

Factors affecting Gold Recovery from Secondary Ore

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Abstract — The basis of this study is that significant amounts of gold exist even in the mass regarded as tailings from earlier gold processing steps. The cyanide concentration, residence time and lixiviant pH have a significant effect on the leaching efficiency of gold. Therefore in this work, effort has been directed towards investigating these factors affecting gold recovery from very low grade ore assaying as low as 0.4 g/t. A 20 kg soil sample was pulped to a 54% solid content by 17 L of water, and at room temperature allowed to leach for 24 hrs. at a pH of 11 and cyanide concentration of 0.056 M. More than 80% of the material passed the 150µm while leaching for an extra 24 hrs. only proved to have a 2% increase in gold recovered.

Index Terms— Arsenic, Baghouse dust, Leaching, Smelting.

I. INTRODUCTION

GOLD is a remarkably precious, ductile and malleable metal which is in high demand in jewellery, medical and high-tech industries. The growing demands of gold necessitate efforts towards optimizing the gold yield from gold concentration processes with particular emphasis on recovery from gold tailings [1].

One of the major environmental problem associated with gold mining is acid mine drainage. This occurs when large volumes of sulphides end up going into the tailings, and becomes oxidized as they are exposed to wind, rain and snow as well as temperature changes thereby creating sulphuric acid. Upon mixing with rainwater the sulphuric acid drains its way out of the tailings and into the waterways, where it can change the pH of the water and precipitate as heavy rains. Therefore, there is a great need to for further processing of the tailing dump.

Manuscript received April 7, 2014.

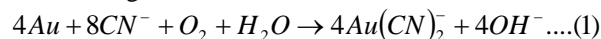
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Restrictions imposed on waste disposal and stringent environmental regulations demand economical viable and eco-friendly technologies [2]. The process of recovery makes sense only if the cost of the recovery is much less than the value of the precious metal. Mechanical separation, pyrometallurgical, hydrometallurgical, and bio-hydrometallurgical technologies have been extensively used to recover gold from secondary sources [3].

Gold has mostly been leached out from ores, secondary sources and gold containing spent materials by cyanidation [3], [4]. The hydrometallurgical process has been utilized more often than the pyro-metallurgical process. Pyrometallurgical processing, including incineration and smelting in a furnace or blast furnace at high temperatures has become a traditional method to recover gold from ores and electronic wastes in the past two decades. Compared with these processes, the hydrometallurgical method is more exact, predictable, and more easily controlled [5].

The basis of this study is that the recovery of gold is greatly affected by the process parameters considered in the hydrometallurgical route. Cyanide is used as the lixiviant and it targets the gold that is inevitably associated with the gangue materials. The increase in cyanide concentration would forthright see the increase in dissolution of the gold up to an extent where-by the concentration will only be competing internally and this results in the objective not being met. The balance in salts and acids creates a medium that is conducive for the reaction of gold-cyanide complex formation being favoured.



The rate at which a desired reaction occurs has got a direct effect on the production quality, thus optimum time is allowed for such a reaction to occur per given amount of reaction mass and grade of gold.

II. PROCEDURE

A sieve analysis of the soil sample was done through apertures of (212, 150, 75 and 53) µm to determine the particle size distribution of the sample, the grades used were 0.40, 0.43, 0.44 and 0.45 g/t respectively, prior to being mixed with 17 L of water to make a pulp of 54% solids.

A 20 kg soil sample was obtained from the large dry sample by using the coning and quartering technique. The pulp was mixed in a laboratory leach tank which consisted of a 4 blade agitator connected at the top so as to stir the mixture.

Small cyanide granules of 5g were dissolved in a beaker of 20 mL of water so as to assist the dissolving of the lixiviant into the pulp. The concentration of cyanide [CN⁻] was determined through titrations of a filtered clear 25 mL solution from the pulp in the leach tank with Silver Nitrate (AgNO₃) used as the titrant and 2 drops of Potassium Nitrate (KI) as the indicator.

A sample of lime was also weighed and prepared for the leaching experiment. The masses used were (8, 12, 24 and 36) g for different pH levels and also different samples displayed different stabilities in the procedures. However before each leach experiment, the pH of the soil was determined so as to classify it as basic or acidic

Samples were also obtained from the process plant from the hydrocyclone tri-streams, that is, the feed, overflow and underflow. The overflow represents the material that is in the finer region, whereas the underflow is that in coarser region. The samples obtained were dried in an oven and weighed, and then put into sample bags, these samples were sent for assaying to determine the grade of gold in each of the tri-streams.

III. RESULTS

The samples leached needed a minimum of 5 g of cyanide to make a minimum concentration of 0.048M, this concentration had been shown to be effective from a kinetics study on similar gold recovery [5]. A basic medium was used, with a minimum pH of 9, and the least time used for the leaching was 7 Hrs. with a maximum of 48 Hrs.

As three parameters were being studied, a single parameter was varied while other two were kept constant. An example is that of leaching at [CN⁻] 0.048M, pH = 9 and thereby varying the residence time as (7, 12, 24 and 48) Hrs. respectively. In doing so, a very small recovery was obtained at a time of 7 Hrs. regarding that a low grade ore was being used, as well as obeying the kinetics theorem, not much dissolution had taken place. However at a pH of 11, [CN⁻] 0.056M and residence time of 24 hours, much higher values of Gold (Au) were attained.

Figure 1 shows the dependence of gold recovery on the residence time allowed for a reaction. Each plot is a representation, of the range in which, with the available data, the gold could have been recovered.

Figure 2 shows the dependence of gold recovery on changing pH values while other parameters are kept constant.

Figure 3 shows the dependence of gold recovery on changing [CN⁻] values while other parameters are kept constant.

Figure 4 shows the different grades obtained in the Hydrocyclone tri-streams.

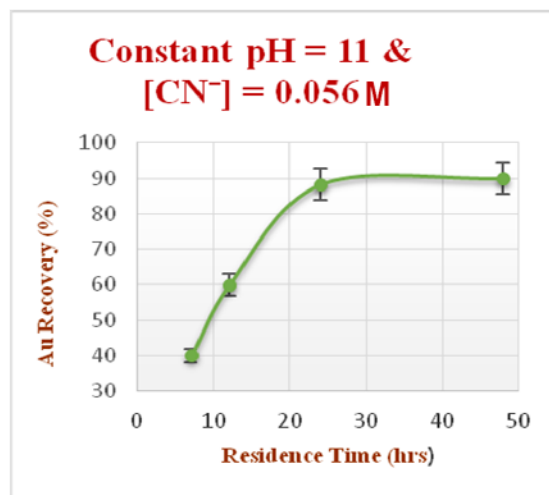


Figure 1: Au recovery dependence on residence time.

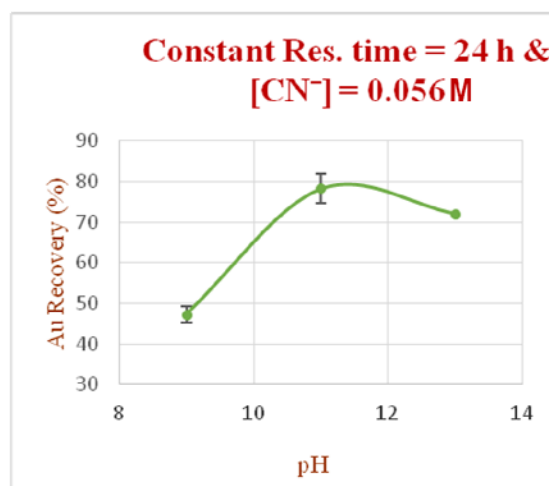


Figure 2: Au recovery dependence on pH.

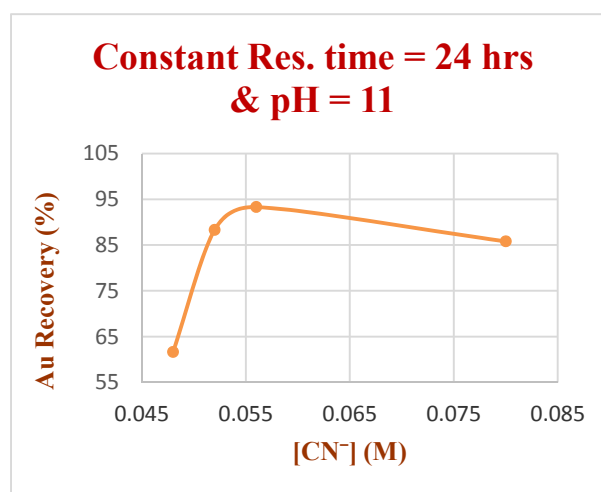


Figure 3: Au recovery dependence on [CN⁻].

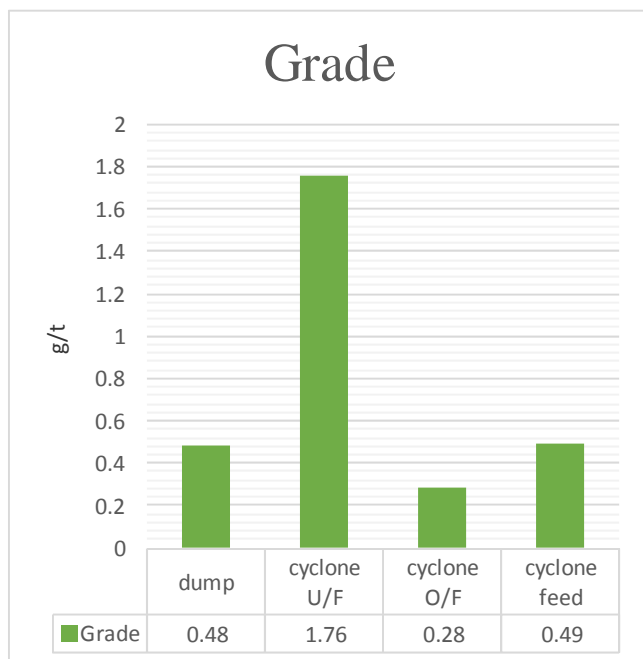


Figure 4: Hydrocyclone tri-streams Au grade

IV. DISCUSSION

Secondary processing usually means that the mass presented for processing is a bit tedious than that of initial processing. A relationship exists between grade and recovery that depicts an inverse association. The higher the grade, the lower the recovery. The amount of lixiviant presented to the mass of sample will have an inevitable direct effect on the recovery, while other parameters are held constant. The reaction kinetics follow the manner depicted in Figure 5;

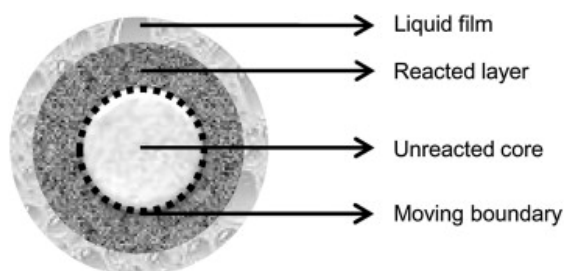


Figure 5: Shrinking core model.

The higher the concentration of the lixiviant, the faster reaction (1) will occur, that is, formation of $Au[CN]_2^-$ complex. However as it is evident that has the unreacted core depletes, the excess cyanide are left unreacted, and this will only mean that the rate of reaction will decrease. Therefore a cyanide concentration of 0.056M has shown to be an optimum concentration for high recovery, as shown in Figure 3.

As the sample used was from a tailings dump, it means that it was once extracted of its value earlier; therefore ample time must be given to the reaction to allow for the lixiviant to penetrate that unreacted core as it will definitely exist on the target material. Figure 1 shows that higher values are

shown to exist after 24 Hrs. of leaching, whereas a further 24 Hrs. increase will only increase insignificantly or in some circumstances actually decrease recovery.

Most samples gave acidic pH readings, therefore a conditioning with the lime was vital in order to make the conditions conducive for reaction (1) to occur, which is the major objective of this work.

The hydrocyclone grabbing gave an understanding of the nature of the different streams and to be able to point out which stream contains most of the gold. Along with the particle size analysis, the most gold was seen in the finer sized ore.

V. CONCLUSION

Cyanide was used to leach gold out of the gangue material. The sample worked on was a very low grade ore, for other minerals it is considered as an outright tailing value, however because it is gold, there is much room for that value to be considered as ore. The valuable material is readily not available in that low grade ore, therefore ample time must be allocated to that reaction and also the lixiviant concentration should be relatively higher so as to penetrate that unreacted core. Highest recoveries were obtained at $[CN^-]$ 0.056M, pH 11 and a residence time of 48 Hrs. at room temperature and pressure.

For the reaction to be accelerated the movement of the lixiviant can be accelerated by an increase in agitator speed, this however will have an upper limit and any further increase of the agitation speed above the upper limit will affect the gold recovery. Further investigations are necessary in order to determine other parameters affecting the rate of gold recovery, for example dissolved oxygen or dosed hydrogen peroxide in the leaching media.

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