Experimental Study on Comprehensive Recovery of High Arsenic Containing Gold Cyanide Slag

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Abstract. The gold grade of high sulfur containing arsenic cyanide slag produced by a gold smelting enterprise is about 4.4g / t, sulfur grade is about 17% -20%, and arsenic grade is about 4.5%. The comprehensive utilization technology of this cyanide residue is carried out, and the gold in the cyanide residue is recovered twice by roasting, acid leaching, cyanide leaching and flotation, so as to realize the resource utilization of hazardous waste of cyanide residue. The experimental data show that the leaching rate of gold after roasting is about 40%, and the leaching rate of gold can further improve the leaching rate up to 51.16%. The direct flotation effect of cyanide slag is very poor, and the highest grade of concentrate gold can reach about 20g / t, and the recovery rate is 57.73%.

Keywords: cyanide residue; roasting; flotation; cyanide leaching; recovery rate

1 Introduction

Cyanide slag is one of the main bulk dangerous solid waste produced in Chinas gold industry. The storage or landfill of cyanide residue will cause irreparable harm to the surrounding environment and ecology[1]. In addition, the valuable elements contained in the cyanide residue can not be used, resulting in a waste of resources[2].

Some of the high-sulfur arsenic cyanide slag produced by a gold smelting enterprise have gold grade of about 4.4g / t, sulfur grade of about 17% -20%, and arsenic grade of about 4.5%. This part of cyanide slag is discharged into the tailings pond, and has not been achieved comprehensive utilization at present. To this end, the comprehensive utilization technology of this part of cyanide slag is tested and studied, and the gold in cyanide slag is recovered twice through roasting, cyanide leaching, acidification flotation and other technical means, producing part of gold concentrate powder for sale or cyanide smelting, so as to realize the resource utilization of solid waste and increase the sales profit of enterprises.

W. He et al. (eds.), *Proceedings of the 2024 10th International Conference on Advances in Energy Resources and Environment Engineering (ICAESEE 2024)*, Atlantis Highlights in Engineering 36,
https://doi.org/10.2991/978-94-6463-708-3_28

2 Detection and Analysis of Cyanide Residue

The results of the sample analysis are shown in Table 1.

Table 1. Total element test results of samples

Sample ore	Grade(%)								
	Au*	Ag*	Cu	Pb	Zn	S	Fe	As	C
Cyanella	4.42	11.14	0.08	0.16	0.18	19.03	20.70	4.58	3.67

Note: * Ellement content in g / t.

According to the test results of the sample, the gold grade of the cyanide slag sample is 4.42g / t, the silver grade is 11.14g/t, and the grade of silver in the cyanide slag is low, so the recovery of silver is not considered. The sulfur grade was 19.03%, iron grade 20.70%, arsenic grade 4.58%, and other valuable elements were low. The organic carbon content of the cyanide slag was 0.03%, the total carbon content was 3.67%, and the total cyanide content of the cyanide slag sample was 193 mg/L.

According to process mineralogy testing of cyanide slag samples, the gold minerals mainly include natural gold and silver gold, with gold content of 93.32% and 6.68% respectively; and pyrite, toxic sand, chalcopyrite, galena, sphalblite and magnetite; and gangue minerals mainly include quartz, feldspar, mica, halblite and ordinary pyroxene. Gold mineral exists mainly with pyrite; associated gold content with pyrite is 78.77%, gold content with toxic sand 10.54%, gold content with quartz 8.15%, and monomer gold content 2.54%. Gold minerals mainly exist in the form of wrapped gold, with wrapped gold content of 82.81%, continuous gold content of 14.65%, and monomer gold content of 2.54%. The grain size of gold mineral is fine. the maximum particle size is 11.91 μ m 7.83 μ m; 93.46% and the fine grain content is 6.54%.

3 Flotation Test

Cyanogen residue contains a small amount of cyanide ions, which can form stable complexing ions with metal ions in sulfide ore, and adsorb on the surface of sulfide ore in the form of chemical adsorption, resulting in the hydrophilic surface of mineral, which is difficult to flotation[3]. Acidification and roasting are the common methods of breaking cyanide slag. More than 99% of the free CN-and dissociable cyanide in the cyanide tailings slurry will generate volatile HCN gas under acidic conditions and escape from the slurry to achieve the effect of cyanide breaking[4]. In the roasting process, cyanide ions will undergo pyrolysis and oxidative decomposition. The study shows that the roasting temperature is 350°C and the roasting time is 1.0h[5]. The target mineral in the flotation process is mainly the sulfide mineral. If the sulfide mineral is excessively oxidized during the roasting process, the flotation will fail to enrich the target mineral efficiently. The roasting and pretreatment of cyanide slag should not only break cyanide, but also avoid excessive oxidation and decomposition of sulfide

ore as far as possible, so as to provide favorable conditions for the subsequent flotation recovery of gold in cyanide slag.

The purpose of this test is to recover the gold by flotation after breaking the cyanide residue, so the temperature of the roasting process should not be too high, and the samples after roasting should be acidified and activated. According to the relevant literature, the four pretreatment conditions are proposed: direct acidification of cyanide slag (QZ1), air atmosphere 400℃ roasting 1 hour (QZ2), air atmosphere 500℃ roasting 1 hour (QZ3), air atmosphere 600℃ roasting 1 hour (QZ4). All four samples need to be concentrated sulfuric acid slurry PH 2 stirring acidification for 8 hours, and then filter the flotation test on the filter cake to compare the flotation index. The results of the four samples are shown in Table 2.

Table 2. Laboratory data of cyanide slag roasting

Sample number	Gold grade /(g / t)	S(%)	As(%)
QZ1	4.42	19.03	4.58
QZ2	4.56	11.33	1.16
QZ3	5.21	6.37	0.81
QZ4	5.01	1.68	0.86

The agent system and test process of flotation[6-7], See Figure 1 for details and the test results in Table 3.

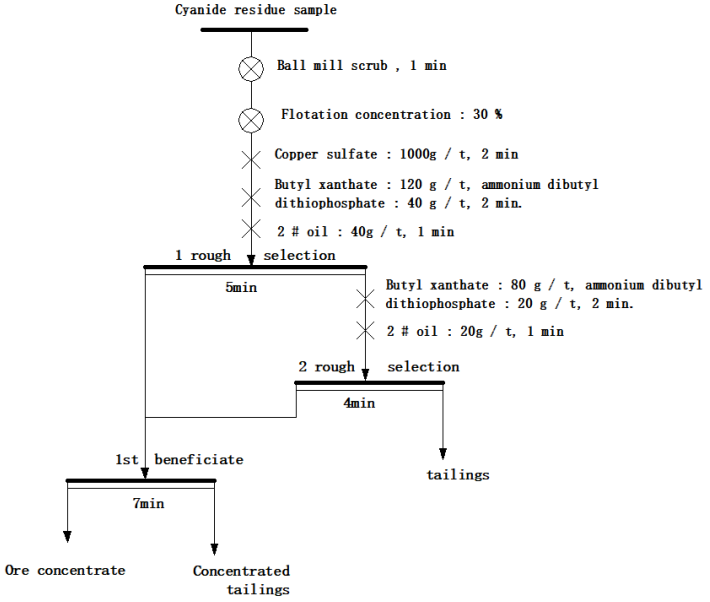

Fig. 1. Flotation test process of cyanide slag samples

Table 3. Flotation test results of cyanide slag samples

Cyanecia samples	Float products	Productivity(%)	Gold grade (g / t)	Percent recovery (%)	Sulfur grade (%)	Sulfur recovery (%)
QZ1	Concentrate	51.89	7.48	82.76	32.33	80.04
	Fine tail	24.25	2.42	12.51	10.05	11.63
	Tailings	23.86	2.18	11.09	7.31	8.33
	Amount to	100.00	4.99	100.00	20.96	100.00
QZ2	Concentrate	44.01	8.24	71.87	22.48	87.71
	Fine tail	28.34	2.56	14.38	2.41	6.05
	Tailings	27.65	2.51	13.75	2.56	6.28
	Amount to	100.00	5.05	100.00	11.28	100.00
QZ3	Concentrate	15.79	19.75	60.20	24.92	67.61
	Fine tail	22.07	3.08	13.12	3.62	13.73
	Tailings	61.44	2.25	26.68	1.48	15.62
	Amount to	100.00	5.18	100.00	5.82	100.00
QZ4	Concentrate	15.38	10.93	33.18	7.23	52.20
	Fine tail	30.59	4.06	24.51	1.51	21.68
	Tailings	52.03	4.12	42.31	1.07	26.13
	Amount to	100.00	5.07	100.00	2.13	100.00

According to the test results, the desulfurization degree of cyanide slag roasting has a great influence on the subsequent acidification flotation index. With the deepening of roasting desulfurization degree, the sulfur content in cyanide slag continues to decrease, and the recovery rate of flotation concentrate decreased significantly from 74.15% to 25.26%; the concentrate rate decreased significantly from 44.01% to 15.38%; the grade of flotation concentrate increased first and then decreased, reaching the highest point of 20.25g/t when the sulfur content is 5.82%. When the degree of roasting desulfurization is low, the sulfur content in cyanide slag is still high, and the enrichment of concentrate is low. When the desulfurization degree is high, although the sulfur content of cyanide slag is low, due to the large increase in the oxidation degree of gold-containing minerals, so the concentrate rate and concentrate grade are low. According to the experimental data, when the desulfurization degree of roasting is moderate and the sulfur content of the baked slag is 5% -8%, the flotation of the roasting residue can obtain the flotation index in which the grade of concentrate exceeds 15g / t and the recovery rate is more than 60%.

4 Cyanination Leaching Test

4.1 Cresidue Roasting + Cyanide Leaching Test

Although the gold grade in the cyanide slag sample is high, but the gold is basically in the state of being wrapped, conventional cyanide leaching to recycle the gold is very difficult, so the cyanide slag sample roasting pretreatment, under different roasting conditions of slag cyanide leaching test, 72 hours, compare the gold leaching rate, leaching test results are shown in Table 4.

Table 4. Test of letest leletest test

Baking temperature (·C)	Baking time (h)	Gold grade before immersion(g/t)	Gold grade after immersio (g/t)	S(%)	As(%)	extraction ratio(%)
400	1	4.56	2.93	11.33	1.16	35.75
500	1	5.21	3.19	6.37	0.81	38.77
600	1	5.01	3.04	1.68	0.86	39.32
Unbaked cyanide slag		4.42	4.42	19.03	4.58	0

From the test results, the roasting process can effectively improve the gold leaching rate of cyanide slag, no roasting process, cyanide slag gold leaching rate is very low, with the degree of roasting, sulfur and arsenic content in minerals, slag gold leaching rate is not big, the leaching rate up to 39.32%, by improving roasting conditions continue to improve the gold leaching rate is difficult.

4.2 Cyanide Slag Roasting + Acid Leaching + Cyanide Leaching Test

Cyanogenic residue 600·The cinace after one hour of C roasting was pretreated by acid immersion for 2 hours and 24 hours, PH 2 and acid immersion temperature 80·C, Conduct the cyanide leaching test after acid leaching, and the test results are shown in Table 5.

Table 5. Cyanide leaching test data after roasting acid leaching of cyanide slag

Acid immersion time(h)	Gold grade (g / t)	Gold grade (g / t)	Extraction ratio (%)
2	5.01	2.82	43.71
24	5.01	2.45	51.16

According to the test results, the acid leaching pretreatment of the dreg can further improve the gold leaching rate of the cyanide slag, and the longer the acid leaching time, the higher the gold leaching rate. When the acid leaching time reached 24 hours, the gold leaching rate reached 51.16%, compared with the slag direct leaching, the gold leaching rate increased by 11.84%.

4.3 Flotation Concentrate Roasting + Acid Leaching + Cyanide Leaching Test

To the cyanide slag flotation concentrate of 600·C roasting for one hour and the slag to PH 2 temperature 80·C acid preconditioning, the acid leaching time was 0 hours, 2 hours and 24 hours respectively. Finally, the cyanide leaching conditions were tested to explore the recovery effect of gold in the floating concentrate of cyanide slag. The test results are shown in Table 6.

Table 6. Cyanide leaching test data after roasting acid leaching of flotation concentrate

Acid immersion time (h)	Gold grade (g / t)	Gold grade (g / t)	Extraction ratio (%)
0	7.71	4.30	44.23
2	7.71	4.12	46.56
24	7.71	3.06	60.31

According to the test results, the acid leaching pretreatment of the cyanide slag flotation concentrate can further improve the gold leaching rate of the cyanide slag flotation concentrate, and the longer the acid leaching time, the higher the gold leaching rate. When the acid leaching time reaches 24 hours, the gold leaching rate reaches 60.31%, which increases by 16.08%.

5 Conclusions

1) Gold minerals in cyanide slag are mainly associated with pyrite, and gold minerals mainly exist in the form of wrapped gold. The wrapped gold content is 82.81%, continuous gold content is 14.65%, and monomer gold content is 2.54%. The grain size of gold mineral is fine, mainly fine grain, and the fine grain content is 93.46%.

2) After acidification of cyanide slag, the recovery rate of gold is highest, but the grade of concentrate gold is low; when the degree of desulfurization is low, the sulfur content in cyanide slag is still high, the acidification and flotation concentrate rate is high and the enrichment is low; when the desulfurization degree is high, the rate of concentrate and the concentrate grade are not satisfactory. According to the experimental data, when the desulfurization degree is moderate and the sulfur content of the roasting slag is 5% -8%, the flotation effect of the roasting slag is best, the grade of the concentrate can exceed 15g / t and the recovery rate exceeds 60%.

3) Under various conditions, the leaching rate is about 40%; the leaching rate is up to 51.16%; after the leaching of the slag, the leaching rate is up to 60.31%.

References

1. Kyle J H, Breuer P L, Bunney K G, et al.Review of trace toxic elements(Pb, Cd, Hg, As, Sb, Bi, Se, Te)and their deportment in gold processing.Part II:Deportment in gold ore processing by cyanidation[J].Hydrometallurgy, 2012, 111:10-21.
2. He Tingshu, Zhang Feng, Xie Jianhong. Flotation test study of gold recovered from cyanide slag [J]. Gold, 2010,7 (31): 39-42.

3. Guo Jiandong, Sun Yiqing, Chen Shunxun, Shang Zhenhua. Experimental study on the comprehensive recovery of gold and sulfur from cyanogenic tailings of gold concentrate [J]. Gold, 2023,6 (44): 51-54.
4. Yuan Yanxia, Qu Xianxu. Production practices of recovering valuable elements from direct cyanide tailings [J]. Science and Technology Communication, 2014 (18): 108.
5. Cheng Weifeng, Zhai Jubin, Lan Xinhui, Cui Chonglong, Li Jiawei. Experimental study on low ogenic breaking in cyanide tail residue [J]. Modern Mining, 2022,11 (11): 144-146.
6. Song Xuewen, Zhu Jiaqian, Luo Zengxin, Chen Bo. Study on mineralogy and gold flotation process of a certain cyanide slag process [J]. Gold Science and Technology, 2018,26 (1): 89-95.
7. O'Connor C T, Dunne R C.The flotation of gold bearing ores—A review[J].Mineral Engineering, 1994, 7(7):839-849.