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Beneficiation of goethite-laterite ore – an alternative

Depleting iron ore reserves coupled with increasing demand for low-alumina iron ore fines to improve blast furnace performance in terms of productivity and reduced slag rate necessitate intensive beneficiation of iron ore. The sample was collected from Barsua iron ore mine assaying 40% Fe, 9.48% SiO_2 and 19.97% Al_2O_3. In order to produce the pellet grade concentrate multiple stages of beneficiation were opted for. Detailed characterization of the iron ore revealed that most of the impurities in the form of alumina and silica are concentrated in the finer size fractions while iron is concentrated in the coarser size fractions. Therefore, it is imperative that removal of ultrafines using a desliming operation would improve the grade. A beneficiation scheme was chosen involving desliming by simple washing, jigging followed by gravity separation. To study the beneficiation prospects of coarse particles a first stage of gravity separation by jigging is carried out. Finally, further comminution and a second stage of tabling out of all the techniques, reduction roasting was found to be the most suitable one.

Keywords: *Laterite, goethite, beneficiation, roasting.*

Introduction

In the recent past a paradigm shift in terms of resource utilization and beneficiation practices is experienced by the Indian mining and mineral sector. The main difficulty in processing and utilization of low grade ores is related to their composition, soft nature of some of the ores and high alumina content as well. Indian iron ores are having higher amount of alumina (as high as 10% to 15%). The situation becomes more complicated when the ore contains significant amount of iron and at the same time characterized by aluminous gangue and thereby calls for capital investment of higher order for beneficiation. Lateritic iron ores predominantly consists of iron in hydroxy form as goethite interlocked with kaolinite and gibbsite. Presence of significant amounts of impurities renders the ore low grade. Lateritic ore is earthy in luster and limonitic red in colour, yellow with white patches, mainly contains goethite, hematite (as subordinate mineral), kaolinite, gibbsite and quartz. Goethite which is common in lateritic profile/ surfaces of iron ore deposits is abundant in all the samples.

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Methodology

The weight percentage distribution of goethite-lateritic ore sample in respect of various size fractions is shown in Table 1. From size measurement it is evident that the ore is coarse in nature at the same time, the finer fraction (<150) accounts for 13% indicating significant amount of slime generation during washing. The coarser fraction requires suitable grinding for proper liberation. The Fe assay is almost uniform over the entire size range.

In case of lateritic iron ores, the iron bearing grains are highly weathered due to surface weathering of the bulk ore in the deposit. The iron occurs mainly in hydroxy form as goethite interlocked with kaolinite and gibbsite. The liberation analysis illustrates that the impurities are concentrated at finer size fraction, which contains ferruginous clay material such as kaolinite etc. These ores must be upgraded by thorough and proper processing after adequate comminution to attain liberation.

Beneficiation of lateritic ore

The 1 tonne of ROM sample was crushed to -2mm and -1mm. Detailed characterization of the iron ore revealed that most of the impurities in the form of alumina and silica are concentrated in the finer size fractions while iron is concentrated in the coarser size fractions. Therefore, it is imperative that removal of ultrafines using a desliming operation would improve the grade. A beneficiation scheme was chosen involving desliming by simple washing, jigging followed by gravity separation. To study the beneficiation prospects of coarse particles a first stage of gravity separation by jigging is carried out. Finally, further comminution and a second stage of tabling operation is found.

The three stage flow sheet was designed for beneficiation of goethite-lateritic ore. By simple washing the Fe values upgraded substantially, as shown in Table.1. Desliming improves the Fe % from 40% to 43% while reducing the silica

Fig.1 Photomicrographs of goethite-laterite iron ore (a) Gibbsitic clay (reddish black) bounded by goethite (grayish white), characteristic of lateritic ore (b) joint and fracture surface along which goethite and clay precipitation takes place (c) vitreous goethite

TABLE 1: DISTRIBUTION OF PARTICLES AND Fe IN CRUSHED TO -2MM

Goethite-lateritic ore					
Particle size, µm	Wt %	Fe assay	Particle size, µm	Wt %	Fe assay
2000	40.24	42.32	200	2.23	37.35
1000	10.60	41.64	150	6.40	37.39
853	5.87	39.07	100	1.68	37.72
600	8.72	38.24	75	2.07	37.20
500	4.08	38.43	66	0.62	35.45
300	5.74	37.64	<66	11.75	33.70
			Composite	100	38.19

and alumina content from 9.48 % and 19.97 % to 7.87 % and 14.97%, respectively. The washed lumps, after desliming contains considerable amount of coarse ore pieces (> 3mm). They were crushed to -3000 µm size. The crushing operation generated significant amount of fines less than 853 µm (Table 2). The -3000 +853 µm size fraction contains 46% total Fe, 4.9% silica and 11.30% alumina. This size fraction was subjected to gravity separation by jigging. Jigging result, as shown in Table 3, indicates that only small amount of gangues are rejected. The Fe% increased to 53.10% with a decrease in the alumina and silica content to 6% and 4.20%, respectively, by jigging. It is found that the resulting concentrate is still not acceptable feed material for pelletisation/sintering. Therefore, further concentration was required.

TABLE 2: RESULT OF DESLIMING OPERATION

	Wt. (%)	Fe (%)	SiO_2 (%)	Al_2O_3 (%)
Feed	100	40	9.48	19.97
>100µm	75.4	43	7.87	14.97
<100µm	24.6	37.94	13.50	21.30

TABLE.3: ANALYSIS OF THE CRUSHER PRODUCTS

	Yield (%)	Fe (%)	SiO_2 (%)	Al_2O_3 (%)
Feed	100	43	7.87	14.97
-3000+853micron product	65.3	46	4.9	11.30
-853 micron product	34.7	35.32	8.9	19.81

To investigate the optimum particle size requirement for adequate enrichment, the iron ore was ground separately to three different sizes, i.e., 300 µm, 200 µm and 150 µm. In order to study the efficacy of gravity concentration, these samples were subjected to concentration in Wilfley Table.

Experimental condition with 3º deck slope, 1.68 cc. per cm/sec. water flow rate was kept constant in all tabling experiments. The results obtained from the best tests are given in Table 5. It was observed that the quality of the ore improved significantly by tabling. Different concentration grade was obtained from the feed ground to different fineness. The concentrate grade improved to 56.29%, 58.57%, 59.01% Fe by processing the three feeds ground to 300 µm, 200 µm and 150 µm, respectively. Processing of 150 µm size ground material shows that the grade of the ore was improved from 53.10 % Fe to 61.01 % Fe (Table 5). The silica and alumina content of this concentrate were 3.05% and 2.01%, respectively.

The tabling concentrate is subjected to calcinations in a muffle furnace at 400ºC temp for 1 hr to remove the moisture content and other material present in that sample; after calcinations it was seen that the Fe% increases from 59 to 60.82 with loss of moisture of 11.54%.

The unclassified feed of -1mm sample was subjected to calcination. The series of experiments were carried out at 450ºC and 500ºC and the time was varied from 20 to 60 min. The grade of concentrate obtained was in the range of 60 to 63% with a loss of 13-14%.

TABLE.4: JIGGING RESULTS OF GOETHITE-LATERITIC ORE

	Yield %	Fe%	SiO_2	Al_2O_3 (%)
Concentrate	79.12	53.10	4.2	6.0
Tailings	20.88	40.04	17.56	7.87
Feed	100	46	4.9	11.30

TABLE 5: TABLING RESULT OF GOETHITE-LATERITIC ORE

Product	Feed size		
	300 m	200 m	150 m
	Fe (%)		
Conc.	56.29	58.57	59.01
Middling	45.25	42.60	37.89
Tails	42.22	39.61	31.61
	SiO_2 (%)		
Conc.	5.12	4.86	3.05
Middling	5.78	6.68	9.37
Tails	10.16	9.93	10.24
	Al_2O_3 (%)		
Conc.	4.65	3.02	2.01
Middling	7.51	5.98	8.11
Tails	8.55	8.48	8.42

TABLE 6: AVERAGE OF 4 TESTS

Wt%	% of loss	% Fe
27.8	11.54	60.82

TABLE.7: CALCINATION RESULT OF GOETHITE-LATERITIC ORE

	Size -1mm				
	Temp 400ºC			Temp 500 ºC	
	Time min	% of loss	% Fe	% of loss	% Fe
1	20	13.17	62.70	13.14	60.75
2	40	13.60	63.00	13.57	62.87
3	60	13.53	63.29	13.83	63.29

Calcination is a pyro metallurgical process consists of the thermal treatment of minerals and metallurgical ores and concentrates to bring about physical transformations in the materials to enable recovery of valuable metals. The calcination is thermal decomposition of a material process normally takes place at temperatures below the melting point of the materials in the absence of air or limited supply of oxygen to remove the volatile mater, moisture, water of hydrates, and organic matter from the ore. Carbonate, bicarbonate and hydroxide ores are generally subjected to calcination which produce the metal oxide after expelling CO_2 or H_2O in the process.

Experimental details

In the above study, muffle furnace was used. Half of the container was filled with the material. The required temperature (400,500°C) and resident time (20 min, 40min, 60min) was set. After cooling the material was weighed and noted down.

Conclusion

Lateritic ore principally composed of hematite, goethite showing colloform growth, oolitic/pisolitic as well as cementing type of texture. The variety of textures cause difficulty in complete liberation of iron ore minerals as it is intimately entangled with variety of gangue minerals. Thus even after fine grinding a significant amount of locked particles were present. Overall the liberation was difficult. In this particular case the abundance of hydroxide minerals created problems in beneficiation. In order to overcome such issues in gravity separation, roasting is found to be helpful.

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