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Receding the entrainment of concomitant ultrafines by MGS in lead concentrate of Rajpura – Dariba Concentrator

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ABSTRACT

Due to the fine dissemination and complex mineralogy the Rajpura–Dariba (RD) lead zinc ore poses special problems in concentration by conventional froth flotation. In order to achieve the desired metallurgical results 'Multi Gravity Separator, a twin drum system, has recently been installed in the lead circuit of RD concentrator. Open and closed trial tests were conducted, without sacrificing the economic metal with substantial abatement of ultrafine and fine siliceous and graphite matter in lead concentrate. The metallurgical alludes achieved are (i) over 85% –400 mesh fines are separated in the form of MGS tails whereas 53% –400 mesh are obtained in MGS concentrate from the feed (lead rougher concentrate) 77% –400 mesh with 52% Pb, 1% Gr. C and 2.5% ISM in respective Wt. % distribution i.e., 47.3 and 3, (ii) tails are characterised by >93% ultrafine of <20 microns particles encompass 21% Pb, 8% Gr. C and 39% ISM with respective Wt. % distribution i.e., 32, 93, 83% in –400 mesh fraction, resulting in effective rejection of Gr. C and ISM, (iii) conventional lead concentrate consists of 28% +400 mesh material only with all the assorted fines and ultrafines. Mineralogically, it is established that composite bigger particles of sulphide gangue and graphite are the main contributor for silica and graphite in MGS concentrate. Over 39% by vol. fines are alienated as MGS tails, in the form of free sulphide, gangue and graphite minerals. Installation of MGS in lead circuit, confirms the significant reduction of Gr. C and ISM in particular to high GMS feed mix in lead concentrate in comparison to lead concentrate by conventional route.

INTRODUCTION

Rajpura Dariba ore is essentially hosted by bi-lithounits viz., Calc-Silicate and Graphite Mica Schist (CS:GMS) in assorted mix. Profusion of flaky acicular gangue and graphite of assorted sizes in high GMS feed, attenuate liberation of galena due to inherently intricated textural complexities. Impeccable liberation of galena is directly proportionate to function of fineness i.e., (MOG), which de facto generates colossal fines/ultrafines in COF, of phlegmatic nature. Such inevitable otiose fines, of lower specific gravity viz., graphite and micaceous gangue froths out in final concentrate during conventional flotation as deleterious matter for smelters.

The Rajpura-Dariba ore is characterized by plethora of gangue mineral vis., quartz, dolomite, calcite, diopside, augite, tremolite, actinolite, kyanite, muscovite, sericite, biotite, phlogopite, staurolite, graphite/carbonaceous matter, cherty silica, gypsum, rutile, talcose matter and chlorite along with ore minerals viz., sphalerite, galena, chalcopyrite, pyrite, pyrrhotite, fahlore, and sulfosalts in various proportion.

To achieve the desired metallurgical grades of lead concentrate suitable for smelter, a new device i.e. Multi Gravity Separator, (MGS) twin drum system has first time been installed in Hindustan Zinc Limited at RD Concentrator in lead circuit. Normally, this equipment is extensively being used for separation of heavy minerals of low metal values e.g., zircon, cassiterite, gold in zinc concentrate, barytes etc.

EXPERIMENTAL

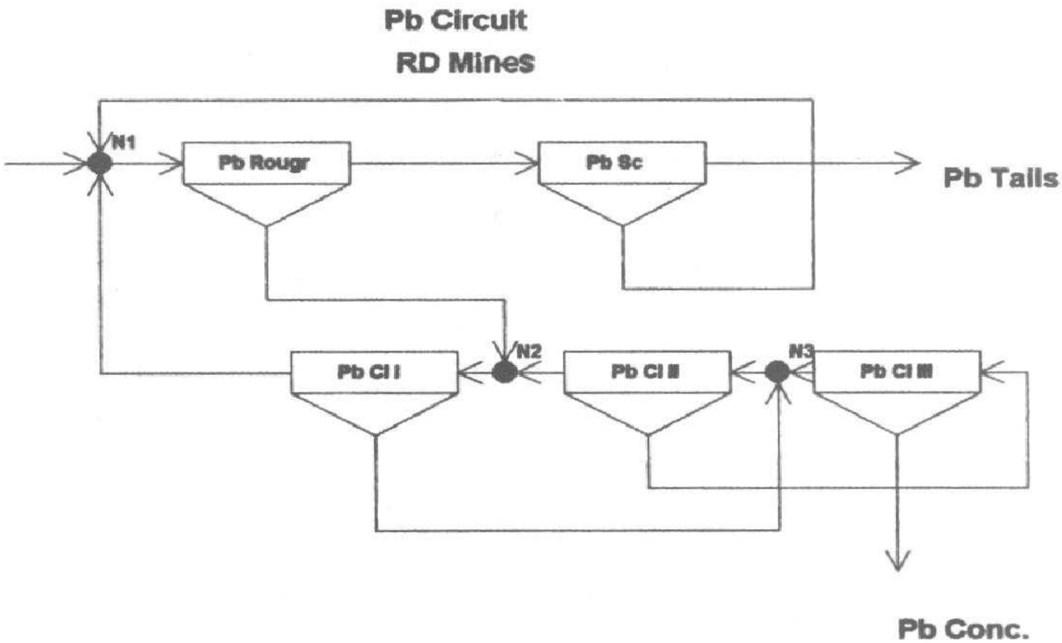
In view to obtain desired metallurgical out put, the grinding was restricted to 65%–200 mesh. for both the test trials and routine conventional production of lead concentrate as shown in Flow sheet 1. MGS was operated in both closed and open circuit as shown in flowsheets 2 and 3. Two different ore ratios were selected i.e. 80 : 20 and 58 : 42, CS : GMS mixes. During the treatment of later ore mixes the following operating parameters were fixed in open trial tests for MGS.

Pb Rougher Concentrate as feed for MGS :-

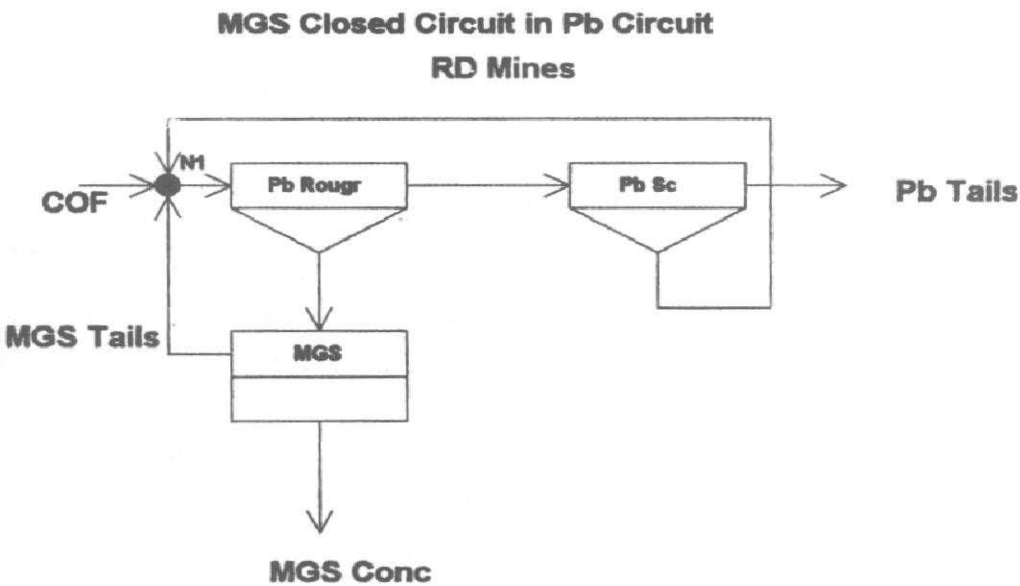
Pulp Density	:	1.2 – 1.25
Thru' put	:	1.5 – 2 tph
Wash Water	:	30 lpm
Inclination	:	10°
Drum speed	:	121 rpm
Shaking speed	:	245 rpm
Shake amplitude	:	15 mm

Similar conditions were continued for Low GMS feed in closed circuit test as shown in Flow sheet 2.

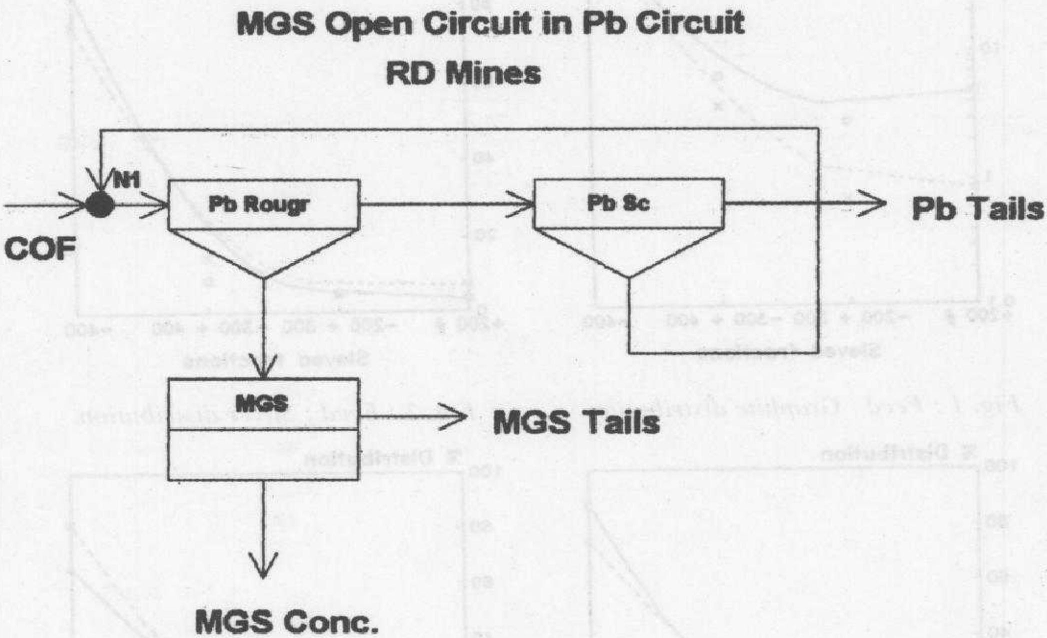
FLOW SHEET - 1



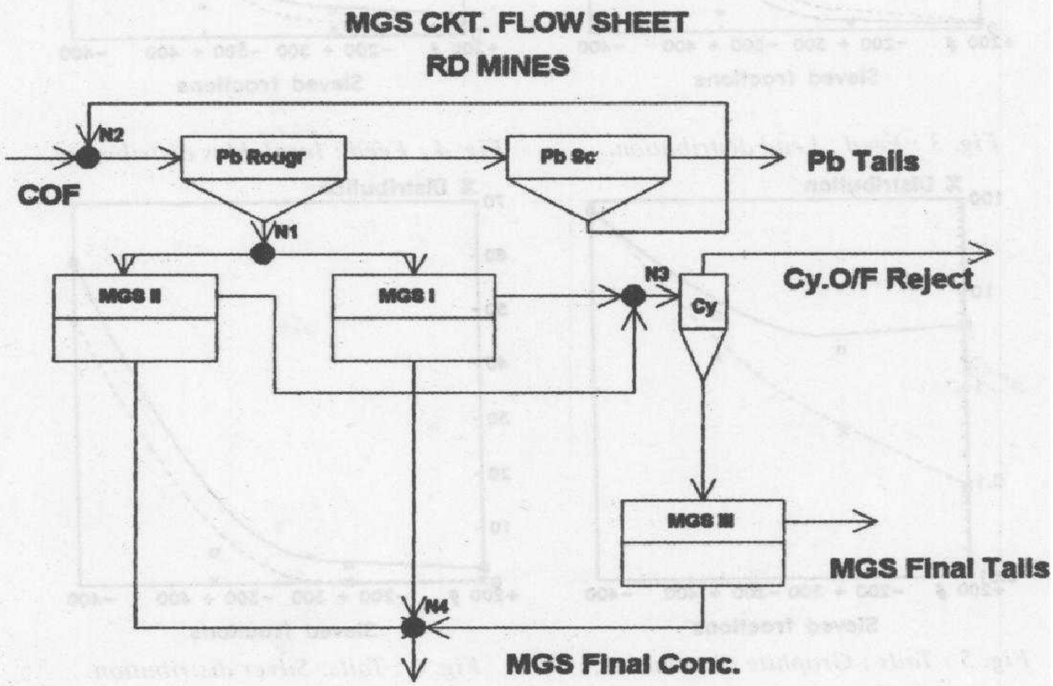
FLOW SHEET - 2



FLOW SHEET - 3



FLOW SHEET - 4



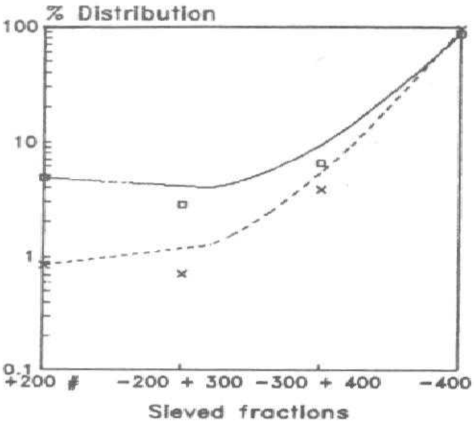


Fig. 1 : Feed : Graphite distribution.

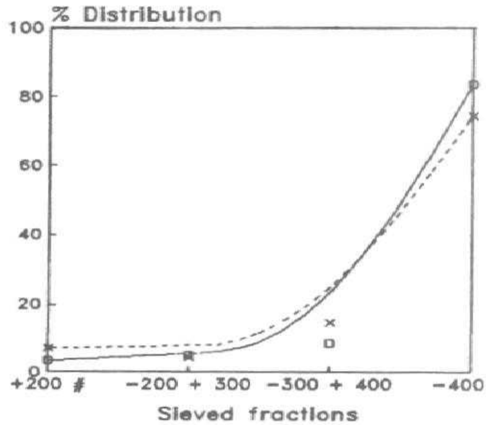


Fig. 2 : Feed : Silver distribution.

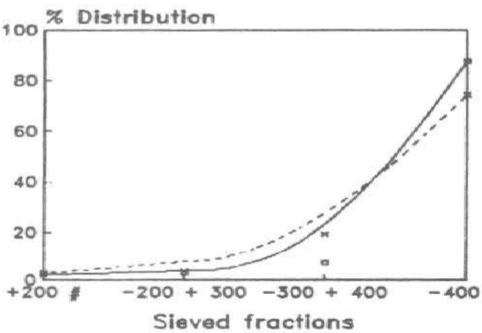


Fig. 3 : Feed : Lead distribution.

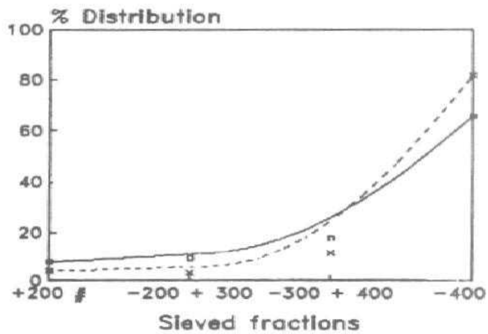


Fig. 4 : Feed : Insolubles distribution.

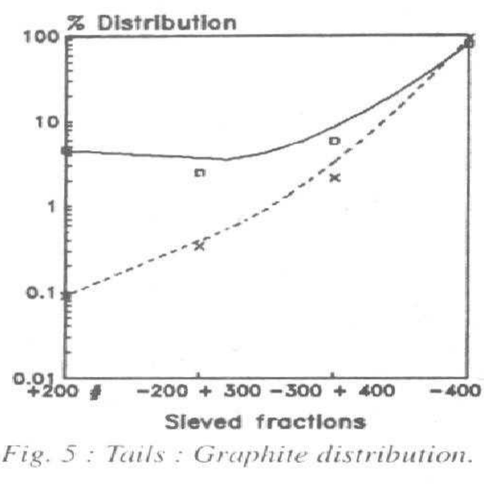


Fig. 5 : Tails : Graphite distribution.

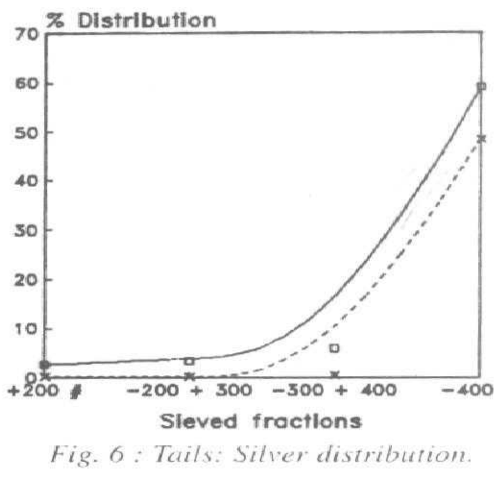


Fig. 6 : Tails: Silver distribution.

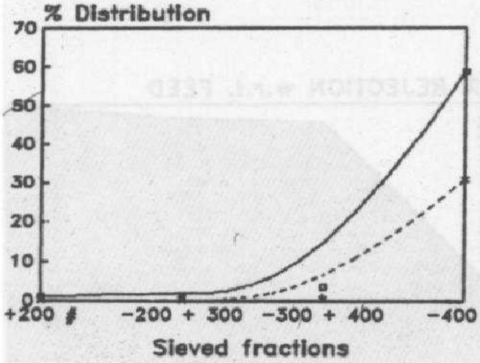


Fig. 7 : Tails : Lead distribution.

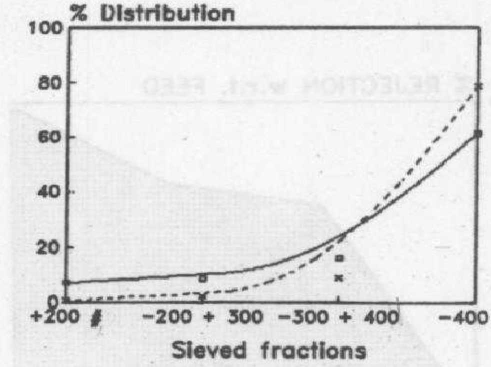


Fig. 8 : Tails : Insolubles distribution.

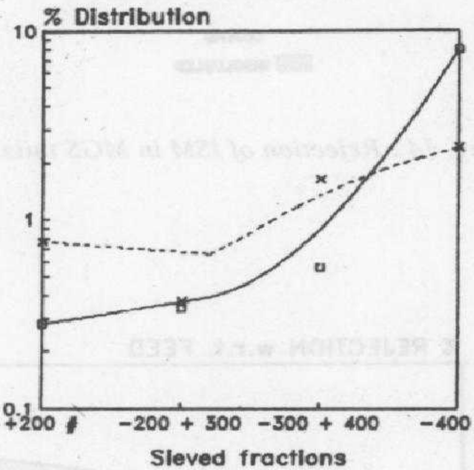


Fig. 9 : Conc.: Graphite distribution.

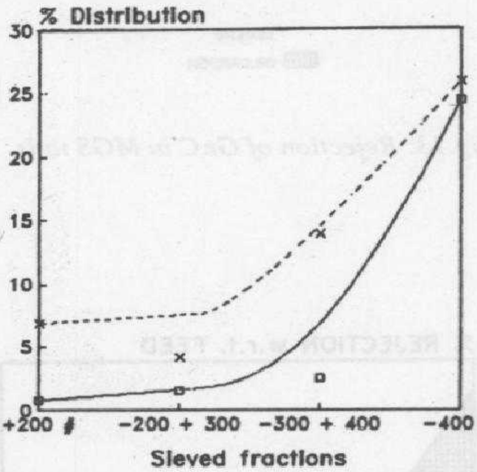


Fig. 10 : Conc. : Silver distribution.

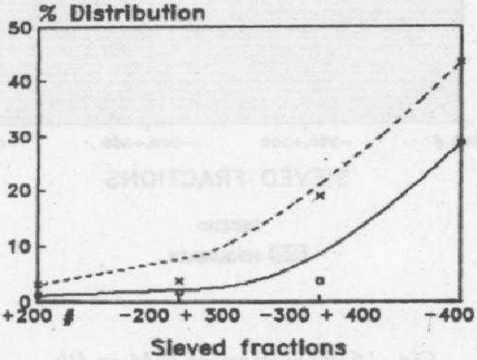


Fig.11 : Conc. : Lead distribution.

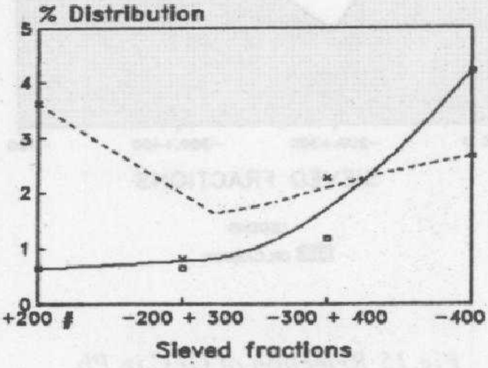


Fig. 12 : Conc.: Insolubles distribution.

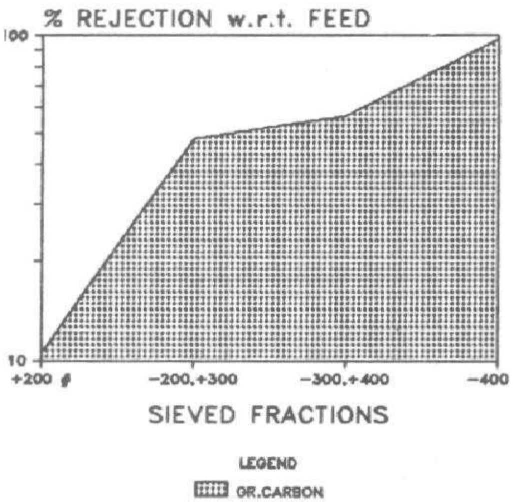


Fig. 13: Rejection of Gr.C in MGS tails.

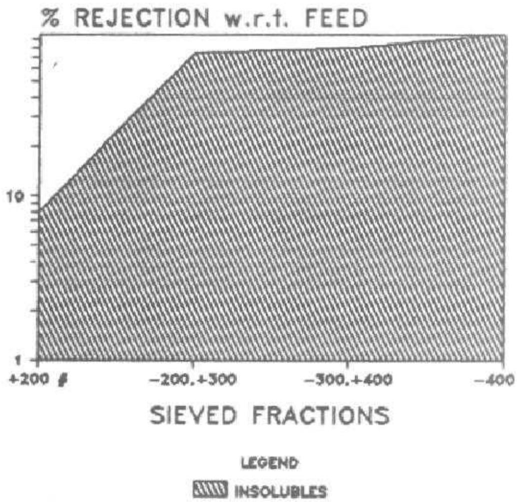


Fig. 14 : Rejection of ISM in MGS tails.

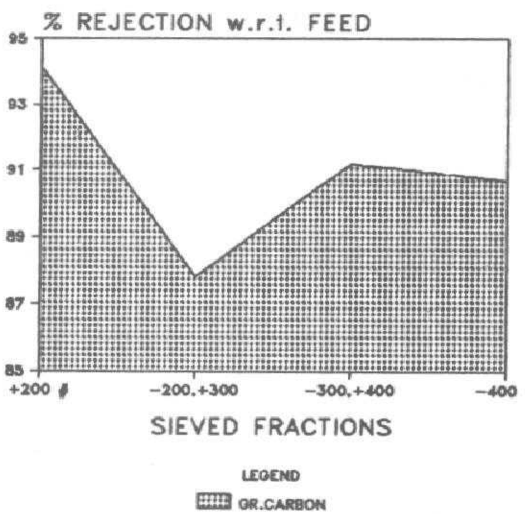


Fig. 15: Rejection of Gr.C in Pb cleaner tails.

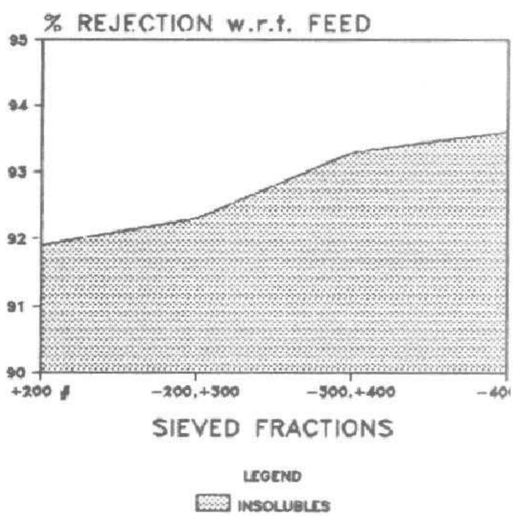


Fig. 16: Rejection of ISM in Pb cleaner tails.

The routine conventional Pb circuit as shown in Flow sheet 1 is presently existed with following operating parameters.

Pb Rougher Concentrate :-

Pulp Density	:	1.3 – 1.4
Thru' put	:	4 to 5 tph
. Residence time for 3 stages cleaning	:	15 minutes

The flow sheet 4 has been considered to substantiate the ultrafines and fine particles of Gr. Carbon and ISM rich minerals, by installation of an additional 2" Hydrocyclone assembly to retreat the MGS tails of open circuit and to recover the Pb and Ag bearing minerals those accelerate out as MGS tails causing losses of economic metals, under prevailing conditions of open circuits.

RESULTS AND DISCUSSION

Based on observation and experimental studies conducted at different ore mixes, various binary diagrams are plotted to understand the difference and the performances in two different routes. Figs. 1 to 4 shows the characterization of Gr. C, ISM, Pb and Ag in lead rougher concentrate with comparison between conventional and MGS routes.

Figs. 5 to 8 characterize the abundances of op. cit. components in lead cleaner and MGS tails. Figs. 9 to 12 depicts the profusion, quality and grain size distribution in terms of Gr.C, ISM, Pb and Ag in +200, –200+300, –300+400 and –400mesh sieved fractions. Figs. 13 and 14 delineated the % rejection of Gr.C and ISM in different sieved fractions with respect to lead rougher concentrate (feed) for lead conventional flotation, while Figs. 15 and 16 confirm the rejection of ultra fines of deleterious nature in MGS tails. The results obtained during test trials in both conventional and MGS routes are summarized in Table 1.

The comparative metallurgical assessment of various components in concentrate produced during test with or without MGS for different ore mixes are given in Table 2.

The sub-sieve size analysis confirms that MGS tails are comprised of ultrafine (<12 μm) of Gr. C particles up to an extent of 76%. The relative rejection in Lead Cleaner Tails and MGS Tails with respect to lead Rougher Conc. by % in –400 mesh are given in Table 3.

Table 1 : Comparative percentage distribution of various constituents

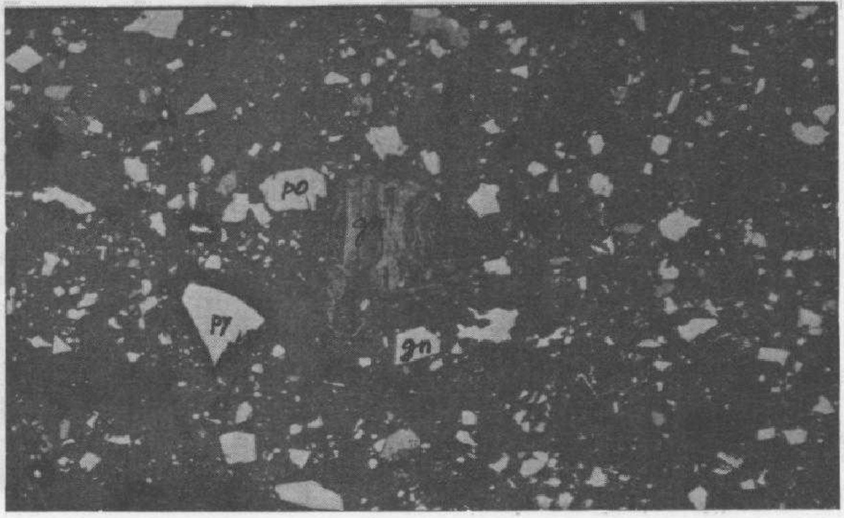
Constituents	Sieved Fraction	Conventional Route Products			MGS Route Products		
		PbR	PbClT	Pb Con.	Feed	Tails	Conc.
Gr C	+200	4.78	4.50	0.28	0.85	0.09	0.76
	–200+300	2.78	2.44	0.34	0.71	0.34	0.37
	–300+400	6.38	5.82	0.56	3.76	2.13	1.63
	–400	86.07	78.10	7.97	94.67	92.25	2.42
Ag	+200	3.29	2.56	0.73	6.95	0.10	6.85
	–200+300	4.86	3.33	1.53	4.25	0.13	4.12
	–300+400	8.42	5.95	2.47	14.48	0.57	13.91
	–400	83.43	59.04	24.39	74.32	48.46	25.86
Pb	+200	2.16	1.01	1.16	3.04	0.05	2.99
	–200+300	3.09	1.44	1.65	367	0.05	3.62
	–300+400	7.25	362	3.63	19.09	0.19	18.90
	–400	87.49	58.78	28.71	74.19	30.85	43.34
ISM	+200	7.62	7.0	0.62	3.93	0.31	3.62
	–200+300	9.40	8.68	0.72	3.16	2.36	0.80
	–300+400	17.33	16.17	1.17	11.52	9.26	2.26
	–400	65.65	61.43	4.22	81.39	78.73	2.66

Table 2 : Comparative metallurgical assessment of the concentrate

Ore Mix	Concentrates	Pb	Gr. C	ISM	Rec Pb	Rec Ag
80:20	Pb Conc.(Conventional)	46-52	2-6	14-25	70	55
	Pb Conc. (MGS)	45-50	1-3	10-15	68	50
58:42	Pb Conc.(Conventional)	40	10-15	15-25	60	55
	Pb Conc. (MGS)	45-48	2-3	12-15	52	40

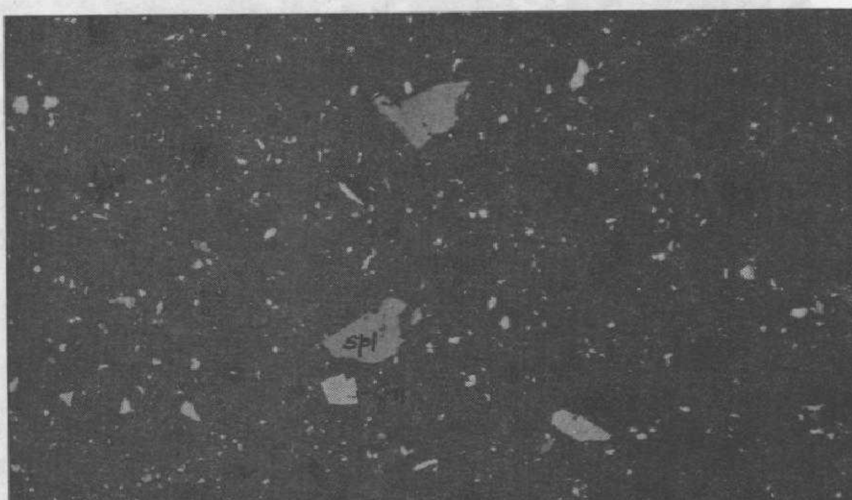
Table 3 : The relative rejection in tailings

Size Fraction (mesh)	Lead Cl. Tails		MGS Tails	
	Gr. C	ISM	Gr. C	ISM
+ 200	94.1	91.9	10.5	7.9
– 200 + 300	87.8	92.3	47.9	74.7
– 300 + 400	91.2	93.3	56.6	80.3
– 400	90.7	93.6	97.4	96.7



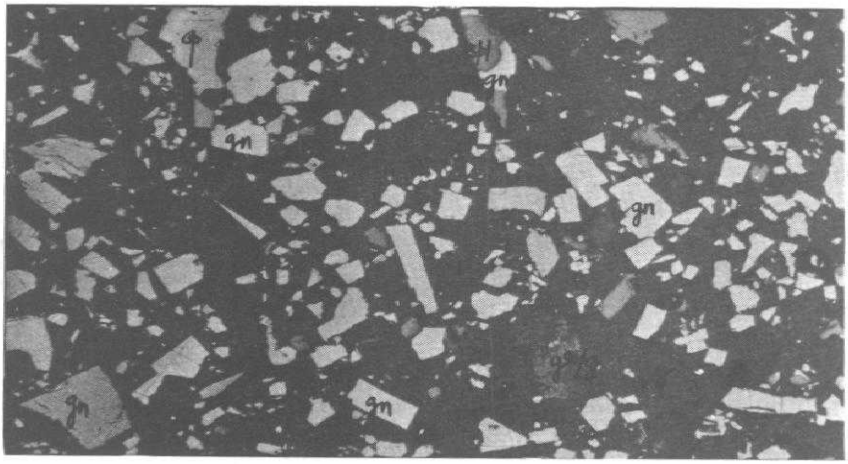
100 µ

Photomicrograph 1 : (MGS FEED) Liberated, euhedral, crystalline galena (gn) of assorted sizes with presences of liberated pyrite (py), pyrrhotite (po), Graphite (gr), gangue (g) and sphalerite (sp) exists in this product. Intermittent and concomitant fines of these grain are also clearly noticed.



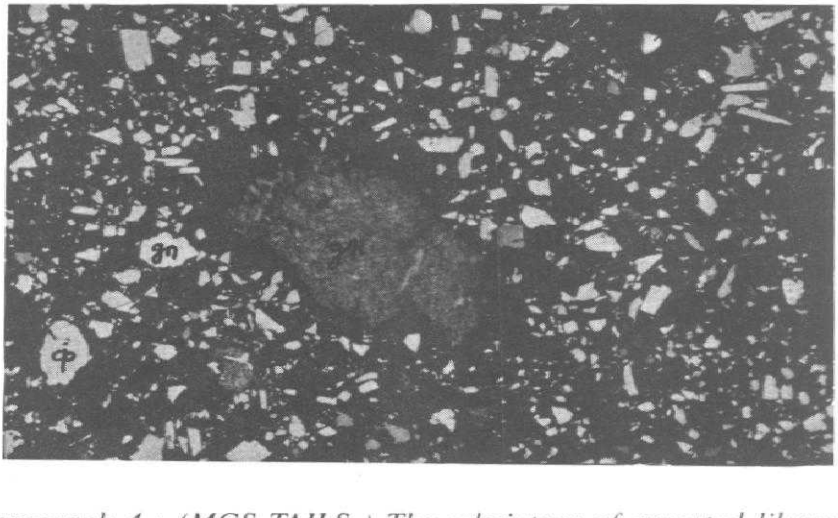
100 µ

Photomicrograph 2 : (MGS TAILS) Rejected fines and ultra fined grains of gangue, graphite and few economic minerals are the main constituents of MGS tails.



100 μ

Photomicrograph 3 : (MGS CONC) Medium to coarse grains of galena, perfectly crystalline euhedral in shape are the main constituents of MGS conc. Few liberated grains of sphalerite, pyrite, fahlore, chalcopyrite as liberated while spl/gn, gn/cp are visible. Reduction of fines are remarkably controlled during concentration by MGS. the presence of gr and g grains of big sizes are the main cause for enhancing the deleterious content.



100 μ

Photomicrograph 4 : (MGS TAILS) The admixture of assorted liberated and locked grains of economic and gangue minerals are the main constituents in conventional lead concentrate. At times bigger grains of graphite also float out with the lead grains.

MINERALOGICAL EVALUATION

MGS Feed (Lead Rougher Concentrate)

Different quality of MGS feed were treated for establishing the experimental studies. Galena in MGS feed ranges between 23 to 56% by volume as liberated grains in assorted sizes of euhedral, crystalline in shapes. Average grains fall in size range of 37-74 μm while fines comprised of 10-37 μm ranges between 45% by volume. Similarly gangue and graphite as fine also contribute volume up to an extent of 20 to 40% as liberated grains. Multiple locking among gangue and economic minerals and gangue and graphite also prevails in a significant amount.

MGS Tails

Over 93% by volume the grains are in liberated form. Tails are commonly characterized by the profusion fines and ultrafines. Liberated galena varies from 25-25% volume and varies between high GMS feed and low GMS feed. Over 45% by volume tails are characterized by ultrafine of economic minerals and rest are comprised of gangue and graphitic mass. Tails are predominantly comprised of <20μm particles consists of 21% Pb, 8% Gr.C and 39% ISM.

MGS Concentrate

Liberated galena is characterized between 40 to 60% by volume as medium to coarse grained. Most of galena ranges between 20 to 74 μm in size ranges. It has been also noticed that the bigger grains with composite in nature, entrained in MGS concentrate owing to higher specific gravity. The entrainment of gangue particles is also one of the major cause for enhancing the silica, insoluble and Gr.C in concentrate.

Lead Concentrate (Conventional)

It encompasses the assorted mix of grains in assorted sizes, causing deterioration in concentrate quality. Only 28% grains confined to +400 fractions of the concentrate.

These mineralogical observations are evidenced in various photomicrographic plates. Photomicrographs are snapped under plane polarized, incident beam of light. Magnifications for all the snaps is 20 x 5X, Scale 12 mm = 100 μm.

CONCLUSIONS

1. An overall rejection of ultra fined Gr.C by MGS has been achieved up to an extent of 40 to 45% in comparison to conventional process.

2. Substantially low recoveries have been noticed during high GMS ore treatment in open circuit. Further R&D work is in progress by incorporating 2" hydrocyclone assembly along with additional Multi Gravity separator to reduce the increased number of ultrafines of economic values in MGS tails as per flow sheet 4.

3. Enhancement of lead grades are achieved by 10% during treatment of high GMS feed to MGS.

4. Particles in the form of composite grains of >74 μm are currently entrained in MGS conc. causing enhancement of Gr.C and ISM owing to higher specific gravity.

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