Innovative Technique to generate saleable Iron Ore Fines from beneficiation plant Tailings

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Abstract

Earlier Iron ore tailings contain iron concentrations of around 45% or more. In future it may become economically viable to extract the iron content from tailings, and due to the high cost of land and environmental factors it is worthwhile attempting to minimize tailings volumes. Further R&D study was conducted for more recovery of saleable fines from on line tailings by wet high intensity magnetic separator, which resulted in to positive impact. A pilot-scale test was done on the continuous type model plant, and the different operations involved are described further. Sesa-codli iron ore tailings were subjected to a laboratory-scale test. By desliming cyclones it was possible to produce concentrate with Fe content of 54%. Desliming cyclones concentrate were subjected for WHIMS tests. It was found that there was appreciable recovery of Fe (up to 60%), and Al2O3 and SiO2 content could be reduced by 50%. The installation of WHIMS plant has enabled resource recovery, reducing the quantity of tailings by about 13%. A scheme for the WHIMS plant for the utilization of tailings for resource recovery is discussed.

Keywords: iron ore tailings, tailings pond, crude ore, WHIMS, LIMS, MIMS

INTRODUCTION

Sesa is India's largest producer and exporter of iron ore in the private sector. The company is a majority owned and controlled subsidiary of Vedanta Resources plc, the London listed FTSE 100 diversified metals and mining major.

For over five decades, Sesa has been involved in iron ore mining, beneficiation and exports. Over the last two decades, it has diversified into the manufacture of pig iron and metallurgical coke.

Sesa has mining operations in Goa and Karnataka The ores from these regions have different physical and chemical properties and they behave differently when subjected to various mineral processing techniques. Usually Karnataka/Orissa region ores are higher in Fe content, where only size separation is done with dry process. Whereas Goa region ores are lower in Fe

Content due to the presence of impurities in the run of mine and it is subjected to wet beneficiation process to improve Fe content. This low Fe content ores are wet beneficiated using crushing, log washing, drum scrubber, vibrating screens, classifiers and 3 stages of hydro cyclones. With the above wet process particles above 45 microns sizes are recovered with 77 % weight recovery. During the above process around 23% by weight below 45 microns size are generated as tailings with Fe content of around 45%. Earlier these tailings were stored in tailing ponds. Later on in Sesa-codli in house, as well as external study was made in 1995 to recover Fe values & saleable fines from on-line plant tailings using LIMS, MIMS and ferrous wheel separators after desliming the tailings. As a result of above study, ultra-fines recovery plant was set up at Sesa-Codli to recover Fe values and saleable fines from online tailings. A mineralogical study on ultra-fines recovery plant tailings revels that, there was an escape of martite, goethite and hematite in tailings. Again an attempt was made in 2010 by conducting in-house and external study to recover escaped iron ore bearing minerals from ultra-fines recovery plant on line tailings using column flotation and wet high intensity magnetic separators. However the WHIMS process is preferred to flotation since reagents cost are high to recover such a finer particles (10 microns) and disposal of flotation pulp containing residual reagents contributes to water pollution.

After conducting several lab scale and pilot scale test work, wet high intensity magnetic separator were selected and the ferrous wheel separators were replaced with WHIMS. With this overall beneficiation plant weight recovery has improved from 77% to 81%, thereby reducing tailing Fe content from 44% to 41%.

Mineralogy and liberation studies:

Hematite and limonite are the main iron mineral in the runoff mine ore whereas goethite and martites are in minor amounts and martitised magnetite is in very minor to traces amounts. Kaoline, quartz are the main gaunge minerals in the ore. These coarser hematite and limonite ores are recovered by using crushing, log washing, drum scrubber, vibrating screens, classifiers and 3stages of hydro cyclones process.

With the above process, particles above 45 microns are recovered.
Particles below 45 microns are tested with magnetic separators.

Preliminary Separation Test work:

A series of laboratory tests employing a low intensity magnetic separator operating at 1000 Gauss were initially conducted. A representative quantity of dried plant tailings (below 45 microns in size) was prepared as homogenous

slurry for feed to the magnetic separator at 20% solids pulp density. Magnetic and non-magnetic fractions were separately collected and analyzed for Fe content. It was found that a Para magnetic concentrate containing at least-60% Fe could potentially be recovered (saleable product grade) with losses of hematite material to tailings.

Further study was made in 1995 to recover the hematite minerals which are escaped in LIMS, with ferrous wheel separator.

A typical assay size analysis of the ultra-fines tailings is given in Table 1.

Table 1: Fraction wise Analysis of Tailings

Separation size in microns	Wt%	Fe%	SiO_2%	Al203%
+150	0.00	0.00	0.00	0.00
-150 +75	2.80	54.23	9.37	3.80
-75 +45	8.50	60.79	7.13	3.16
-45 + 10	12.50	58.80	8.09	3.32
Sub-Total:- +10	23.8	58.97	7.9	3.32
-10	76.2	42.5	11.48	12.42
Calc. Head	100.0	46.45	10.63	10.25

SELECTION OF 'MAGNETIC SEPARATOR:

Further bench scale test work determined that the tailings could be upgraded by wet high intensity magnetic separation. Medium intensity magnetic separation was not particularly effective for concentrating the predominantly fine hematite and limonite Fe minerals contained in the tailings.

a) Bench scale WHIMS Tests:

A sample of Codli plant tailings containing around 45% Fe was prepared for the magnetic separation test work. This sample was first passed over a laboratory scale; medium intensity wet drum to remove strongly magnetic material, principally magnetite, in the sample before WHIMS separation. This step was deemed necessary to prevent overloading of WHIMS. The results demonstrated that at a WHIMS field strength of 10000 Gauss, 26% of the tailings sample could be recovered. The results were sufficiently encouraging to proceed with pilot

scale tests.

b) Pilot Scale WHIMS Tests:

A series of pilot scale tests were conducted using a pilot scale WHIMS at the Codli process plant. Tests were conducted at different magnetic intensities for different grade R.O.M ores. Typical results obtained are shown in Table 2.

Table2: WHIMS test results.

Material	Plant feed, Fe%	Whims feed		Mags			Tailings		Plant Rec %
		T/H	Fe %	T/H	Fe %	Rec%	T/H	Fe %	
C2	58.89	3.88	51.61	1.98	60.01	51.25	1.90	42.87	3.42

Based on this pilot scale test work, Plant scale WHIMS are installed at all our processing plants to recover fines from the plant tailings. All WHIMS are working successfully with expected results.

Typical tailing fractional analysis of tailings after installation of WHIMS is shown in the Table3

Table 3: Fraction wise Analysis of Tailings

Separation size in microns	Wt%	Fe%	SiO_2%	Al203%
+150	0.00	0.00	0.00	0.00
-150 +75	0.80	49.34	8.45	5.54
-75 +45	5.40	54.76	9.21	3.81
-45 + 10	8.45	53.24	9.56	4.01
Sub-Total:- +10	14.65	53.59	9.37	4.01
-10	85.35	41.03	12.54	13.21
Calc. Head	100.0	42.87	12.07	11.86

In order to confirm the relative distribution of minerals within the tailings feed and magnetic concentrate together with their mineral characteristics, samples were analyzed. Sub sieve Size analyses were also performed and it was found that 90% of the concentrate produced was typically coarser than 10 microns in size whereas 85% of the separator tailings were typically finer than 10 microns. Mineralogical evaluation established that the concentrate was mainly hematite,

and that the major constituents of the tailings were amorphous, poorly crystallized clay minerals such as kaolinite. The concentrated hematite grains were mostly above 10 microns in size.

About Wet high intensity magnetic separator:

The paramagnetic materials from medium intensity magnetic separator are treated in WHIMS. It separates paramagnetic materials which are escaped in MIMS stage. This stage enables to recover finer hematite, limonite and goethite minerals from the tailings. Installation of WHIMS has enabled to improve overall beneficiation plant weight recovery from 77% to 81%. Tailing Fe content of the plant has reduced to 41%.

***How it works*:**

An electromagnetic field is generated within the separating zone. A drum, rotating on its horizontal axis, houses a matrix of paralleled rods. From the feed box, slurry is introduced into the matrix as it passes through the separating zone. The magnetic particles in the slurry are attracted to the surface of the rods in the matrix then carried out of the separation zone to the top of the drum. Once outside of the separation zone, where the magnetic field is negligible, the magnetic materials are flushed into the concentrate box. Conversely, while the matrix is still in the separation zone, gravity and the force of hydrodynamic pulsing of the slurry drag the non-magnetic particles through the matrix pile into the tailings box.

Pulsating mechanism and vertical ring configuration:

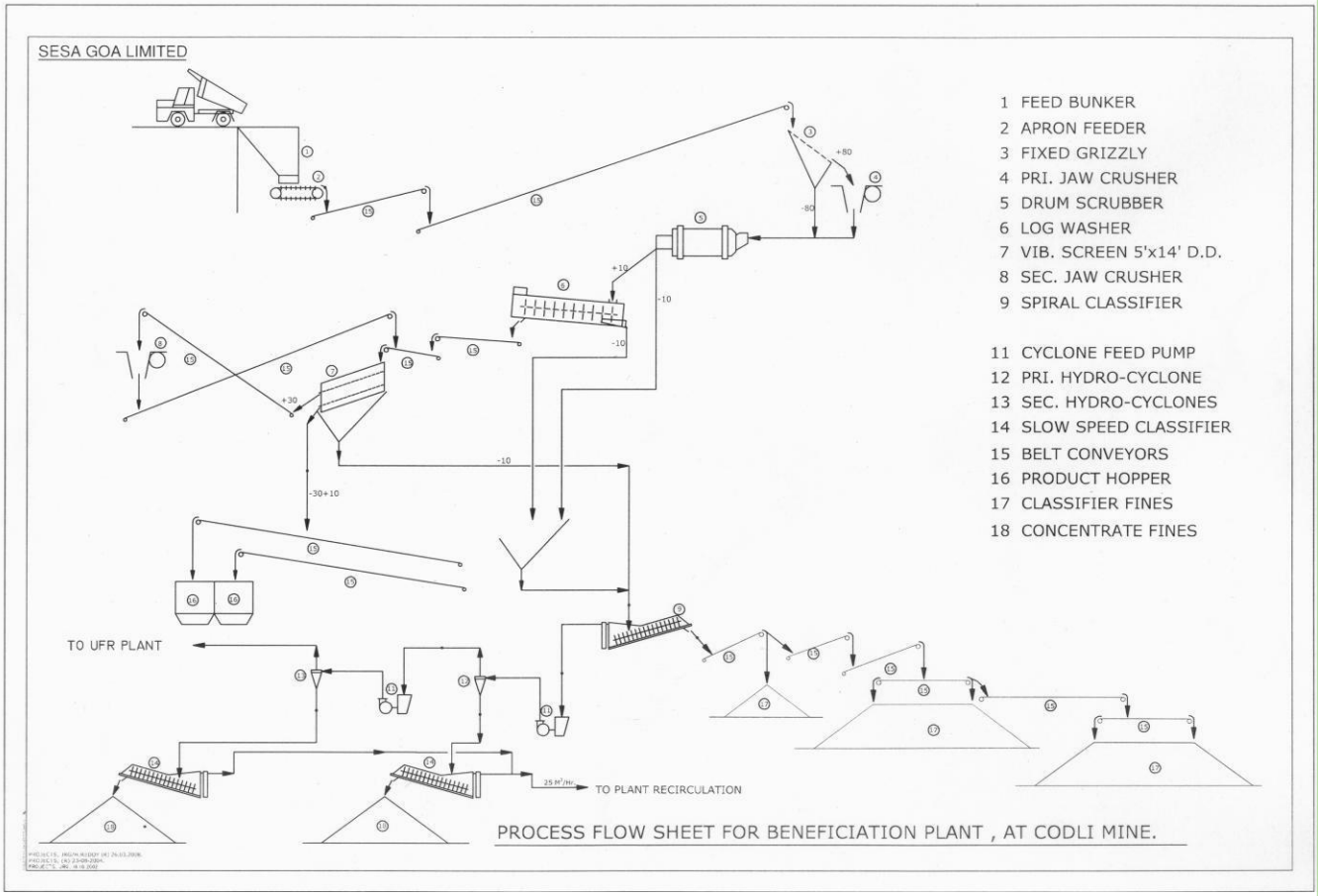
A diaphragm actuated by a crankshaft provides the pulsating mechanism. The pulsation drives the slurry in the separating zone up and down keeping particles in a constantly loose state; so fewer non-magnetic particles become trapped. Since the pulsing causes the slurry direction to reverse, particle accumulation occurs on both sides of the matrix. This creates a greater surface area of collection points thus the matrix can process more slurry before becoming saturated, and so capture more magnetic particles in less processing time.

The working ring of the WHIMS rotates vertically, rather than horizontally like traditional WHIMS. This configuration allows for flushing in the opposite direction of the feed so that strongly magnetic particles and coarse particles can be washed away without having to pass through the entire depth of the matrix. Additionally, the flush zone is designed to have less stray magnetic field and so reduce any residual grip on the magnetic particles. These unique features help the units achieve

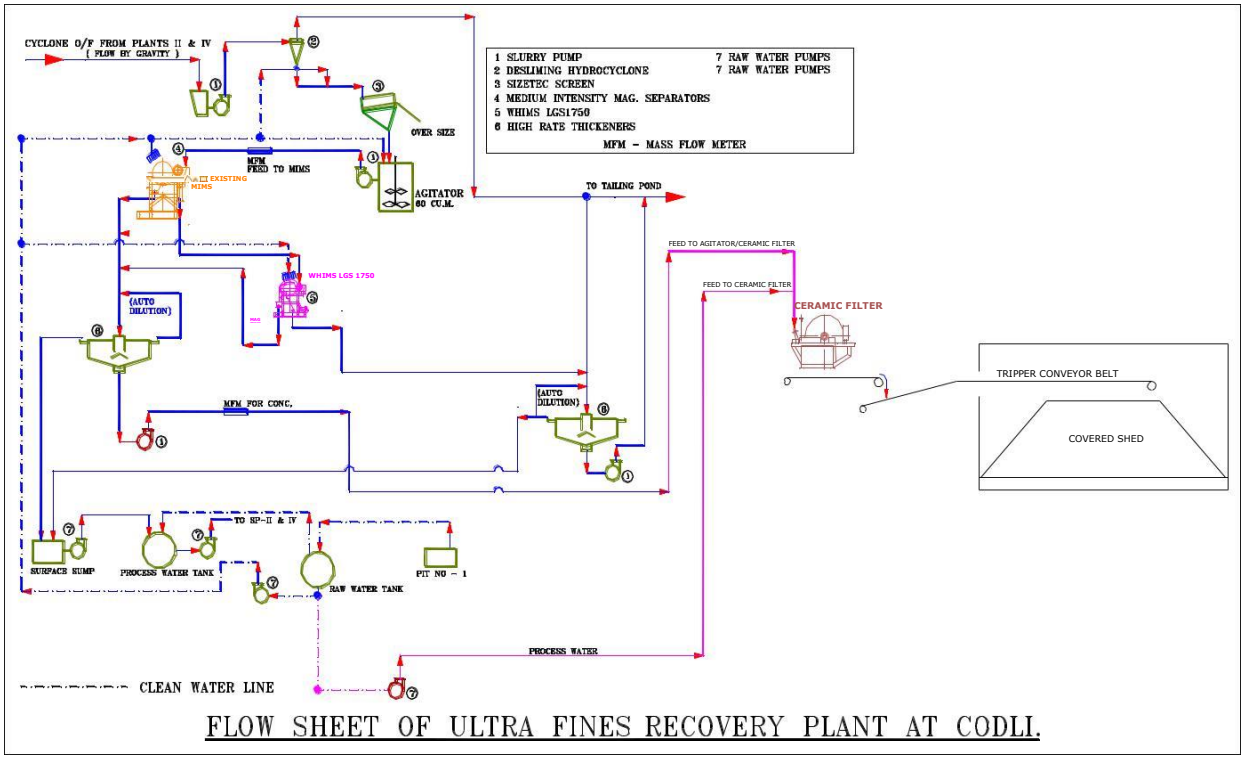
a higher ratio of beneficiation, higher efficiency, and considerable flexibility, all at high capacities.

Typical iron ore beneficiation plant & WHIMS Plants (Ultra fines recovery plant) are shown in the Annexure 1 &2.

ANNEXURE-I



ANNEXURE-II



FLOW SHEET OF ULTRA FINES RECOVERY PLANT AT CODLI.

Conclusion

With the synergy from the above study, further in-house and external R& D study on historical tailings (below10 microns to 45 microns in size) with wet high intensity magnetic separator/Reverse flotation or Column flotation is in progress to recover saleable fines from tailing ponds.

Present Status

The Wet High Intensity magnetic Separators (WHIMS) are installed at all existing Wet Beneficiation plant circuits across IOG, Goa and Overall product recovery has been improved by 2.5-3% with saleable Fe% content.