Flotation Test of a High Silica Copper Oxide Ore in Yunnan

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Abstract—In this paper, the beneficiation of a copper oxide ore of Yunnan was investigated through bench-scale froth flotation tests. During the froth flotation, the conditions that effect on the flotation performance was researched, including the grinding fineness and the dosage of lime as depressant, sodium sulphide as regulator, sodium n-butylxanthate as collector and terpenic oil as frother. Via a serious of tests, the tests conditions are determined that grinding fineness is 70%, the dosage of lime, sodium sulfide, butyl xanthate and terpenic oil was 1000g/t, 1000g/t, 150g/t and 30g/t, respectively. Finally, through the tests of close circuit of "two roughing, two concentrations and one scavenging", a copper concentrate assaying 20.20% Cu can be obtained with the recovery of 68.11%.

Keywords-high oxide rate; high silica; flotation; copper ore; Yunnan;

I. INTRODUCTION

Copper is one of the metal which is discovered and used by human n ancient time. Generally, copper is amaranth. Copper has good electrical conductivity and thermal conductivity, and it has strong corrosion resistant ability. Therefore, in metal material consumption, the consumption of copper is only next to iron and steel. Copper is the important strategy resource. With the exploiting of the copper ore consistently, the copper resource is gradually decreasing. Moreover, the rich ore is less and less. Copper ore in China has the following features: the cooper ore that is suitable for the industrial production occurs in a variety of ore deposit types; cooper ore has complex ore texture and uneven disseminated particle size; chemical composition of ore is varied. Copper oxide ore occupy for the most of available copper ore resource. And, copper oxide ore is difficult to be concentrated. As a consequence, the research on refractory copper oxide is vital.

II. MINERALS

The ore is typical copper oxide ore. Main copper minerals are chalcopyrite,
malachite, chrysocolla, little chalcosine, bornite and covel lite. The gangue minerals are mainly consisted of quartz, calcite and serpentine and so on. Results of the multi-element chemical analysis of run of mine are shown in Table 1.The oxidation rate of sample reaches up to 33.10%, including 7.59% free copper oxide and 23.45% combined copper oxide.Results of phase analysis of copper are shown in Table 2.

TABLE I THE MULTI-ELEMENT CHEMICAL ANALYSIS OF THE RUN OF MINE

Elements	*Cu*	*S*	*SiO2*	*Al2O3*	*Fe2O3*	*MgO*	*CaO*
Content/%	1.45	0.62	83.15	2.10	8.21	1.11	1.21

TABLE II RESULTS OF PHASE ANALYSIS OF COPPER

Phase	*Sulfate*	*Combined copper oxide*	*Free copper oxide*	*Copper sulphide*	*Total*
Content/ %	0.03	0.34	0.11	0.97	1.45
Occupation/%	2.06	23.45	7.59	66.90	100

A. *Effect of grinding fineness on copper flotation*

The test mainly studies the influence between flotation index and various grinding fineness. Each of the test samples weighing 500g was ground by lab-type ball mill with a grinding concentration of 65%. Through a roughing, 1000g/t sodium sulfide, 500g/t lime, 150g/t butyl xanthate and 30g/t terpenic oil were used to conduct the tests and it lasted for 4 minutes. Flotation indexes of rough concentrate were achieved at 65%, 70%, 80%, 90% of grinding fineness -0.074mm, respectively. The results are shown in Fig .1.

As can be seen in Fig .1, the highest roughing recovery of copper is up to 61.23% at 70% -0.074mm

grinding fineness. Both recovery and grade decrease as the increasing of grinding fineness. Therefore, from economy and technical perspective of view, the grinding fineness of 70% -0.074 mm was regarded as the best condition.

B. Effect of lime dosage

Lime is the depressant for pyrite, and it has the effect of size mixing. The effect of different dosage of lime on copper flotation was researched. In roughing process for 4 minutes, the grinding fineness of70% -0.074mm, 1000g/t sodium sulfide, 150g/t butyl xanthate, and 30g/t terpenic oil were used to conduct the tests. Flotation indexes of rough concentrate were obtained with the amount of lime at 0g/t, 500g/t, 1000g/t and 1500g/t, respectively. The results are given in Fig .2.

It can be shown in Fig .2 that when the dosage of lime is 1000g/t, the best copper recovery of 67.36% can be obtained with the copper grade of 19.96%. The recovery changes little when the dosage of lime is between 800g/t to 1000g/t. Meanwhile, the copper recovery slightly drops and the copper grade sharply decreases with the increase of lime dosage. Moreover, excess lime would lead to a high foam viscosity, which contributes to the difficulty of separation. Therefore, 800g/t lime is optimal for the tests.

C. Effect of Sodium sulfide dosage

Sodium sulfide was used as activator for rougher flotation, where 1000g/t sodium sulfide, 150g/t butyl xanthate and 30g/t terpenicoil were added with the grinding fineness of 70% -0.074mm.The dosages of Sodium sulfide range from 0 to 1500g/t. The tests results are presented in Fig .3.

From the Fig .3, we can know that a peak of the roughing recovery and grade of copper was obtained at the dosage of 1000g/t sodium sulfide. The recovery and grade sharply decreased with the increasing of sodium sulfide dosage, which indicates that copper sulfide minerals are depressed. Compared with no sodium sulfide, the recovery increases drastically. Effective vulcanizing agent should be added to enforcing the recovering of copper oxides. Therefore, 1000g/t sodium sulfide is regarded as the best condition.

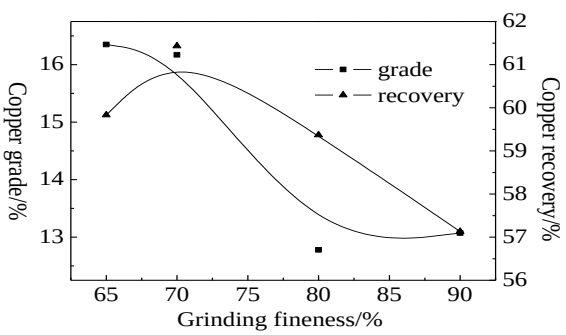

Figure 1. Effect of grinding fineness on copper flotation

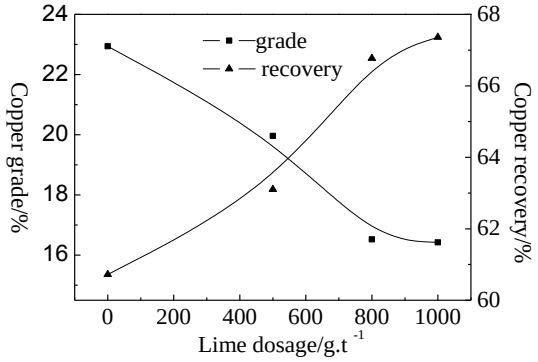

Figure 2. Effect of lime on copper flotation

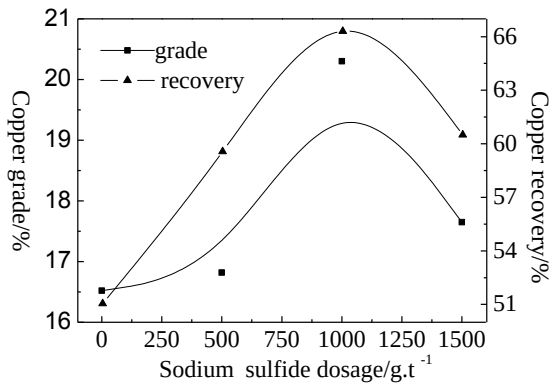

Figure 3. Effect of sodium sulfide on copper flotation

D. Effect of the dosage of Butyl xanthateon in flotation

Butyl xanthateon is widely applied to recover non-ferrous metal sulfide ore and has stronger collecting ability. It is particularly suitable for flotation of chalcopyrite, sphalerite, pyrite. In order to study the effect of Butyl xanthate dosage on the flotation, 1000g/t lime, 1000g/t sodium sulfide and 30g/t terpenic oil were used. Butyl xanthate dosage increased from 100g/t to 175g/t in the roughing process. The results are presented in Fig .4.

It can be known by Fig .4 that in the early stages, with the increasing of dosage of butyl xanthateon gradually both recovery and grade of copper increased. The top recovery and grade were simultaneously obtained at the dosage of 150 g/t butyl xanthate. Then, continuing to increase the dosage of butyl xanthate, both recovery and grade of copper decline sharply. Excessive butyl xanthate has inhibitory effect on collecting of copper. Thus, the dosage of 150g/t butyl xanthate is regard as the best condition.

E. Effect of the dosage of terpenic oil

Bubble is crucial for flotation. Bubble in the solution make solution contain solid phase, liquid phase and gas phase, which have contribution to achieve effective separation of different minerals. Terpenic oil is the most common foaming agent and is widely used. Under the condition of a grinding fineness of 70%, the dosage of lime, sodium sulfide and butyl xanthate was 1000g/t, 1000g/t and 150g/t, respectively, the effect of terpenic oil

dosage from 20g/t to 40g/t on the recovery and grade of concentration was studied. The test results are shown in Fig .5.

From the Fig .5 it can be deduced that as the terpenic oil added constantly, the grade of copper declined gradually and the recovery of copper increased all the time. This is perhaps because that a lot of bubble mixed with part of the gangue. The more bubbles, the more gangue is carried. Considering the recovery and grade of copper, the best test index is obtained with the pine oil dosage of 30g/t. Thus, the optimum of terpenic oil dosage is 30g/t.

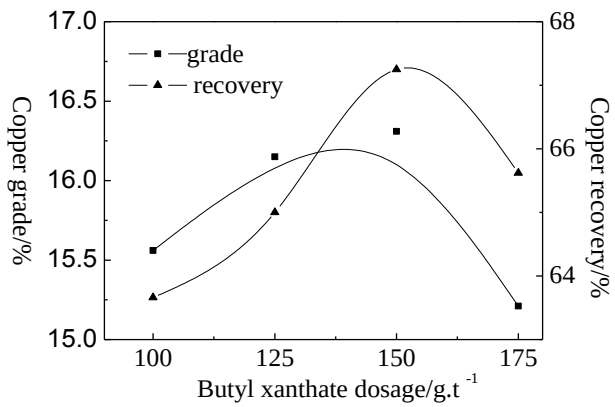

Figure 4. Effect of butyl xanthate on copper flotation

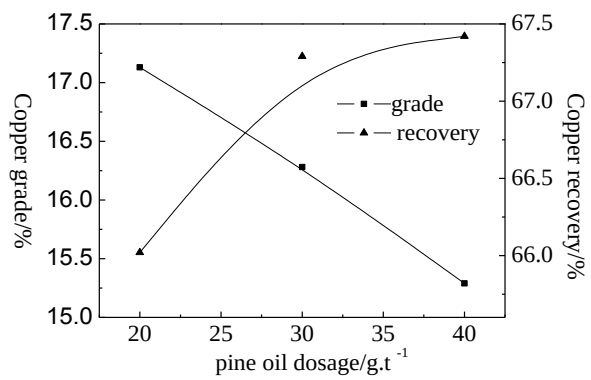

Figure 5. Effect of terpenic oil on copper flotation

III. THE TESTS OF CLOSE CIRCUIT

In order to simulate industrial production and obtain stable concentrate index, small closed-circuit tests were conducted in the laboratory. Based on a number of condition tests, the tests of close circuit of "two roughing, two concentrations and one scavenging" were carried out. The tests results are shown in Table 3. The close circuit and quantity-quality flow-sheet are shown in Fig .6, Fig .7, respectively.

TABLE III THE RESULTS OF CLOSE CIRCUIT TESTS

Products	*Yield/%*	*Grade/%*	*Recovery/%*
concentration	4.89	20.20	68.11
Tailings	95.11	0.49	31.89
Run of mine	100	1.45	100

IV. CHEMICAL ANALYSIS OF THE CONCENTRATE

Through the close circuit tests, qualified concentrate can be obtained. In order to further learn the concentrate quality, chemical analysis of the concentrate was carried out. The result of chemical analysis of concentrate though close circuit test is shown in Table 4.

TABLE Ⅳ THE RESULTS OF CHEMICAL ANALYSIS OF THE CONCENTRATE

Element	*Cu*	*S*	*CaO*	*SiO_2*	*MgO*	*Fe_2O_3*
Content/%	20.20	2.64	3.12	16.34	3.20	4.23

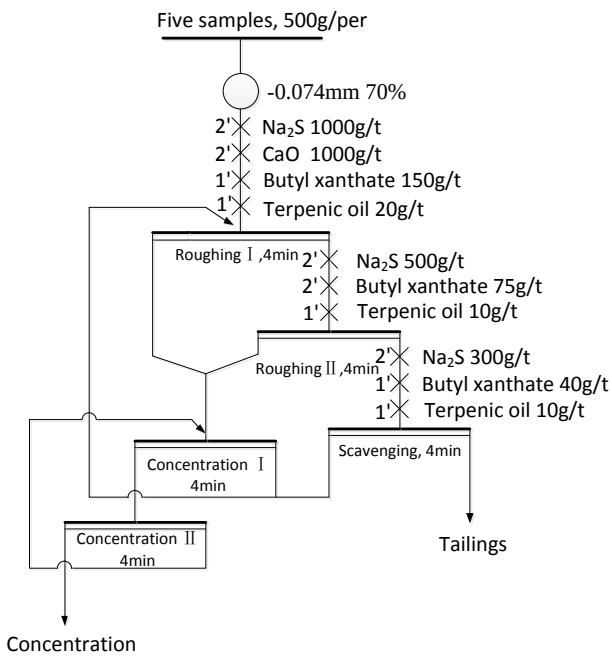

Figure 6. The close circuit of flotation test flowsheet

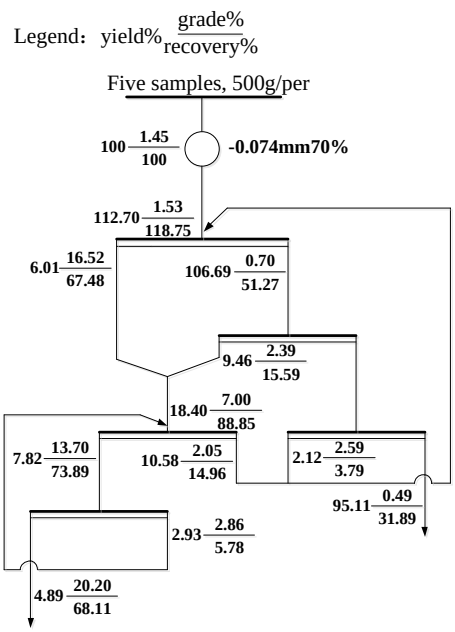

Figure 7. Quantity-quality flow-sheet of copper close circuit tests

V. CONCLUSION

The research of ore property shows that the ore is a typical copper oxides ore, and copper is an available element for recycling. The occupancy of copper sulfide and copper oxide is 67.13% and 32.87%, respectively. And there are 7.69% free copper oxides, 23.08% combined copper oxides. After mineral processing experiment and study, conventional floatation method is suitable to recover copper. When recovering copper, effective vulcanizing agent should be added to enforcing the recovering of copper oxides. The technology process of two roughing, two concentrates and one scavenging is recommend. The qualified copper concentrate was obtained with a grinding fineness of 70% through a small closed circuit test. Finally, the recovery of copper concentration was 68.11% with a grade of 20.20%.

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