BENEFICIATION OF LOW GRADE LEAD ORE

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(Rceeived July 27, 1966)

In the beneficiation of the low grade indigenous lead ore by froth floatation, optimum, conditions with respect to the particle size of the feed, pH of the pulp, speed of the propeller, nature of the collector and frother, and effect of aeration during the froth floatation process have been investigated. Potassium ethyl xanthate and cresol, used as collector and frother respectively, give 79.1% pure PbS with 93% recovery.

Introduction

Galena occurs in both crystalline and non-crystalline rock. It is commonly associated with other sulphide minerals such as pyrite, sphalerite and chalcopyrite. The non-metallic minerals, e.g., quartz, calcite, barytes, flourspar, etc., constitute the gangue. The chief modes of occurrence are in veins, in flat or off-shoots from veins, usually following the bedding planes replacing limestone.

Galena occurs in some areas in Pakistan,[1] e.g., Chitral, Swat, Dalbandin and Hazara distriscts. A small quantity of the lead ore is being produced from the Ziarat[2] Balanosh area of Chigai district. At certain places the lead ore occurs in small quartz-calcite veins dying out within short distances, both horizontally and vertically.[3] Though the individual veins are small, extensive mineralization in the area calls for detailed surface and sub-surface exploration.

Certain deposits of galena are not rich with respect to lead contents. Extraction of lead from galena has been reported in another communication.[4] This paper deals with beneficiation of low grade lead ore by froth floatation process.

The average analysis of the ore from Hazara district runs as follows:

PbS	..	42.5%
SiO_2	..	52.5%
Al_2O_3	..	2.1%
Fe_2O_3	..	1.6%
CaO	..	1.1%
Total:	..	99.8%

Experimental

Crushing of Ore.—The ore was crushed in a set of crushing rolls. It was then ball-milled to different mesh sizes.

Conditioning and Floatation of Ore.—The conditioning of the ore weighing (1000 g.) was accomplished in Denver Laboratory Super Agitator and Conditioner. The ore was first made into a slurry by adding 2–3 times water and then fed to the conditioner. Ten-minute conditioning time was found to be sufficient. Twenty minutes were given for the froth to collect.

A number of reagents[5] (collecting, conditioning and frothing) were employed to investigate the floatability of the mineral particles.

Results and Discussion

TABLE 1.—EFFECT OF CONDITIONING REAGENTS ON PURITY AND RECOVERY OF PbS.

Reagents	lb/ton		% of PbS	Recovery %
Na_2SiO_3	0.2	..	48	55
Na_2CO_3	0.2	..	65	75
NaOH	0.2	..	62	67
H_2SO_4 pH 4-5	—	..	42	50
$K_2Cr_2O_7$	0.2	..	50	52

The reagents were tried under the following conditions:

Weight of the batch	1000 g
Particle size	−100+120 mesh (B.S.S.)
Conditioning time	10 min
Time for froth collection	20 min
Collector	Potassium ethyl xanthate 0.2 lb/ton
Frother	Cresol 0.2 lb/ton

From Table 1 it is evident that Na_2CO_3 is the best conditioning agent.

pH of Pulp: Table 2 indicates the effect of pH on the floatation behaviour of lead sulphide.

TABLE 2.—EFFECT OF pH ON THE PERCENTAGE PURITY OF LEAD SULPHIDE.

pH	..	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5
% Purity of lead sulphide	..	45	58	70	78.5	79	78	72	70

The observations indicate that the pH of the slurry is an important factor in froth floatation. The alkaline medium proves to be more effective and this is due to the reason that in alkaline bath at the specific pH value, the bubble formation is such that the surface area and the contact angle of the bubble go in favour of accumulating galena on the surface. Lower pH, neutral pulp and higher pH values adversely affect the purity and recovery.

Table 2 shows that the pH of the bath for the maximum yield between 8.5 to 9.5, under the conditions mentioned, should be maintained by adding sodium carbonate solution and it is perhaps due to this reason that conditioning with sodium carbonate gives a product of comparably better purity (65%) and recovery (75%).

Floatation.—The slurry of the −100 +120 mesh conditioned with sodium carbonate for 10 minutes at 9.0 pH was used for floatation. A number of frothers and collectors were tried. The froth was collected for 20 minutes in each case. The results are presented in Table 3.

TABLE 3.—EFFECT OF DIFFERENT COLLECTING AND FROTHING AGENTS ON THE PURITY AND RECOVERY OF PbS.

No.	Reagents		% of PbS	Recovery %
	Collectors	Frothers		
1.	Butyl xanthate[6] 0.2 lb/ton ..	Aerofloat No. 241 10 drops, Promotor cresylic acid	61	72
2.	Butyl xanthate 0.2 lb/ton	Pine oil 10 drops	62.25	70.2
3.	Amyl xanthanate[7] 0.2 lb/ton	Aerofloat frother No. 70, 10 drops	68	78
4.	Amyl xanthate 0.2 lb/ton	Sodium Aerofloat 10 drops, activation by cu^{++}ion	69.3	68
5.	Amyl xantheate	Aerofloat, 10 drops No. 25	67.8	74.7
6.	Isopropyl xanthate 0.2 lb/ton	Aerofloat No. 31, pine oil 10 drops	65.4	72.5
7.	Isopropyl xanthate 0.2 lb/ton	Aerofloat No. 31, pine oil 10 drops, Crecylic acid 5 drops	71.4	74
8.	Aero xanthate, sulphonated castor oil 0.2 lb/ton	Pine oil, 10 drops, activation by Cu^{++}ion	49	56
9.	Oleic acid 0.2 lb/ton Soft soap	Pine oil, 10 drops	52	58
10.	Potassium amyl xanthate[8] 0.2 lb/ton with Na_2SO_3	Aerofloat No. 25, 10 drops	59	63
11.	Potasium amyl xanthate	Aerofloat frother No. 70, 10 drops	61.2	66.1
12.	Potassium ethyl xanthate[9] 0.2 lb/ton	Pine oil, 10 drops	69.1	76
13.	Potassium ethyl xanthate 0.2 lb/ton	Pine oil, 5 drops, cresol, 5 drops	76.5	85.3
14.	Potassium ethyl xanthate[10] 0.2 lb/ton.	Cresol, 10 drops	79.1	93
15.	Potassium ethyl xanthate 0.2 lb/ton	Cresol 10 drops, activation by Cu^{++}ion	76.0	91.8

A number of reagents tried as collectors and frothers, reveal that xanthates, in general, respond very well. Amongst xanthates, amyl xanthate, isopropyl xanthate and potassium ethyl xanthate work satisfactorily. The iso-and potassium ethyl xanthate in combination with pine oil (frother) indicate better purity. The experiments with the partial replacement of pine oil by cresol indicate far better purity and recovery. Total replacement of pine oil by cresol gave more favourable results. This combination of collector and forther in conjunction with the activation by Cu^{++}, however, lowered the purity as well as the recovery. The study thus leads to the conclusion that potassium ethyl xanthate in combination with cresol is much effective. With this combination the uprgraded product gives the following analysis: PbS 79.1%, SiO_2 18.0%, Al_2O_3 1.2%, Fe_2O_3 0.9%, CaO 0.5%.

The frothers Aero-Float No. 25 and 70 used with collectors (amyl xanthate and potassium amyl xanthate, respectively) bring about a marked difference in percentage purity and recovery. The beneficial role of an additional potassium ion in the complex is not understood and demands critical study.

Effect of Variation of Particle Size of the Feeds.—Galena of varying particle sizes was subjected to floatation, employing potassium ethyl xanthate as collector and cresol as frother at pH 9.0. The percentage purity of PbS obtained with varying particle sizes is given in Table 4.

TABLE 4.—EFFECT OF PARTICLE SIZE ON PURITY AND RECOVERY OF PbS.

Particle size	Purity of PbS%	Recovery %
− 70 + 80	68.2	72
− 80 + 100	77.0	90.8
−100 + 120	79.1	93.0
−150 + 200	58.0	64.0
−200	50.0	55.0

Table 4 shows that particle size upto −100+120 gives better purity and recovery of PbS, which decreases with the increasing fineness.

Effect of Speed of Propellor of Floatation Cell.—The speed of the propellor of the cell has a definite bearing on the puritv (cf. Table 5).

TABLE 5.—EFFECT OF PROPELLOR SPEED ON PERCENTAGE PURITY AND RECOVERY OF PbS.

Speed of propellor rev/min	Purity of PbS%	Recovery%
700	68.0	79.8
800	78.0	90.0
900	79.1	93.2
1000	74.0	86.0
1200	65.2	71.8

A propeller speed of 800–900 rev/min gives optimum yield. Lower as well higher speeds adversely affect the purity and recovery. Lower speeds do not sufficiently agitate the pulp enough to produce froth necessary for the adherence of galena particles to the collector. Similarly, higher speeds deprive the galena particles to be selectively attached to the collector.

Effect of Aeration.—Aeration further improved the results. Keeping all the necessary conditions for the optimum purity constant, the percentage purity decreased from 79.1% to 74–75% PbS when the pulp was not aerated during the floatation process.

Concentration of Frother and Collector.—It has been observed that an excess of collector causes over-forthing and markedly decreases recovery. This cause is attributed to the formation of multi-films[12] on the coated particles. The oriented films present their polar ends towards water and repel bubble attachment. The formation of lead xanthate and its solubility in the strong solution of the corresponding alkali xanthate adversely affects the bubble attachment which also decreases with increasing concentration of alkali.

Pilot Plant Study.—A pilot plant experiment was carried out with a batch of 20 kg using the reagents in the same ratio as in the laboratory experiments. The analysis of the float with a recovery of 89% is as follows : PbS 76.7%, $SiO_2$20.6%, Fe_2O_3 0.1%, Al_2O_3 1.6%, CaO 0.8%.

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