OPTIMIZING THE FLOTATION TIME IN THE PHASE OF ROUGHER Pb - Zn FLOTATION

KABA PB-ZN FLOTASYON DEVRESİNDE, FLOTASYON SÜRESİNİN OPTİMİZASYONU

Blagoj Golomeov *
Boris Krstev *
Mirjana Golomeova *

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ÖZET

Bu çalışmada "Zletova-Probistip" madenine ait çinko-kurşun cevherinin flotasyonunda, en uygun flotasyon süresinin tespitine gönelik araştırmalar sunulmuştur.

ABSTRACT

In this work, the optimization of the flotation time in rougher Pb-Zn flotation in "Zletovo-Probistip "mine, supported by the modem investigations and the accomplishment of the mineral flotation, are summarized.

Faculty of Mining and Geology - Stip, Macedonia

Introduction

The success in thP selective flotation concentration process as the most important, and in industrial conditions the most common step in the flotation concentration of typical lead-zing ores, is first of all seen, in obtaining qualitative selective lead and zinc concentrations adequate for further metallurgical treatment nth high metal recovery in the concentrations.

In order to achieve this, it is necessary to make maximum separation of lead minerals and zinc minerals during the phase of rougher lead flotation. If this is not reached, there will be an increase of zinc content in the lead concentration which has a double negative impact. Firstly, <Ar< increased zinc content in the lead concentration lowers its value down, and secondly the preserice of zinc in lead concentration at the same time means its loss, because zinc from such concentration can not be efficiently recovered.

Having all this in mind, n 3 clear the process of rougher riotat ion of lead minerals is the most significant segment in the whole process or selective flotation of lead-zinc minerals.

The most important ractors which influence the effeciency of separation of lead minerals and zinc minerals during the phase of rougher flotation of lead among others »irsi the degree of opening or mineral raw material, pH and pulp density, the collector expenditure for lead minerals, the depressant expenditure for zinc minerals and, by all means, the flotation time.

Mil this factors are more or less well examined **for** all deposits that &rts in the process of exploitation.

The aim of this work is optimizing, or time determination of the occurrence or maximum separation efficiency of lead and zinc mineral from /letovo Mine deposit, which, at the same time, represents the time when the process of rougher lead mineral flotation should end.

1. OPTIMIZING THE FLOTATION TIME DURING THE ROUGHER Pb - Zn FLOTATION

We dealt with the kinetic of l-'b - *in* ore flotation related tu f-tgar' s equation for kinetic of flotation which is the roi lowing:

$$I = I_{max.} \cdot \{ 1 - \exp[-k \cdot (t+b)] \}$$

where

1 - is the use of *valuable* component

$J_{max.}$ - is maximum possible use of valuable component

k - is the kinetic constant

t - is the flotation time

b - correction time of flotation

Wccording to Hgar's theory, kinetic constant "k" and the correction flotation time "b" can be calculated by the following equations:

$$k = - \frac{\{ n \cdot \sum_{i=1}^{n} t \cdot \ln[(I_{max.} - I) / I_{max.}] - \sum_{i=1}^{n} \ln[(I_{max.} - I) / I_{max.}] \cdot \sum_{i=1}^{n} t \}}{n \cdot \sum_{i=1}^{n} t^2 - (\sum_{i=1}^{n} t)} \quad (1)$$

where »n* is the number of experimental date

$$b = - \frac{\{ k \cdot \sum_{i=1}^{n} t + \sum_{i=1}^{n} \ln[(I_{max.} - I) / I_{max.} \}}{n \cdot k} \quad C2>$$

while optimum flotation time, or the time after which the concentration ot valuable minerals during the flotation process stops (the time when the grade of concentrate produced is equal to the flotation feed) by the equation:

$$t_{opt.} = \frac{\{ \ln[I_{max.m} \cdot k_m / (I_{max.j} \cdot k_j)] - k_m \cdot b_m + k_j \cdot b_j \}}{k_m - k_j}$$

where: m - ıs the sign for metal (in our case it is lead)
j - is the sign for tailing (in our case it is zinc + the rest of the minerals)

Nevertheless, our case is about a polyrnetal 1 ıc lead—zinc raw material. During the phase of rougher lead concentration, we c«m treat zinc as constituent part of the tailing (the rest of minerals), by the application of the equation (*) we can calculate the optimum duration time in the process, in other words the time after which the flotation process does not concentrate lead minerals, but we also need additional information about the process of kinetic flotation of *zinc* minerals and in what optimum fime the maximum separation efficiency of lead and zinc minerals occurs. Without such date we can not have a thorough knowledge ot the process of rougher flotation of lead, which means that we can not make any corrections during the process.

according to what we have said and according to equation (*) we think that we *can* determine the optimum time in the flotation of lead minerals» in relation to zinc minerals by the equation:

$$t_1 = \frac{\{ \ln[I_{max.m} \cdot k_m / (I_{max.z} \cdot k_z)] - k_m \cdot b_m + k_z \cdot b_z \}}{k_m - k_z}$$

where: j - ıs the sign for zinc

This will represent the time when the maximum separation efficiency of lead and zinc minerals .ccurs. This time will be shorter than topt. This implies that after this time the concentration of lead minerals does not stop. It will continue until topt- , but after ti zinc minerals will start tlotating taster than thr. lead minerals (after ti time the increase of zinc distribution in lead concentration will be greater than the increase of lead recovery) In this way we can separately determine the kinetics of lead minerals, the kinetics of zinc and the kinetics of flotation of other minerals together with the zinc.

Un the basis of this we determine the optimal flotation time of lead mineral ' t opt.' and the time of the occurrance of maximum separation of lead and zinc minerals 'ti'. In this way we get all the necessary information during the occurrance of the process of rougher flotation of lead.

On the basis of this information we can determine the duration time of the process of rougher flotation of lead so that we can get greater recovery of lead minerals and at the same time lower distribution of zinc minerals in the rougher lead concentration.

bearing in mind what we have sail.' so far we comprised a computer programme in "turbo pascal - version b" programme language which allows us in a quick way (in any other way it would be- a difficult task) to calculate the afore rment ı oned parameters.

1.1. Experimental Examinations

Our experimental examinations included the kinetic process of rougher flotation of lead from the Pb - Zn ore in "Zletovo" mine Probıstıp.

the work parameters were the following:

- fineness of opening of the mineral raw material
  6S% -0.074mm;
- pulp density £5% hard;

- conditioning time j, ruin. »
- reagent regime:

pH =	8.6
KEX	lb g/t
ZrıSüt	14ü g/t
NaCN	i£ g/t

Experimental examinations were macJe in a laboratory-flotation machine 'Denver' type with a flotation time of 14 min. During the experiment we separated nine concentrates in the intervals of: after 3U s, 60 s, "?'. s, 1£0 s, £40 s, 36U s, 48U s, 600 s ı 840 s The obtained concentrates have the following quality:

lable 1

lime (sec;	Loncentrat ion mass> <g>	(%>	Pb%	Ln%
30	58.3	3.68	57.76	£.£0
60	47.9	3.19	49.56	3.£9
90	31.1	£.07	4£.07	3.97
1£0	19.O	1.£l	33.95	4.97
	c'9.O	1.93	£1.79	6.40
360	££.0	1.46	9.11	7.38
480	£1.4	1.4£	4.30	7.50
600	£6.si	1.74	£.66	6.££
§40	49.6	3.30	1.30	4.53
residue	1195.5	79.70	0.18	1.30

1.2. Computer Processing of Experimental Data

fill the data (flotation time, mass of obtained concentrates, contents of PbJ4 and Zn7t in individual products), have been fed in the computer programme in higher programme language Turbo Pascal in IBM 0T-£86 computer.

The programme consists of two parts. During the first part a comuiative evaluation and calculation of the given data is made. Ihe cumulative recovery of lead, cumulative distribution of zinc and cumulative distribution of other minerals toqether with zinc in rougher Pb concetrate as well as the cuni'.utive contents of lead and zinc in the same concentrate are made.

Ihe calculation ot cumulative separation efficiency of lead in relation to zinc (S> and in relation to other minerals together with the zinc (S") is made.

Ün the basis of the obtained results, which are shown in Table 1, calculations of kinetic data for lead (kinetic constant "k_{Pb}, maximum possible recovery "$I_{Pb}max$" and the correction time "b_{Pb}") for zinc (kinetic constant "k_{2n}", maximum possible distribution of zinc in lead concentration "$1_{Zn}max$" and the correction time "b_{Zn}") and for the rest of minerals together with the zinc (kinetic constant "k_{ZnTm}", their maximum possible distribution in the lead concentrate "$1_{ZnTm}max$" and the correct ion time "$b_{Zn»rm}$") are made in the second part.

Ht the end, on the be. _ .s of the obtained kinetic data, we calculated the time when the lead concentration finished "$t_{opt.}$" and the time when maximum separation efficiency of lead and zinc minerals "t_{ι}" occurred. These are the periods when zinc and other minerals begin flotating faster than the lea-d minerals. Kinetic data can be calculated with different precision (1%; O. ti'A (.>.£%; O. 154 and 0.0554) This reffers to the determination of values for "I max"; "$1_{Zn}max$" and "$I_{ZnTm}ma«$".

flccording to Agar's theory when determining the values of these parameters the their upper (maximum) value is assigned. On its basis other kinetic data ars calculated (kinetic constant and the correction time) by equations 1 and i£. Then by the method of the smallest quadrats the residue £ r is determined by formula:

$$\sum_{q=1}^{n} r_q^2 = \sum_{q=1}^{n}\{\ln[(I_{max}-I_q)/I_{max}]\}^2 + k^2\cdot\sum_{q=1}^{n} t_q^2 + n\cdot k^2\cdot b^2 + 2\cdot k^2\cdot b\cdot\sum_{q=1}^{n} t_q + 2\cdot k\cdot\sum_{q=1}^{n}\{t_q\cdot\ln[(I_{max}-I_q)/I_{max}]\} + 2\cdot k\cdot b\cdot\sum_{q=1}^{n}\ln[(I_{max}-I_q)/I_{max}]$$

where **n** is the number of experimental data.

Öfter that, the value for "1 **man";**$_{Pb}$ "1 **max"**$_{Zn}$ and "I **mx"**$_{ZnTm}$ is lowred and the whole step is repeated until the values of kinetic data whien minimize the value E ^{r} » separately for lead, for zinc and for the rest of minerals with the sine *Ars* found.

The values for "1 max"?$_{Pb}$ **"I max"**$_{Zn}$ **and "I max"**$_{ZnTm}$ ***carı* be** reduced in different steps (1%; 0.5% 0.£%; 0.IX and 0.05%). The smaller the step is, the precision in calculation of kinetic data is greater. Since the calculations are made by c\ computer, exept the upper (maximum) value for "I **max";**$_{Pb}$ ''1 **max"**$_{Zn}$ and "1 **max"**$_{Zn*rm}$ we must give their lower (minimum) value which for itself must be greater than the values obtained during the second assay.

Ihis limit is caused by the application of **the smallest** quadrat method.

ftfter input of the results of the Table 1 in **the computer** programme we have obtained the following results:

CUMULATIVE GRADE RECOVERY DATE

I(sec.;	1-Pb<%>	(-•b%	I (54; 2n	Zn% 1	fyOZn+RM	S(*>	S" C/.)
30.00	3/.5a	IJ/. 7b	4.34	£.£0	1.33	33.£1	36.16
C-O.00	64.0£	54.Ot.	9.b8	<'.b9	£.86	54.34	61.16
90.oo	76.61	til.35	13.86	£.96	4.00	64.75	74.60
l£u.uu	et>.a0	49.£3	17.Ob	3.££	4.83	68.74	80.97
c4U.UO	9E.84	44.94	£3.34	3.7£	b.38	69.51	86„•'•£,
JÔI.I.00	95.oa	41.13	t:6.B3	4.11	7.79	66.£5	87.£8
4Ü0.00	9b.lO	37.b9	34.£7	4.43	9.£5	61.84	66.85
bOO.00	96.ea	34.09	39.78	4.61	11.07	57.10	85.81
Ö40.00	97.DO	£8.75	47.39	4.b0	14.57	50,£1	83.03

K I N E T I C D ft T E

Lb «D:

k> = o.o£19795 per sec.
Imax - 9vi.40 %
D = -c.59 sec.

ZINC:

k = 0.0097035 per sec.
Imax = db.£o %
D = -11.94 sec.

ZINC + REST OF MINERALS
t-
k = 0.03 05463 per sec.
Imax = 7.00 %
b = -9.47 sec.

Topt. £94.77 sec.

(AFTER THIS TIME FLOTATION PROCESS
DOES NOT CONCENTRATE THE Pb-MINERALS>

Tl « 17c:.50s

(AFTER THIS TIME I HE Zn-MINERALS START
FLOTATION FASTER THAN Pb-M1NERHLS)

1.3. Analysis of the Obtained Results

Recording to output results of the computer programme for the kinetic process of rougher flotation of lead from the iead-zinc ore from "Ïletovo" Mine Probıstıp, Macedonia we may corne to the following conclusion:

- Maximum possible recovery of lead during rougher flotation of lead is 93.40%. Namely, according to ftgar's theory, that is the percent of mainly completely liberated minerals of lead grains in the feed. F-r:[1] the table "Cumulative evaluation of the obtained results" given above it is clear that extended flotation may yield greater lead recovery in the roupher lead concentration (after 840 **s** of Motation, recovery of lead of 37. fc% is obtained) Nevertheless, that is the result of transition of mainly lead-bearine intprtirown mineral grains in rougher lead concentrate.
- Maximum distribution of zinc in the rougher concentrate is c'b.c!"/.. In fact that is the zinc percent which in the piven conditions of depression of its minerals easily _ _>ses into roupher lead concentrate. It is clear that with extended flotation (after 840 s of flotation, the distribution o1 zinc in the rougher lead concentrate is M7.Si%) distribution of zinc in the rougher Pb- concentrate is much larger. Tnis is reasonable because extended flotation allows the interprown zinc bearing mineral grains to pass into rougher Pb-concentrate which leads to the collection of certain amount of already depressed mineral zinc grains. One should bear in mind that the sphalerite from Zletovo deposit is characterized by its explicit flotabı11ty.
- Maximum distribution of other minerals together with the zinc in rougher Pb-concentrate, in thesr. specific conditions, is 7%.
- I he equaticn adequate to the kinetics of flotation of lead minerals is the following:

$$I_{Pb} \bullet 93.40 -\{1-\exp[-0.0319795 - Ct -6.59:)]\}$$

- The equation adequate to -the kinetics of flotation of zinc minerals in this phase of process is:

$$I \cdot 26.20 \cdot \{1-\exp[-0.0097035 \cdot Ci -11.94)]\}$$

- "Hie equation adequate to the kinetics of flotation of the rest ot the minerals together with zinc minerals is the folowing:

$$I > 7.00 \{l-\exp[-0.0105463 - Ct -9.473]\}$$

- The time when the concentration of lead minerals ceases or the» time after which the flotation process does not concentrate Pü minerals is ^94.0 s. After this time the grade of c. centrate leaving the flotation cell lip is equal to the quality of flotation feed. That is the time after which the rest of the minerals begin flotating faster than the lead minerals.
- The time when maximum separation efficiency of lead and zinc minerals occurs is 17c'. 30 s This is the time after which the zinc minerals begin flotating faster than the lead minerals.
- ün the basis of this it is clear that if we want to achieve maximum recovery of lead in rougher Pb-concentrate, the duration time of the rougher lead flotation process should last about 5 minutes. If we want to achieve maximum separat ic efficiency of lead and zinc minerals, or if we want minimum contamination of rougher Pb- concentrate from zinc minerals, then the duration time of rougher lead flotation process should last about 3 minutes. In any case this is the highest (5 m m) and lowest <3 rnin) limit time during the process of rougher flotation of lead minerals. It is up to the engineers who *are* in charge of the process what time they will choose: the first, the second or some time between.

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