METHODS OF A CYANIDE CLEAN-UP, AS GENERALLY ADOPTED ON THE KALGOORLIE FIELD.

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By F. O. McArdle, B.E.

This paper is written in order to give a general idea of the methods which are usually adopted in the cyanide "clean-up" on the principal mines of Kalgoorlie. In large cyanide plants where a great quantity of sludge has to be treated, experience has shown that it is advisable, for economic and other reasons, to carry out the "clean-up" as speedily as possible.

The different stages of a clean-up may be divided as follows, viz.:—

(1) Cleaning up the boxes.
(2) Aciding the gold sludge.
(3) Pressing the gold sludge.
(4) Drying and roasting.
(5) Smelting the sludge.
(6) Re-melting and refining the bullion.
(7) Cleaning and sampling of bars.

In dealing with each division, an endeavour will be made to describe the methods adopted to minimise the cost and to expedite the operation.

A.—Cleaning up the Boxes.

The actual stage of precipitation of gold in a zinc box depends mostly on the conditions of the solutions. If the boxes are working well, about 90 per cent. of the gold ought to be precipitated in the top compartment and the remainder distributed between the second, third, and fourth compartments. This gold precipitate is generally cleaned out of the boxes monthly. The contents of the top compartment, if containing very little short zinc, may be taken direct to the aciding vat, after first syphoning out all the clear solution. The zinc in the second, third, and fourth compartments has to be washed and scrubbed to force the gold precipitate from the short zinc. This is done by shaking the trays of zinc vigorously in the compartment to allow the fine gold precipitate to fall through the sieve. It may also be necesssary to scrub the zinc on a sieve, but is a bad practice, as it wastes zinc and is

more trouble in after-treatment. The fine sludge is then cleaned out in the same manner as the first compartment. The main object to be aimed at is to keep the sludge low in bulk and consequently higher in grade, so that there is a lesser amount to be handled for a given amount of bullion obtained. This result can only be obtained by careful attention to the boxes during the month. Low-grade sludge is generally due to the following causes:—

(a) Ore Slime.
(b) Hydrates of Fe, Al, Ca, Mg, etc. } precipitated from the solution.
(c) Zn compounds.
(d) PbS, FeS, etc.
Inattention to the boxes.

It is only by eliminating these troubles that the grade of sludge can be raised and the bulk reduced.

(a) Ore Slime. — The solution coming from the presses always carries in suspension a certain amount of ore slime. This is due to leaks in the presses, lumps of slime, etc., falling into the launders when the presses are being emptied, and holes in the filter-cloths. Formerly, all the solution from the presses was run into tanks before going to the zinc boxes, in order to allow the slime to settle, but as the slime was so fine, and consequently took such a long time to settle, the method was discarded as being efficient. The present practice is to pass all the solution through clarifying presses, and in some cases both settlers and clarifying presses are used, with the result that no ore slime finds its way into the boxes.

(b) Hydrates of Fe. Al, Ca, Mg, Etc.—If caustic alkalies are present in the solution, the above hydrates will be slowly precipitated throughout the plant. When the ore has been imperfectly roasted, soda ash is often added to the solutions to raise the alkalinity, and this will bring down a white precipitate in the boxes consisting mainly of the above hydrates. Consequently, every endeavour should be made to secure a perfect roast, and so obviating the necessity of adding soda ash.

(c) Zinc Compounds Precipitating from the Solution.—An imperfect roast will also give rise to the presence of a thick, heavy, greasy, white precipitate, which forms a coating on the zinc. This precipitate can be got rid of by adding cyanide to the top of the box, as it is soluble in strong cyanide solutions. In solutions of low cyanide strength, the double cyanide of potassium and zinc seems to break up according to the following equation:—

$K_2 Zn Cy_4 = 2 KCy$ and $Zn Cy_2$.

as also do other compounds of zinc and cyanogen. A treble

cyanide of potassium, iron and manganese readily forms when the solutions are weak, which is due to the presence of ferro-cyanides.

Zn S will also form as a white precipitate when the roasting is bad, viz.:—

$$Zn\,S + KCN + 2H_2O = KCNS + Zn\,(OH)_2 + H_2$$

Potassium sulpho-cyanide will always form when alkaline sulphides are present. When in contact with Zn, it is broken up as:—

$$KCNS + Zn = KCN + Zn\,S.$$

This white precipitate is a nuisance, as it is practically insoluble and is impossible to get rid of.

(d) Pb S, Fe S, etc.—In all extractor-boxes a thin, light, black slime, resembling gold slime, but much lighter, is found. This is formed through the KCNS in solution being acted on by the lead and iron in the zinc:—

$$KCNS + Pb = KCN + Pb\,S.$$

Fresh zinc put in the lower compartments of a box will become black in a day or two. Under good working conditions, this black precipitate on the zinc is not gold, but sulphides of lead and iron. If the ore has been imperfectly roasted, this precipitate will sometimes coat the zinc with a bright copper colour, and, in fact, will go all colours of the rainbow. Although its appearance is very similar to precipitated copper, no copper can be found, but sulphur can easily be detected. This colouring and rapid blackening always causes bad precipitation in the boxes. Once it is there it is had to get rid of, and is a nuisance during clean-up, as time is wasted while allowing it to settle. To keep good precipitation, the boxes should be worked so that a small amount of zinc can be put in the last two or three compartments every day, as it requires bright, fresh zinc to take out the last grains of gold from the solution.

(e) Lack of Attention to the Boxes during the Month.—As regards the clean-up, this is a most important item. Even though the solutions are foul, much work and energy is saved by proper attention during the month. The main idea is to free the gold slime from the zinc by shaking the trays vigorously and allowing it to fall to the bottom of the compartment. The gold slime is then collected and put up into the top compartment. This should be done every five or six days, and only the slime be kept in the top compartment. Any short zinc that falls through with the slime will thus have every opportunity to dissolve away, and in this manner the gold slime is obtained as free from zinc as possible. At the end of the month it also saves shaking and scrubbing the zinc, and collecting gold slime from five or six compartments down the box on clean-up day. This method enables the boxes to be cleaned up in the shortest possible time. For instance,

on one of the mines at present four men clean out, shift up the zinc, and put fresh zinc in nine boxes in six hours, whereas formerly it used to take them three days, and also taking out much more short zinc with the gold slime than the method described above. The amount of sludge to handle is thus reduced, as the division line between the gold slime and short zinc free from the gold slime is easily observed, and consequently there is practically no scrubbing or washing to be done. Attention to the boxes has proved to be most economical as regards cost where time, labour, smelting and fluxes are concerned, as all are very considerably reduced. The zinc consumption resulting from the clean-up is also greatly reduced by the attention given the boxes during the month, as very little short zinc gets into the clean-up.

B.—Aciding the Gold Slime.

The gold slime and short zinc, when cleaned out of the boxes, is carried and dumped into a tub alongside the aciding vat, and the general practice is to acid the whole of it. Six or eight jars of acid should first be poured into double the amount of water in the vat, and the slime added slowly with a shovel. The acid solution should be kept as thin as is possible according to the capacity of the vat. When all is dissolved, it should be well stirred, diluted as much as possible, and left to stand a few hours. It is most convenient to leave it over-night, and is then ready for pressing in the morning. The aciding treatment, although it considerably reduces the bulk of sludge and frees it from zinc and other base metals, etc., is nevertheless very costly. There is a tendency on the field to leave out the aciding process and to roast direct, and, as a matter of fact, this is being done on a number of the large Kalgoorlie mines. The bulk could be reduced and freed from short zinc by a good washing and passing it through a fine screen; this would catch all the short zinc which could be put back into the top compartment of the box again. The fine product could easily be pressed, and would be small enough in bulk to roast direct.

C.—Pressing.

The solution in the acid vat should be as dilute as possible, as very concentrated acid solutions are difficult to press, and besides getting very miserable little cakes, it is ruinous to the press, as a high pressure has to be used, and the acid will attack the frame faces. Sheets of blotting paper placed on the cloths tend to make it press easier, and also protects the cloths. The cake is also freed from the cloth, and so the press is kept clean and in good order. The cake should be well washed in order to get rid of all acid solution and basic sulphates, then dried thoroughly.

D —Drying and Roasting.

After pressing, the sludge should be dried in semi-circular roasters or muffles. For quick work, they should be made of iron, although they do not last as long as fire-clay muffles. The heat is quickly got up in iron muffles, and a charge of about 300lbs. ought to be well roasted in about six hours. The opening at the back of the muffles should be large enough for a good draught to pass through it. The roasting should be done as thoroughly as possible, and should be rabbled constantly after a red heat is obtained, care being taken to avoid dusting as much as possible. The temperature should not be high enough to frit the sludge, but sufficiently high to oxidise all sulphides and base metals present. Iron muffles are now being made with false bottoms, so that they can be easily replaced when burnt through. Good roasting assists the smelting in many ways. The particles of basic oxides and gold seem to separate more readily, and when fluxed thoroughly seem to run down very rapidly, and, in addition, a very much higher grade bullion is obtained. The better the roast, the smaller proportion of fluxes is necessary. When the roasting is finished, it is taken out of the roaster, placed on a tray, and weighed on a spring balance. It is then emptied out on to the floor, which should have a fine, smooth, cement surface. The floor is the most convenient place to flux large quantities of sludge, and one can easily prevent losses by good sweeping.

E.—Smelting.

The smelting furnaces used on the Kalgoorlie mines are retort tilting furnaces. They are very handy in dealing with large amounts of sludge, and especially in pouring the contents. The general method is to have a large slag pot on a carriage, which is run up to the furnace, which is then tilted over and the slag poured out. A much better method is to have the slag pots suspended by a chain from a crawl fixed to the principals of the roof. These are much safer, handier, and quicker to handle, and when filled they are run back and slid on to bearers on one side. There is no spilling of slag on the floor, and practically no energy is exerted in handling the pots. The tilting furnaces should be lighted at such a time that they will not have to wait for the contents of the roasting furnaces, or *vice versa*. When the sludge is tipped on to the floor it is spread out and the fluxes sprinkled over it. It is then coned up two or three times, and when homogeneously mixed it is put into the tilter by means of scoops. The following charges have been found to give the best slag as regards speed in running down, fluidity, etc.:—

Sludge after Acid Treatment.		When Roasted Direct
Sludge.....	100	100
Borax	45	40
Sand	18	20
Soda	12	—

The time taken for the charge to run down depends mostly on the grade of the sludge. When the furnace is really hot, a charge of about 350lbs. ought to run down in three or four hours. The coke in the furnace should have every attention, frequent rabbling, keeping the coke under the belly of the pot, and a good draught. Just before pouring, the slag should be tested by stirring it with an iron rod and observing the slag which cools on it; if quite fluid, clear and free from all infused lumps, it is ready to pour. One man tilts the furnace by means of a wheel attached to a pinion wheel gearing, another man looks after the pots on the bearers, and another manipulates the pot which is being filled. The gold will run out into the last mould, and, when cooled, the slag is detached and the gold weighed. The size of the gold button should be a convenient one to go into the re-melting pot easily.

F.—Re-Melting or Refining.

Where large amounts of gold have to be smelted, there is generally not sufficient time to refine the gold very much. Consequently, it is simply run down in a convenient size crucible to pour into ingots. The moulds are generally of from 300ozs. to 500ozs. capacity. It is convenient to run down just sufficient gold to fill either three or four moulds, and the bars should be as near as possible the same size and weight. When the gold is put in the pot a small amount of borax is added, sufficient only to cover about a quarter of the surface of the gold when molten. This amount will be quite sufficient to absorb all oxides formed. Just before pouring, the slag is skimmed off by adding a pinch of bone-ash or mabor and stirring it well with the slag by means of a skimmer. A thick, sticky mass is formed, which can be lifted out of the pot pretty well in one lump. The best method of pouring is by means of basket tongs suspended by tackle from a crawl. The pot is lifted, and can be run right back from the heat of the furnace and poured into the moulds, which have been well heated and greased. Candle grease, or a mixture of graphite and oil is about the best for the moulds, and the gold is easily detached. When pouring, it should be started slowly to avoid splashing up the sides of the mould, gradually increasing till nearly full, and then slow off quickly. This will give a nice bar, free from rolls or rough surfaces. To keep the top surface free from the formation of oxides, a pinch of a mixture of cyanide and candle-grease is a good remedy. The bars, when set, are

then dumped out and put in a pickling bath which consists of H_2SO_4, made up 1 to 1. A pinch of KNO_3 is generally added to form a little nascent HNO_3. This removes most of the oxides and impurities on the surfaces.

G.—Cleaning Bars and Sampling.

The bars, after pickling, are then given a sound hammering with a good fitter's hammer, in order to smooth off all rough surfaces, round up sharp edges, etc. They are then given a good scrubbing in water with file-cloth brushes and a little soda carbonate, until a nice, clean, polished bar is obtained. The bar is then sampled by boring with a 3-16in. bit into the bar, top and bottom and opposite ends. The drillings from the first ⅛in. are discarded as rough clippings, and the boring continued for the sample. The holes made are carefully cleaned out and the edge of the hole tapped down smoothly. The bars are then carefully weighed, and are ready for the bank.