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Preferential Flotation of a Refractory Cu-Pb-Zn Polymetallic Ore

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Abstract. According to the mineralogy of the polymetallic ore，the process of preferential flotation of copper was adopted, and the separation of lead, zinc and sulfur were carried out and implemented．Four products, including copper concentrate assaying 22.67% Cu at a recovery of 91.77%, lead concentrate assaying 18.10% Pb at a recovery of 12.74%, zinc concentrate assaying 47.13% Zn at a recovery of 85.89%, sulfur concentrate assaying 37.42% S and a recovery of 31.40%, were obtained by the preferential flotation in the order of copper, lead, zinc and sulfur.The flowsheet recommanded provides the reference for the future commercial operation of the processing plant.

Introduction

The beneficiation process and separation technology of refractory Cu-Pb-Zn polymetallic ore has been regarded a tough probelm in the beneficiation industry and an important research field.

Several main research difficulties are shown as follows: a) The minerals have been founded with the nature of being finely associated with each other in the ore. b) Due to a small amount of secondary copper minerals are often contained in the ore, some free state Cu^{2+} will be released in the process of grinding by the breakage of lattice bond[1]. By which sphalerite and pyrite both are activated, resulting difficulties in the separation of Cu-Zn and Cu-sulfur. c) A very similar flotation behavior of self-induced and capture-induced has been founded between copper and lead minerals, leading a tough problem to the separation of copper and lead, resulting a high grade of metal mutual bearing in concentrate products and a low separation index of Cu-Pb[2].

Based on the research results of process mineralogy, the study on the beneficiation of a complex copper-lead-zinc Polymetallic Ore was carried out.

Mineralogical Study

Analysis on mineral consitituents. Table 1 lists the mineral consitituents and the contents in the ore . Analysis results of the main chemical elements are shown in Table 2. The phase analysis results of opper, lead and zinc can be seen from Table 3 to Table 5, respectively.

Table 1
Main mineral constituents of the ore

Mineral	Pyrite/ Pyrrhotine	Chalcopyrite /Chalcocite	Sphalerite	Galena	Arsenopyrite	Franklinite /Calamine
content(%)	6.3	6.74	11.25	0.25	0.024	1.75
Mineral	Ferrum	Quartz	Mica	Actinolite/Raphilite	Chlorite/ Amphibole	Calcite
content(%)	2.2	26.43	12.3	1.7	18.9	6.3

Table 2
Analysis results of main chemical elements

Element	Cu	Pb	Zn	Fe	S	As
Content(%)	1.66	0.81	7.21	5.91	10.45	0.042
Element	SiO2	Al2O3	CaO	MgO	Au	Ag
Content(%)	29.53	7.68	3.64	4.11	0.35 [I]	62.73 [II]

I, II content unit of Au and Ag: (g/t)

Table 3
Analysis results of copper phase

Copper phase	Cont. (%)	Distribution(%)
Primary sulfide	1.425	85.84
Secondary sulfide	0.167	10.06
Free oxide	0.021	1.27
Bound oxide	0.047	2.83
Total	1.660	100.00

Table 4
Analysis results of lead phase

Lead phase	Cont.(%)	Distribution(%)
Lead sulfide	0.69	85.19
Lead oxide	0.05	6.17
Others	0.07	8.64
Total	0.81	100.00

Table 5
Analysis results of zinc phase

Zinc phase	Content(%)	Distribution(%)
Zinc sulfide	5.73	87.48
Zinc of goethite spinel	0.47	7.18
Zinc oxide	0.24	3.66
Other	0.11	1.68
Total	6.55	100.00

Disseminated Characteristics of the Main Minerals in the Ore. Chalcopyrite, mainly in the form of irregular monomineral, is disseminated in the crystal and broken cracks of granular minerals ,such as quartz, pyrite and calcite. Of which the particle size is fairly coarse, generally reaching 50-100 μm, even more than 1 mm. A small amount of chalcopyrite in the form of fine droplet,is disseminated in the sphalerite, with the particle size of 20-70 μm. There are two kinNaHS of existence, in the form of black high-iron sphalerite with the particle size of more than 1 mm;or in the form of light yellow sphalerite, finely disseminated on the surface between the calcite and chalcopyrite. Most of the galena is finely associated along the surface of chalcopyrite, with the grain size of 1-2μm, even less than 1μm.

Discussion of Results

Grinding Fineness Tests. Process of Grinding fineness test is shown in Fig. 1, and the test results are shown in Fig. 2.

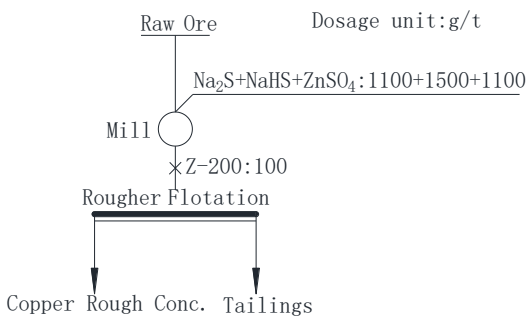

Fig. 1 Process of grinding fineness test

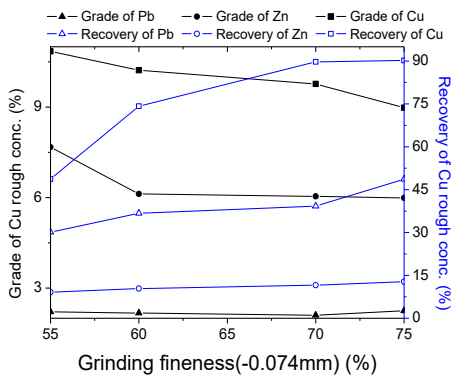

Fig. 2 Results of grinding fineness test

As can be seen from Fig. 2, with the increase of the grinding fineness, the copper recovery rate of the copper coarse concentrate is incresed at a high level, and the content of lead and zinc is slightly increased when the fineness is high. Therefore, it is determined that the grinding fineness in the roughing flotation of the copper is 70% -0.074 (mm).

Flotation Conditions Tests of Copper Sulfides

Tests of Different Copper Collectors. A roughing process is uesd in the type test of copper collector at a grinding fineness of 70% -0.074(mm). The combined depressants of "Na_2S+NaHS+ $ZnSO_4$" is adopted with the amount of "1100+1500+1100 (g / t)" respectively. And the test results are shown in Table 6.

Table 6
Technical performance of rough copper concentrate obtained by different copper collectors

Collectors		Grade(%)			Recovery(%)		
Type	Dosage(g/t)	Cu	Pb	Zn	Cu	Pb	Zn
25# dithiophosphate + sodium ethyl xanthate	50+50	6.97	1.62	9.55	89.41	48.37	29.54
25# dithiophosphate	100	6.64	1.89	8.23	85.63	57.65	27.75
Sodium ethyl xanthate	100	7.52	1.72	8.25	89.91	48.33	24.43
Z-200	100	10.17	1.11	6.61	86.77	32.51	17.28

As can be seen from Table 6, Z-200 has a strong selective capability to collect copper minerals, so being chosen as a copper mineral collector.

Combined Use of Different Depressants in Copper Roughing. As the ore contains some secondary copper minerals, Cu^{2+} concentration of pulp will be increased by grinding[3], then the sphalerite and other minerals will be activated[4], which should be depressed. Therefore,it is necessary to added combine Inhibitors to the ball mill. On the one hand, the elimination of free heavy metal ions generated by grinding on the sphalerite activation will be maximized with the use of regulators. On the other hand, inhibition to lead and zinc minerals can be pre-achieved, providing a priority to the flotation of copper minerals. A roughing process is used in the test , with a grinding fineness of 70% -0.074 (mm), Z-200 dosage of 100 (g / t) and the amount of 500 (g / t) for each inhibitor. The test results is shown in Table 7.

Table 7
Technical performance of rough copper concentrate obtained by different depressants

Depressants	Grade(%)			Recovery(%)		
	Cu	Pb	Zn	Cu	Pb	Zn
Na_2S+NaHS+$ZnSO_4$	10.08	2.11	6.68	87.37	43.44	12.18
Na_2S+Na_2CO_3+$ZnSO_4$	7.23	2.57	12.76	88.95	75.03	35.71
Na_2S+$ZnSO_4$	12.89	3.34	11.27	83.61	47.25	16.26
Na_2CO_3+$ZnSO_4$	7.07	2.49	12.31	87.36	69.63	32.17

As can be seen from Table 7, by the use of the combined depressants of "Na_2S + NaHS + $ZnSO_4$" to depress the lead and zinc mineral, the best index of copper coarse concentrate can be obtained.

Activated Carbon Dosage Test in 1st Cleanning of Copper. In order to further improve the quality of copper concentrate and minimize the lead grade of copper concentrate, the combined depressants of "CMC+NaHS+$ZnSO_4$" is added in the 1st cleanning of copper. Before using the depressants, some right amount of activated carbon is added to remove the residual collector, which can enhance the effect of depressing lead. The test results is shown in Fig. 3.

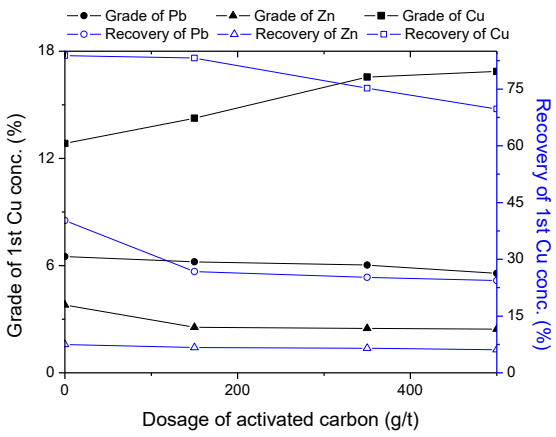

Fig. 3 The dosage of activated carbon

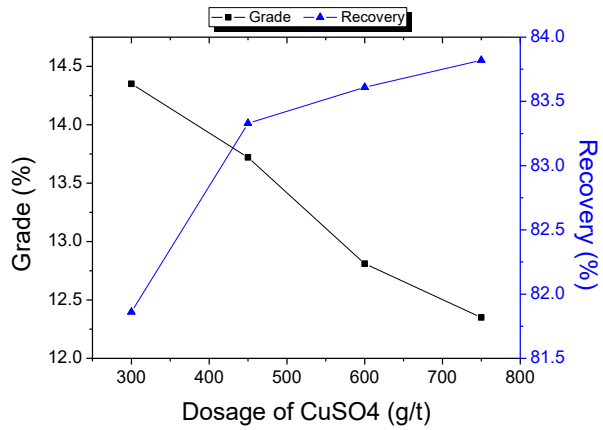

Fig. 4 The dosage of $CuSO_4$

It can be seen from Fig.3, with the increase in the amount of activated carbon, copper grade of 1st copper concentrate get rised, and the recovery of copper, lead and zinc all get declined, notably, lead content of 1st copper concentrate get decreased. Considering overall factors, activated carbon dosage of 150 (g/t) is determined.

The Dosage of $CuSO_4$ in Zinc-Sulfur Sulfides Bulk Roughing. A roughing process is adopted to the zinc and sulfur bulk flotation from lead tailings. Collector butyl xanthate dosage of 200 (g / t) and foaming agent pine oil of 15 (g / t) are determined in the test. The results are shown in Fig. 4.

Closed-Circuit Test. On the basis of the condition test and open-circuit test, the whole process of closed-circuit test is carried out. The test process is shown in Figure 6 and the test results are shown in Table 8.

Table 8
Results of closed-circuit test

Product	Yield(%)	Grade(%)				Recovery(%)			
		Cu	Pb	Zn	S	Cu	Pb	Zn	S
Copper concentrate	6.72	22.67	3.93	6.22		91.77	32.60	6.38	
Lead concentrate	0.57	3.12	18.10	10.95		1.07	12.74	0.95	
Zinc concentrate	12.23	0.47	2.44	47.13		3.46	36.84	88.00	
Sulfur concentrate	8.77	0.31	0.47	2.61	37.42	1.64	5.09	3.49	31.40
Tailings	71.71	0.048	0.14	0.11		2.06	12.73	1.17	
Raw ore	100.00	1.66	0.81	6.55	10.45	100.00	100.00	100.00	100.00

As can be seen from Table 8, using the process shown in Fig.5 to deal with the ore, copper concentrate containing 22.67% Cu at a recovery of 91.77% , lead concentrate containing 18.10% Pb at a recovery of 12.74% , zinc concentrate containing 47.13% Zn at a recovery of 88.00% , sulfur concentrate containing 37.42% S at a recovery of 31.40% are obtained, effectively realizing a comprehensive utilization of the ore.

Conclusions

Z-200 is used as a highly selective copper collector, effectively reducing lead and zinc content in copper concentrate and providing a good condition for the copper sulfide flotation. The combination depressants of "Na_2S + NaHS + $ZnSO_4$" is pre-added to the ball mill, by which the elimination of free heavy metal ions generated by grinding on the sphalerite activation will be maximized, providing a priority to the flotation of copper minerals. The technological process of "preferential flotation of copper--lead floatation--zinc and sulfur bulk flotation--separation of zinc from sulphur" was rasied to deal with the ore. And copper concentrate containing 22.67% Cu, lead concentrate containing 18.10%

Pb, zinc concentrate containing 47.13% Zn, sulfur concentrate containing 37.42% S, are obtained, which get the recovery of 91.77% , 12.74% , 85.89% and 31.40%, respectively.

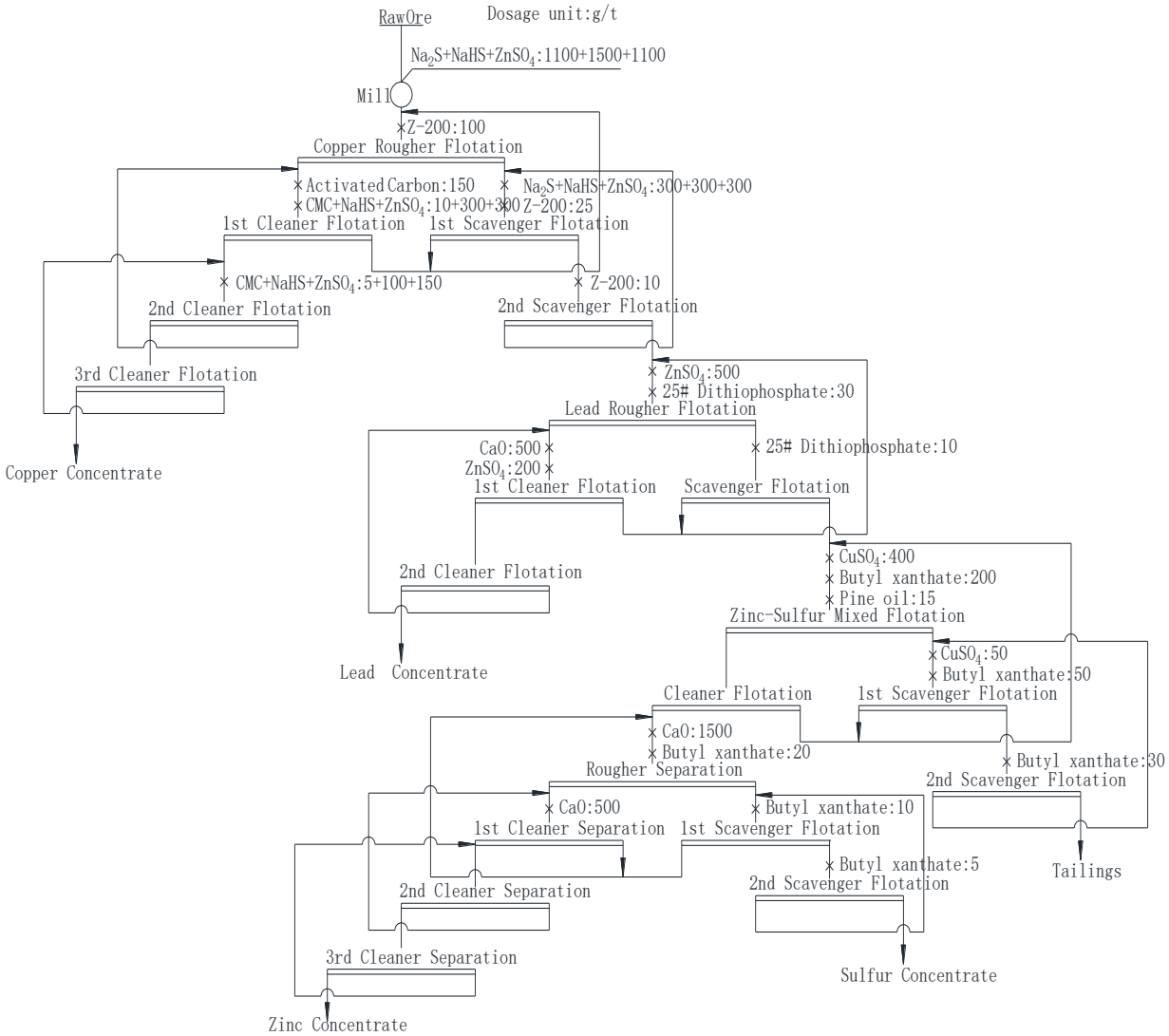

Fig. 5 The flowsheet of closed-circuit test

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