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AN INVESTIGATION OF THE LEACHING OF
COPPER TAILINGS BY MEANS OF POTASSIUM CYANIDE,
PRECIPITATION OF THE DISSOLVED COPPER BY MEANS
OF ALUMINUM, WITH CONSEQUENT REGENERATION OF
THE CYANIDE CONSUMED.

By

THADDEUS REAMY GOLDSBOROUGH,

A

Thesis

Submitted to the Faculty of the
SCHOOL OF MINES AND METALLURGY OF
THE UNIVERSITY OF MISSOURI
in partial fulfillment of the work required for
the
DEGREE OF
BACHELOR OF SCIENCE IN METALLURGICAL ENGINEERING.

Rolla, Mo.

1914.

Approved by
acting

Horace T. Mann
Professor of Metallurgy.

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One of the principal disadvantages attending the use of most of the usual solvents for Copper, such as Sulphuric Acid, Ferrous Chloride, etc., in the treatment of tailings products, is that the solvent is not regenerated upon precipitation by iron, and in fact is destroyed by the precipitant. This of course involves a dead loss of a definite portion of acid or other reagent, proportional to the amount of Copper dissolved. A solvent which would be regenerated upon precipitation is eminently desirable. At the same time, a carbonate gangue, or one of such a nature which will react with the solvent used, also entails an unavoidable loss.

It is a well known fact that Aluminum forms no Cyanide compounds. Advantage is taken of this at Nipissing, where the silver bearing Cyanide solutions are precipitated by Aluminum, in the presence of Sodium Hydroxide. This results in a more or less complete regeneration of the Potassium Cyanide, and the formation of Sodium Aluminate.

With these results in mind, and knowing the strong tendency of Copper to go into a Cyanide solution, a series of tests were made with a view of

determining the value of a process of Cyaniding Copper tailings, and precipitating the Copper with Aluminum, the data of which will be given later.

The tails upon which the tests were made came from Miami. The copper content, as determined by the Iodide Method, was 0.57%. The tailings also ran rather high in Iron, although no quantitative tests were made for the latter. The water-soluble acids required an added alkalinity of two pounds of Calcium Oxide per ton, but, due to the latent acidity, a much greater amount was needed to prevent undue Cyanide consumption.

The results of the first series of tests are shown in table No. 1. It will be noted that the Cyanide consumption was much too high for practical work, and the regeneration too small to be taken into consideration. The extraction, as determined from an analysis of the residues by the Cyanide method, was good. Several runs of a similar nature were made, giving consistently high extraction and high Potassium Cyanide loss, with but little regeneration.

The results of tests shown in table No. 1 proved two things, i.e., that the treatment with Potassium Cyanide would give good extraction, but that when applied to the ore in question the Cyanide loss was prohibitive, in spite of the two pounds of Calcium Oxide used per ton. The regeneration was so small, due probably to the small amounts of Copper involved, that it was determined to make a number of tests on pure Copper compounds, Copper minerals, and Cement Copper. Several weeks were spent on the latter work. In the latter tests an effort was made to determine the actual percentage of the dissolved Copper that could be precipitated by Aluminium, and to discover the probable composition of the Copper-Cyanide salt formed.

In view of the fact that most of the Copper salts available gave an extremely high Cyanide consumption, due to the acid radicle present, the results are possibly not so good as might be expected.

The first experiment on a Copper salt was made on Copper Chloride (CuCl), by dissolving an unweighed portion in a 9.2# to the ton Potassium Cyanide solution, and adding 3# Calcium Oxide, (CaO) per ton. After dissolving, the solution ran 5.2# Cyanide per ton, a loss of 4# per ton.

Upon precipitation with Aluminum, the solution ran 7.9# per ton, a regeneration of 67.5% of the Cyanide lost. The Cyanide not recovered may possibly have been irrevocably lost by reaction with the acid radical. The copper came down in flocculent masses, easily filtered.

A second test similar to the above gave a regeneration of 70.1% of the Cyanide lost.

In view of the unsatisfactory results of the tests with Cuprous Chloride, precipitated Cu_2S was next tried. This dissolved nicely, but the titration with Silver nitrate, for Cyanide content, was impossible, due to the formation of Silver sulphide which obscured the end point.

The next Copper salt tried was Copper Oxide (CuO), obtained by precipitating 381.5 milligrams of Copper Sulphate with Sodium Carbonate (Na_2CO_3), and boiling the precipitate. This dissolved with difficulty, and only after agitation with air for three days in strong Cyanide solution. The strength of solution used to dissolve this salt was not determined, as solid Potassium Cyanide was added from time to time during course of dissolution. Before, precipitating, however, the solution ran 3.46#

Cyanide per ton, and after precipitation it ran 4.0# per ton, showing regeneration of .54# per ton. The solution before precipitation was 262.5 c.c, containing 152.02 milligrams of Copper, of which 126 milligrams was recovered, or 83%. The regeneration of .54# cyanide per ton corresponded to a regeneration of 71 milligrams in the amount of solution used, with precipitation of 126 milligrams of Copper, which calls for the formula Cu_2CN . This does not agree with the theoretical formula, $\text{Cu}(\text{CN})_2 \cdot 2\text{KCN}$.

Several experiments were tried with the Copper Oxide before abandoning it, but all were equally barren of conclusive results.

A quantity of supposedly pure basic Copper Carbonate was next tried, but due to some impurity which interfered with the end point in the Silver Nitrate titration, no results could be obtained.

Cuprous Carbonate was then taken up, and the results of the various tests therewith are given in table No. 2.

TABLE No. 2

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RESULTS OF TESTS MADE ON CUPROUS CARBONATE.

:Wt. :Cu. : C.C. :KCN :KCN :KCN :Cu. :%Cu :KCN :
:CuCO ₃ :Wt. : Sol. :#/Ton :#/Ton:Recov. :ppd. :ppd. :Recov. :
:Mgs. :Mgs. : :Bef. :After:#/Ton :Mgs. : : Mgs. :
: : : :ppt. :ppt. : : : :
:.5951 :.149 : 240 :6.15 : 7.1 : 1.05 :125 :84 : 126 :
:.9130 :.194 : 255 :9.70 :11.60 : 1.90 :194 :85 : 242 :

None of the above seemed to correspond to the theoretical, which would require a regeneration of approximately 4 milligrams of Cyanide per milligram of Copper precipitated.

TABLE No.3.
RESULTS OF TESTS ON CEMENT COPPER.

:Wt.Cu.:	C.C.	: KCN	: KCN	: KCN	:Cu.ppd:	% Cu	:KCN
: Gms.	: Sol.	:#/Ton	:#/Ton	:Recov.:	Gms.	ppd.	:Recov.:
:	:	:Before:	:After:	:#/Ton	:	:	: Gms.:
:	:	: ppt.	: ppt.	:	:	:	:
: 1.5 :	: 350 :	: 12.2 :	: 36.2 :	: 24.0 :	: 1.36 :	: 91 :	: 4.20 :
: 1.5 :	: 350 :	: 9.4 :	: 32.9 :	: 23.5 :	: 1.35 :	: 90 :	: 4.10 :
: 1.5 :	: 350 :	: 8.6 :	: 33.6 :	: 25.0 :	: 1.32 :	: 88 :	: 4.37 :
: 1.5 :	: 350 :	: 7.5 :	: 30.3 :	: 22.8 :	: 1.29 :	: 86 :	: 3.9 :

Although merely approximate, the above results on Cement Copper, would seem to indicate the formation of a compound having the formula $K_2Cu(CN)_4$, giving rise to the regeneration of 4# Potassium Cyanide per pound of Copper precipitated.

Another test with Cuprous Nitrate ($Cu(NO_3)_2$), neutralized with Ammonia, and dissolved in potassium Cyanide after having been evaporated nearly to dryness, gave a regeneration of 3.79 milligrams of Cyanide per milligram of Copper precipitated, or a recovery of approximately 95% of the theoretical amount required for solution.

After having thus determined the practicability of precipitation with Aluminum in the presence of Potassium or Sodium Hydrate, there remained the question of the high Cyanide losses as shown in table No. 1. The follow

ing tests were made, using in each case ten pounds of Calcium Oxide per ton of ore, instead of two as indicated by titration of water soluble acids. The time was twelve days.

Table No. 4.

TESTS ON CYANIDE CONSUMPTION,
USING ORIGINAL TAILINGS.

: Wt. :	C.C. :	KCN :	KCN :	KCN :	KCN :	Extrac:	CaO :
Gms. :	Sol :	#/Ton :	#/Ton :	#/Ton :	Net :	tion. :	Mgs. :
:	:	Orig. :	Before:	After :	Loss :	Not. :	:
:	:	:	Pption:	Pption.:	#/Ton :	Deter.:	:
: 5 :	150 :	5.92 :	4.0 :	4.1 :	1.82 :	:	30 :
: 5 :	160 :	6.67 :	4.7 :	4.8 :	1.87 :	:	30 :
: 5 :	170 :	7.32 :	5.5 :	5.7 :	2.62* :	:	30 :
: 5 :	180 :	7.90 :	6.3 :	6.3 :	1.60 :	:	30 :
: 5 :	190 :	8.43 :	6.5 :	6.5 :	1.93 :	:	30 :
: 5 :	200 :	8.90 :	6.7 :	6.9 :	2.00 :	:	30 :
:	:	:	Average	loss :	1.97 :	:	:

*This seems to be an unusually high loss. Probably due to error in titration.

In the above tests, the ratio of solution to tails, namely 30, is a rather high one. On multiplying this ratio by 1.97, the average loss per ton, the total loss is seen to be 59# of cyanide per ton of ore treated, which is of course too high for commercial work. The loss per ton of solution remained fairly constant however, irrespective of the amount of solution. By using a fairly strong

strong solution, and a ratio of solution to ore of say two or three, plus a high lime content, the loss could probably be reduced to a commercial practicable basis.

In conclusion, it is my opinion that the process is entirely practicable insofar as the precipitation by Aluminium and regeneration of the Cyanide is concerned, and that a fairly good extraction is possible. The Aluminium could be added in excess, and removed by filter pressing, using only sufficient Sodium or Potassium Hydrate to give a good precipitation.

On the other hand, it is apparent that the high Cyanide consumption (which Cyanide is entirely lost) in treating a tailing similar to the one used, would render the process useless unless some means were devised to prevent this loss of Cyanide.