Study on Technological Solutions to Increase the Recovery and Quality of the Copper Concentrate at Ta Phoi Beneficiation Plant in Vietnam

NHU Thi Kim Dung[1)], PHAM Thi Nhung[1)], VU Thi Chinh[1)], LE Viet Ha[1)]*

[1)] Faculty of Mining, Hanoi University of Mining and Geology, Hanoi, Vietnam
*Corresponding author: nhuthikimdung@humg.edu.vn

http://doi.org/10.29227/IM-2023-02-35

Submission date: 19-08-2023 | Review date: 27-09-2023

Abstract

The Ta Phoi beneficiation plant is one of the main copper beneficiation plants in Vietnam. The plant has been put in operation since 2019 and annually process more than one million tons of ROM copper ore to collect 32 thousand tons of copper concentrate of 23% Cu. In the first years of operation the plant's metallurgical performance has not been consistent and not been as good as in design. The most important task at the company in this day is to improve and stabilize this performance with a target to obtain the copper concentrate of 23% Cu and recovery of over 91.5%. This report presents some research results to increase the recovery and quality of the copper concentrate at Ta Phoi beneficiation plant. As the results, some technological solutions have been proposed concerning the optimization of the reagent regime as well as of flotation flowsheet. Some of these solutions have been tested directly in the plant production line and have the perspective to apply.

Keywords: *copper concentrate, optimization, reagent regime, flotation flowsheet*

1. Introduction

Ta Phoi Copper Joint Stock Company – VINACOMIN was established on January 15, 2009. After its establishment, the Company actively carried out exploration work and was approved by the National Mineral Reserve Evaluation Council with reserves of 11.3 million tons of primary ore, equivalent to 99.2 thousand tons of copper metal and 3.5 tons of gold. Experiencing many difficulties and challenges, after a lot of efforts, Ta Phoi Copper Joint Stock Company ended the investment phase in 2019. On November 16, 2019, Ta Phoi copper beneficiation plant went into official production. During the operation, the plant's employees always strive non-stop, apply new technology in production and improve the processing technology scheme to bring the plant into stable operation to achieve the annual set target. The production and business efficiency of the plant in recent years is higher than in the previous year, the capacity and the technological performance have exceeded or reached approximately to the design.

Since going into official production up to now, Ta Phoi copper beneficiation plant has changed its technology flowsheet three times. In the first stage, the plant operates at the design diagram and technology regime. By May 2021, the plant has introduced 3 tank cells for rougher flotation and fast cleaner. And in July 2021, the plant will remove the grinding stage 2. The current technological flowsheet of the plant is as shown in Figure 1.

At present, the capacity of Ta Phoi copper beneficiation plant is 1 million tons of ROM ore per year, with copper content is about 0.8%. The content and recovery of copper ore concentrate after flotation has basically reached the design level (concentrate content: 23% Cu, recovery: 91.5%) [3]. The actual plant performance shows that the content and recovery of copper concentrates are still unstable and there is still potential for improvement in technology and equipment to increase the copper recovery (to > 91.5%) and the stabilize the concentrate content at level of 23% Cu.

2. Methods and reagents

– A number of open-circuit flotation tests were conducted at the laboratory of the Mineral Processing Department, University of Mining and Geology, using a mixture of different collectors and depressants. The purpose is to choose the best reagent regime for Ta Phoi copper ore.

– Tests on plant's ground samples at the laboratory of Ta Phoi copper beneficiation plant with the selected reagent regime to evaluate the ability to increase the content and recovery of copper concentrate products.

– Proposing a plan to run tests at the actual plant production line with a change in the reagent regime.

– The reagents that were used in tests as following [4-5]:

Modifier: Lime;

Collectors: Sodium Butyl xanthate (SBX), Potassium Amyl Xanthate (PAX), AP2, Ammonium Dibutyl Dithiophosphate (ADD);

Depressants: Dextrin, water glass;

Frother: Pine oil

3. Results and discussion

3.1. Tests at the laboratory of the Mineral Processing Department

– The samples are collected at the plant, taken at the feed conveyor belt to the mills. The results of the analysis of the sample material composition are shown in documents [1-2]. The ore sample belongs to copper sulfide ore, with a small amount of copper oxide minerals (malachite, azurite). Copper content in raw ore sample ~0.8%.

The open-circuit test flowsheet as in Figure 2.

The fixed flotation conditions are as follows: Mesh of grind:

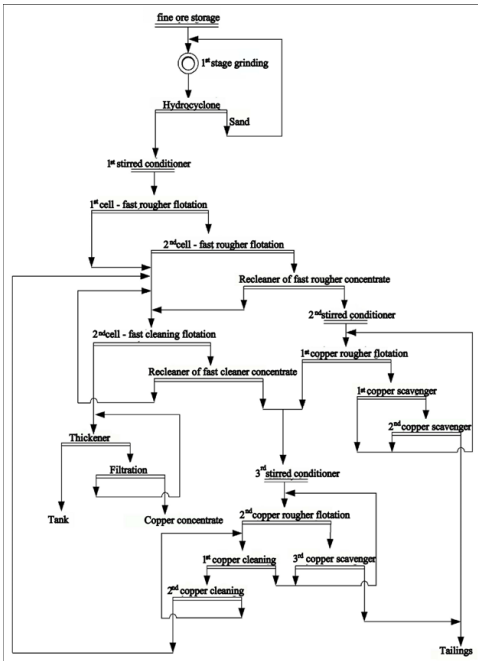

Fig. 1. The current technological flowsheet of the plant

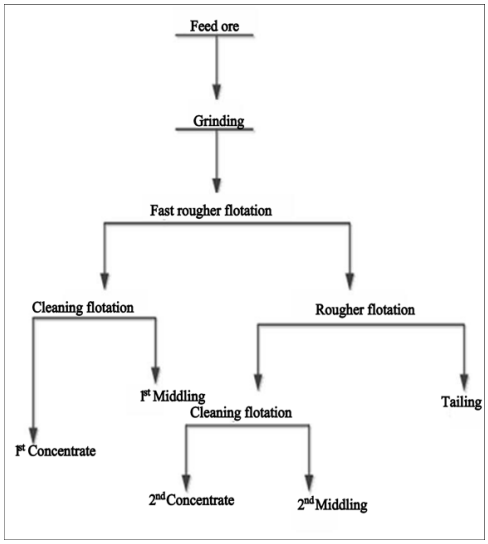

Fig. 2. The open-circuit test flowsheet

62.67% -0.074 mm; pH medium modified by lime: 9–10; pine oil added to the fast rougher flotation stage: 10 g/T and to rougher flotation: 10 g/T.

a) Tests at collector combination

The combination of collectors that added to the fast rougher flotation stage and the rougher flotation stage: Butyl xanthate with Amyl xanthate; Butyl xanthate with Dithiophosphate; Butyl xanthate with AP2, Amyl xanthate with AP2 [5].

Dosage at fast rougher flotation stage: 10/10 (g/T)

Dosage at rougher flotation stage: 20/20 (g/T)

The test results are shown in Table 1.

The results in Table 1 show that, when butyl xanthate and dithiophosphate is combined, the content of 1st copper concentrate and 2nd copper concentrate is higher, the loss of copper to the tailing is the least (3.36%). Therefore, in the following tests, the combination of butyl xanthate and dithiophosphate was choosen.

b) Tests at depressant combination

– Collectors dosage to the fast rougher flotation stage: Butyl xanthate/Dithiophosphate = 10/10 (g/T); and to the rougher flotation stage: Butyl xanthate/Dithiophosphate = 10/10 (g/T);

– The depressant dosage to the cleaning flotation: Dextrin/water glass = 50/50 (g/T)

Change the depressant dosage to the fast rougher flotation stage: Lime/dextrin = 100/20; 500/100; 1000/200; 2000/400 (g/T).

The test results are shown in Table 2.

The results in Table 2 show that, at the dosage of lime/dextrin = 1000/200 (g/T) the first copper concentrate and the second copper concentrate have obtained with higher content and recovery, and lower tailing content of 0.07% Cu. Therefore, in the fast rougher flotation stage, the additional depressants of lime and dextrin with a dosage of 1000/200 (g/T) is desirable.

3.2. Tests on plant samples

– The samples were taken after the mill circuit, at the hy-

Tab. 1. The results of the collectors combination tests

Collectors	Products	Yield (%)	Content of copper (%)	Recovery (%)
Butyl xanthate/ Amyl xanthate	1st Concentrate	2.24	23.82	68.50
	1st Middling	1.64	5.34	11.24
	2nd Concentrate	0.96	8.66	10.74
	2nd Middling	2.49	1.11	3.56
	Tailing	92.67	0.05	5.96
	Feed	**100.00**	**0.8**	**100.00**
Butyl xanthate/ Dithiophosphate	1st Concentrate	0.86	30.55	33.50
	1st Middling	1.06	16.75	22.52
	2nd Concentrate	1.13	20.23	29.22
	2nd Middling	1.12	7.78	11.10
	Tailing	95.83	0.03	3.66
	Feed	**100.00**	**0,8**	**100,00**
Butyl xanthate/AP2	1st Concentrate	1.49	26.27	49.19
	1st Middling	2.20	9.49	26.28
	2nd Concentrate	1.18	10.02	14.82
	2nd Middling	2.14	1.44	3.86
	Tailing	92.99	0.05	5.85
	Feed	**100.00**	**0.8**	**100.00**
Amyl xanthate/AP2	1st Concentrate	1.15	28.82	40.94
	1st Middling	1.99	11.30	27.77
	2nd Concentrate	1.08	13.45	17.93
	2nd Middling	3.03	1.12	4.19
	Tailing	92.75	0.08	9.16
	Feed	**100.00**	**0.8**	**100.00**

Tab. 2. The results of the depressants combination tests

Lime/Dextrin (g/T)	Products	Yield (%)	Content of copper (%)	Recovery (%)
100/20	1st Concentrate	1.91	27.02	64.78
	2nd Concentrate	0.99	12.44	15.46
	1st Middling	1.88	2.12	4.99
	2nd Middling	1.71	1.96	4.20
	Tailing	93.51	0.09	10.56
	Feed	**100.00**	**0.80**	**100.00**
500/100	1st Concentrate	1.90	27.43	64.80
	2nd Concentrate	0.96	15.02	17.87
	1st Middling	1.57	1.92	3.74
	2nd Middling	1.49	2.28	4.23
	Tailing	94.08	0.08	9.36
	Feed	**100.00**	**0.80**	**100.00**
1000/200	1st Concentrate	1.92	27.61	66.15
	2nd Concentrate	0.99	15.43	19.10
	1st Middling	1.62	1.96	3.97
	2nd Middling	0.91	2.23	2.53
	Tailing	94.56	0.07	8.26
	Feed	**100.00**	**0.80**	**100.00**
2000/400	1st Concentrate	1.85	27.02	62.37
	2nd Concentrate	1.02	12.05	15.33
	1st Middling	1.90	2.22	5.26
	2nd Middling	1.70	1.98	4.20
	Tailing	93.53	0.11	12.84
	Feed	**100.00**	**0.80**	**100.00**

Tab. 3. The first closed-circuit flotation test results

Products	Yield (%)	Content of copper (%)	Recovery (%)
1st Concentrate	2.12	27.04	71.97
2nd Concentrate	0.98	16.76	20.62
1st Tailing	93.98	0.06	7.08
2nd Tailing	2.92	0.09	0.33
Total of copper concentrates	***3.10***	***23.79***	***92.59***
Total of Tailings	***96.90***	***0.06***	***7.41***
Feed	**100.00**	**0,8**	**100.00**

Tab. 4. The second closed-circuit flotation test results

Products	Yield (%)	Content of copper (%)	Recovery (%)
1st Concentrate	2.14	26.51	68.81
2nd Concentrate	1.11	17.09	23.01
1st Tailing	94.76	0.05	5.75
2nd Tailing	1.99	1.01	2.44
Total of copper concentrates	***3.25***	***23.29***	***91.82***
Total of Tailings	***96.75***	***0.07***	***8.18***
Feed	**100.00**	**0.8**	**100.00**

drocyclone overflow pipeline supplied to the flotation at the plant. The sample has a content of about 0.8% Cu, the mesh of grind is about 62% -0.074mm.

– The closed-circuit flotation was tested at plant's laboratory in 02 flowsheets (Figures 3 and 4) based on the results of open-circuit flowsheet tests with the combination of collectors and depressants (Section 3.1) as well as the plant's data.

– The reagent regime as the following:

The first flotation stage: Lime/dextrin: 1000/200 (g/T); Butyl xanthate/Dithiophosphate: 10/10g/t; Pine oil: 10 g/T

The second flotation stage: Butyl xanthate/Dithiophosphate: 20/20 (g/T); Pine oil: 10 g/T

The first cleaning stage: Dextrin/Water glass = 50/50 (g/T)

The second cleaning stage: Dextrin/Water glass = 50/50 (g/T)

The scavenger stage: Butyl xanthate/Dithiophosphate: 10/10 (g/T); Pine oil: 10 g/T

The test results are shown in Tables 3 and 4.

The results of the tests according to the 1st and 2nd closed-circuit flotation flowsheet showed that the copper concentrate reached the target in terms of content and recovery, content was over 23% Cu, recovery was over 91.5%. The copper content in tailing is 0.06–0.07%. The concentrate at the 1st closed-circuit flotation flowsheet has the higher copper content than in the 2nd flowsheet and lower copper content in the tailing.

4. Conclusion

From the research results, the following conclusions can be drawn:

– Currently, the technology flowsheet of the plant has 3 tank cells for rougher and fast cleaning, abandoning the 2nd grinding stage. The capacity of the plant is 1 million tons of ROM ore per year, copper content is about 0.8%. The content and recovery of copper concentrates after flotation were basically achieved the design level (content: 23% Cu, recovery: 91.5%).

– The collector put in flotation stages are butyl xanthate and AP2.

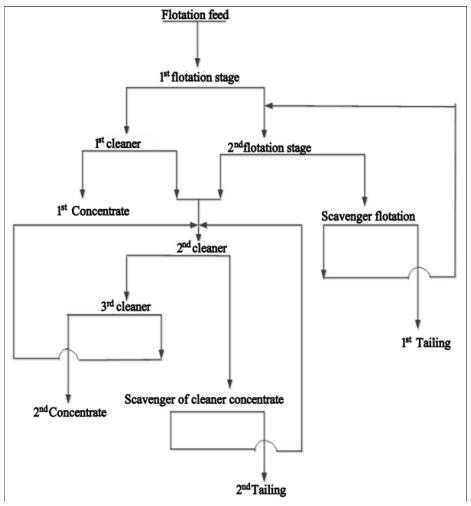

Fig. 3. The first closed-circuit flotation flowsheet

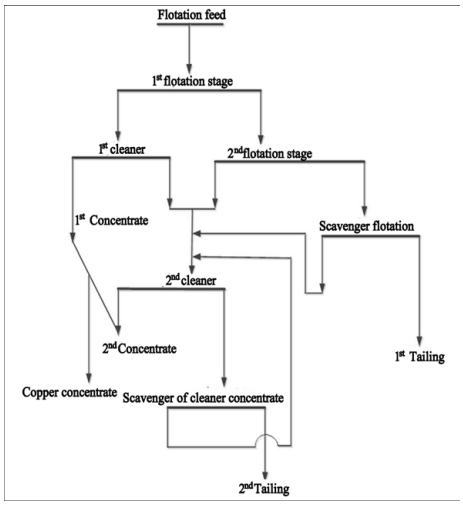

Fig. 4. The second closed-circuit flotation flowsheet

–The tests results of some flotation flowsheets in the laboratory using a combination of collectors and depressants give the copper concentrate with quite good processing performance. The combination of butyl xanthate with dithiophosphate gives the best seperation results, the depressants can combine are lime with dextrin and dextrin with water glass.

– Closed-circuit flotation using a combination of collectors and a combination of depressants: butyl xanthate with dithiophosphate, lime with dextrin and dextrin with water glass, allows to obtain the copper concentrate reaching the target content of over 23% Cu, recovery over 91.5%. The tailing copper content is 0.06–0.07%.

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