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Experimental study on Nanshan polymetallic sulphide ore containing silver

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ABSTRACT

Copper, lead, zinc and other nonferrous metals was shortage seriously in China. The main metal minerals were sphalerite, galena, pyrite, chalcopyrite in Nanshan polymetallic sulfide ores containing silver. It was difficult to process because of close relationship between the metal minerals. The flowsheet of mixed flotation of Cu\Pb\Zn\S, mixed flotation of Cu\Pb from mixed concentrate of Cu\Pb\Zn\S, separation of Cu\Pb to mixed concentrate of Cu\Pb, separation of Zn\S to tailings after mixed flotation of Cu\Pb was used and the index of grade of sulfur concentrate for 38.59%, recovery of sulfur concentrate for 64.43%, zinc grade in zinc concentrate for 54.28%, recovery of Zn for 39.38%, concentrate grade of Ag for 1504g/t, the recovery of Ag for 55.65% were got. The Qualified concentrate of copper and lead can't be obstained and concentrate of copper and concentrate of lead was combined to the concentrate of silver.

KEYWORDS

Polymetallic sulfide ore; Close symbiotic relationship; The associated silver; Bulk flotation; Regrinding; Polymetallic separation.

INTRODUCTION

Therer are many kinds metal mineral for recycling in nanshan polymetallic sulphide ore containing silver. The main metal sulfide minerals are sphalerite (ZnS), galena (PbS), chalcopyrite ($CuFeS_2$) and pyrite (FeS_2), etc.. The silver should be recovered comprehensively because of it's high content.

Metal mineral in this ore was formed in two period. Pyrite and galena were formed in Early and chalcopyrite and sphalerite were formed in late. The minerals which was formed in same period filled in crack each other. The mineral which were formed in late filled in crack of minerals which were formed in early or replaced the minerals which were formed in early. So, It is difficult to separate metal mineral because of their's close relatation.

Separating complex polymetallic sulfide ore effectively is difficult. The several of testing scheme was explorated according to the characteristics of the ore. The concentrate of silver, concentrate of zinc, concentrate of sulfur were got and the index of concentrate grade of Ag for 1504 g/t, the recovery of Ag for 55.65%, concentrate grade of Zn for 54.28%,the recovery of Zn for 39.38%,concentrate grade of S for 38.58%, the recovery of S for 64.43% were obstained by the flowsheet of bulk flotation–polymetallic separation to concentrate of bulk flotation and feasible conditions of test.

PROPERTIES OF RUN-OF-MINED ORE

Multi-element chemical analysis of run-of-mined ore

The multielement chemical analysis results of run-of-mined ore were shown in TABLE 1.

TABLE 1 : The multielement chemical analysis results of run-of-mined ore

elements	Pb	Zn	TFe	S	SiO_2	Cu	As	Au (g/t)	Ag (g/t)
Content (%)	9.18	18.78	12.55	22.22	28.41	1.77	0.08	0.20	368

The TABLE 1 showed that the valuable elements were Cu,Pb,Zn,S,and harmful element was As in the ore

Momposition and its characteristics of run-of-mined ore

The metal minerals in the ore were sphalerite, galena, pyrite, chalcopyrite, bornite and so on. The gangue minerals were mainly quartz. Galena and pyrite of metal minerals formed in mineralization hydrothermal in the early time,and. a part of galena filled in crystal gap of pyrite because of the different crystallization time. Chalcopyrite and sphalerite formed in mineralization hydrothermal in secondary later, and filled in crystal gap and fracture of minerals formed early or replaced minerals formed early. Silver minerals have not been found in the microscopic, probably it was very fine or occured in other metal sulfides in the form of isomorphism.

The sphalerite distributed in xenomorphic or irregular shape,its average particle size was 0.05~0.2 mm. Symbiotic relationship of sphalerite with chalcopyrite was close for sphalerite and chalcopyrite formed in secondary mineralization hydrothermal. Sphalerite was along the fissure or filled in crystal gap of minerals which formed by stress in the early. Galena distributed in xenomorphic and irregular shape, its verage particle size was 0.01~0.1mm. Galena and pyrite formed in a metallogenic hydrothermal of early and the period of galena crystal is later than pyrite, therefore, the part of galena filled in crystal gap of pyrite. Chalcopyrite with irregular shape or thin vein filled in cataclastic structure of Galena. Pyrite distributed in aggregation of idiomorphic, hypautomorphic or xenomorphic of square, rectangle,ect. and grain size was coarse, general was 0.1~1.0 mm. pyrite of early formed fracture structure on the condition of breaking by stress. Chalcopyrite was alone the fractures or filled in the crack of pyrite. Pyrite which was replaced was island shape and harbour shape. Chalcopyrite was

xenomorphic irregular granular or shape of thin vein,it's average particle size was 0.05~0.2mm. Chalcopyrite formed later than pyrite and galena,and chalcopyrite was along or filled the crystal gap of pyrite and galena. Chalcopyrite and sphalerite formed at the same time, and symbiotic relationship was close. The content of bornite was less, bornite existed in xenomorphic and irregular shape, its particle size usually was 0.05~0.4mm. Bornite, chalcopyrite and sphalerite formed in secondary mineralization hydrothermal together. In general, bornite co-existed with sphalerite.

FLOTATION TEST

The content of metal mineral was higher and composition of metal mineral was complex, symbiotic relationship was close. The leaching rate by cyanide is only 10% through exploration test of all sCaO cyanidation. Therefore, silver couldn't be separate form ore to form output, and it could be recovered into concentrate products by flotation. The flowsheet of bulk flotation–polymetallic separation to concentrate of bulk flotation was used according to the characteristics of the ore[1,2].

Test of bulk flotation

Mesh of grind test

Full liberation of metal minerals and gangue minerals was one of the important factors affecting the flotation index. Grinding fineness determines the degree of liberation between different mineral. Much gangue mineral can be removed in appropriate grinding fineness and makes the metal mineral to enrich fully[3]. Useful minerals in the ore are sulfide mineral containing silver. The concentration effect of silver and sulfur was examined by using a time flotation operation and on the condition of dosage of CaO for 1000g/t, the dosage of Na_2SiO_3 for 1000g/t, the dosage of ethyl xanthate for 50g/t, dosage of Butylamine aerofloat for 50g/t,dosage of no.2 oil for 30g/t and flotation time for 7min in mesh of grind test. The test results of mesh of grind were shown in Figure 1.

Figure 1 showed the recovery of Ag and S in mixed concentrate tended to be lower, grade of S increased, and grade of Ag was on the rise with the increase of mesh of grind. When mesh of grind for -0.074 mm between 70% and 90%,the grade of Ag in mixed concentrate reduced. The mesh of grind for -0.074 mm 95.3% was used in the succeeding test.

The dosage of CaO test

CaO was adjustor of pH in slurry. The flotation of sulfide ore should be done in the suitable pH range in order to obtain better separation effect. Test of CaO dosage was done on the condition of mesh of grind for - 0.074 mm71.8%, the dosage of Na_2SiO_3 for 1000g/t, the dosage of ethyl xanthate for 50g/t, dosage Butylamine aerofloat for50 g/t, dosage of no.2 oil for 30g/t and flotation time for 7min. The test results were shown in Figure 2.

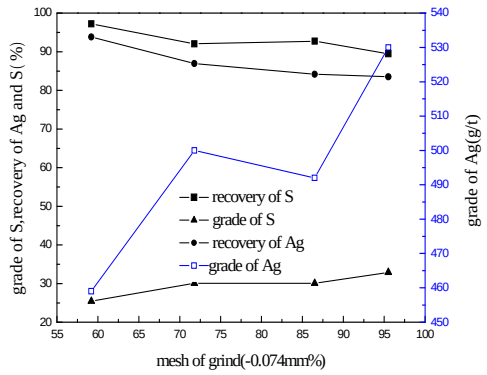

Figure 1 : The results of mesh of grind test

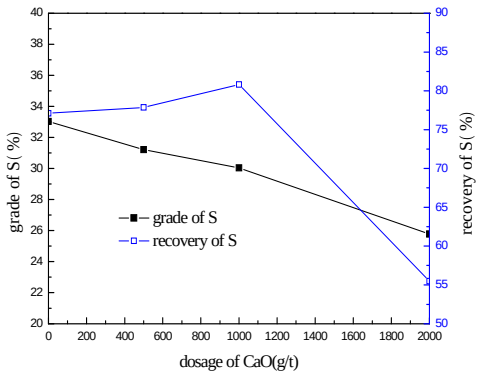

Figure 2 : The results of dosage of CaO

Figure 2 showed the grade of concentrate was high when dosage of CaO was small. Grade of S was gradually reduced and recovery of S increased at first and decreased later with the increase of dosage of CaO. The recovery of S was the largest when dosage of CaO was 1000g/t. CaO has obvious inhibitory effect to the pyrite when dosage of CaO was excessive. So, suitable dosage of CaO was 1000g/t.

The dosage of Na_2SiO_3 test

Na_2SiO_3 was depressant and dispersant of gangue mineral and was profitable to the separation of sulfide minerals and gangue minerals. Dosage of Na_2SiO_3 shoulds not be too large, otherwise selective will be lose[4,5]. Test of dosage of Na_2SiO_3 was done on the condition of mesh of grind for - 0.074 mm71.8%, the dosage of CaO for 1000g/t, the dosage of ethyl xanthate for 50g/t, dosage Butylamine aerofloat for 50g/t, dosage of no.2 oil for 30g/t and flotation time for 7min. The test results were shown in Figure 3.

Figure 3 showed that grade of S in concentrate reduced, the recovery of S increased with the increase of dosage of Na_2SiO_3. Grade decreased slowly and and the recovery improved fast when dosage of Na_2SiO_3 was less than 1000g/t. Grade decreased fast and and the recovery improved slow when dosage of Na_2SiO_3 was more than 1000g/t. So, suitable dosage of Na_2SiO_3 was 1000g/t.

The dosage of collector test

Xanthate and aerofloat are common collector in flotation technology of metal sulphide. The sulfide mineral and gangue could be separated well because the bivalent sulfur atoms which can act on surface of sulfide minerals by chemical adsorption was contained in polar groups of Xanthate and aerofloat[6,7]. Test of total dosage of collectors were done on the condition of mesh of grind for - 0.074 mm71.8%, the dosage of CaO for 1000g/t, the dosage of Na_2SiO_3 for 1000g/t,dosage of no.2 oil for 30g/t and flotation time for 7min (ratio of ethyl xanthate and butylamine aerofloat was 1:1). The test results were shown in Figure 4.

Figure 4 showed recovery of S increased gradually with increasing dosage of collector. The grade of concentrate was the biggest when the dosage of collector was 80g/t. So, suitable dosage of ethyl xanthate and butylamine aerofloat was both 40g/t.

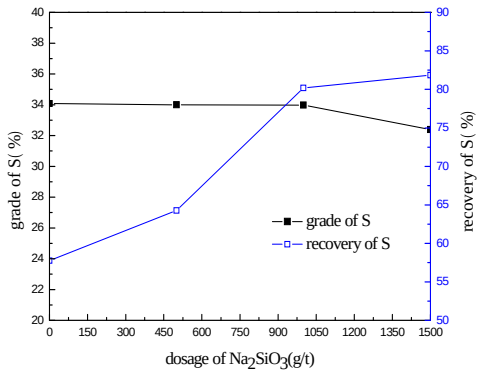

Figure 3 : The results of dosage of Na_2SiO_3

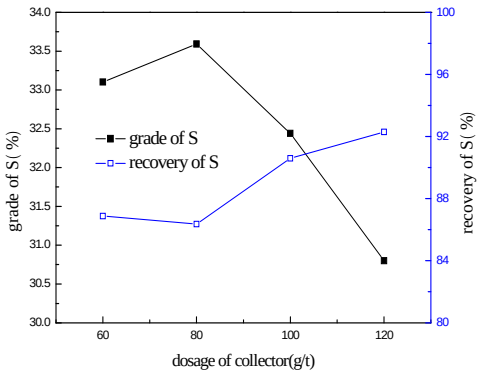

Figure 4 : The results of dosage of collector

Floating Cu and Pb from mixed concentrate

There were Cu, Pb, Zn and S in mixed concentrate, the flotation properties of Cu, Pb was close, so flowsheet of floating Cu and Pb from mixed concentrate of Cu, Pb, Zn and S, then separating Cu and Pb to mixed concentrate of Cu,Pb, separating Zn and S to tailings of bulk flotation of Cu\Pb were used in test.

Mesh of regrind to mixed concentrate

Purpose of regrind to mixed concentrate was to make the metal sulfide minerals to realize the monomer dissociation as far as possible, and regrind could remove the agents from the surface of

particle. Test of mesh of regrind were done on the condition of the dosage active C for 200g/t, the dosage of Zn_2SO_4 for 1000g/t, the dosage of Na_2SO_3 for 500g/t,dosage of Z-200 for 20g/t and flotation time for 6min. The test results were shown in TABLE 2. use Con. as concentrate in all of table and Figure

TABLE 2 : Test results of mesh of regrind of mixed concentrate

mesh of regrind (-0.074mm%)	grade of Con.(%)		operation recovery of Con.(%)		grade of mixed Con.(%)	
	Cu	Pb	Cu	Pb	Cu	Pb
84	2.70	13.9	67.79	58.81	2.04	12.16
91.8	2.49	14.58	71.22	68.95	2.15	12.75
98.5	2.96	16.62	69.65	71.63	2.23	12.20
99.6	2.94	16.62	66.85	67.00	2.19	12.36

TABLE 2 showed that grade and recovery of concentrate were higher, when mesh of regrind was content of -0.074mm for 98.5%, suitable mesh of regrind was -0.074mm for 98.5%.

The dosage of depressant test to mixed concentrate

Test of dosage of depressant of separation Cu\Pb and Zn\S from mixed concentrate by floating Cu\Pb and depressing Zn\S. were done on the condition of mesh of regrind for - 0.074mm98.5%, the dosage of Z-200 for 20g/t and flotation time for 6min. The test results were shown in TABLE 3.

TABLE 3 : Test results of dosage of depressant of mixed concentrate

Depressant (g/t)		grade of Con.(%)			operation recovery of Con.(%)			Grade of mixed Con.(%)		
Zn_2SO_4	Na_2SO_3	Cu	Pb	S	Cu	Pb	S	Cu	Pb	S
500	500	5.40	12.98	24.66	26.67	11.84	11.33	2.39	12.96	25.72
500	1000	5.41	11.90	24.15	34.03	13.73	13.98	2.32	12.70	25.31
1000	500	5.72	10.58	26.27	37.83	13.03	16.94	2.50	13.41	25.61
1000	1000	5.14	12.32	26.63	47.24	20.90	23.22	2.42	13.10	25.49

The results of TABLE 3 showed that grade of zinc in concentrate of Cu\Pb was high when the dosage of Zn_2SO_4 was big. improving dosage of Na_2SO_3 was profitable to improving recovery of Cu\Pb. Therefore, the suitable dosage of depressant for Zn_2SO_4 and Na_2SO_3 were 1000 g/ t and 500 g/t respectively

Separation of Cu\Pb test

The process of floating copper depressing lead was generally used to separate Cu\Pb. $K_2Cr_2O_4$ was common Depressor of galena[8]. The dosage of $K_2Cr_2O_4$ was studied in separation of Cu\Pb test. Test flowsheet and condition were shown in Figure 5, the results were shown in TABLE 4.

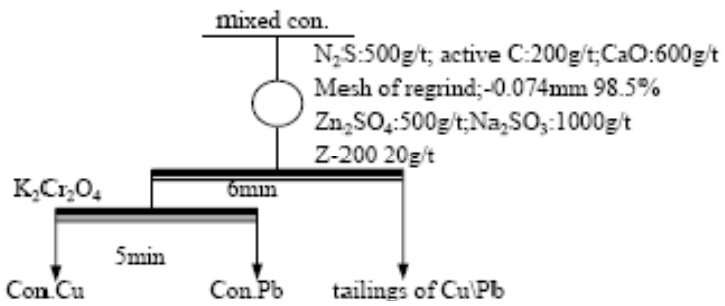

Figure 5 : Test flowsheet of separation of Cu\Pb

TABLE 4 : Test results of separation of Cu\Pb

$K_2Cr_2O_4$ (g/t)	Grade of Con.				Operation recovery of Con.				Con.Cu\Pb	
	Con.Cu		Con.Pb		Con.Cu		Con.Pb			
	Cu	Pb	Cu	Pb	Cu	Pb	Cu	Pb	Cu	Pb
200	3.80	27.60	3.70	18.10	24.62	29.66	75.28	70.34	3.33	20.16
300	5.70	13.30	3.00	15.40	31.81	17.49	68.19	82.51	3.53	14.99
400	5.40	20.60	4.00	18.10	29.75	26.31	70.25	73.69	4.73	18.70
500	6.00	13.00	4.00	13.70	24.79	18.66	75.21	81.34	4.71	13.56

TABLE 4 showed that the grade of Cu in concentrate increased with increasing of dosage of i $K_2Cr_2O_4$. The recovery of Cu was highest when dosage of $K_2Cr_2O_4$ was 300 g/t,and dropped later. The suitable dosage of $K_2Cr_2O_4$ was 300 g/t.

Separation of Zn\S test

The main mineral was sphalerite and pyrite in tailings after floating Cu\Pb,So tailings after floating Cu\Pb can also be called mixed concentrate of Zn\S, The purpose of this test is to separate sphalerite and pyrite from mixed concentrate of Zn\S. In general CaO was used inhibiting pyrite and Cu_2SO_4 was activator of sphalerite in separation of Zn\S. The dosage of CaO and Cu_2SO_4 should be examined in test of separation of Zn\S. Test flowsheet and condition were shown in Figure 6, the results were shown in TABLE 5.

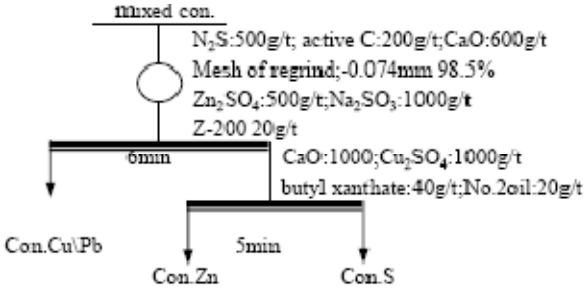

Figure 6 : Test flowsheet of separation of Zn\S

TABLE 5 : The dosage of CaO and Cu_2SO_4 test in separation of Zn\S

CaO (g/t)	Grade of Zn (%)	Recovery of Zn (%)	Cu_2SO_4 (g/t)	Grade of Zn (%)	Recovery of Zn (%)
1000	32.00	85.96	500	31.80	59.50
2000	32.10	80.91	800	30.50	81.62
3000	31.60	79.63	1000	28.40	74.90

The test result shows that d, grade of Zn in concentrate changed little and recovery of Zn decreased obvirous with increasing dosage of CaO. The grade and recovery of Zn in concentrate were high when dosage of Cu_2SO_4 was 800g/t. The suitable dosage of CaO\Cu_2SO_4 were 1000g/t\800g/t respectively.

The close-circuit test

The suitable flowsheet and conditions of close-circuit were determined by condition test and comprehensive condition test. Flowsheet of close-circuit test was shown in Figure 7, conditions of close-circuit test was shown in TABLE 6, test results of close-circuit were shown in TABLE 7.

TABLE 8 showed that grade and recovery of S in sulphur concentrate are high, grade of Zn in zinc concentrate is high, but the recovery is low, Zn was lossed in concentrate of copper, lead, sulfur mainly. The index of copper, lead concentrate is very poor, and it is difficult to separate copper, lead,

zinc and sulphur. Separation of zinc and sulphur can be done,but separation of copper and lead was difficult. Product qualified of copper concentrate and lead concentrate cannot be obstained. At the same time, the silver was exist in concentrate of copper and lead mainly, concentrate of silver in which the grade of Ag for 1504 g/t, recovery for 55.65% could be got by combine concentrate of copper and concentrate of lead together. The content of Cu, Pb, Zn, S, As were 8.89%,37.62%, 30.89%,28.29%,0.32% in concentrate of Ag

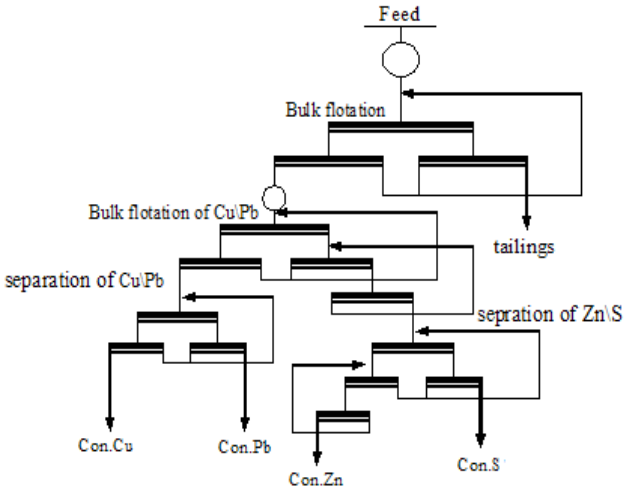

Figure 7 : Flowsheet of test

TABLE 6 : The condition of close-circuit test

Agents (g/t)	bulk flotation			bulk flotation of Cu/Pb			separation of Cu/Pb			separation of Zn\S		
	rougher	Cleaners	scavengers	rougher	Cleaners	scavengers	rougher	Cleaners	scavengers	rougher	Cleaners	scavengers
CaO	1000			600						1000	200	
Na_2SiO3	1000											
butyl xanthate	50	20								40		20
Butylamine aerofloat	50	20										
2# oil	30	10								20		10
Na_2S				300								
active C				200								
Zn_2SO_4				500	300	800						
Na_2SO3				1000	500	1500						
Z-200				20		20			10			
$K_2Cr_2O_4$							300	100				
Cu_2SO_4										800		400

TABLE 7 : The results of close-circuit test

Name	Yield (%)	Grade (%)					Recovery (%)				
		Cu	Pb	Zn	S	$Ag10^{-6}$	Cu	Pb	Zn	S	Ag
Con.Cu	5.68	9.80	36.00	28.27	25.67	2190	30.71	22.92	9.73	6.20	37.36
Con.Pb	6.64	8.11	39.00	33.29	30.53	917	29.71	29.03	13.39	8.62	18.29
Con.Zn	11.86	0.66	4.12	54.28	31.60	164	4.32	5.48	39.38	15.94	5.84
Con.S	39.26	1.05	4.72	10.41	38.58	228	22.74	20.77	24.75	64.43	26.88
Tailings	36.56	0.62	5.32	5.76	3.09	106	12.52	21.80	12.75	4.81	11.63
crude	100.00	1.81	8.92	16.51	23.51	333	100.00	100.00	100.00	100.00	100.00

CONCLUSION

(1)There were many valuable component in nanshan polymetallic sulfide ore containing silver. The main elements which can be recovered were Copper, lead, zinc,sulfur and silver. Main metal minerals in the ore was mainly sphalerite, galena, pyrite, chalcopyrite and bornite. Galena and pyrite formed earlier than chalcopyrite and sphalerite. Separation of all kinds of metal minerals was difficult for close symbiotic relationship between minerals. The polymetallic ore containing silver was difficult to process and smelt.

(2)The concentrate of silver,concentrate of zinc, concentrate of sulfur were got and their grade were high. The index of concentrate grade of Ag for 1504 g/t, the silver recovery for 55.65%, concentrate grade of Zn for 54.28% and the recovery of Zn for 39.38%,concentrate grade of S for 38.58%, the recovery of S for 64.43% were obstained by the flowsheet of bulk flotation- multi-metal separation to concentrate of bulk flotation and feasible conditions of test. Silver, zinc and sulfur were recovered comprehensive,and good economic benefit can be obtained.

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