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VIBRO ASSISTED CEMENTATION OF GOLD ONTO ZINC GRANULES

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ABSTRACT: Cementation of gold complexes onto zinc granules instead of dust was studied in a dynamically modified system, i e. by the use of vibrations. It was shown that recoveries and kinetics were improved substantially for both the test systems used - lean and high grade solutions Efforts were made to evaluate the influence of the foreign ions addition on the degree of cementation Two type of cementators were tested - column and bed type and compared for their efficiency.

1. INTRODUCTION

Two common processes for gold and silver recovery from pregnant hydrometallurgical solutions are the carbon adsorption process and the Merrill-Crowe dust cementation. Carbon adsorption processes have been quite fashionable with many plant installations Also many researchers are looking at solvent extraction or ion exchange as process alternatives (Prasad et al, 1991). However, the conventional Merrill-Crowe process is still efficient especially for large tonnage and low grade solutions produced by liquid solid separations of leached pulps As a precipitating media for the gold, zinc shavings were originally suggested by McArthur in 1890 as part of the cyanide process The efficiency of zinc precipitation was greatly improved by the introduction of soluble lead salts in conjunction with the zinc to produce a lead-zinc couple From 1911 onward zinc shavings were gradually superseded by zinc dust which offered a greater surface area per unit mass. Although the initial consumption of zinc dust was high due to oxidizing side reactions, the development of Merrill-Crowe process with vacuum de-aeration of solution prior to precipitation greatly improved the economics and efficiency of the process (Stanley 1987) However, despite of the advanced modifications, both in technological and in instrumentation aspects, many problems stili remain, and the main ones often are associated with forecasting the exact stoichiometric amount of zinc required and the excessive dust surface causing problems with the following solid liquid separation This concern has stimulated the presented research which has turned back to "re-invention" of the original approach suggested by McArthur, i e to use zinc granules instead of dust, however with application of additional dynamic vibrational impacts Similar approach has been suggested by the German company KHD (Esna-Ashari et al, 1982), however directed towards zinc solution purification As regards gold cementation assisted by vibrations there are no developments documented in the literature until today

Since the cementation reaction is a metal displacement surface reaction similar in many ways to an electrochemical corrosion reaction, it was hoped that the vibration impact will yield positive results, by the means of a constant attrition of zinc granules and thus by exposing instantly a newly formed fresh zinc surfaces for the continuous gold cementation to take place In other words the vibrations of the both reactors will generate forces of impact and friction at the granules which result in the granule surface being immediately freed from the deposited residues so that they will be available for further reaction The main objective of the presented research was to establish a method with the following advantages

- Flexibility with respect to raw material feed - i.e. it has to handle both high and low grade solutions.
- Continuous, single-stage, easy-to-control operation with a short reaction time, i e. fast process kinetics, giving a high recovery values.
- Low zinc consumption, substitution of the conventionally used zinc dust which is more expensive than the granules.
- Use of labor-saving and easy to maintain equipment.
- Low cost.

2. EXPERIMENTAL METHOD

The gold/zinc cementation experiments were performed in a two laboratory arrangements - in a fluidised bed and static column The two experimental set-up schemes are shown respectively at Figure 1 and Figure 2. In the case of the fluid bed cementator it was found optimal to maintain 10 % cementator volume filled with granules The end of the bed-cylinder is fitted with a slotted disk which allows the barren solution and the suspended gold-zinc colloids to pass, but retain the cementation agent. Similar role in the column is anticipated to play the false bottom. Both test solutions and operating parameters of the reactors (shaking frequency and amplitude) have been varied and controlled by a measuring device

In an attempt to model both high grade solutions arising from loaded carbon elution and lean solutions arising from conventional leaching, an artificial solutions on a chloride basis with different gold concentration were prepared The chloride solution was made by adding $HAuCl_43H_20$ (Merck) to a solution of HCL (0.01N). Solutions pH was in the range of 2.5 - 3, measured with a Seibold G-104 meter. In order to study the effect of the most commonly met ions in the real plant solutions, copper, lead and iron were added in some instances to the test solutions. Each gold solution, prior to cementation has been subjected to oxygen removal by bubbling of nitrogen gas into the solution

At selected intervals 5 ml aliquots were collected and analyzed using an Inductively Coupled Plasma spectrometer (SPECTROFLAME) to determine the gold concentration remaining in the solution. Changes in volume due to removal of solution were taken into account in all calculations.

The zinc granules were obtained from a metallurgical refinery trade sector and have been in the size range of 3-5 mm.

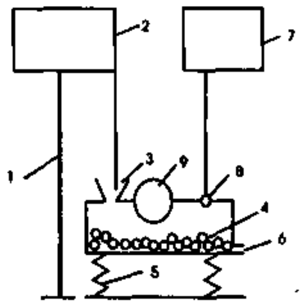

Figure 1. Experimental lab set-up in the case of bed cementator

1. Holder
2. Inflow Solution container
3. Inflow solution
4. Zinc granules
5. Spring
6. Outlet solution
7. Control and display unit
8. Vibro data acquisition probe
9. Vibrator

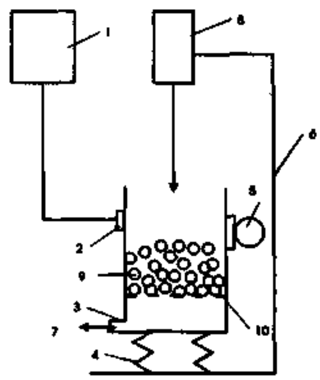

Figure 2. Experimental **lab set-up in the case of** column cementator

1. Control and display unit
2. Vibro data acquisition **probe**
3. Plexiglas column
4. Spring
5. Vibrator
6. Holder
7. Outflow solution
8. Inflow solution container
9. Zinc granules
10. Glass-wool **false bottom**

3. RESULTS AND DISCUSSIONS

Before starting the cementation tests with vibrations, a standard static experiments were performed to obtain extraction values with which to compare the results with vibrations. Both high grade and lean solutions were studied and compared, however only the bed cementator was tested in this batch for the sake of comparison.

3.1. Results with Non-vibrating Reactor

The experimental results for the high-grade solutions (-700 ppm) show that some cementation do occur - in the neighborhood of 45%, however at the expense of the very low kinetics - 45 minutes. In a similar conditions "lean" solutions does not react with the cementation media at all - the recovery is almost nil, regardless of the test duration. These relationships are shown at Figure 3.

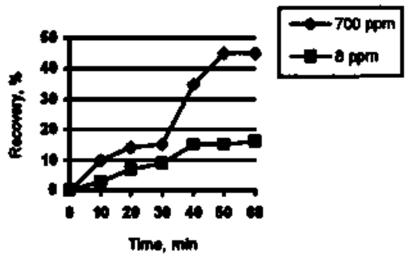

Figure 3. Kinetics of gold cementation recovery for "non-vibrating" bed cementator. Initial concentration of solutions - 8 and 700 ppm, flow rate 20 ml/min

3.2. Results with Vibrating Reactor

These results are summariaed at Figure 4 below. It could be seen that the kinetics was influenced dramatically for both the test solutions.

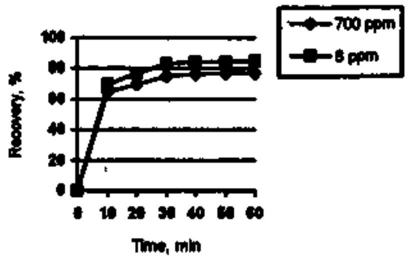

Figure 4. Kinetics of gold cementation recovery for "vibrating" bed cementator. Initial concentration of solutions - 8 and 700 ppm, flow rate 20 ml/min Shaking frequency f=53 Hz, amplitude A= 4 mm

The results presented at Figure 3 and Figure 4 unambiguously have suggested that the vibrations do have a strong influence on the behavior of the cementation process Accordingly it was decided to study further the most promising reactor configuration and it has been found that the fluidised bed has a superior performance and hence in the subsequent test program the column configuration was abandoned Further on the effect of foreign ion addition was studied Lead, copper and iron salts were added at concentrations simulating real base metals bearing liquors arising from leaching complex sulfide gold bearing ores These results are presented at Figure 5

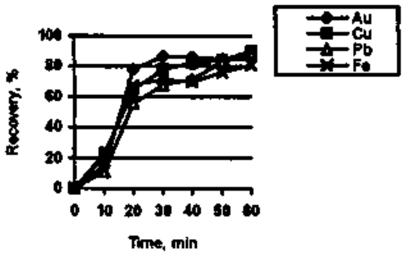

Figure 5 Influence of foreign ions addition on gold cementation with "vibrating" bed cementator. Initial concentration of solutions, ppm Au -123, Cu - 215, Pb 87 2, Fe -70 Solution flow rate 20 ml/min. Shaking frequency f=53 Hz, amplitude A= 4 mm

As is evident from the above results, foreign ions addition principally do not affect the general trend of the gold cementation at least at the studied concentration ranges and flow-rate However, when the solution was run faster through the cementator it has to be noted that gold cementation decrease about twice fold, which suggest that the cementation reaction perhaps is a diffusion controlled one.

With a view of outlining the optimal degree of vibration parameters, which generally are of decisive importance for mass transfer processes such as the studied one, further tests were done at different frequency and amplitude The former parameter was set on 50 and 58 Hz, while the later - on 4 and 4 5 mm These series of tests are summarized at Figures 6 to 8

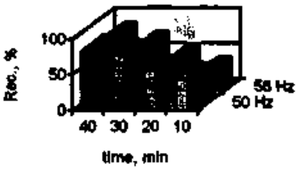

Figure 6. Influence of shaking frequency on the degree of gold cementation. Initial gold concentration 700 ppm. Solution flow rate 25 ml/min. Amplitude A= 4 mm

Figure 6 suggests that the frequency of vibrations does not effect significantly the cementation of "high-grade" solutions, at the amplitude of 4 mm. The increase in the amplitude up to 4.5 mm does not show also great influence in this situation In contrast of the above, however, when "lean" solutions were passed through, surprisingly the slight change in the amplitude has yield a pronounced effect on the degree of cementation. Here the frequency seems also to be a decisive factor, hence these vibration parameters have to be studied in combination in this particular case. The discussed above observations are shown at Figures 7 and 8

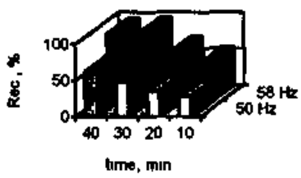

Figure 7. Influence of shaking frequency on the degree of gold cementation. Initial gold concentration 8 ppm Solution flow rate 25 ml/min. Amplitude A= 4 mm

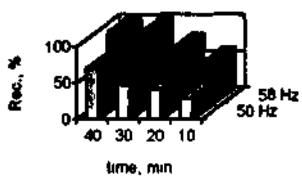

Figure 8. Influence of shaking frequency on the degree of gold cementation. Initial gold concentration 8 ppm. Solution flow rate 25 ml/min Amplitude A= 4.5 mm

4. CONCLUSIONS

The presented research although exploratory in nature, from our point of view has lead to some very interesting results which undoubtedly will rise future motivation for more detailed study in this direction Moreover, as was said in the introduction, according to **our state** of knowledge by far there are no **laboratory developments** on similar issues of vibro **assisted gold** cementation. The basic conclusions **which could be** derived from our experiments could be **figured** out as follows:

1. The vibro action applied on the both studied reactors does have a positive effect on the degree of gold cementation due to significant enhancement of process kinetics.
2. The stability of the gold cementation with respect to foreign ions addition is a particular highlight of the suggested approach.
3. Both shaking frequency and amplitude have significant complex influence when "lean" solutions were tested and have to be studied for further optimization.
4. The lab scale model of the fluidised bed cementator has shown superior performance compared to the column and its construction has to be born in mind in case of future scaling-up of the process.
5. Further detailed research will be directed towards characterization of the gold particles washed out at the end of the process and on the surfaces of the used zinc granules.

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