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Experimental Study on the Dressing and Smelting of a Pyrrhotite-bearing Primary Gold Ore

Yanbo Chen* Junjie Wang

Selection and metallurgy laboratory of Shandong Gold Mining Technology Co.Ltd.

Abstract. The content of pyrrhotite in a primary gold mine containing pyrrhotite is 0.68%. In the process of alkaline leaching pretreatment, there are problems such as large ore quantity and high alkali consumption. In the process of cyanide leaching, there are problems such as high cyanide consumption and slow gold leaching rate. In order to solve these problems, combined with production practice, experimental studies on magnetic separation, magnetic separation tailings leaching, magnetic separation concentrate alkali leaching pretreatment - leaching, magnetic separation concentrate flotation - cyanide leaching, etc. were carried out. A new process of "magnetic separation-magnetic flotation flotation flotation flotation flotation alkali leaching pretreatment mixed cyanide leaching" has been developed to reduce the pretreated minerals to less than 2% of the original ore, which is higher than the gold leaching rate of the conventional "alkali leaching pretreatment cyanide leaching" process, and the alkali (sodium hydroxide) consumption and cyanide (sodium cyanide) consumption are reduced by 80.83% and 32% respectively, and the annual reagent cost is saved by more than 600000 yuan.

1. Introduction

A gold mine concentrator deals with two kinds of ores, primary ore and oxidized ore. The primary ore is treated by conventional flotation process, and the oxidized ore is treated by full-slime cyanidation leaching process. At present, with the increase of mining depth, the amount of oxidized ore gradually decreases and the amount of primary ore gradually increases. There are problems of insufficient feed in the oxidation ore leaching system and overload operation of the primary ore flotation system[1]. In order to solve this problem, the mine plans to add part of the primary ore after alkali leaching pretreatment to the existing oxidation ore full-slime cyanidation leaching system for leaching. However, the primary ore is rich in sulfide ore (mainly including pyrite, arsenopyrite and pyrrhotite, with the contents of 5.41%, 3.59% and 0.68% respectively). Sulfide ore, especially pyrrhotite, is prone to react with cyanide, dissolved oxygen and protective alkali in the cyanide system, which consumes a large amount of cyanide and oxygen, reduces the leaching rate and leaching rate of gold, increases the production cost and worsens the leaching index. In order to solve one of the problems, take the primary gold ore containing pyrrhotite in the mine concentrator as the research object, carry out the experimental research on magnetic separation, magnetic separation tailings cyanidation leaching, magnetic separation concentrate alkaline leaching pretreatment - cyanidation leaching, magnetic separation flotation - cyanidation leaching, etc. Finally, a new process of "magnetic separation-magnetic flotation flotation flotation flotation flotation alkali leaching pretreatment mixed cyanide leaching" was developed to reduce the pretreated minerals to less than 2% of the original ore, which is higher than the gold leaching rate of the conventional "alkali leaching pretreatment cyanide leaching" process, and the alkali (sodium hydroxide) consumption and cyanide (sodium cyanide) consumption were reduced by 80.83% and 32%, respectively, and the annual reagent cost was saved by more than 600000 yuan.

2. Chemical multi-element analysis

Chemical multi-element analysis was carried out on the primary gold ore sample containing pyrrhotite, and the analysis results are shown in Table 1.

Table 1 Chemical multi-element analysis results

Element	Au(g/t)	Ag(g/t)	Cu	Pb	Zn
Content/%	6.64	2.62	0.013	0.027	0.015
Element	Fe	S	As	SiO_2	Al_2O_3
Content/%	14.47	3.69	1.65	18.99	1.12
Element	MgO	CaO	Na_2O	K_2O	
Content/%	0.80	23.45	0.03	0.36	

As shown in Table 1, the only element that reaches the industrial utilization grade is gold, with a content of

*595907901@163.com

6.64g/t. The grade of other associated elements (such as silver, copper, lead, zinc, etc.) is low and has no direct industrial recovery value.[2]

3. Experimental study

3.1. Magnetic separation test

In nature, pyrrhotite mainly exists in monoclinic and hexagonal pyrrhotite. Monoclinal pyrrhotite is a strong magnetic mineral, and its magnetism and floatability are stronger than hexagonal pyrrhotite. The pyrrhotite in this ore sample is mainly monoclinic. In theory, effective separation can be achieved under weak magnetic field (surface magnetic field strength<2000Gs) and medium magnetic field (2000Gs<surface magnetic field strength<5000Gs) conditions. Therefore, weak magnetic field and medium magnetic field are selected for test magnetic field strength conditions. [3-4] Due to the inclusion of non-target minerals in the primary magnetic separation concentrate, it is necessary to carry out the magnetic separation frequency test to investigate the yield, gold grade, iron grade and sulfur grade of magnetic concentrate and magnetic tail.See Table 2 for test results.

Table 2 Magnetic Separation Test Results

Magnetic field intensity	Sample name	productivity/%	Gold grade/（g/t）	Iron grade/%	Sulfur grade/%
Medium magnetism（3000Gs）	The roughing tailings	89.4	6.48	12.37	3.29
	Primary cleaner tailing	4.02	8.27	15.64	4.34
	Secondary cleaner tailing	1.94	16.9	20.96	8.68
	Magnetic concentrate	4.64	4.84	42.34	6.83
	total	100	6.68	14.06	3.6
Weak magnetism（1000Gs）	The roughing tailings	92.36	6.79	12.28	3.52
	Primary cleaner tailing	3.05	6.76	17.04	3.96
	Secondary cleaner tailing	1.23	3.55	39.98	6.45
	Magnetic concentrate	3.36	3.54	50.2	5.32
	total	100	6.64	14.04	3.63

It can be seen from Table 2 that under the two magnetic field intensities, the yield of refined II tail is low and the sulfur grade is high, which indicates that the secondary cleaning will lead to pyrrhotite entering the refined II tail to a certain extent, affecting the recovery rate of pyrrhotite from magnetite concentrate. Considering reducing the production rate of magnetite concentrate and ensuring the recovery rate of pyrrhotite in magnetite concentrate, it is appropriate to determine a single cleaning; Under the medium magnetic condition, the grade of magnetite refined sulfur is higher, and the recovery rate of pyrrhotite is higher theoretically, so the magnetic field strength is determined as medium magnetic; Under the two magnetic field intensities, the iron grade of the magnetic concentrate is lower than the minimum standard of iron concentrate quality (TFe of the magnetic concentrate is not less than 60%), indicating that the iron concentrate product cannot be obtained from this ore sample through magnetic separation.

3.2 .Beneficiation and smelting test of magnetic concentrate

3.2.1. "Alkali leaching pretreatment - cyanide leaching" test of magnetic separation concentrate

The magnetic separation concentrate is pretreated by alkali leaching alone, the pretreated ore sample is washed and filtered, and the filter cake is mixed to carry out cyanide leaching test to investigate the gold leaching rate and cyanide consumption.See Table 3 for test results

Table 3 Test Results of Alkali Leaching Pretreatment Cyanide Leaching of Magnetic Separation Concentrate

Alkali leaching pretreatment pH	Gold leaching rate/%	Sodium cyanide consumption/（kg/t）
7	85.65	3.98
12	85.41	2.54

It can be seen from Table 3 that the gold leaching rates of the two groups are similar. After alkali leaching pretreatment, the cyanide consumption of magnetic separation concentrate is significantly reduced, with a reduction of more than 36%.

3.2.2. "Flotation-cyanide leaching" test of magnetic separation concentrate

(1) Magnetic precision flotation test [5-6]

Referring to the production site, the flotation test process flow is determined as primary roughing, the activator is oxalic acid (100g/t), the collector is Y89 (100g/t) and butyric ammonium black powder (50g/t), and the foaming agent is 2 # oil (20g/t). The magnetic concentrate yield, gold grade and iron grade of flotation concentrate and tailings were investigated. The test results are shown in Table 4.

Table 4 Flotation Test Results of Magnetic Separation Concentrate

Name of flotation product of magnetic concentrate	productivity/%	Gold grade/(g/t)	Iron grade/%	Gold recovery rate/%
Flotation concentrate	28.02	26.13	24.15	85.43
Flotation tailings	71.98	1.73	40.67	14.57
total	100.00	8.57	36.04	100.00

It can be seen from Table 4 that the yield of concentrate obtained by magnetic concentrate re-flotation is 28.02%, and further reduction can be achieved by flotation of magnetic concentrate, reducing the pretreated minerals to 1.84% of the original ore. The iron grade of flotation concentrate and flotation tail obtained after magnetic flotation is lower than 60%, which can not meet the requirements of iron concentrate products.

(2) Cyanide leaching test of magnetic concentrate flotation products

Cyanide leaching test was carried out on magnetic fine floatation concentrate and floatation tail to investigate the cyanide consumption. The test results are shown in Table 5.

Table5 Cyanide Leaching Test Results of Magnetic Concentrate Flotation Products

Name of flotation product of magnetic concentrate	Alkali leaching pretreatment pH	Gold leaching rate/%	Sodium cyanide consumption/（kg/t）	Reduce the percentage of sodium cyanide/%
Flotation concentrate	7	93.03	10.38	——
	12	93.15	6.12	35.10
Flotation tailings	7	38.15	2.07	——

It can be seen from Table 5 that the consumption of sodium cyanide is reduced from 10.38kg/t to 6.12kg/t after the pretreatment of magnetic fine flotation fine alkali leaching, with a relative reduction of 35.10%.

3.3. Comprehensive condition test

Take two equal parts of primary gold ore samples containing pyrrhotite, one according to the conventional "alkali leaching pretreatment - cyanide leaching", and the other according to the process flow of "magnetic separation - magnetic flotation - flotation concentrate alkali leaching pretreatment - mixed leaching" , and investigate and compare the gold leaching rate, alkali consumption and cyanide consumption of the two groups of tests. See Table 6 for test results.

Table 6 Comprehensive Condition Test Results

Sample name	Reaction time/h	Gold leaching rate/%	Cyanide consumption/（kg/t）	Alkali consumption in alkali leaching pretreatment stage/(kg/t)
Magnetic tail、floating tail and filter cake	6	61.58	2.04	0.46
	12	74.32		
	24	78.75		
	36	81.72		
	48	81.70		
Raw ore	6	62.35	3.00	2.40
	12	73.22		
	24	76.40		
	36	78.23		
	48	81.11		

It can be seen from Table 6 that the gold leaching rate of "magnetic separation-magnetic flotation flotation flotation flotation alkali leaching pretreatment mixed leaching" is higher than that of "alkali leaching pretreatment cyanidation leaching" process, and the alkali (sodium hydroxide) consumption and cyanide consumption are reduced by 80.83% and 32% respectively, and the annual reagent cost is saved by more than 600000 yuan.

4. conclusion

For a primary gold mine containing pyrrhotite, a new process of "magnetic separation-magnetic flotation flotation flotation flotation alkaline leaching pretreatment mixed cyanidation leaching" was developed by carrying out experimental research on magnetic separation, flotation and leaching. Compared with the conventional "alkali leaching pretreatment - cyanide leaching" process, the gold leaching rate is higher, and the alkali (sodium hydroxide) consumption and cyanide (sodium cyanide) consumption are reduced by 80.83% and 32% respectively, and the annual reagent cost is saved by more than 600000 yuan.

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