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Advanced Gravity Separation
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IMPROVED GRAVITY SEPARATION : TYPICAL CASE STUDIES IN RELATION TO SLIMES

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The present paper describes typical case studies of improved gravity separation of slimes in relation to (a) the separation of synthetic mixture of blue dust and kynite (concentration criterion 2) in advanced gravity separation equipment, and (b) preparation of bauxite feed following stage-grinding and size classification for enhanced separation following WHIMS.

A sort of size classification has been achieved over the deck of belt concentrator which necessitates need to treat the slimes in a narrow size range, especially when the concentration criterion is less. A significant better yield and better grade of the products has been observed while following an improved method of feed preparation (stage grinding and size classification) vis-à-vis those following conventional one (grinding and de-sliming) for their separation.

Keywords : *Gravity separation, Slimes, Bautixe, Bartles Mozley Separator, Cross belt concentrator.*

INTRODUCTION

While treating finely disseminated lean grade or complex ores through wet processing the generation of slimes and tailings is substantial and if not recovered, causes a heavy material loss besides, loss of process water. This necessitates treatment of these products through the process routes incorporating advanced gravity separation.

Bartles Mozley Separator and Cross Belt Concentrator

Some gravity separators such as Bartles Mozley Separator (BMS) as a rougher devise in tandem with Bartles cross belt concentrator (CBC) as a cleaner have made a major advance in slime gravity concentration. These equipment are ideally suited for treating lean grade ores constituting of minerals with high concentration criterion, such as, lean grade tungsten ores constituting of wolfamite mineral and quartz. These equipment have also application in the sub-sieve range of the minerals like, tin, gold, silver, platinum etc. Keeping the versatile utility in view, these have been added to the NML' facilities as regards to gravity separation.

The Fig. 1 shows the BMS consisting of four decks under tilt position (washing cycle) when heavies are collected and the Fig. 2 shows the separation of minerals over the deck of CBC[1].

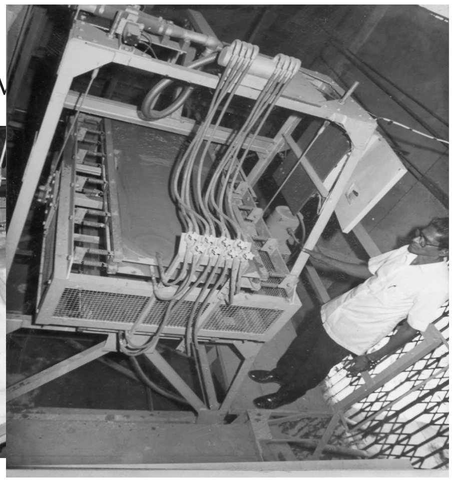

Fig. 1 : Bouttes M

Fig. 2 : Separation of minerals over duel cross belt concentrator.

Orbital motion is imparted to the whole assembly driven an out of balance weight which is powered by an electric motor. Slurry is distributed to each of the four decks by a system of feed pipes. The heavy minerals settle on the decks during the

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orbital motion while tailings being continuously discharged into a launder. The heavy mineral is periodically removed from the decks by an automatic pneumatically operated lifting device in tilt position when wash water is introduced in place of slurry. After washing the deck the assembly is returned to the normal operating position and slurry is re-introduced. The BMS, used in the present study, consists of a 2.4 m wide endless variable speed synthetic polymer belt, the surface of which is inclined transversely from a central longitudinal ridge to both sides of the belt. The belt assembly is hung from a free standing main frame by four suspension wire. Like, BMS a variable orbital shear motion is imparted to the belt by rotating a out of balance weight.

RESULTS AND DISCUSSION

The efficacy of BMS and CBC was established by carrying out separation of a synthetic mix at 10 % pulp density consisting of 15% blue dust and remaining kyanite ground to -106 micron size. The concentration criterion in this case was 2 [(5.1-1.08)/(3.1-1.08)]. The concentrate from the BMS was re-pulped to 10% solid in a conditioner and pumped to the feed end of the CBC. The concentrate and tailings produced from the CBC were separately collected. Table shows the results in terms of mass balance, Fe_2O_3 in the products and size analysis.

Table 1 : Results on separation a synthetic mixture of blue dust and Kynite

Feed/ Product/ Process	Solid flow rate	Fe_2O_3 flow rate	% Fe_2O_3	Mean diam.
Feed to the BMS	100 kg/h	12.62 kg/h	12.62	
Tailings from the BMS	42 kg/h	2.40 kg/h	5.71	
Concentrate from the BMS	58 kg/h	10.22 kg/h	17.62	
(Feed to the CBC)	58 kg/h	10.22 kg/h	17.62	27.1 m
Tailings from the CBC	40.2 kg/h	4.97 kg/h	12.38	13.9 m
Concentrate from the CBC	17.8 kg/h	5.25 kg/h	29.51	50.6 m

It is evident from the Table 1 that separation on the deck of the CBC has not only upgraded the Fe_2O_3 content the heavies, but a sort of size classification was also achieved in their sub-sieve range, possibly due to the difference in terminal velocities of the smaller and larger particles vis-à-vis those of heavy (hematite) and lighter (kyanite) minerals under hindered settling condition. The observation indicated that the need to treat the slimes in a narrow size to affect better separation in terms of grade even though these equipment are meant for the size range in between 150 and 5 micron. This is important when the minerals with high specific gravity are brittle and therefore selectively and preferentially ground to a much finer size. Tungsten bearing mineral could be one of the possible examples[2].

Size Classification before Separation

Preparation of the feed sample before separation plays a crucial role in the overall process of beneficiation. A case study in relation to the beneficiation of the bauxite sample from Maharashtra State, India is presented here[3]. The objective was to remove Fe_2O_3 and TiO_2 from the sample following gravity and magnetic separation techniques so that the product meets the refractory specification.

The material was stage- crushed to 100% -2 mm size fraction. Table 2 shows the size distribution and chemical analysis of the (crushed) sample. It is apparent from the table 2 that grater quantities of impurities reported to the finer fractions, which indicates that the gangue minerals are finely disseminated. The sample was predominantly gibbisitic in nature with titanium and iron bearing minerals (hematite, goethite, magnetite, rutile and anatase) as major impurities[4].

Table 2 : Sieve size distribution and chemical analysis of -2 mm crushed bauxite sample

Size fraction, mm	Wt., %	Al_2O_3 , %	Fe_2O_3 ,%	TiO_2, %
-2000 + 650	34.0	59.55	3.10	4.14
-650 + 320	15.2	58.81	3.34	3.97
-320 + 150	14.5	58.76	3.47	4.28
-150	36.3	54.26	4.78	8.42
Total	100.0	57.40	3.80	5.69

De-slimed Feed (Process `A')

One kg of -2 mm crushed bauxite sample was wet ground in a rod mill to 87 wt.% passing a 150 m screen aperture. The ground sample was de-slimed to separate sand and slime. Both sand and slime fractions were separately subjected to the wet high intensity magnetic separation (WHIMS) at 1.25 T. Table 3 shows the results of separation.

Table 3 : Results of WHIMS (1.25 T) of crushed and de-slimed bauxite feed

Product	Wt. , %	Al_2O_3, %	Fe_2O_3 , %	TiO_2, %
Magnetic fraction of sand	15.3	54.07	7.17	7.49
Non-magnetic fraction of sand	27.5	62.26	1.91	1.43
Sand total	42.8	59.33	3.79	3.60
Magnetic fraction of slime	11.2	46.76	13.65	9.05
Non-magnetic fraction of slime	46.0	57.07	3.50	5.41
Slime total	57.2	55.05	5.49	6.12
Magnetic total	26.5	50.98	9.91	8.15
Non-magnetic total	73.5	59.01	2.90	3.92
Feed	100	56.88	4.76	5.05

Stage Ground and Size Classified (Process `B')

One kg of -2 mm crushed bauxite sample was scrubbed and de-slimed. The sand fraction was wet ground in a rod-mill for six minutes. The ground sample, which had the size distribution 6.0% +212 m, 35.5%-212+150 m and 58.5% -150m, was separated into coarse and fine fractions and treated separately following wet high intensity magnetic separation (WHIMS) at 1.25 T. Table 4 shows the results of separation.

Table 5 compares the chemical assays of the products following the two processes of feed preparation as mentioned above (Tables 3 and 4). The assays of the magnetic & non-magnetic products of the de-slimed feed have been normalized keeping the assay of the stage ground and size classified feed (Al_2O_3, % = 57.98, Fe_2O_3, % = 3.81, TiO_2,%= 5.34) in view.

Table 4 : Results of WHIMS (1.25 T) of stage ground & size-classified bauxite feed

Product	Wt., %	Al_2O_3, %	Fe_2O_3, %	TiO_2, %
Magnetic fraction of coarse	7.3	51.16	9.97	10.28
Non-magnetic fraction of coarse	36.7	63.67	1.25	1.26
Coarse total	44.0	61.59	2.70	2.76
Magnetic fraction of fine	5.6	52.80	8.40	7.46
Non-magnetic fraction of fine	16.4	60.42	3.20	3.17
Fine total	22.0	58.48	4.52	4.26
Magnetic fraction of slime	4.5	39.33	12.44	18.83
Non-magnetic fraction of slime	29.5	55.05	3.65	7.96
Slime total	34.0	52.97	4.81	9.40
Magnetic total	17.4	48.63	10.10	11.58
Non-magnetic total	82.6	59.95	2.49	4.03
Feed	100	57.98	3.81	5.34

Table 5 : Results of the magnetic separation of the bauxite samples following two different routes of feed preparation (de-sliming and stage grinding & size classification)

Product (process)	Wt.,%	Al_2O_3,%	Fe_2O_3, %	TiO_2,%
Non-mag (de-slimed feed)	73.5	60.15	2.32	4.15
Non-mag (Stage ground & size classified)	82.6	59.95	2.49	4.03
Mag (de-slimed feed)	26.5	51.97	7.93	8.61
Mag (stage ground & size classified)	17.4	48.63	10.10	11.58

It is interesting to note that 9.1% (in absolute term) material recovery of the non-magnetic fraction has been accomplished (82.6% vis-à-vis 73.5%) when the feed (for the magnetic separation) has been prepared following the Process `B' as mentioned above compared to that following the Process `A', while the quality (chemical analysis) of the products remains approximately the same. It is also apparent from Table 5 the quantity of reject, that is, the magnetic fraction (17.4 wt. %) when the stage grinding and size classification was followed (Process `B') was lesser than that (26.5 wt. %) in when the sample was de-slimed and treated (Process `A'). Besides, quality of the reject was also poorer (alumina content was less; Fe_2O_3 and TiO_2 were higher) in case when the Process

`B' for the feed preparation was followed compared to those in case of Process `A'.

The gangue minerals (Fe_2O_3 and TiO_2) in bauxite ore sample had been finely disseminated; more of which reported to the finer fraction on grinding (Table 2). Excessive grinding (of the whole sample) when the Process `A' was followed resulted in the significantly higher generation of slimes (57.2 weight %) which had difficult separation characteristics because of its unfavourable granulometry: the feed to the magnetic separator was extremely fine which did affect the separation. The slime generated in case of Process `B' was only 34% of the total feed and when treated separately resulted in more cleanliness of the products (magnetic and non- magnetic fractions) as shown in Table 4. This is expected since the finer faction was not mixed with the slime.

The above explanation could be substantiated from the results of gravity separation of the bauxite sample. Table 6 shows results of tabling of the feed at two different mesh of grind.

Table 6 : Results of Tabling of the bauxite ores at -35 mesh and -65 mesh of grind

Product	Feed size : -35 mesh of grind				Feed size : -65 mesh of grind			
	Wt. %	Al_2O_3,%	Fe_2O_3, %	TiO_2,%	Wt. %	Al_2O_3,%	Fe_2O_3, %	TiO_2,%
Heavy	18.10	57.53	4.54	5.58	4.00	49.49	11.94	7.92
Middling	26.90	60.69	2.27	3.03	22.50	61.55	2.34	3.17
Light	55.00	56.82	4.31	6.35	73.50	57.30	2.84	5.85
Head	100.0	57.95	3.81	5.32	100.0	57.95	3.81	5.32

It is apparent from the Table that more of light fraction (and less of heavy fraction) were generated with decrease in feed size from -35 mesh of grind to -65 mesh of grind. Besides, alumina constituent was enriched while Fe_2O_3 and TiO_2 were reduced only in the middling fraction of the feed. That is, better separation was achieved only in the middling portion of the sample. When the feed size was coarser (-35 mesh of grind) the generation of middling fraction was higher (26.90 wt. %) compared to that (22.50 wt. %) when the feed size was lesser (-65 mesh of grind)[3].

A separate investigation on the gravity separation of bauxite sample Panchpatmali mines of M/s NALCO, Bhubaneswar has shown the effect of feed preparation on the beneficiation efficiency in relation to Tabling. Grinding of the sample was carried out in stages with de-sliming at every stage.

The sample was ground to -10 mesh (-0.2 mm) size and scrubbed for 2 minutes to remove slimes (a). De-slimed product was ground for 4 minutes to 75% passing through -48 mesh (-0.295 mm) size. The ground sample was again de-slimed to remove slimes (b). The slimes thus generated were mixed together, as slimes (a+b). The two products namely, sand and slimes were separately treated in a concentrating tables fitted with sand and slimes decks respectively. Results of the Tabling are shown in Table 7[5].

Table 7 : Results of tabling tests of Panchpatmali bauxite ore (sand and slime fractions)

Feed	Product	Wt. %	Al_2O_3,%	Fe_2O_3, %	TiO_2,%	SiO_2, %
Sand	Head	45.96	39.19	31.85	3.61	1.28
	Heavy	11.96	23.53	50.31	7.05	1.41
	Middling	5.00	37.13	34.29	4.06	1.29
	Light	29.00	46.00	23.81	2.11	1.22
Slime	Head	54.04	37.48	28.86	2.27	2.29
	Heavy	1.24	32.50	38.03	4.85	1.87
	Middling	0.91	34.60	36.71	3.55	1.91
	Light	51.89	37.65	28.50	2.19	2.31
Feed		100.00	38.26	30.23	2.88	1.82

It is apparent from Table 6 that the sand fraction of the bauxite sample had undergone a substantial enrichment following gravity separation. The content of alumina increased from 39.2 wt. % in the feed to 46.0 wt. % in the light fraction. The content of Fe_2O_3 and TiO_2 decreased from 31.85 wt. % and 3.6 wt. % in the feed to 23.8 wt. % 2.3 wt. % respectively in the concentrate. Table 6 further shows that the process of Tabling was not effective in case of slimes as the quantity of generated middling and heavy products was meager. The poor separation efficiency in case of slimes may be attributed to the hetero-coagulation of the particles and possibly, the application of dispersant in order to maintain the stability of the dispersed suspension phase and reduce hetero-coagulation may be helpful. Besides, the of treating the slime fraction in advanced gravity separation units such as, Bartles- Mozley separator and cross belt concentrator could be looked into.

CONCLUSION

(a) A sort of size classification of the materials is observed over the deck of cross belt concentrator while treating slimes with low concentration criterion (around 2). This suggests that it is necessary to size classify the feed material for treating these over the deck. In case of placer deposits, such as tin gold etc. with high concentration criterion this may not be required.

(b) The preparation of feed is crucial in affecting the separation of minerals from ores/ slime. A typical case study of the beneficiation of bauxite ore for the removal of iron and titanium bearing minerals has been presented. A significantly higher recovery of the valuable material has been observed when the feed to the wet high intensity magnetic separator was prepared following grinding the bauxite ore in stages and size classification compared to that when the whole bauxite ore was ground and de-slimed.

(c) Alumina content is enriched while Fe_2O_3 and TiO_2 are reduced only in the middling fraction of the bauxite feed during the Tabling of the sample with feed size -35 mesh and -65 mesh. Besides, more of light fraction is generated with decrease in feed size from -35 mesh of grind to -65 mesh of grind.

(d) The efficacy of separation during the Tabling of the sand portion of bauxite ore is higher than that in case of slime fraction. The content of alumina increased by around 7 wt. % (in absolute term) in the light fraction of Tabling

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the sand. The slime portion of the bauxite sample responds very poorly during the process of Tabling as the quantity of middling and heavy products generated was meager.

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