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STUDY OF THE MONTHLY EXTRACTION RECORD AND CURVE OF A
MODERN MEXICAN CYANIDE PLANT.

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INTRODUCTION:-

This data is taken from the records of the mill and cyanide plant belonging to Compañía de Minas La Blanca y Anexas, S.A., Pachuca, Hidalgo, México; of which the writer has been in charge during the four years it has been in operation.

The plant may be termed a "silver plant" as the silver values predominate, the ratio being about 200 grams of silver to 1 gram of gold. Its monthly product in concentrates and bullion runs between 6 - 7,000 kilos of silver and gold.

It is one of the most modern cyanide-plants in this the main silver district of México; being an "all-slime" plant with stamp-batteries, tube-mills, continuous agitation and dewatering, vacuum filtration, and zinc dust precipitation; treating about 550 tons daily.

The data on which the sheet and curve showing "Extraction by Stages" are based, is the operating records for the plant during the month of October 1914; the assay values given for various stages being the averages obtained at end of the month from the daily assays.

This means that the plant is sampled daily for every assay value given, and these are the averages obtained at end of the month in question; and which form part of the permanent technical record of the plant's operation.

All tonnages and assay values are understood to be in terms of the metric system.

OUTLINE OF THE PLANT

As this work is not intended to be a description of the plant, or of its rautine practice; but the study of its extraction record for a certain month, the following outline is only a brief statement for the purpose of adding clearness to the main matter. Referring to the flow-sheet attached herewith, it may be noted that the ore is delivered from the shafts, over the track scales, by two ton gable bottom cars and electric locomotives to the main storage-bin holding 3,500 tons. By properly arranged gates beneath, this bin delivers to 2-30" conveyor belts, having a picking section from which is removed the tube-mill rock; this rock then going from its separate bin by 1-ton cars to the tube-mill section of the plant. The second of these two belts discharges on to a 1½"grizzly, the oversize feeding 2 #4 K Gates gyratory crushers, the product of which joins the undersize on an 18" inclined conveyor belt to the upper level of the sampling plant; composed of 3 sets of Vezin samplers and rolls, whereby the various cuts finally deliver a sample of 2 kilos per ton of ore handled. This sample is finally worked up by hand and pulp-grinders, and serves as the basis of the daily values charged to the plant.

All rejects from the Vezin samplers are delivered to a second 18" conveyor belt, running over the battery bins, and the ore is properly distributed by a Jeffrey distributing machine.

The batteries, which have shaking screens to by-pass the fines, consist of 40-1250 # stamps, crushing in solution through 4 and 6 mesh screens; and, by a launder classification, delivering sands to 8-Deister sand concentrators, and the slime to 8 Deister slimers. No effort is made for close concentration, the idea being to take out a major portion of the sulphides in order to keep down cyanide consumption. As the capacity of 550 tons daily is only obtained by coarse screens on the batteries, the sand-tables are relieved of the tremendous overload of coarse sand by 8-mesh screens in the feed-boxes of the Deister sand-tables; so arranged that the motion of the table also classifies and rejects the oversize. The concentrates, after flowing to the concentrate storage, are shipped to the smelters. The balance of the product is delivered to 7-Duplex Dorr Classifiers, working in closed circuit through 2 - 30" bucket elevators with 7 Krupp roller type tube mills. Three of these mills are 4' x 20' and four are 5' x 20'. These mills are fed continuously with the quartz from the mine by means of double scoop feeders; and each mill screens its discharge, the oversize, of+4-mesh from breaking up of the quartz, being returned to the battery bins. The overflow from the Dorr Classifiers goes to 4 30' x 12' primary Dorr Thickeners, which discharge a product of 1.35 Sp.Gr. continuously to the Pachuca tank circuit, part of the clear overflow being returned to the battery storage tanks, the balance being used as explained later.

The agitation circuit is composed of 8 - 15' x 60' Pachuca tanks, operated according to the continuous system, simple overflow connections; part of the cyanide, lead, etc. being added at first Pachuca, and part at the tube-mills.

The agitation circuit delivers to 3 secondary Dorr Thickeners, uniform with the primaries; but the continuous discharge from the agitation circuit is diluted to about 1.20 Sp.Gr. with clear overflow solution from the primaries, and also with the solution from the concentrate storage tanks. This serves the double purpose of providing room for barren solution in the battery circuits without precipitating the low value mill solution direct; and also diluting the charge to the secondary thickeners with low value solution, so they are able to deliver a lower grade thickened product to the filter plant. The underflow from the secondary thickeners, thickened again to about 1.35 Sp.Gr., flows to the mechanical-stirrer storage tank of the filtering system. The filter-plant is of the Moore vacuum type, movable baskets, operating 5 units, 40 leaves each, standard size 6' x 10', by means of 2 Gantry cranes; suction is by means of 2 Deane duplex 12' x 14' vacuum pumps.

The vacuum pumps deliver to a solution storage, which feeds a centrifugal pump, through which the solution reaches the same deposit receiving the clear overflow from the secondary Dorr Thickeners.

Thus the product of the secondary Dorr Thickeners, and the filter-plant join at this point, giving but one grade of solution to be precipitated; which is pumped to the clarifiers above, and is then drawn off to the precipitation plant. The Merril system of precipitation by zinc dust is employed, using an endless belt, operated by floats in the Merril tanks, and enulsifying the zinc dust in a small tube-mill, containing steel balls; the emulsion flowing to a connection with the Merril tank discharges, and thus through the triplex- pumps, which return the solution to the standard Merril triangular precipitation presses. These are 4 in number, each of 20 leaves. The precipitation and operation are such that two classes of barren solution are produced at will-complete barren solution, which is used for barren washes at the filter plant, and partial barren which replenishes the battery circuit. By the close assay and control of all solution precipitated a high grade precipitate is produced, which runs 85% fine on the dry weight; and, without any other treatment than a simple fluxing and melting, produces bullion of 950 fineness.

THE EXTRACTION RECORD AND CURVE

The "extraction record by stages" is intended to show in concise tabular form what the curve illustrates graphically. It will be observed from the flow-sheet that the 12 stages into which the total extraction is divided by the record and curve follows naturally from the mechanical arrangement and operation of the plant; and it does not follow that this number has any significance, except for this particular plant, or would be applicable to any other plant.

The striking feature immediately observed in regard to the curve is the fact that it reverses itself. Either of the two points, D or E, may be considered the point of reversal; depending on whether the stage D-E is considered to belong to the preceding or the succeeding stages. As emphasizing this feature, I have purposely connected the points of the curve with straight lines, instead of drawing an irregular curve; as in drawing the irregular curve it would be necessary to arbitrarily choose D or E as the point of reversal. As helping to explain this point, it may be observed that the first 3 stages, as well as the last 2, do not represent equal periods of time; and are affected more by arbitrary mechanical manipulation of the plant than are the intermediate 7 stages of the agitation circuit, which are the results of chemical extraction divided into equal periods of time. The first stage, being the effect of concentration, bears no real relation to the stages which follow and which result from chemical extraction; but is useful in that it gives us the heads for the cyaniding operations. This first stage varies with the screens we use on the batteries, or what amounts to the same thing in our case, the tonnage.

And the second and third stages, B-C C-D, it will be observed, could be properly combined in one stage; because the two together form the total extraction by cyanide in the milling operations: the division into two stages resulting from the removal from the milling circuit of part of the dissolved values.

It is easily seen that these two stages would vary as to the division of values between them, according to the amount of solution diverted to the secondary thickeners; and thus to the precipitation plant, thus affecting the amount of dissolved values entering the agitation circuit. This is simply a question of manipulation on the plant, depending on total precipitation capacity. As observed from the record, it will be seen that we removed about 1/3 of these dissolved values from the charge to the agitation circuit. My opinion is that the percentage should be doubled, but owing to fact that we are treating a much greater tonnage than the plant was designed for, we are unable to increase to this figure. Referring again to these two stages as a unit, and as showing the amount of extraction in the milling circuit, it may be observed that they indicate what a good extractor a tube-mill is; as, except for the small amount from battery action, it is the result of the fine-grinding of the tube-mills. Our experience here in experimental work is that a tube-mill compared with a Pachuca tank will extract fully as much as the latter in equal periods of time.

As previously observed the extraction stages from D to K inclusive, covering the Pachuca agitation circuit, are more comparable than the other stages; and, therefore, more interesting because they represent equal periods of time as well as exactly similar mechanical units, two features obviously not possible to obtain in the other stages. For this reason, it would seem that D is the proper point to consider the curve as having changed. The striking thing here is that the extraction in the first Pachuca is greater than all the six following combined; also the rapidity with which the curve approaches a straight line after the second Pachuca.

The fact of the rapidity with which the major part of the values become dissolved in the first Pachuca tank, as the charge is saturated with air, and the slowness in getting the remainder indicate the importance of designing a plant so that the solution in contact may be readily renewed -a feature now embodied in the so called "counter-current" system. But to my mind it also indicates that cyanide operators have attached too much importance to long continued and excessive agitation. In other words that some of the final Pachuca tanks in this circuit, as in many other plants, would show just as much extraction if they were serving as quiet storage tanks, after having received the charge saturated with air, as they do now under violent agitation.

Having the plant constructed as it is, it becomes necessary to agitate all the Pachucas with air in order to keep the charge from settling and to keep it circulating; but probably a simple mechanical storage would accomplish the same thing without the high air cost, which is a feature of the Pachuca tanks, particularly the 60 ft. tank such as we have here. As bearing on this point, attention is called to stage #11 K-L of the curve, covering the flow of the charge through the secondary thickeners, which shows an extraction about equal to the one obtained by violent agitation in the last Pachuca. This would indicate that having the charge once saturated with air what is required is sufficient time of contact and not continued violent agitation. It may be added that there are plants in this district where the Pachuca tank capacity is more than twice that of this plant, per ton of ore treated.

In order to avoid giving an erroneous idea, attention is called to the last stage L-M, the extractive effect of the barren washes at the filter plant, and to the foot-note on the tabulated sheet, showing that this stage is extracted, but not recovered.

From this, it is seen that the "Filter cake unwashed" that is the soluble and insoluble values in the filter cake on discharging, were the same as the insoluble values in the filter-heads.

But though the filter failed to recover the 3 grams per ton, which it put into solution, the records show that it recovered all of the 193 grams per ton of ore in soluble values which it received from the secondary Dorr Thickeners.

The extraction figures for the gold have not been reduced to a curve, owing to a desire not to complicate the result. But by checking the percentages, it can be seen that the gold follows generally the silver, though extracting faster and more completely, thus illustrating the commonly known fact that gold is more amenable to cyanide treatment than the silver. The tabulated sheet shows this most strikingly by summing the stages 2 and 3, B-D, showing values extracted by the cyanide in the milling circuit. In the case of the silver, this is 25.8% of the total, but in the case of the gold amounts to 31.5%. As the silver values predominate in this plant, thus requiring very strong solutions, we hold the gold as of secondary importance, knowing that if the treatment secures the silver, we are fairly certain of the gold.

As being of interest in connection with the curve, it may be noted that in the many experiments in manipulation of the plant we have tried adding the fresh cyanide at various points; during the month covered by this curve it was added at Pachuca #1, but is now divided between the Tube-Mills and Pachuca #1. When added at other points than Pachuca #1, the net result is to change the various percentages, as indicated by the stages, but not materially the net total: that is to say we thereby change the form of the curve but not its final point. This rather curious result could be made the basis of a number of interesting speculations which will suggest themselves to the cyanide operator.

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Mill Superintendent.

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