78''' International Mining Congress and Exhibition of Turkey-IMCET 2003. © 2003, ISBN 975-395-605-3

The Flotation of Murgul - Çakmakkaya Copper Mine and The Determination of the Results of Locked Cycle Flotation Tests

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ABSTRACT: In this work, locked cycle flotation test results have been determined by simulation method as a result of Murgul-Çakmakkaya copper ore flotation by using discontinuous laboratory test data. Thus locked cycle flotation periods and necessary total cell volumes has been determined without applying locked cycle tests which are very difficult to perform, long timing and sometimes impossible.

1 INTRODUCTION

Before plant setup stage, locked cycle flotation tests and pilot plant studies must be carried out. Discontinuous flotation tests done in laboratory does not represent the continuous test results completely. By these tests, parameter optimization has been supplied and necessary preliminary information has been obtained about métallurgie performance of enriching operation.

Locked cycle flotation tests are long lasting flotation tests that give cleaner tailings and scavenger concentrates which are obtained in the preceding circulation. They are collected in required places tor floating again (Nishimura at all, 1989, Yalçın, 1992).

These tests are lime consuming. It is necessary for a simple cycle to be balanced. 5 or even generally 6 circulations. And also cycle can't be balanced or tests can not be finished because of heavy load (Nishimura at all, 1989, Çilek, 1995).

To annihilate these disadvantages of locked cycle flotation, some studies show that locked cycle flotation test results can be pre-determined from discontinuous test results. For tis purpose various mathematical models have been developed which can simulate flotation tests (Nishimura at all, 1989, Yalçın, 1992, Reuter at all. 1992. Deng at all. 1996. Çilek, 2000).

Due to these mathematical models by connecting classic flotation data and plant conditions, optimum conditions are obtained. Therefore, disadvantages of locked cycle flotation tests are removed and at the same time faults in setting up the plant are minimized.

2 METHOD

In this work distribution coefficient (D) obtained from discontinuous laboratory test data is given was used in all cycles (close flotation, cleaner and scavenger flotation) in applied simulation method. Distribution coefficients in flotation cycle are calculated by rating solid amount, water amount and grade value to the same properties of the feed.

Then feed is distributed to inferior cycles related to the distribution coefficients calculated specially for grade, weight and water amount and these conditions continue until arriving to balance point.

Accepting that distribution coefficients in the cycles does not change until chemical conditions differ in these conditions; weight and grade values are calculated by created mathematical equations (Yalçın. 1992).

3 EXPERIMENTAL

Murgul-Çakmakkaya copper ore have been used in this experimental research. Run of mine ore has 3.7 % chalcopyrite and 10.6 % pyrite minerals. Elemental analysis of the ore gave the result of 1.27 % Cu, 6.12 % Fe and 78.95 SiO_2. Free grain size for pyrite and chalcopyrite from gangue is 74 urn, and pyrite from chalcopyrite is 43 urn.

Table 1. Collective flotation test results.

Products	Rougher			Scavenger			Cleaner		
	%Weight	%Grade	% Solid	%Weight	%Grade	%Solid	%Weight	%<Gradc	%Solid
Concentrate	17.77	6.00	25.01	11.24	1.27	12.56	58.45	9.52	12.04
Tailing	82.23	0.25	31.34	88.76	0.12	38.67	41.55	1.04	8.07
Feed	100.00	1.27	30.00	100.00	0.25	31.34	100.00	6.00	25.01
Flotation period		2 min.			4 min.			2 min.	

Table 2 Selective stage rougher and cleaner cycle flotation test results.

Products	Rougher			Cleaner		
	%Weight	%Cu	%Solid	%Weight	f/rCu	%Solid
Concentrate	55.62	12.14	12.21	22.91	24.44	8.67
Tailing	44.38	6.236	21.00	77.09	8.484	10.48
Feed	100.00	9.52	15.00	100.00	12.14	12.21
Flotation period		10 min.			2 min.	

Table 3 Selective stage scavenger 1 and scavenger 2 flotation test results.

Products	Scavenger 1			Scavenger 2		
	%Weight	%Cu	%Solid	%Weight	9iCu	%Solid
Concentrate	53.81	8.03	15.58	48.66	7.26	14.30
Tailing	46.19	4.146	19.02	51.34	1.195	15.70
Feed	100.00	6.236	21.00	100.00	4.146	19.02
Flotation period		5 min.			5 min.	

4 EVALUATION OF LABORATORY TEST RESULTS BY SIMULTANEOUS METHOD

4.1 Determining mathematical equations for collective stage

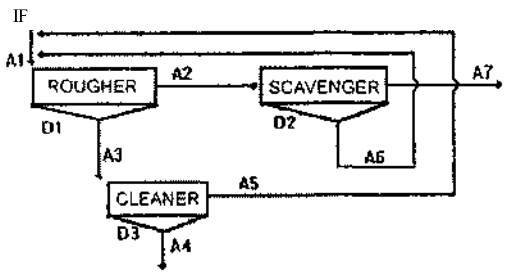

Figure 1 Locked cycle flow chart for collective flotation.

Initially:

$IF=Ai$

$A_{:}=A|D|$

$A,=A,(I-Di)$

$A_4=Ai(l-Di)(l-Di$

$A,=A,D,=A|D1(l-D,)$

$Afi=A:(l-D2)=A|D,(l-D_2)$

$A_7=A:D2=\hat{A}|D|D;$

Balanced:

$A_1=1F+A_5+A_f,$

$A|=IF+A,D_3(1-D,)+A,D|(1-D_2)$

$IF=A,[1-D,(1-D,)-D,(1-D:)]$

$$A_1=\frac{IF}{[1-D_3(1-D_1)-D_1(1-D_2)]}$$

4.2 Determining mathematical equations for selective stage

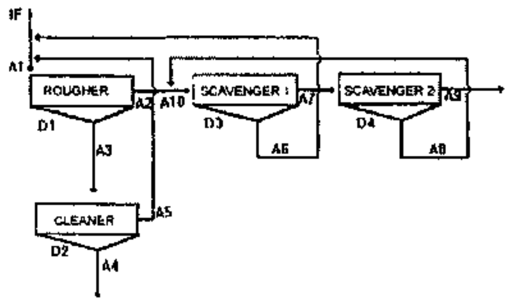

Figure 2 Selective stage locked cycle flow chart.

Initially: A,=IF

A_2=AjD,

A,=AI(1-DI)

A_4=A,(I-D_2)=A,(1-D|)(1-D_2)

A<;=A,D:=AıD$_2$(l-Dı)

A6=A_2(I-D_1)=A,D,(I-D,)

A_7=A_2Di=A|D|D,

AK=A_7(I-D_4)=A|D|D,(1-D_4)

A>J=A_7D4=A|D|D,D_4

Balanced: Ai=lF+A-;+Ar,

AKI=A;+AS

A«=A_7(I-D_4)

A_7=A|(>DI

A«=A,nD,(l-D_4)

AI,FAID|+AH,DI(1-D4)

$$A_{10}=\frac{A_1D_1}{[1-D_3(1-D_4)]}$$

A_A=A|,KI-D0

$$A_1=\frac{A_1D_1(1-D_3)}{1-D_3(1-D_4)}+A_1D_2(1-D_1)+IF$$

$$A_1=\frac{IF}{1-[D_1(1-D_3)/1-D_3(1-D_4)]-D_2(1-D_1)}$$

4.3 Calculating locked cule flotation results by simulation method

"IF" value used in the equations below for three different concepts, is used as *i\ first feed amount* for weight balance calculations: secondly it is used as a *first feed unit* for grade balance calculations and thirdly it is used as a *water content in first feed,* for watei balance calculations.

So "IF'" is accepted as below;

For collective stage weight balance calculations.

IF= 474 t/h

For collective stage grade balance calculations;

IF= 127 t/h

For collective stage water balance calculations;

IF= 1106 t/h

For selective stage weight balance calculations;

IF= 59.09 t/h

For selective stage grade balance calculations:

IF= 952 t/h

For selective stage water balance calculations;

IF= 33.84 t/h

Then as explained in Part 2 distribution coefficients are calculated related to laboratory test data obtained. So;

Weight balance distribution coefficients;

In collective stage

Forroughei cyctcrD|=0.822

For scavenger cycle D_2=0.888

For cleaner cycle Di=0.416

In selective stage

For rougher cycle D,=0.4438

For cleaner cycle D_2=0.7709

For scavenger 1 cycle Di=0.4619

For scavenger 2 cycle D_4=0.5134

Grade balance distribution coefficients;

In collective stage

For rougher cycle D|=0.1618

For scavenger cycle D_2=0.426

For cleaner cycle Di=0.072

In selective stage

For rougher cycle D|=0.2907

For cleaner cycle D_2=0.5387

For scavenger I cycle Dv=0.307l

For scavenger 2 cycle D_4=0.1480

Water balance distribution coefficients;

In collective stage

For rougher cycle Di=0.772

For scavenger cycle D_2=0.642

For cleaner cycle Di=0 526

In selective stage

For rougher cycle D|=0.295

For cleaner cycle D_2=0.731

For scavenger 1 cycle Di=0.402

For scavenger 2 cycle D_4=0.486

Table 4 Collective stage locked cycle flotation test results calculated by simulation method.

Flow branch	Weight		Grade %	Pulp solid/ liquid rate	Water How m'/h	Pulp flow m-Vh	Pulp density gr/cm
	ton/h	%					
Al	568.48	119.92	1.25	23.70	1830.82	2020.31	1.19
A2	467.29	98.57	0.25	24.85	1413.39	1569.15	1.20
A3	101.19	21.35	5.90	19.51	417.42	451.15	1.15
A6	62.33	11.04	1.25	9.37	505.99	523.43	1.07
A7	414.95	87.53	0.12	31.37	907.39	1045.70	1.26
A4	59.09	12.47	9.36	22.99	197.86	217.55	1.18
A5	42.09	8.88	1.02	16.08	219.56	233.59	1.12

Table 5 Selective stage flotation results calcidated by simulation method.

Flow branch	Weight		Grade %	Pulp solid/ liquid rate	Water How mVh	Pulp flow mVh	Pulp density gr/cm
	ton/h	%					
Al	224.42	379.79	7.26	14.97	1274.61	1349.42	1.11
A2	99.60	168.55	4.76	20.94	376.01	409.21	1.16
A3	124.82	211.24	9.26	12.19	898.60	940.21	1.09
A6	69.15	117.03	6.43	19.25	290.12	313.17	1.15
A7	59.36	100.45	3.32	23.33	195.03	214.81	1.19
A8	28.87	48.88	5.81	22.36	100.25	109.87	1.18
A9	30.47	51.57	0.96	24.32	94.78	104.93	1.20
A4	28.60	48.40	18.64	10.58	241.72	251.25	1.08
A5	96.22	162.84	6.47	12.77	656.88	688.95	1.09

5 CALCULATING LOCKED CYCLE FLOTATION PERIODS AND REQUIRED CELL VOLUMES

For determining flotation periods in actual plant size applications, periods used in laboratory discontinuous flotation tests and yield values obtained from laboratory tests are utilized. Flotation periods necessary for continuous system determined from laboratory tests can be found from the equations below;

$$\left.\begin{array}{l} R_I = 1 - e^{kt I} \\ \\ R_E = kt_E/(1+kt_E) \end{array}\right\} \quad R_L = R_E$$

Necessary flotation periods obtained from the equations above;

Collective stage
Rougher cycle flotation period=5.75 min
Cleaner cycle tlotation period=9.74 min
Scavenger cycle tlotation period=6.36 min

Selective stage;
Rougher cycle tlotation penod= 19.75 min
Cleaner cycle tlotation period=2.761 min
Scavenger 1 cycle flotation period=9.54 min
Scavenger 2 cycle tlotation period= 14.94 min

Cell volumes for every cycle related to tlotation periods and pulp How volumes:

Collective stage;
For rougher cycle= 193.61 m^3
For scavenger cycle= 166.32 m
For cleaner cycle=73.23 rtr

Selective stage;
For rougher cycle=444.18 m^3
For scavenger I cycle=8(). 14 m
For scavenger 2 cycle=53.49 m^1
For cleaner cycle=43.27 m

6 RESULTS

- When grade values; obtained from calculations and discontinuous flotation test results are compared it is seen that all concentrate grades go down in value in the end of locked cycle tlotation tests.
- It is observed that tlotation periods obtained from calculations and the periods applied in the values in the plant arc coincide to each other. However calculated cell volume is bigger than actual size plant's cell volume this situation is the result of studying on the test situation which have low solid rate and higher cycling load amount.

- Bulk concentrate obtained from collective flotation is 9.36 % Cu and it has an amount of 59 t/h. In the light of these data collective stage yield has been calculated 91.83%. In the ore dressing plant bulk concentrate amount is 45 t/h, grade 9.5 % and collective stage yield is 90.19%.
- Il is determined that grade of Cu concentrate is 18.64 % Cu and as an amount of 28.6 t/h with a yield 90 % as a result of calculations. On the other hand Cu concentrate produced in the site plant is 20 t/h, and it has a grade of 20 % Cu. Cu preparation yield in site plant is then 87 %. One stage cleaner process has been done while three stages is being done in site plant.
- As a result, this research study can be explained that using mathematical method in locked cycle flotation tests as presented here, not only determines problems that might be appeared in process but also process analysis can be evaluated without demolishing site plants working conditions. Therefore it is possible to compare alternative flow sheets with the actual applied flotation cycle in progress.

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