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Research and Industry Application of New Process of Low Grade Copper Oxide Ore

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Abstract: The experiments of refractory copper oxide ore which comes from Tangdan of Yunnan Province were studied in laboratory using bulk flotation process and a new process that Ammonia leaching-Extraction-Electrode position-Residue flotation under normal temperature and pressure respectively. The results show that new process, compared with bulk flotation, had an effect to add 10.8 percent points to recovery. And then it is confirmed by industry experiment. So it is successfully applied to industry production and technology indicators were improved dramatically.

Introduction

Owing metal reserves of one million tons, copper ore deposit of tangdan is one of large deposits of copper oxide ore ascertained in China. The copper oxide ore has high content of gangue mineral and slurry, as well as high oxidation ratio [1,2,3]. Since the 1950s, The refractory copper oxide ore of Tangdan has been studied by nearly ten authoritative research institutes at home and abroad and former SU, using mineral separation, hydrometallurgy and beneficiation - metallurgy process, etc [4]. Industrial applications acquired low cumulative average copper recovery rate in the last 30 years, which is less than 65%, by using single sulphide flotation process through the end of 2008. Although, the high pressure leaching technology of hydrometallurgy and beneficiation - metallurgy process has taken breakthrough, they have not always applied to industry because of many shortcomings of economy and technology [5,6,7,8,9]. Through analyzing and summarizing achievement of last researches, we clearly realize that the recovery only up to 70% by using single sulphide flotation process to refractory copper oxide ore of Tangdan. Furthermore, The ore, with copper content in the run-of-mine ores ranging about 1.00 percent, is disposed by using hydrometallurgy and beneficiation - metallurgy process under high temperature and high pressure, which set the all technology questions at rest. Even so, economic benefit is difficultly obtained. Therefore, in order to solve the problems previously mentioned, a new process that Ammonia leaching-Extraction-Electrode position-slag flotation under normal temperature and pressure will be studied in this work. Not only copper oxidized ores leached easily and floated difficultly are recovered by Ammonia leaching under normal temperature and pressure, but also sulfide minerals and associated noble metal minerals leached difficultly and floated easily are recovered by floatation. It avoided dangerous of high temperature and pressure and had two advantages such as simple process and low energy consumption.

Micro-experiment materials and methods

The ore used in this study was collected from the Tangdan, which located in Yunnan province, China. The chunk ore was crushed by laboratory jaw and roll crushers, and then was blended with shovels. After that, it was ground dryly by using a standard laboratory rod mill to obtain the final sample in the fineness of 80～85% for tests in this work. It was weighed 700g each time for leaching test as per specified ratio of liquor to solid. The tests were done by stirring using Numerical Show Precise Power Mixer (JJ-1) in a breaker. Then, pulp was filtered to filtrate and residue. Following was that filtrate was extracted in separating funnel, and then accumulated extracted liquor was treated by electro-deposition. At the same time, the slag was floated by flotation machines, concentrates and tailings of floatation were dried by Electric constant temperature drying oven. The dried materials were sampled for copper content analysis.

In this study, the ammonium, ammonium bicarbonate and ammonium bifluoride from the Zhuzhou Flotation Reagents Ltd was used as leaching agents. Lix84-I from the Kunming Chemical Reagents with chemical purity were used as extracting agent. The isoamyl xanthate from Chengdu Chemical Reagents was used as collector. The sodium sulfide from the Zhuzhou Flotation Reagents Ltd was used as sulphidizing agent. The pine oil from the Kunming Chemical Reagents was used as foaming agent. Vitriol from the Zhuzhou Flotation Reagents Ltd was used as abluent agent of extractant.

Process mineralogy research

2.1 The analysis results of copper phase

Table 1 Chemical composition of ore

Copper phase	Pure copper	Active copper sulphide	Inert copper sulphide	Combined copper oxidized	Free copper oxidized
Composition/%	1.20	0.370	0.045	0.237	0.548

Tab. 1 shows the analysis results of copper phase. Low copper grade, high oxidation ratio and high combined ratio are shown in Tab.1. The ore is refractory copper oxidized ore type, with copper content in the run-of-mine ores ranging about 1.20 percent. Some 65.42 percent of the ores are oxidized ores type on average. Meanwhile about 19.75 percent of the ores are combined ores type.

2.2 . Chemical compositions of ore

Table 2 Chemical composition of ore

Elements	Cu	CaO	MgO	SiO_2	Al_2O_3	Fe_2O_3	S
content/%	1.20	24.68	17.36	19.89	1.42	1.30	0.09

Tab.2 shows the analysis results of Multi-element chemical analysis results of representative samples. The ratio of quartz is 19.89%, the ratio of calcium and magnesium is 42.04%.

2.3. The Spectrum analysis results of representative samples

Tab. 3 The Spectrum analysis results of representative samples

Elements	Ag(g/t)	As	B	Ba	Co	Mo	Pb	Ni
content/%	0.0007	0.01	0.003	0.03	0.001	0.0003	0.01	0.001
Elements	Sb	Sn	Ti	V	Zn	Ge	Ga	Zr
content/%	0.005	0.005	0.1	0.0003	0.007	0.0005	0.0003	0.001

Tab.3 shows the Spectrum analysis results of representative samples. The content of each element are lower except copper, so they are not recovered.

Flowsheet

Fig.1 shows the flowsheet of new technology applied to refractory copper oxidized ore of Tangdan.

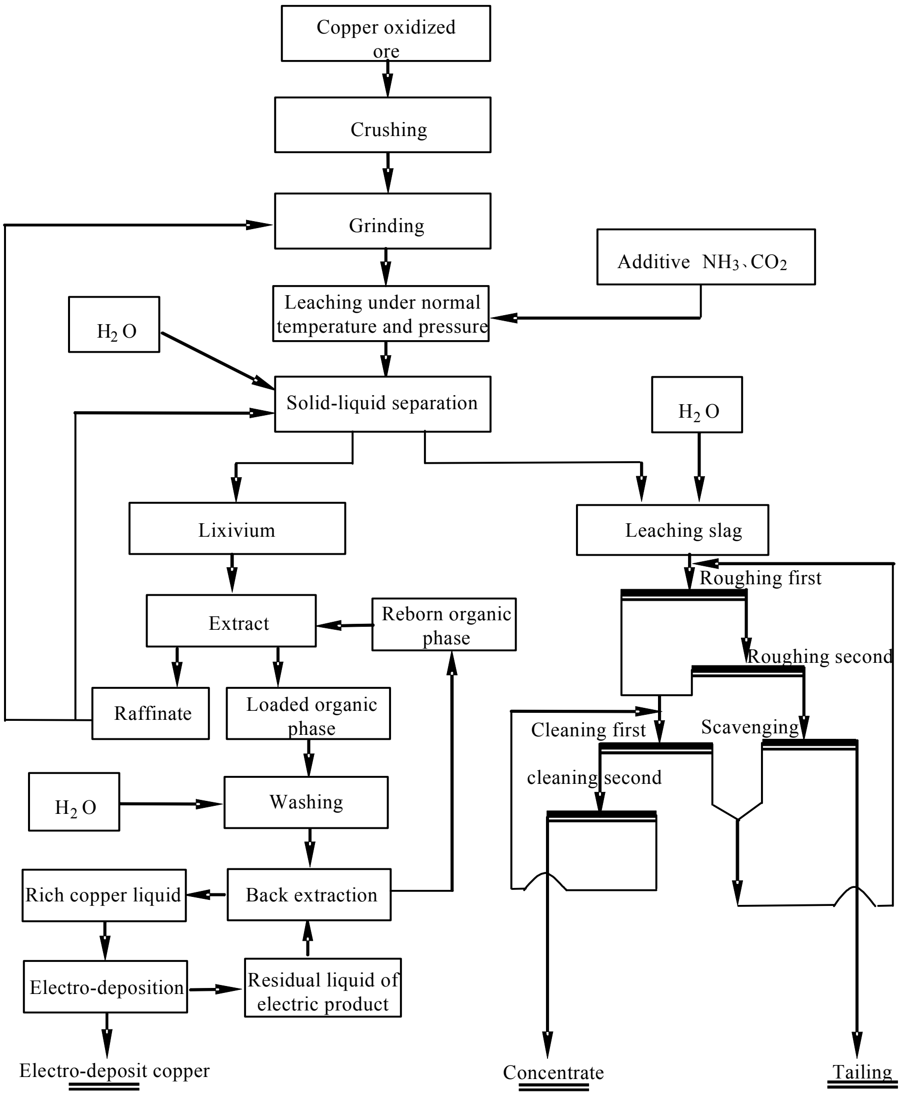

Fig. 1 Principle flowsheet of test

Results and discussion

4.1 Micro-experiment

The comparison of experimental results of new process and bulk floatation are illustrated in Tab.4, Tab.5, Tab.6, Tab.7 and Tab.8. Among them, Tab.6, Tab.7 show that the analysis results of copper phase of leaching residue and floatation production of it.

Tab.4 The experimental results of leaching-extract operation

Copper grade of raw-ore	Leaching rate of copper	Extraction yield of copper	Copper grade of leaching slag	Recovery relative to raw-ore
1.20	55.92	99.9	0.546	55.86

Tab.5 The experimental results of floatation operation to leaching residue

Copper grade of leaching slag	Copper grade of concentrate	Copper grade of tailing	Recovery relative to leaching slag	Recovery relative to raw-ore
0.546	16.03	0.225	59.93	26.42

Tab.4 and Tab.5 show that the leaching rate of copper 55.92% is acquired in ammonium leaching operation. Meanwhile, Extraction yield of copper 99.9% is achieved in extraction. Copper recovery 26.42% is also reached in floatation of leaching slag, and copper concentrate grade is up to 16.03%. Total recovery attain to 82.28% by using new process, which is very perfect.

Tab.6 Phase analysis of leaching slag（%）

Copper phase	Free copper oxidized	Combined copper oxidized	Active copper sulphide	Inert copper sulphide	Pure copper
Leaching slag	0.047	0.211	0.239	0.045	0.542
Occupancy	8.67	38.93	44.10	8.30	100.00
Leaching rate	91.42	10.97	35.40	0.00	

Tab.6 shows that about 91.42 percent of free copper oxidized is leaching to liquid. However, the leaching rate of combined copper oxidized is only 10.97 percent. In addition, the leaching rate of active copper sulphide is up to 35.40 percent, Inert copper sulphide is not leached completely. All certify that free copper oxidized and active copper sulphide are recovered easily by leaching operation, others are on the contrary.

Tab.7 Phase analysis of flotation productions of leaching slag（%）

Copper phase	Free copper oxidized	Combined copper oxidized	Active copper sulphide	Inert copper sulphide	Pure copper
Copper concentrate	1.67	1.40	11.03	1.90	16.00
Occupancy	10.44	8.75	68.94	11.87	100.00
Phase recovery	55.28	13.66	95.18	87.22	100.00

Tab.7 shows that about 55.28 percent of free copper oxidized is leaching to liquid. However, the leaching rate of combined copper oxidized is only 13.66 percent. In addition, the leaching rate of active copper sulphide is up to 95.18 percent. Specially, almost 87.22 percent of inert copper sulphide is floated. We can see that some mineral is floated readily if it is leached easily. As it is noted, indeed, combined copper oxidized is reclaimed difficultly.

Tab.8 Closed-circuit flotation performance of run-of-mine

Copper grade of run-of-mine	Copper grade of concentrate	Copper grade of tailing	Productivity	Recovery
1.20	20.23	0.358	4.24	71.48

Contrast the results of Tab.4, Tab.5 and Tab.8, the recovery is increased by 10.8% compared with the results of bulk floatation. In terms of process, new process of Ammonia leaching-Extraction-Electrode position-slag flotation under normal temperature and pressure, is more flexible and better adaptability to complicated ore properties than bulk floatation process.

4.2 Industry test

Tab. 9 Main performance of 1500t/d industrial demonstration plant during 30-continuous days

Grade of raw-ore/%	Oxidation ratio/%	Combined ratio/%	$[NH_3]$ mol/L	$[CO_2]$ mol/L	Liquid-solid Ratio	Leaching rate/%	Grade of leaching slag
1.02	66.45	16.73	1.44	0.44	1.627	57.28	0.45

Tab. 10 Main performance of 1500t/d industrial demonstration plant during 30-continuous days(%)

Grade of concentrate	Grade of tailing	Recovery of floatation	Recovery relative to raw-ore	Recovery relative to raw-ore	Extracti on ratio	Recovery of electrodeposition	Total recovery
17.23	0.218	52.25	23.01	23.01	94.29	54.01	77.02

Tab.9 and Tab.10 show that the recovery of electro-deposit copper has reached 54.01 percent, concentrate grade has reached 17.23 percent, concentrate recovery has reached 23.01%, total recovery of whole process has reduced to 77.02 percent, all acquired by the new technology. As it is proved by industry experiment, the process is reliable and scientific.

4.3 Industry produce

Table 11 Performance comparison between the new technology and conventional flotation/%

Process	Row ore capacity/t	Raw ore grade	Oxidized ratio	Combined ratio	Concentrate grade	Tailing grade	Total recovery
Floatation	20958	1.11	57.76	15.79	19.21	0.46	60.05
New process	24713	1.15	64.15	19.46	18.02	0.292	75.22

Table 12 The main material consumption of SX-EW （kg /t·Cu）

Materials	Raw ore	Ammonia	Ammonia bicarbonate	Extractant	Kerosene	Sulfuric acid	Positive plate	Electric kWh/t.Cu
Consumption	181500	1260	1660	2.98	50	164	4	6102

Table 13 The main material consumption of slag flotation （g/t·slag）

Materials	sodium sulfide	n-butyl xanthate	pine oil	steel ball	Electric kWh/t.Cu
Consumption	500	199	99	550	9.73

Tab.11 shows that the recovery is significantly improved when the new process was implemented. The effect of Ammonia leaching-Extraction-Electrode position-Residue flotation under normal temperature and pressure is better than floatation operation. It can improve the recovery from 60.05% to 75.22%. Therefore, reliability and scientificalness of the new technology are proved again. Besides, economic effectiveness is considerable by using it as shown in Tab.11, Tab.12 and Tab.13.

Conclusions

Beneficiation - metallurgy new process, Ammonia leaching-Extraction-Electrode position-slag flotation under normal temperature and pressure, combined and used the ore properties of refractory copper oxidized ore of Tangdan. On the one hand, copper oxidized ore leached easily and floated difficultly is recovered effectively by Ammonia leaching. On the other hand, copper sulphide ore leached difficultly and floated easily is also reclaimed by floatation.

Simple process, convenient operations and reliable technology are advantages of the beneficiation - metallurgy new process. Especially, it can adapt neatly the complex ore properties.

The results of industry produce make clear that the recovery increased by 15% compared with the result of bulk floatation. As it is proved, the process is appropriate.

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