PROCEEDINGS: PROF–97
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Beneficiation studies on Bolani iron ore

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ABSTRACT

The iron ore washing plants generate slime on an average of 10 - 20% by weight of the ore and is wasted. Apart from loss of resource, these slimes pose problem of disposal and consequent damage to environment. To reduce problems of slime, it should be treated, as a part of beneficiation, to minimise waste generation. Out of five number of different varieties of Bolani iron ore bulk samples, two bulk composite samples were prepared in the proportions as decided by the sponsor. The first sample was found to be of very good quality assaying 66.69% Fe, 1.27% SiO_2 and 1.8% Al_2O_3 and only crushing and sizing (dry) were done for physical characterisation. The second sample (assaying 63.68% Fe, 2.05% SiO_2 and 2.6% Al_2O_3) was beneficiated to produce washed lump weighing 49.9% and with assay of 65.0% Fe, 1.8% SiO_2 and 2.1% Al_2O_3. Combined fines weighed 42.7% assaying 63.95% Fe, 1.81% SiO2 and 2.54% Al_2O_3 leaving slime reject 7.4% by weight and assaying 51.27 % Fe, 5.6 % SiO_2 and 8.82% Al_2O_3 which not only reduced waste generation but improved recovery also.

INTRODUCTION

There is constant need for updating the performance of the working iron ore washing and preparation plants based on the changed ore characteristics and stringent specifications being imposed on raw materials in order to meet the quality and increase in efficiency in iron making. The quality of blast furnace raw materials influences the size of the processing plant and the capital investment as well as operating cost. Alumina content of iron ore is one such important factor that controls the blast furnace performance. In fact, on crushing and sizing the ROM ores, the high alumina bearing laterite and friable ores have greater propensity to break down into fine sizes as compared to hard ores. This leads to concentration of alumina in ore fines, the slime being richer in alumina and alumina content may vary from 4 - 8% in fines and slimes. The high alumina in iron ore fines lead to high value of 21 - 26% in slag. In addition to high alumina in ore / sinter coupled with high alumina of coke ash increases the slag viscosity, reduces drainage rate, impairs upward flow of reducing gas and decreases reduction kinetics of iron oxide. Therefore, it has become apparent that complete characterization and amenability to beneficiation of the iron ore sample should be studied to develop the process for upgradation to meet the to-day's specific quality. Further, about 12 million tones of iron ore slimes are generated in India every year analysing 50-60% Fe [1]. While on one hand they constitute loss of national resource, on the other hand they cause severe degradation of the environment. So, treatment of slime is very relevant because efficient slime rejection not only improves recovery but minimises waste generation also.

In reference to above, for modernisation of Durgapur Steel Plant, a project was assigned to National Metallurgical Laboratory, Jamshedpur primarily to carry out extensive characterisation study on two composite iron ore samples in terms of the physical properties, chemical constituents, nature of association of principal and gangue mineral phases and their distribution in different size fractions to evolve a optimal flowsheet developed through studies on combination of various unit operations. To make the flowsheet complete, studies were undertaken on estimation of related physical properties of different products of beneficiation to generate technical information needed for their transport, storage, disposal etc. [2].

This paper highlights the findings of the observations of the studies on the above two iron ore samples. Only the results of beneficiation studies are incorporated in the present paper.

SAMPLE

Out of five different varieties of Bolani iron ore bulk samples designated as laminated, blue dust, soft laminated, hard laminated and lateritic ores, two bulk composite samples were prepared after thorough mixing in the proportions as decided by the sponsor. All the samples contained sizes ranging from about 100 mm down to fines except blue dust. First composite sample (Sample -I) consisted of laminated variety (55%) and blue dust (45%) and the second composite sample (Sample -II) consisted of soft laminated (3.9%), lateritic (6.3%) and hard laminated (89.8%) varieties. Each of the five samples, however, were a mixture of different type samples with one type being predominant. The chemical analyses of all the five iron ore samples are given in Table - 1.

EXPERIMENTAL STUDIES

Representative samples of both Sample -I and Sample - II were drawn, after thorough mixing and homogenising, for chemical analyses. While Sample -I assayed 66.69 % Fe, 1.27 % SiO_2 and 1.8 % Al_2O_3, Sample -II assayed 63.68 % Fe, 2.05 % SiO_2 and 2.6 % Al_2O_3.

Table 1 : chemical analyses of Bolani iron ore (as received)

Sample	Assay (%)			
	Fe	SiO_2	Al_2O_3	LOI
Laminated	65.86	1.63	2.23	2.0
Blue dust	67.7	0.83	1.28	1.1
Soft Laminated	62.1	4.22	2.8	2.9
Lateritic	60.85	2.87	3.97	3.8
Hard Laminated	63.95	1.9	2.5	3.1

Sample - I

Chemical analyses showed that Sample -I was a very high grade ore and good enough for direct utilisation after sizing only. A representative sample prepared from two varieties was crushed to - 50 mm size, as desired by the sponsor, for different physical tests for plant designing. A representative portion of the crushed material was used for carrying out tests like size distribution and chemical analyses of each size fraction, angle of repose, shatter test , bulk density and screenability test. Another portion of the crushed sample was subjected to dry screening on 10 mm screen in order to have - 50 + 10 mm lumps and –10 mm fines for further studies. Above physical tests were carried out for both the fractions. Results of dry screening are given in Table - 2. From the table, it can be seen that - 50 + 10 mm lumps weighed 31.3 % and assayed 66.1 % Fe, 1.41 % SiO_2 and 1.86 % Al_2O_3 with Fe recovery of 31.0 % whereas the - 10 mm fines weighed 68.7 % assaying 66.9 % Fe, 1.21 % SiO_2 and 1.77 % Al_2O_3 with recovery of 69.0 % Fe in it.

Table 2 : Dry screening of composite sample I (crushed to 50 mm)

		Assay (%)			
Size	Wt (%)	Fe	SiO_2	Al_2O_3	LOI
–50+10 mm	31.3	66.1	1.41	1.86	1.50
–10 mm	68.7	66.9	1.21	1.77	1.00
Head(Calc)	100.0	66.65	1.27	1.80	1.16

Sample - II

Sample -II was also crushed to - 50 mm, as in the case of Sample -I, in a jaw crusher. The whole crushed material was divided into two representative parts. First part was used for carrying out tests like size distribution, chemical analysis of each size fraction, screenability, shatter test etc. The second part was taken for scrubbing and wet screening followed by various physical tests of the washed products i.e., washed lumps and classifier sand. The classifier overflow i.e., slime, weighing 17.3 % and assaying 57.68 % Fe, 3.27 % SiO_2 and 5.31 % Al_2O_3 was treated using hydrocyclone for improved recovery and better slime rejection. Results of scrubbing and wet screening are given in Table - 3. Hydrocyclone tests were carried out with the slime, whose granulometric and chemical analyses are given in Table - 4. Cumulative particle size distributions for -200 # fractions, obtained using Shimadzu particle size analyser, of cyclone overflow and underflow products are shown in Fig. -1 and Fig. -2 respectively. The final product distribution including hydrocycloning of slime is given in Table - 5.

Table 3 : Scrubbing - wet screning of composite sample II (crushed to 50 mm)

		Assay (%)			
Products	Wt (%)	Fe	SiO_2	Al_2O_3	LOI
–50+10 mm washed lump	49.90	65.00	1.80	2.10	2.80
–10 mm classifier sand	32.80	64.40	1.90	2.50	3.90
Slime	17.30	57.68	3.27	5.31	6.70
Head(Calc)	100.00	63.54	2.09	2.78	3.84

Finally a flowsheet for Sample -II is presented in Fig. 3.

Table 4: Granulometric and chemical analyses of slime

Size		Assay (%)			
(mesh)	Wt (%)	Fe	SiO_2	Al_2O_3	LOI
+100	2.5	57.1	3.5	5.1	9.1
–100+150	3.0	56.0	3.4	6.1	10.1
–150+200	4.5	57.4	2.7	5.4	9.4
–200+250	4.5	57.2	3.0	5.8	8.8
–250+325	5.0	58.4	3.1	5.4	7.7
–325	80.5	7.7	3.3	5.4	8.0
Head(Calc)	100.0	57.63	3.26	5.43	8.17

RESULTS AND DISCUSSION

Results of experimental studies with Sample - I and Sample - II are presented in Tables (2-5). The first sample (Sample - I) was good enough for direct use but crushing and sizing (dry) alongwith extensive studies on physical properties of different products were carried out, as desired by the sponsors, to generate plant

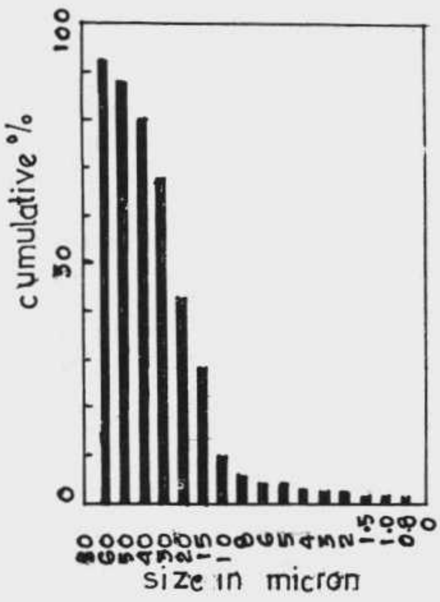

Fig. 1 : Cumulative particle size distribution of cyclone overflow.

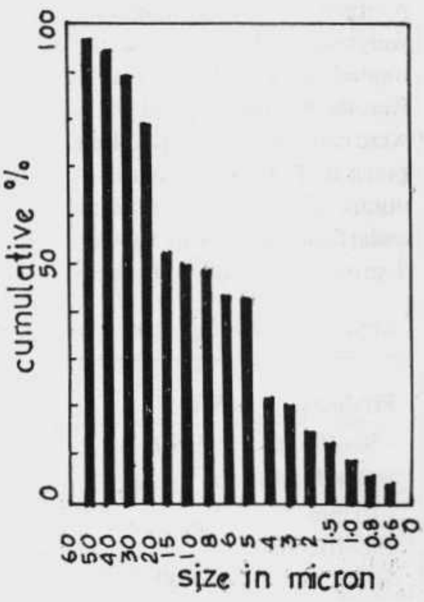

Fig. 2 : Cumulative particle size distribution of cyclone under flow (–200 mesh fraction).

data. The second one (Sample - II) was beneficiated to meet specific quality. The slimes produced after washing were treated using hydrocyclone to improve recovery and reduce environmental pollution. With proper selection of hydrocyclone design and operating parameters, it was found that more than 57% of the slime could be made usable [Table 5].

Table - 5: Final product distribution

Products	Wt (%)		Assay (%) Fe		SiO_2		Al_2O_3	
WASHED LUMP (+10 mm)	49.9		65.0		1.8		2.1	
FINES(-10mm)	32.8	42.7	64.4	63.95	1.9	1.81	2.5	2.54
+								
CYCLONE U/F	9.9		62.47		1.53		2.69	
SLIME (CY . O/F)	7.4		51.27		5.6		8.82	
Head(Calc)	100.00		63.54		2.09		2.78	

The treatment of mineral wastes in the form of slimes and its utilisation, for conservation of mineral wealth and management of pollution, have become very important now-a-days. From the above study, one can see that washing of second composite sample produced 17.3% slimes having 57.68% Fe 3.27% SiO_2 & 5.31% Al_2O_3 [Table 3]. They are normally, if not further treated, considered as waste. In the present study, 2" hydrocyclone was used to treat the slimes. Table 5 shows that nearly 50 % of the composite ore could be upgraded as lumps (+10mm) suitable for direct use, and another 42.7 % fines suitable for sinter feed leaving only 7.4% as reject. This not only helps in conservation of national resource, but controls, to some extent, degradation of environment also.

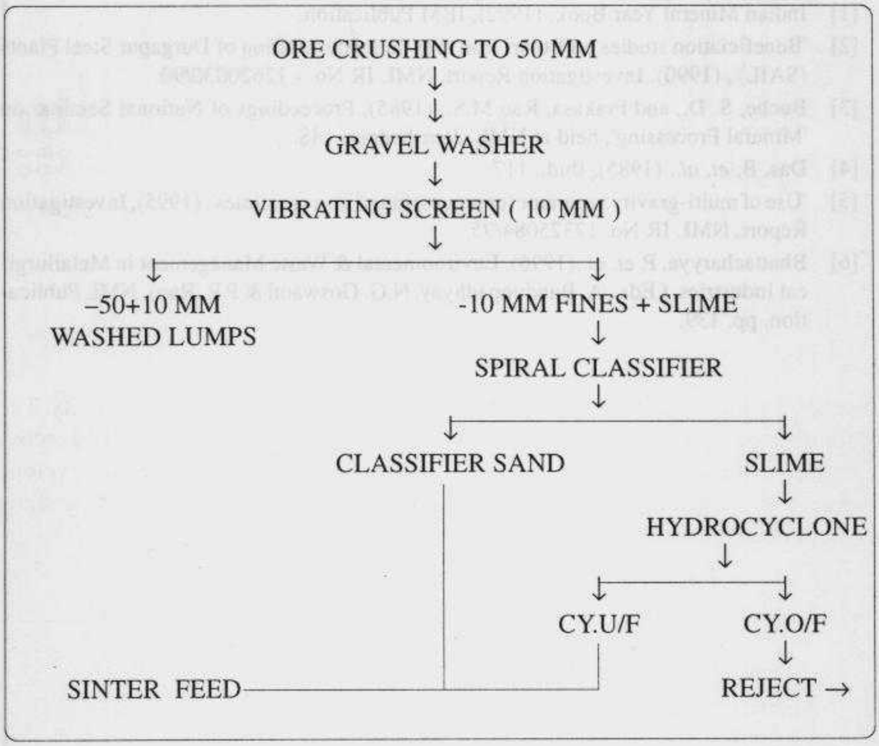

Fig. 3 : Flowsheet for sample - II.

Generally, hydrocyclone or wet high intensity magnetic separator or combination of hydrocyclone and gravity separator are used for the treatment of iron ore slimes [3,4]. Recently, use of multi-gravity separator has also been reported to study its effectiveness in reducing the alumina content [5,6]. As far as process economy is concerned, hydrocyclones undoubtedly outweigh others. But hydrocyclone, in its conventional form, has got some limitation. Improved hydrocyclone design and its efficient application seems to be the solution, to a great extent, to iron ore slime problem.

ACKNOWLEDGEMENTS

The authors are thankful to Prof.P.Ramachandra Rao, Director, NML for his kind permission to present the paper in the Seminar. Authors are also thankful to other colleagues who contributed to generate the data discussed in this paper.

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