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Recovery of economic minerals from graphite float of Rajpura Dariba mines

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ABSTRACT

A 3000 tpd lead-zinc ore beneficiation plant was commissioned in 1983 to produce lead and zinc concentrates suitable for Indian smelters. The problems encountered in the production of individual concentrates are mainly high graphite and lower lead grade in lead concentrate and high silica in zinc concentrate. Due to variable nature of ore quality, Graphite mica-schist, the incidence of high graphite and lower grade of lead in lead concentrates can be explained and taken care by use of pre-flotation of graphite and by gravity techniques. It has been observed during extensive laboratory scale testing by in-house R&D of HZL and by the National Laboratories in India and plant operations for over a decade that incidence of graphite mica-schist in the ore affects zinc flotation only to a limited extent whereas lead metallurgy is adversely affected. Hence, one of the methods tried was pre-flotation of graphite ahead of lead-zinc selective flotation. In this paper, efforts made towards recovery of lead and zinc minerals present in the pre-graphite float are discussed. The studies include lead and zinc depression during reverse flotation, graphite depression and lead flotation and use of gravity techniques. The results indicate that gravity techniques are effective in removing most of the liberated graphite, thereby ensuring enrichment of lead and zinc minerals present in the higher specific gravity fractions, which can be recirculated and recovered in the plant.

INTRODUCTION

Rajpura-Dariba mines are located 80 kms. from Udaipur and situated in Rajsamand district of Rajasthan State. About 26 million tonnes ore reserves are proven. The host rock mineralization is in Calc silicate (CS) and Graphite mica-schist (GMS) zones. As far back in 1974, it was realized that ore from CS zone would be simpler for beneficiation, as lead and zinc liberation is at coarser sizes compared to ore of GMS zone. Hence, production of fairly clean lead and zinc concentrates from the CS ore is relatively simpler while processing of GMS ore is complicated due to high pyrite content coupled with interlocking of finer grains of galena with graphite and carbonaceous gangue.

A 3000 tpd beneficiation plant was planned and commissioned in the year 1983 for producing 50% lead in lead concentrate and 52% zinc in zinc concentrate with low levels of impurities i.e., graphite and silica in lead and zinc concentrates (1.5 and 2.5% max., respectively).

The expected results could not be obtained in the plant. One of the reasons has been varying characteristics of ore treated. Efforts were made towards improvement in quality of lead concentrate by pre-flotation of graphite ahead of lead flotation, thereby restricting floatable graphite and gangue to come up with lead concentrate. It was envisaged that by adopting this technique, a portion of floatable graphite and smeared gangue could be taken out ahead of lead flotation by addition of small dosage of a frother.

The plant was operated for six months, with pre-graphite flotation circuits treating 148300 tonnes of ore and approximately 700 tonnes of prefloat was produced. Composite assay of prefloat are given in Table 1.

Table 1 : Assay & distribution range of graphite float

Constituents	Assay	Distribution (%)
Pb, %	11.50 – 12.1	2.66 – 2.80
Zn, %	4.95 – 5.93	0.38 – 0.04
Gr C, %	9.90 – 12.5	1.52 – 2.42
Ag, ppm	538.00 – 554.0	3.23 – 3.63

Efforts were made to recover lead and zinc minerals along with silver values from graphite float, so that this product can be of use in hydro–metallurgical operations or can be recirculated with middlings in the beneficiation plant.

TEST WORK

Flotation Tests

At Rajpura Dariba plant differential flotation of lead and zinc are followed. So preferably flotation route was chosen for separation of graphite and economic minerals from sample.

Tests were carried out on the following lines :

i) Depression of graphite by a graphite depressant Hubasine and flotation of sulphides by sodium isopropyl xanthate and aerofloat promoter 242.

ii) Depression of sulphides by potassium dichromate and zinc sulphate and flotation of graphite using MIBC.

Results obtained with route (i) are given in Table 2.

Table 2 : Depression of graphite with xanthate flotation of sulphies

		Assay (%)				Recovery (%)			
Products	Wt.(%)	Pb	Zn	Ag (ppm)	GrC	Pb	Zn	Ag	Gr.C
Sulphide float	1.7	8.0	6.8	1220	15.7	2.2	1.5	3.2	3.3
Cleaner tails	8.0	6.8	6.9	75	11.0	9.0	7.5	1.0	11.0
Sc. Tails	90.3	5.9	7.4	685	7.5	88.8	91.0	95.8	85.7
Head (Calc)	100	6.1	7.4	645	7.9	100	100	100	100

It is seen that there is no enrichment of Pb and Zn in sulphide float. In next test, Aerofloat 242 was used in place of sodium isopropyl xanthate. The results obtained are given in Table 3.

Table 3 : Depression of graphite and sulphide flotation with Aerofloat 242

		Assay (%)				Recovery (%)			
Products	Wt.(%)	Pb	Zn	Ag (ppm)	GrC	Pb	Zn	Ag	Gr.C
Sulphide float	6.8	13.0	7.2	2200	6.3	14.5	6.6	23.0	5.4
Tails	93.2	5.5	7.4	532	8.1	85.5	93.4	77.0	94.6

It is seen from Table 3, that aerofloat 242 is a better collector for sulphides, than isoproyl xanthate but recovery of Pb in sulphide float was only 14.5% while silver recovery was 22%.

In the next scheme (route ii), lead and zinc sulphides were depressed using potassium, dichromate and zinc sulphate. Pyrite was depressed by hydrated lime. Graphite was floated out using MIBC as frother. The results are given in Table 4.

Table 4 : Depression of sulphides and graphite flotation

		Assay (%)				Recovery (%)			
Products	Wt.(%)	Pb	Zn (ppm)	Ag	GrC	Pb	Zn	Ag	Gr.C
Sulphide float	10.4	4.0	5.8	490	13.0	6.9	8.1	7.9	17.0
Tails	89.6	6.3	7.6	663	7.4	93.1	91.9	92.1	83.0
Head (Calc)	100.0	6.1	7.4	645	8.0	100	100	100	100

It is seen that although sulphides are depressed, only 17% graphite could be seperated out.

Gravity Separation Tests

The pre-float sample was subjected to size analysis on 200 mesh and 300 mesh screens and these were subjected to gravity separation on Wilfley Shaking Table. The results obtained are given in Table 5.

Table 5 : Gravity seperation test data on graphite float

		Assay (%)			Recovery (%)		
Products	Wt.(%)	Pb (ppm)	Zn	Ag	GrC	Pb	Gr.C
Table conc + 200 mesh	7.4	4.8	2.9	400	12.9	5.9	8.0
Table tails + 200 mesh	4.9	5.3	2.8	465	17.5	4.4	7.3
Table conc + 300 mesh	4.3	5.7	4.1	405	6.3	4.0	2.3
Table tails + 300 mesh	1.0	3.0	2.0	180	12.3	1.0	1.9
Table conc - 300 mesh	7.4	13.9	5.8	1055	3.6	17.2	2.4
Table tails - 300 mesh	74.1	5.4	3.6	555	12.5	67.5	78.1
Head (calc)	100	5.9	3.7	564	11.8	100	100

It is seen from the data that gravity separation on Wilfley Shaking Table is not effective.

Sub-Sieve Analysis and Mineralogy

Keeping in view the unsatisfactory separations, it was thought worthwhile investigating the extent of interlocking of graphite with lead and zinc sulphides and size ranges of locked/free particles. A sample was subjected to subsieve analysis on Infrasizer and fractions obtained were studied under microscope for minerals liberation. The results are given in Table 6 and 7.

Table 6 : Sub-sieve analysis and chemical analys of sized products

Size in Microns	Wt.(%)	Assay (%) Pb	Zn	Ag (ppm)	GrC	Recovery (%) Pb	Zn	Ag	Gr.C
–63+52	41.0	5.75	7.1	300	6.04	39.9	43.9	31.6	30.8
–52+37	21.6	5.90	7.2	400	10.3	21.6	23.4	21.4	27.9
–37+26	16.3	6.7	6.4	465	9.1	18.6	15.7	19.5	18.5
–26+18	13.0	6.3	5.8	510	7.9	12.5	10.4	15.5	12.9
–18+13	1.7	5.0	5.5	555	12.9	1.4	1.3	2.5	2.6
–18+9	1.5	4.5	5.4	610	13.1	1.1	1.2	2.5	2.5
–9	4.9	5.9	5.6	560	7.7	4.9	4.1	7.0	4.8
Head (Calc)	100	5.9	6.6	392	8.0	100	100	100	100

Table 7 : Mineralogical data on sized fractions of graphite float

Mineral Assemblages	1 –63+54 Microns	2 –52+37 Microns	3 –37+26 Microns	4 -26+18 Microns	5 -18+13 Microns	6 -13+9 Microns	7 -9 Microns
A.Liberated Gr	4.0	1.70	5.5	6.9	14.1	14.5	29.1
B.Un-liberated							
Locked with							
Spl. Gr	5.8	4.0	5.5	5.1	6.7	5.7	2.7
Py, Cp, Te-Tn							
Reminder G	90.2	94.3	89.0	88.0	79.2	79.8	68.2
Total (A+B)	100	100	100	100	100	100	100

Gr	-	Graphite	Py	-	Pyrite
Gn	-	Galena	Cp	-	Chalcopyrite
Spl	-	Sphalerite	Te-Tn	-	Tetrahydribe-Tennantite
G	-	Gangue + others			

It is seen from Tables 6 and 7 that maximum liberation of graphite is in the fractions of below 18 micron size, which is only 8.1% of total weight. On an average 5-6% graphite is liberated with sulphides and rest is with gangue.

Hence, gravity separation equipment like laboratory vanner was employed to separate sulphides from gangue and graphite, as the equipment is designed to handle particles below 100 microns.

Tests on Vanner

The sample was tested on laboratory Bartlay-Mozley Vanner. Results obtained in a single pass are given in Table 8.

Table 8 : Separation of graphite on vanner

Products	Wt.(%)	Assay (%) Pb	Zn	Ag (ppm)	GrC	Recovery (%) Pb	Zn	Ag	Gr.C
Conc.	50.2	9.5	10.0	930	4.6	79.0	68.0	72.5	29.3
Cl Tails	23.2	2.0	4.0	284	6.5	7.7	12.6	10.2	19.0
Tails	26.6	3.0	5.4	420	15.5	13.3	19.4	17.3	51.7
Head	100	6.1	7.4	644	8.0	100.0	100.0	100.0	100.0

It is seen that 79% of Pb, 68% Zn, 72.5% Ag values are recovered in vanner as gravity concentrate. As the results obtained were encouraging, a test was carried out with four cleanings of rougher concentrate

The metallurgical results given in Table 9 indicate better rejection of graphite.

Table 9 : Cleaning of graphite on vanner

Products		Wt.(%)	Assay (%) Pb	Zn	Ag (ppm)	GrC	Recovery (%) Pb	Zn	Ag	Gr.C
Concentrate										
	1	1.1	35.2	1.7	1440	1.04	6.5	0.40	2.4	0.2
	2	4.0	17.8	5.4	1400	2.72	11.8	3.5	8.7	1.1
	3	0.7	21.2	5.3	1200	2.9	2.5	0.20	1.3	0.1
	4	2.5	10.0	12.9	1000	3.9	4.5	5.6	3.9	1.3
Tails		91.7	4.9	5.1	590	8.4	74.7	90.3	83.7	97.3
Head		100	6.0	5.7	644	8.0	100	100	100	100
Conc.(1+2+3+4)		8.3	24.8	9.6	1240	2.5	25.3	9.7	16.3	2.7

CONCLUSIONS

It can be concluded from the abovestudies that 97% of graphite can be rejected from the pre-float, resulting in a gravity concentrate, (8.3% by weight), assaying 24.8% Pb, 9.7% Zn and 2.5% Gr.C with recoveries of 25.3, 9.7 and 2.7%, respectively.

The low metal contents in the sulphide concentrate may be due to poor liberation of graphite from valuable minerals and gangue and occurrence of liberated grains in finer fractions viz., 13 micron size, which could not be recovered in vanner.

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