Beneficiation of iron ore slimes

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INTRODUCTION :

National Mineral Development Corporation (NMDC) is a premier mining organisation in the field of iron ore mining in India. The activities of NMDC for the last 25 years broadly relate to explore, develop and exploit mineral resources, mainly iron ore of the country and has so far produced nearly 100 million tonnes of iron ore by mechanised mining.

Current trend in mechanisation of hematitic iron ore mines is to meet the requirement of steel industry for production of lump ore of specified size and fines for sinter manufacture. The general processing method being adopted is washing, wet screening and classification of wet screened fines. Usually classifier/cyclone overflow slimes are rejected. The table—1 gives an idea of the quantity of slimes generation in some of the iron ore mines in NMDC. These slimes are being rejected as waste.

As can be seen from the table the huge loss of classifier/cyclone overflow slimes to the extent of 1.5 million tonnes per annum is a matter of great concern as it is causing pollution in the adjoining areas also. It has therefore become imperative to take a serious note of this loss from mineral conservation point of view as well as to minimise pollution. However, if the slimes are to be beneficiated to produce an acceptable grade of iron ore concentrate for utilisation of iron making by adopting techniques such as microballing followed by sintering, INRED, ERLED, PLASMARED, etc. substantial quantity of this beneficiated iron ore could be utilised usefully, and the pollution problem could also be reduced.

In all the NMDC mines, wet processing is employed for production of lump ore and fines to meet the stringent export specifications. Fine sized high quality blue dust which is available from the mining faces along with other iron ores is being fed to the ore dressing plant. The classifier overflow slimes of Bailadila-14 and Bailadila-5 are being rejected. In the case of Donimalai, the classifier overflow slimes are further treated in cyclone to recover cyclone underflow and cyclone overflow is rejected. Because of the rich blue dust in the slimes, slimes assay as high as 62-63% Fe.

Objective :

In order to assess the possibility of recovering iron values from these slimes, Research and Development Division of NMDC took up the beneficiation studies with the slimes of Bailadila-14, Bailadila-5 and Donimalai. A scheme of beneficiation was therefore evolved to study the effect of different techniques of beneficiation with a view to achieve the best possible grade of the concentrate. The scheme involves simple cycloning, cycloning followed by spiralling, cycloning followed by tabling, straight flotation and wet high intensity magnetic separation.

Characteristics of slime samples :

The chemical analysis of slime samples from Bailadila-5, Bailadila-14 and Donimalai are given in Table 2.

Typical size analysis of these slimes are given in Table-3.

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Table — 1 : Iron ore slimes

Name of Mine	ROM Capacity (Million tonnes per year)	Nature of slimes	Slimes %	Slimes qty based on ROM (million tonnes per year)
Bailadila-14	3.20	Classifier Overflow	19.7	0.63
Bailadila- 5	5.00	Classifier Overflow	12.0	0.60
Donimalai	2.25	Cyclone Overflow	10.0	0.22

Table—2 : Chemical analysis of slimes.

Constituents	Assay Percent		
	Bailadila-14	Bailadila-5	Donimalai
Fe	63.30	60.64	54.30
SiO_2	2.76	7.76	8.86
Al_2O_3	4.40	3.10	7.78
LOI	2.22	1.98	4.38
P	0.05	0.058	0.094
S	0.05	0.02	0.03

Table—3 : Size analysis of slimes.

Size mm/Mesh (Tyler)	Bailadila-14		Bailadila-5		Donimalai	
	Wt. %	Assay % Fe	Wt. %	Assay % Fe	Wt. %	Assay % Fe
– 2 mm + 65 mesh	—	—	18.1	51.86	—	—
– 65 + 100 mesh	1.2	53.20	5.1	53.26	7.3	66.00
–100 + 150 „	1.0	59.60	6.2	52.59	2.8	65.60
–150 + 200 „	4.4	64.40	14.7	63.95	5.4	65.20
—200 + 270 „	5.0	66.30	8.5	65.74	3.2	65.00
—270 + 325 „	11.8	67.96	10.7	66.52	5.0	65.00
—325 „	76.6	62.97	36.7	61.97	76.3	51.67

Mineralogical studies of the Bailadila-14 and Bailadila-5 slimes revealed the presence of hematite and goethite as chief iron bearing minerals associated with lateritic and siliceous gangue. The texture of iron bearing minerals were fine grained to cryptocrystalline. Mainly alteration and replacement phenomenon was noticed. Specific gravities of Bailadila-14 and Bailadila-5 slimes were 4.6 and 4.5, respectively.

Donimalai sample was powdery in nature. Microscopic studies revealed the presence of laterite, hematite, quartz and little of ochre as various constituents in the order of abundance. The texture was cryptocrystalline. Specific gravity of the slime sample was found to be 4.0.

Test Results :

Results of the beneficiated concentrate produced under each of the above techniques is given in Table 4, 5 and 6 respectively.

DISCUSSIONS :

The slimes of Bailadila-14 could be upgraded to +65% Fe by all the beneficiation methods ennunciated earlier. By wet high intensity magnetic separation, 72.6% of total iron present in the test sample could be recovered in the concentrate assaying 67.72% Fe and constituting 68.7% by weight. Straight cycloning alone could recover 78.2% iron present in the test sample assaying 65.7% Fe content. Spiral concentration of cyclone underflow produced a concentrate of 68.5% Fe with iron recovery of 39.4% only. These test results indicated that wet high intensity magnetic separation yielding about 72% of iron recovery in the concentrate with a grade of +67% Fe is more effective than the remaining processes adopted.

Although gravity concentration by tabling or spiralling yielded good grade concentrate assaying +66.0% Fe, better recoveries were obtained by wet high intensity magnetic separation and flotation assaying +65.0% Fe with 81.2% and 70.2% iron recoveries respectively. The gravity separation was not effective as far as recoveries are concerned, probably because of wide size range of feed. An optimum process for treatment of Bailadila-5 slimes was therefore found to be wet high intensity magnetic separation wherein 81.2% iron is recovered.

Due to very poor grade of Fe in the 'as received' sample, Donimalai slimes could be upgraded to maximum of 65.58% Fe by tabling of cyclone underflow and to 65% Fe by spiral concentration. The other methods like wet high intensity magnetic separation and flotation were not very effective and yielded poor recoveries and grades.

Conclusion :

Iron ore slimes being thrown away as waste can be beneficiated by adopting wet high intensity magnetic separation in Bailadila-14 and Bailadila-5 mines whereas cycloning and gravity separation (spiralling) in Donimalai mines to conserve a substantial quantity of rejected material.

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Table—4 : Slimes from Bailadila-14

	Process	Nature of concentrate	Concentrate		
			Weight %	Assay % Fe	Recovery % Fe
i	Cycloning	Cy. U'flow	75.3	65.70	78.2
ii	Cycloning followed by tabling of Cy. U'flow	Table concentrate	44.7	66.58	47.2
iii	Cycloning followed by spiral concentration of Cy. U'flow	Spiral concentrate	36.4	68.50	39.4
iv	Wet high intensity Magnetic separation	Magnetic cencentrate	68.7	67.72	72.6
v	Flotation (silica flotation)	Sink	70.8	66.55	74.1

Table—5 : Slimes from Bailadila-5

	Process	Nature of concentrate	Concentrate		
			Weight %	Assay % Fe	Recovery % Fe
i	Cycloning	Cy. U'flow	84.6	61.69	86.2
ii	Cycloning followed by tabling of Cy. U'flow	Table concentrate	31.5	66.49	34.6
iii	Cycloning followed by spiral concentration of Cy. U'flow	Spiral concentrate	49.0	66.70	54.0
iv	Wet high intensity Magnetic separation	Magnetic concentrate	75.4	65.17	81.2
v	Flotation (silica flotation)	Sink	65.3	65.40	70.2

Table—6 : Slimes from Donimalai

	Process	Nature of concentrate	Concentrate		
			Weight %	Assay % Fe	Recovery % Fe
i	Cycloning	Cy. U'flow	70.8	56.40	74.0
ii	Cycloning followed by tabling of Cy. U'flow	Table concentrate	19.2	65.58	23.3
iii	Cycloning followed by spiral concentration of Cy. U'flow	Spiral concentrate	25.0	65.00	29.9
iv	Wet high intensity Magnetic separation	Magnetic concentrate	47.8	59.69	52.2
v	Flotation (silica flotation)	Sink	40.9	63.40	47.1

DISCUSSION :

Pradip, Pune.

Question 1 : Have you also investigated the economics of these five options ? How does HGMS compare with others ?

Author : No. But it has been found that HGMS can produce concentrates assasying +65% Fe (with high recoveries) which are suitable for processes like INRED, ELRED etc.

Question 2 : What is the unit of WHIMS ?

Author : High intensity magnetic separator manufactured by Eritz, CF-5 Model.

P. S. R. Reddy, R.R.L., Bhubaneswar.

Question 1 : Has cost economics been calculated for different methods ?

Author : No.

Question 2 : Any sintering tests have been carried out on the benificiated concentrates ?

Author : No.

Question 3 : Have you done any pelletization studies ?

Author : No.

Question 4 : What is the intensity used in magnetic separation ?

Author : Bailadila-14 = 5Amps.
Donimalai = 5 Amps.