Reprocessing of iron ore beneficiation plant tails

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Abstract - *The slimy tails of iron ore dressing plant were collected and subjected with a view to study the amenability of slimy tails for producing cement grade iron concentrates.* Reddish brown coloured powdery composite slimy tails sample from tailing ponds of iron ore beneficiation plants around Ballari area assayed 35.64% Fe(T), 23.61% SiO_2, 10.28% Al_2O_3, 6.09% alkalies and 7.70 % Loss on Ignition[LOI]. It contained mainly iron ore minerals (50-55%) consisting of hematite, goethite, limonite with trace amounts of martitized magnetite with sub-ordinate amounts of ferruginous clay (15-20%), feldspar (20%) and quartz (10-15%).The sample was subjected to hydrocycloning followed by split rougher WHIMS at 10000 gauss yielded a composite of O/F and U/F magnetic concentrate assaying 15% SiO2 , 43% Fe with 78.7% Fe distribution at 65.7 wt.% yield, just meeting specifications and aiding the vexed problem of environmental management of slimy tails and mineral conservation.

***Key Words*: Iron ore slime processing, Desliming, VPHGMS, WHIMS**

1. INTRODUCTION

Indian Iron ore occurs mostly as oxides in nature. The deposits are fairly well distributed in the states of Jharkhand, Chattisgarh, Orissa, Karnataka, Maharashtra, Goa and Andhra Pradesh [1&2]. The lack of consistency with respect to the ratio of Al_2O_3 to SiO_2 make these ores unsuitable for direct use in the blast furnace [1-3] and needs beneficiation to industrial use. The iron ore minerals are liberated from gangue minerals by ball mill grinding, followed by hydrocycloning, gravity concentration and WHIMS producing BF grade conentrates. During the preparation of ore as a feed to blast furnace a significant amount of slimes (-0.050 mm) and non magnetic tails are being generated. The tails assaying 30-45 %Fe are deposited to tailing pond.. The iron ore beneficiation have resulted in production of millions of tons of slimy tails stacked tail pond necessitating a suitable beneficiation process for recovering the iron values from the perspective of mineral conservation, effective space utilization of the tailing ponds and to enhance the life of the existing operating mines. The improvement in the environmental regulations, fresh lease of land for tails impoundment is next to impossible and mitigation of vexed tailing pond management with little environmental problem of silting, dust and ground water contamination is getting complicated as the time passes on. Iron ore is also used in cement industry and accounts for 3% total consumption of iron ores. In view of the above and increased pressure the steel manufacturers have also established cement plants to manufacture slag based cement plants where in the granulated BF calcareous slangs, limestone are used to used. The cement plants consume iron ores to improve the burning properties, imparting colour and to balance composition of the mix. The specifications of iron ore for use in cement industry is[1] Fe (T) 45% Min., SiO_2 (T) 15% Max, SiO_2 (Free) Max 10%, TiO_2 Max 4%, S and P Max 0.1%. The review of literature The review of literature on processing of Indian iron slimes is enormous where in centrifugal concentration devices, selective dispersion – selective flocculation, inverse cationic column flotation, wet high intensity magnetic separation (WHIMS)/ High gradient magnetic separation (HGMS) have been used.[1-16]. Hence an attempt was made to study the amenability of iron ore beneficiation plant tails from Bellary Hospet Sandur region to produce cement grade iron ore concentrates. The tails are produced after subjecting the sub grade iron ore mostly anhydrous type to scrubbing, classification, grinding to liberate the values, gravity concentration and wet high intensity magnetic concentration yielding pellet grade concentrates, while the WHIMS-spiral tails and untreated slimes constitute the final tails dumped in the tailing pond. The tails were collected from tailing ponds of the beneficiation plant to study the amenability of the sample to produce cement grade iron ore concentrates.

2. MATERIAL AND METHODS

Two slime samples from tailing dams of iron ore beneficiation plants of M/S BMM Ispat Ltd. Danapur and M/S JSWL, Vaddu, spread across Bellary district were collected, dried and mixed. The sub samples were drawn after homogenization followed by coning and quartering method. The composite feed subjected to physical, chemical and mineralogical characterization. Mozley hydro cyclone [10.25 and50 mm dia] test rig was used for desliming if needed. The particle size analysis was done by classical method. Lab model WHIMS was used for carrying out lab tests. Initially tests were carried out varying the %Solids, desliming [as it is and desliming 10 microns], intensity, matrix and was followed up with a cleaner and scavenger stage for improving the grade and recovery.

3. RESULTS AND DISCUSSION

The experimental comprises of characterization studies of four different iron ore slimes samples followed by the effect of desliming and other machine parameters of WHMIS The effect of scavenging, cleaner stage operations and split concnetratons were also investigated.

3.1 Characterization studies

The representative samples were subjected to chemical analysis by classical methods, the mineralogical studies , particle size analysis by classical fine sieve and sub sieve analysis methods. The representative sample consisted of reddish brown coloured powder with 3.7 specific gravity. The sample assayed 35.64% Fe(T), 23.61% SiO_2, 10.28% Al_2O_3, 6.09% alkalies and 7.70 % Loss on Ignition[LOI]. The size analysis indicated the size of D_{100} 0.250mm, D_{80} 0.040mm, D_{50} 0.012mm. The sample contained mainly iron ore minerals (50-55%) consisting of hematite, goethite, limonite with trace amounts of martitized magnetite. It contained sub-ordinate amounts of ferruginous clay (15-20%), feldspar (20%) and quartz (10-15%). Amenability tests comprising of particle size refining by screening over 500 mesh, followed by heavy liquid and Iso dynamic separation indicated that the sample is amenable for reduction of silica and upgradation of iron values to above combination process comprising of desliming and split sequential concentration by gravity and magnetic separation similar to previous characterisation findings[10 and 17].

3.2 Effect of Desliming

De-sliming studies were carried out in a laboratory Mozley cyclone test rig with 25mm hydro cyclone by varying the vortex finder and spigot dia. The tests were carried out at feed consistency of around 12% solids and inlet pressure of around 25psi. Products of each test were collected and analyzed for grade and yield. The results obtained are shown in Table – 1. From the results it was observed that about 36.3% sand reports in under flow rich in silica while the silica content in the overflow is just above desired 15% SiO_2.. Similar observations were made by earlier investigators on desliming of iron ore slimes. [6, 8, 10 and 13].

Table-1: Results of De sliming tests

Products	Wt.%	% SiO_2	
		Assay	Distn.
Cyclone O/F	63.7	15.79	42.6
Cyclone U/F	36.3	37.31	57.4
Head Cal.	100.0	23.60	100.0

3.1 Effect of field intensity

Tests were carried out by varying the intensities at 7000, 10000 and 13000 gauss at 25%S in a lab model WHIMS. The results are given in Table 2. The results indicate that an increase in intensity increases the wt% yield, % silica and % Fe distribution of concentrate. The tails value decreases significantly with increase in intensity. The magnetic intensity of 10,000 gauss was found to be optimum.,. At intensities > 13,000 gauss the dilution of grade occurs due to concentration of ferruginous clayey impurities. The results are concordant with previous works [8, 11,12, 14 - 16]

Table -3: Effect of intentsity

Intensity Gauss	Products	Wt.%	% SiO_2	
			Assay	Distn.
7000	Mag conc	24.0	12.18	13.2
	Non mag tail	76.0	26.50	86.8
	Head Calc	100.0	23.20	100.0
10000	Mag conc	32.6	12.20	17.2
	Non mag tail	67.4	28.38	82.8
	Head Calc	100.0	23.10	100.0
13000	Mag conc	35.6	12.85	19.6
	Non mag tail	64.4	29.02	80.4
	Head Calc	100.0	23.36	100.0

3.3 Effect of gradient

WHIMS tests were conducted by varying the ball matrix size from 6 and 9mm at 25%S and 13000 gauss. The results are given in Table 4. The results indicate that an increase in ball dia decreases the wt% yield, marginally decreases % SiO_2. distribution and increases the grade of concentrate. Also the % Fe grade of tail losses increases significantly if the ball size increases more than 6 mm.. The results are akin to previous findings [8, 11,12,14 to 16]

Table -3: Effect of Gradient

Ball dia mm	Products	Wt.%	% SiO_2	
			Assay	Distn.
6mm	Mag conc	32.6	12.20	17.2
	Non mag tail	67.4	28.38	82.8
	Head Calc	100.0	23.10	100.0
9mm	Mag conc	24.0	11.50	12.0
	Non mag tail	76.0	26.63	88.0
	Head Calc	100.0	23.00	100.0

3.4 Amenability of samples to final split process

The final process flow sheet comprises of Hydrocycloning, followed by Rougher WHIMS at 10000 gauss, 2 stages of Cleaner WHIMS of Rougher concentrate at 9000 and 8000 gauss for both cyclone over flow and cyclone under flow. The results are given in Table 4.

Table 4 ;Final split HGMS test

Products	Wt.%	Assay		Distn.	
		% SiO_2	Fe(T)	% SiO_2	Fe(T)
IICl mag CyOF	21.3	10.00	45.16	9.1	26.9
II Cl Non mag CyOF	9.6	14.35	41.25	6.1	10.9
I Cl Non mag CyOF	10.5	18.10	38.94	8.0	11.4
R Non mag CyOF	22.5	19.83	30.49	18.7	19.0
IICl mag CyUF	20.1	9.73	48.96	8.3	27.5
II Cl Non mag CyUF	1.3	43.67	24.50	2.4	0.9
I Cl Non mag CyUF	3.1	59.80	12.17	7.9	1.1
R Non mag CyUF	11.8	78.98	6.87	39.5	2.3
Head Calc	100.0	23.60	35.64	100.0	100.0
Comp. IICl Split mag conc	41.4	9.90	47.01	17.4	54.4
Final tails	58.6	33.27	27.73	82.6	45.6

The above split VPHGMS process yielded a composite concentrate analyzing 47.07% Fe and 9.90% SiO_2 with 54.4% Fe Dist. at, 41.4 wt% yield meeting the cement grade specs.

On the contrary a single stage split rougher HGMS yielded a composite concentrate assaying 15% SiO_2, 10.2% Free silica 43% Fe with 78.7% Fe distribution at 65.7 wt.% yield, just meeting the specifications.

4. CONCLUSIONS

Iron ore beneficiation plant tails composite samples were collected with an view to study the amenability of sample producing the cement grade iron concentrate with silica less than 15%. The composite tails sample from tailing ponds of iron ore beneficiation plants around Ballari area assayed 35.64% Fe(T), 23.61% SiO_2, 10.28% Al_2O_3, 6.09% alkalies and 7.70 % Loss on Ignition[LOI] and contained mainly iron ore minerals (50-55%) consisting of hematite, goethite, limonite with trace amounts of martitized magnetite with sub-ordinate amounts of ferruginous clay (15-20%), feldspar (20%) and quartz (10-15%). The sample was subjected to hydrocycloning followed by split rougher WHIMS at 10000 gauss yielded a composite of O/F and U/F magnetic concentrate assaying 15% SiO2 , 43% Fe with 78.7% Fe distribution at 65.7 wt.% yield, just meeting specifications. The above process reduced the tailing pond area to 33% mitigating the vexed tailing pond management besides generating revenue and conserving mineral and environment. The obtained results are under translation in industry where in preliminary results are encouraging confirming the findings

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