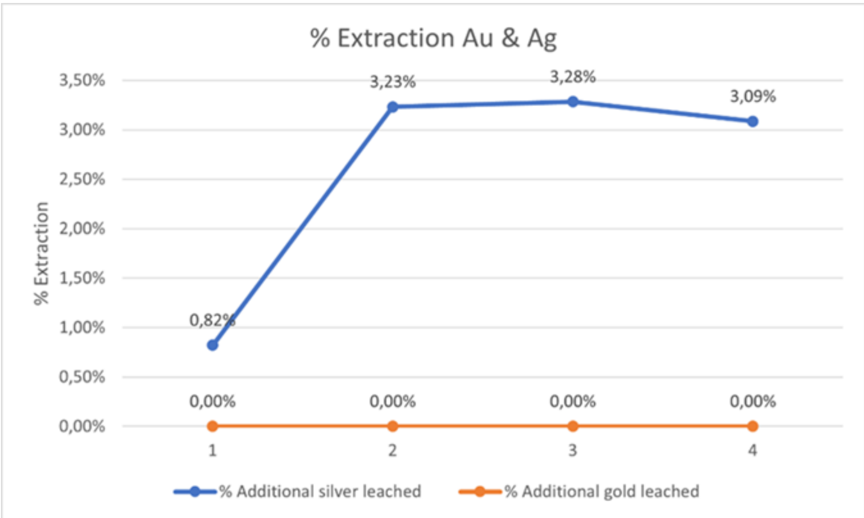

Figure 3 %Au Vs Ag Extraction

The calculation of % extraction can be obtained from the formula in equation 1:

$$\%Extraction = (Metal\ In\ Feed - Metal\ In\ Tail) / Metal\ In\ Feed \quad (1)$$

In the test, 4 different conditions were carried out, namely as is as a control, conditions of adding cyanide concentration up to 1000 ppm, and conditions of adding cyanide concentration with grinding up to 75 µm. Through Figure 3, it can be seen that there is no effect on gold, but an increase occurs in silver from the condition of adding 1000 ppm cyanide and grinding up to 75 µm so that it is obtained that the

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parameters that greatly affect the test are ore size reduction and cyanide concentration.

Conclusion

As for the conclusions and suggestions obtained through the tests that have been carried out, several results were obtained, namely:

1. The percentage of silver extraction tends to be higher compared to gold in the testing of the three samples with increasing cyanide concentration and size reduction to 75 µm.
2. Testing using the bottle roller test with a stirring time of 2 hours still does not provide accurate results.
3. The percentage of gold extraction obtained was 0%.
4. Some conditions in this test are as is as a control, conditions of adding cyanide concentration up to 1000 ppm, and conditions of adding cyanide concentration with grinding up to 75 µm.
5. The percentage of silver extraction obtained respectively were 0.82%, 3.23% and 3.28%.
6. Through the AAS test results, the Au content was obtained respectively at 0.003 g/t, 0.002 g/t, 0.001 g/t and 0.001 g/t and the Ag content was respectively at 0.322 g/t, 0.525 g/t, 0.559 g/t, and 0.532 g/t.

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