Managing Iron Ore Fines of Dalli – Rajhara For Improvement In Yield

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Abstract

"A journey of a thousand miles begins with a single step"- **Confucius**

Beneficiate ore, improve yield, conserve mineral & develop sustainably.

Quality of fines has to meet the technological requirement of customers in terms of size, desired lower alumina and silica content. Conventional iron ore processing generates slimes to the tune of 10 to 15 % of run-off-mine (ROM). Low grade fines and slime occupy huge space and cause environmental and ecological problems.

Adoption of a combination of techniques for mining, beneficiation, sintering and pelletisation of ore has resulted in increased use of the fines in iron making. Low-grade ores, with iron content lower than 58% are now used, resulting in increase in mine life and reduction of waste, thereby reducing the need for additional land to dump the waste.

Techniques such as Dredge Mining from slime pond, alternate use of BHQ (Banded Hematite Quartzite) in blast furnace and recycling of waste materials have proven result in reduction in consumption of iron ore per ton of hot metal.

The scope of this paper confines to the ore fines of Dalli-Rajhara. The said deposits show characteristics of low to moderate grade ore which comprises Hematite and Goethite as ore minerals and Quartz, Pseudo Ore and Ferruginous Clay as gangue minerals. Ore minerals distribution is around 28% as a whole and gangue minerals distribution is around 72 % area as a whole.

Main ore mineral is Hematite with 20% area out of which around 6% grains are in free-state and remaining 14% grains are in un-liberated state. Around 7% un-liberated grains could be liberated at 20 micron size. Remaining grains are in less than 15 micron size.

Goethite covers around 10 % area as a whole. All Goethite grains are in less than 30 micron size, out of which around 2% grains are in free-state and remaining 8% grains are not liberated. All un-liberated grains are in less than 20 micron size.

About 9.47 Mt of low grade fines (in course of manual mining in the past) is available and around 14.5 Mt of slimes have accumulated in the tailing dam. Exploratory works have proved more reserves in the wake of lowering of mining cut-off grade from 55% to 45%. The resource base adds to sustenance.

Amenability to beneficiation has been established through lab scale and pilot scale tests. Since the products of slime beneficiation will be of very fine nature, Pelletisation shall be the next logical step. Adverse environmental impact due to accumulated slime, dumped low grade fines shall be mitigated.

Charging of pellets in blast furnaces will improve the performance of the furnaces, which will be reflected in lower coke rate, higher productivity and improved hot metal quality.

Introduction

Utilisation of low grade ore and fines has to play an important role in improving yield of a mine.In India, partly due to the sponge iron sector, the overall percentage of lumps usage in steel making (47 %) is higher than most other countries. As hard ore reserves is depleting day by day, lump generation suitable for blast furnace operation is coming down resulting in production of large amount of surplus fines.

Alternative iron making processes for production of steel may lead to changing pattern of use of material inputs and feed stock causing significant shift in respective share of lumps and agglomerated iron ore (sinter & pellets) and will also enable the use of ores which could not be utilized earlier.

As fines forms considerable part of iron ore resources, value addition to the iron ore fines through various activities such as beneficiation and pelletisation is the need of the hour.

Overview of Dalli - Rajhara

Dalli - Rajhara Iron ore complex is the existing captive iron ore source of Bhilai steel Plant(BSP).It includes Dalli manual mines,Dalli mechanized mines, Jharandalli mines,Mahamaya mines, and Rajhara mechanized mines. Rajhara mine was developed in the year 1960 and Dalli mine was developed in the year 1962.The ore processing plant of Rajhara involves 3 - stage crushing and screening to produce BF grade lumps and sinter grade fines. The ore processing plant of Dalli involves 2 - stage crushing, scalping and scrubbing, wet screening and finally classification.

The above mines are a part of Rajhara hill lease and Mahamaya- Dulki lease of Balod district, Chhattisgarh. The said deposits show characteristics of low to moderate grade ore which comprises Hematite and Goethite as ore minerals and Quartz, Pseudo Ore and Ferruginous Clay as gangue minerals. Ore minerals distribution is around 28% as a whole and gangue minerals distribution is around 72 % area as a whole.

Main ore mineral is Hematite with 20% area out of which around 6% grains are in free-state and remaining 14% grains are in un-liberated state. Around 7% un-liberated grains could be liberated at 20 micron size. Remaining grains are in less than 15 micron size.

Goethite covers around 10% area as a whole. All Goethite grains are in less than 30 micron size, out of which around 2% grains are in free-state and remaining 8% grains are not liberated. All un-liberated grains are in less than 20 micron size.

Challenges

Post modernisation and expansion, the requirement of iron ore for BSP will be around 14 MTPA. Iron ore reserves of the said mines are depleting very fast and it is becoming difficult to meet the requirement of plant. Considering this aspect,BSP is in the process of developing Rowghat mine to meet its future requirement of iron ore.

About 9.47 MT of low grade fines generated in course of mining have been stored in the form of dumps. Fe content varies from 55% to 58%, and silica varies from 7.1 % to 9.5% in these dumps.For fines to be utilised in steel plants, their quality has to meet the technological requirement of ore handling plants, sinter plants and blast furnaces in terms of size, desired lower alumina and silica content.

Wet circuit iron ore processing generates slimes to the tune of 10 to 15 % of run-off-mine (ROM).In Dalli mines, which is processing iron ore through wet circuit, 0.7 MT slimes are produced per annum. About 14.5 MT of slimes has accumulated in the Hitkasa tailing pond. Fe content varies from 49% to 55% in the accumulated slime.

As the mining gets in deeper benches, occurrence of high percentage of silica has been found in iron ore.

Low grade fines and slime occupy huge space and cause environmental and ecological problems.

Managing Iron Ore Fines and Slimes

Beneficiation has a major role to play in utilisation of low grade ore and fines in iron making. It will help in conservation of mineral wealth and mitigation of adverse impact on environment. Combination of beneficiation, sintering and pelletisation of ore will result in increased use of fines in iron making.

Amenability to beneficiation of low grade fines and slime has been established through laboratory scale and pilot scale tests. Beneficiation of low grade fines will be done by Jigging, Spiraling and Grinding mills.

Reclamation of slime from tailing pond will be done by excavators and tippers. The slime beneficiation circuit will consist of hydro-cyclones, magnetic separators, ball mills and concentrate thickeners. Since the products of slime beneficiation will be of very fine nature (<100micron), pelletisation has been considered as the next logical step. Pilot scale studies have been carried out successfully for production of BF grade pellets from the beneficiated iron ore concentrate.

Pelletisation process will include processes like grinding of raw material, balling and induration of green balls.

The final product will be

- Sinter grade fines (- 8 mm size) having average Fe content 64 %, Silica 3.5 % and Alumina 1.65 %
- Pellets (9 - 16 mm size) having average Fe content 65 %

Rejects of slime beneficiation plant will be disposed after pressure filtration in the form of solids (containing around 20% moisture) in a new tailing dump.

Benefits Envisaged

Beneficiation will help in conservation of mineral wealth. Low-grade ores, slimes and micro fines with iron content lower than 50% will be used, resulting in increase in mine life and reduction of waste.

Adverse environmental impact due to accumulated slime, dumped low grade fines shall be mitigated.

The process of pelletisation produces very low environmental emissions as compared to sintering which can be seen from the table given below.

Process	SO_X , gm/t	NO_X , gm/t	CO, kg/t	CO_2 , kg/t	Particulate, gm/t
Sintering	1,670	640	38	220	260
Pelletising, Hematite ore	200	500	1	30	130
Pelletising, Magnetite ore	100	200	<1	25	125

Charging of pellets in blast furnaces will improve the performance of the furnaces, as pellets are characterised by:

- Good Reducibility: Because of their high porosity (25-30%), pellets are usually reduced considerably faster than hard burden sinter or hard natural ores/lump ores.
- Good Bed Permeability: Their spherical shapes and containing open pores, gives them good bed permeability.
- Less heat consumption than sintering: ~ 35-40% less heat is required in pelletisation than in sintering.
- Uniform chemical composition & very low LOI:The chemical composition in the concentration remains within controllable limits. In reality, no LOI makes them cost effective.

Conclusion

Mineral resource need to be conserved and extracted optimally in an ecologically acceptable manner to ensure sustainable development. Since iron ore reserves are depleting very fast, increasing the mineral resource base and full exploitation of available resource is the need of the hour. For encouraging use of pellets made from low grade iron ore / slimes / dump fines after beneficiation, as a value added product, government must give incentives by way of IT benefits, lower royalty rates and removal of export duty on pellets.

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