CHALLENGES OF INDIAN IRON ORE INDUSTRY – GEOLOGY, MINING AND PROCESSING PERSPECTIVE[1]

Suresh Srivastava[2]
Milind Chikhale[3]

Abstract

National Steel Policy of India envisages more than 200 million tonnes of steel production by 2025-26. An iron ore requirement of about 500 million tonnes, more than 2.5 times the current iron ore production of about 200 million tonnes, needs to be met for achieving this including the export demand and commitments. This paper covers the issues and concerns related to geology, mining and processing of Indian iron ore, and the possible solutions and way ahead for achieving the desired goals. It includes reserves and resources of Indian iron ore, its type, distribution and mineralisation, the need for detailed exploration as well as improved mining practices in view of conservation and better utilisation for sustained growth; the challenges of processing low grade in-situ ores, stacked -10/6 mm fines and -0.150 mm slimes impounded in tailing ponds as a result of selective mining and processing of high grade iron for decades for pig iron and sponge iron production through BF-BOF/LD and DRI (mainly coal based)/EAF-IF routes; agglomeration of fine concentrate mainly into pellets and its need for maximum utilisation in the existing and upcoming Blast Furnace, DRI as well as alternate process based iron making plants.

Key words: Iron ore; Beneficiation; Mining; Geology.

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[2] *Head, Iron Ore, Hatch Associates India Pvt. Ltd., India.*
[3] *Specialist Process Engineer, Hatch Associates India Pvt. Ltd., India.*

1 INTRODUCTION

The Indian steel industry entered into a new development phase from 2007-08, riding high on the resurgent economy and rising steel demand. This led to India occupying the position of 5th largest iron ore and 4th largest steel producing country in the world, producing more than 200 million tonnes of iron ore and nearly 70 million tonnes of steel in 2010-11. Though the Indian Iron and Steel Industry witnessed exponential growth in the last decade, it falls short of national and world expectation. In consequence, a draft National Steel Policy 2012 has been formulated by the Government of India which aims to accelerate the growth in order to meet the estimated demand of 202 million tonnes per annum of steel by 2025-26 (considering a GDP growth of 7% per annum). Thus, the projected iron ore requirement for achieving the envisaged crude steel production capacity of 244 million tonnes per annum by 2025-26 is about 392 million tonnes, almost double of current iron ore production.(1)

Such a quantum jump in production would require matching iron ore resources and their exploitation on a sustainable basis. As per the National Mineral Inventory (as on 01.04.2010) the total iron ore resource in the country is around 28.52 billion tonnes, of which about 17.88 billion tonnes is hematite and 10.64 billion tonnes is magnetite.(2) The present iron ore production comes mainly from high grade hematite reserves. Magnetite reserves because of its poor grade and non-lumpy nature are not exploited. The reserves of hematite are estimated to be about 8 billion tonnes, which may be just sufficient for 15-20 years. Depleting high grade reserves coupled with increasing demand poses huge challenges for the geological, mining and beneficiation activities.

This paper discusses the existing scenario of the resources, its exploitation, mining and processing/beneficiation, the challenges ahead for achieving sustainable growth of the iron ore as well as iron and steel industry, and the way forward for meeting the set goals.

2 INDIAN IRON ORE RESOURCES

India is endowed with large resources of iron ore, which is estimated to be about 28.52 billion tonnes of both hematite and magnetite ores.

Table 1. Iron Ore Resources as on 01.04.2010 (In billion tonnes)(2)

Ore	Reserves	Remaining Resource	Total
Hematite	08.09	09.79	17.88
Magnetite	00.02	10.62	10.64
Total	**08.11**	**20.41**	**28.52**

The above figures are likely to have an upward revision by 15-20% due to the fact that the published figures are based on +60% Fe cut-off as against +45% Fe cut-off now adopted by the industry. Thus, there is urgent need of adopting exploration programmes to convert more and more resources to reserves category.

Around 96% of total hematite resources of India are distributed in 5 states with the balance in 7-8 other states. The state –wise distribution position of of major resource is given in Table below, in their order of abundance.

Table 2. State-wise Distribution of Hematite Reserves/Resources of India (In million tonnes)[2]

State	Reserve	Remaining Resource	Total resources
Orissa	3,313.001	2,617.232	5,930.233
Jharkhand	2,304.142	2,292.479	4,596.621
Chhattisgarh	900.110	2,391.714	3,291.824
Karnataka	876.866	1,281.811	2,158.677
Goa	469.844	457.327	927.171
Andhra Pradesh	152.216	229.261	381.477
Maharashtra	13.414	269.794	283.208
Madhya Pradesh	56.814	174.631	231.445
Other States	7.139	74.302	81.441

3 GENERAL GEOLOGY

The iron ore occurrences in India are distributed in different geological formations but the most important deposits of economic importance belong to Pre-Cambrian age. The Pre-Cambrian banded iron ore formations are grouped into five (5) major zones as shown in Figure 1.

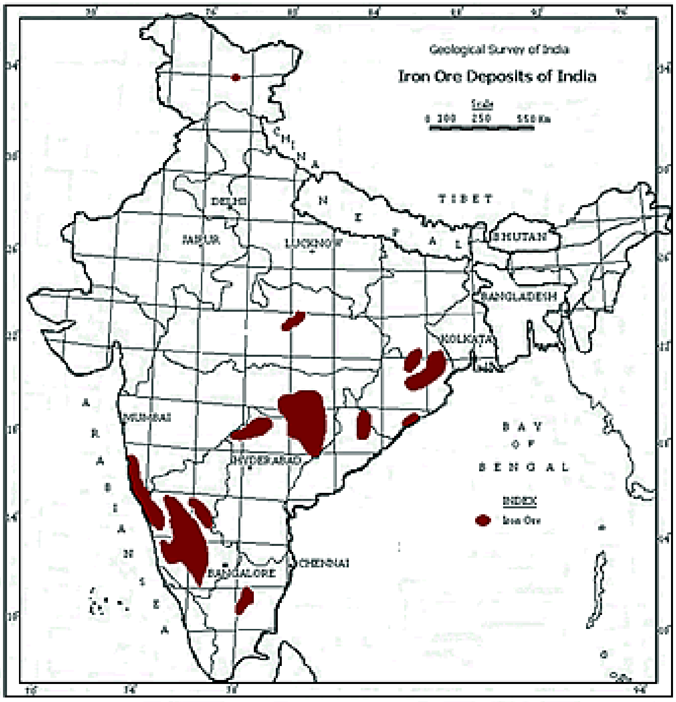

Figure 1. Zonal distribution of Indian iron ore. *Source: Geological Survey of India*

Table 3. Zone-wise characterisation of Indian iron ore[3]

Zone	Location	Nature of mineralisation
A	Bonai Iron ore ranges in Jharkhand & Orissa and in adjoining areas in eastern sector	In BHQ/BHJ formations, the mineralisation occurs as massive ore (58-66% Fe), laminated ore, shaly ore, blue dust (66-68% Fe).
B	N-S trending linear belt in Central India in the States of Chhattisgarh, M.P. & East M.S.	Associated with BHQ, mainly laminated & massive ore of high grade hematite (64-68% Fe).
C	Bellary-Hospet region of Karnataka	BHQ/BHJ intercalations of ferruginous shale containing long, narrow and scattered patches of hematite (58-64% Fe).
D	Goa & West Maharashtra	Predominantly (nearly 80%) blue dust (63-64%) Fe and fines (59% Fe) with little lumps.
E	Magnetite deposits of Karnataka	Occurs as thick bands and lenses of hematite/magnetite in BHQ/BMQ formations (57-62% Fe).

Hematite and magnetite are the major ore minerals. Hematite deposits are mainly in the States of Jharkhand, Orissa, Karnataka, Chhattisgarh and Goa. Magnetite deposits are mainly in the States of Karnataka and Tamil Nadu. The quality of Indian iron ore resources is excellent with high Fe content and high share of lumpy ore. Almost 60% of hematite resources have Fe grades above 62% and 45% lumpy ore, 33% fines and 12% classified as lump with fines and balance not classified.

3.1 Exploration

The level of exploration carried for resource estimation has not been adequate. Most of the iron deposits were explored 50-60 years back when the Integrated Steel Plants (ISP) first came up. The exploration was done as per the prevailing technology then and keeping in view the raw material requirement of the Steel plants. Hence, iron ores having more than 60% Fe were considered for resource estimation. The low grade ores were overlooked. Their estimation is little where they co-exist with the high grade ores and even lesser for exclusive deposits.

Thus, the figures of resources might appear huge but do not depict the actual resource position because of the following reasons:

- shallow and scanty levels of detailed exploration;
- no modern methods of exploration having been implemented;
- extremely high cut-off grades viz. +55 - +60% in evaluation which is extremely high.

3.2 Challenges and Way Ahead

India has a vision to reach a level of 500 million tonnes per year of iron ore production including domestic and export requirements. Hence, it becomes imperative to expand the resource base and convert the resources assessed to reserves category to provide raw material security in the long run. The Fe cut-off has been revised and brought down to 45%. Hence, there is a requirement of reassessing the entire resources and reserves at the current cut-off through detailed classification of ore types. Further, measures on conservation need to be systematically adopted.

In order to ensure raw material security for sustainable growth in steel production, the following measures need to be taken-up:

- exploration for new deposits both low grade and high grade, exploration of free-hold area/ other areas in mining leases not yet explored;
- conversion of remaining resource of hematite to reserves category through detailed exploration,
- exploration of low grade ores co-existing with high grade ores or exclusively;
- systematic evaluation of sub-grade ores like lateritic ore, siliceous ore, thick iron banded BHQ, Conga ore, ferruginous shaly ore;
- proper evaluation of magnetite resources, which stand at 10 billion tonnes and not yet exploited properly;
- exploration at greater depths than 50/60 meters as well as below existing pit bottoms of working mines.

A systematic and detailed approach using modern technology for exploration needs to be adopted. Geophysical methods may be employed for faster coverage.

4 MINING

Mining of iron ore in India is carried out by open-cast/open-cut method. The operation is manual as well as mechanised. Manual mining is confined to float ores. More than 90% of iron ore production comes from the mechanised mines. In general, shovel-dumper combination is adopted for winning iron ore. Bench formation is accomplished by drilling and blasting. The bench height ranges from 6 to 14 m and slope of benches from 45^o to 60^o. Where the ore is softer, bench height ranges from 4 to 7 m, and hydraulic excavator and wheel loader are the principal loading equipment. The bench height depends on various factors such as production required, disposition of ore-body, geological disturbances, machinery to be deployed etc. The bench width depends mainly on the size of the machinery deployed and is approximately three times the width of dumper. The length of face is dependent on factors such as output required, variation in grade and blending requirement, contours of the deposit etc. The pattern of blast-holes is governed by the hole-diameter, bench height, drilling machinery, nature of rock and type of explosives used. Normally, rotary drill of size 150 to 250 mm is used.

4.1 Challenges and way ahead

With the envisaged increase in production of iron ore for targeted steel production, there is a need to go for large scale mining operations. Larger and deeper mines will have to be operated at higher rate of production. This will call for greater bench heights, larger blast-hole diameters and larger machinery. Desired grade control of ROM feed to the processing/beneficiation plant for treating the ore in its totality will be required. Opening up and simultaneous working on multiple benches at different depths will have to be carried out. This will also bring into play greater considerations required for minimal environmental impact and degradation due to large scale operations.

The challenges can be overcome by application of appropriate technology and proper mine design. On the technology side, continual advancement in equipment design has made possible deployment of high performance equipment. Feasibility of innovative techniques like continuous surface miner for harder formations, high angle belt conveying system and In-pit crushing and conveying system (IPCC) both semi-

mobile and mobile needs to be studied for various deposits particularly new ones. Similarly, underground mining techniques for, mainly, magnetite deposits in eco-fragile regions need to be studied for its implementation. There is vast scope for implementation of automation and control like automatic truck despatch system in the Indian mining industry. Advancement in the blasting techniques and explosives system need to be leveraged. On the mine design side, it is imperative to go for detailed mine design with scheduling for the life of the mine for getting the desired ROM ore output.
The technological developments which have taken (some which are still under trial phase) in the fields of drilling, blasting, excavation and haulage and transport system have been adopted in various part of the world. India too needs to follow the same success path. In fact many of the recent technological developments as summarised below have already been adopted with satisfactory results.

4.1.1 Drilling

Large diameter rotary drills up to 500 mm are being used globally. Efficient and safe, automated such drills with dry/wet dust suppression system can provide expanded drilling pattern and be used with appropriate explosives.

4.1.2 Blasting

Emulsion explosives have already replaced nitro-glycerine (NG) and water gels. Electronic delay detonators hold great promise. Non- electric delay initiation and bulk explosive systems have been adopted by the Indian mining industry. ‘Opti-blast’ and ‘Air decking’ have potential for wider application. Controlled blasting technique and computer blast models provide better blasting results.

4.1.3 Excavation

Bigger and better electric rope shovels, front end loaders as well as hydraulic shovel with dual engine concept having superior bucket design are available and finding application in the Indian mining industry. Riper Dozer has found application in softer ores and for overburden as an alternative to drilling and blasting. Surface Miner has potential for application. Global Positioning System (GPS) needs to be adopted for better shovel productivity.

4.1.4 Haulage and Transportation System

High capacity dumpers are available for deployment with the bigger shovels for achieving higher productivity. Trolley assisted truck haulage system has good potential for deep mines. Statically excited electric control drive system and articulated dumpers have been adopted. Improved haul road design, In-Pit Crushing and Conveying for deeper mines, GPS based computer aided truck dispatch system and advanced methods of condition monitoring for maintenance await introduction and wider application in near future.

5 IRON ORE PRODUCTION, CONSUMPTION AND EXPORT

The production of iron ore was 218.6 million tonnes in 2009-2010 and 208 million tonnes in 2010-2011.[3] The production of lumps, fines and concentrates in 2010-2011 is presented in Figure 2.

Figure 2. Production of iron ore lumps, fines and concentrates.

The grade-wise production of iron ore lumps and fines in 2010-2011 is presented in Figure 3 and Figure 4.

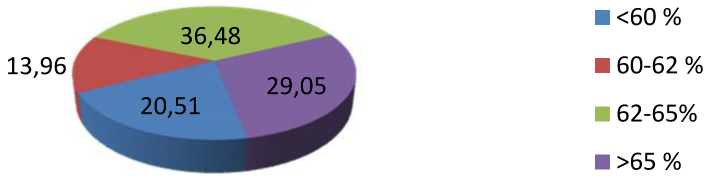

Figure 3. Grade-wise production of iron ore lumps.

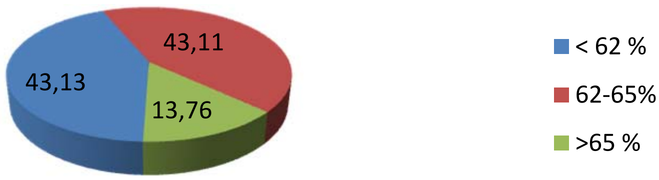

Figure 4. Grade-wise production of iron ore fines.

In 2010-11, the total domestic consumption was about 104.05 million tonnes. Iron and Steel Industry accounted for 98% of it. The figures indicate that only about 50% of iron ore produced is consumed domestically. The rest mainly constituted by fines is exported due to absence of adequate beneficiation and agglomeration (pelletization and sintering) facilities.

The general user specification of iron ore lumps, fines and concentrates is presented in Table 4.

Table 4. General specification of iron ore lumps, fines and concentrates

Lumps, Fines and Concentrate	**Chemical Constituents**			
	Fe (T)	**SiO_2**	**Al_2O_3**	**P**
High-Grade	65% & above	2% max	2% max	-
Medium-Grade	62 to 65 %	3% max	3% max	0.1% max
Low-Grade	60 to 62 %	4.5% max	4% max	0.1% max
Unclassified	The range of a minimum and maximum value of chemical constituents is too wide to be fitted in to any of the above grade			

6 IRON ORE PROCESSING/ BENEFICIATION

6.1 Background and Practice

In India, processing of iron ore rather than its beneficiation has been carried out until recently.

The processing of iron ore has been mainly of higher grade hematite ore produced for meeting the raw material requirement of the iron and steel industry. The high grade iron ore is produced by selective mining.

Steel production in India is majorly by two routes:

- Blast Furnace and Basic Oxygen Furnace (BF and BOF/LD) generally adopted in Integrated Steel Plants (ISP);
- Scrap/DRI or Sponge iron and electric arc furnace (EAF) and Induction Furnace (IF) adopted by Mini Steel Plants (MSP).

Lumps in size -40+10 mm/- 30+6 mm, sinter and pellets form the feed to the Blast Furnace for production of pig iron whereas lumps in size -18+6 mm, steel scrap and pellets are required for production of sponge iron through DRI route.

About 2.5 tonnes of run of mine (ROM) iron ore or 1.7 to 2.0 tonnes of processed iron ore is required for 1.0 tonne of steel production. Hematite and magnetite are the most prominent iron ores found in India. However, hematite because of its high grade and lumpy nature is the most exploited one for iron making.

The domestic production of lumps and fines is in the ratio of about 2:3. High grade lumps and fines are utilised whereas the remaining iron ore which is invariably fines is exported due to absence of adequate agglomeration facilities in the country. Also, usage of lumps in India is around 40% against 15-20% globally.

During the past six decades the general practice adopted has been utilisation of medium to high grade ore (+62%) in the major steel plants. This is achieved by selective mining of high grade ore keeping the cut-off to 58-60% Fe. Thus the main objective of processing/beneficiation is to meet the physical standards and reduction of alumina content which is high in Indian iron ore.

The high grade ROM ore is subjected to dry processing through multi-stage crushing and screening for production of -40+10/-30+6 /18+6 mm lumps and -10/6 mm fines. The lumps are utilised for iron making, however, the fines are either exported or stacked at the mine site. This kind of practice is prevalent in the non-captive sector.

In the captive sector, the ROM ore is processed through multi-stage crushing, screening and washing for production of -40+10 mm/- 30+6 mm lumps and -10/6+0.150 mm sinter fines for their ISPs. The -0.150 mm (100 mesh) slimes is impounded in the tailings pond. The slime loss is about 20-25%.

The dry and wet processing schemes are shown in Figures 5 and 6.

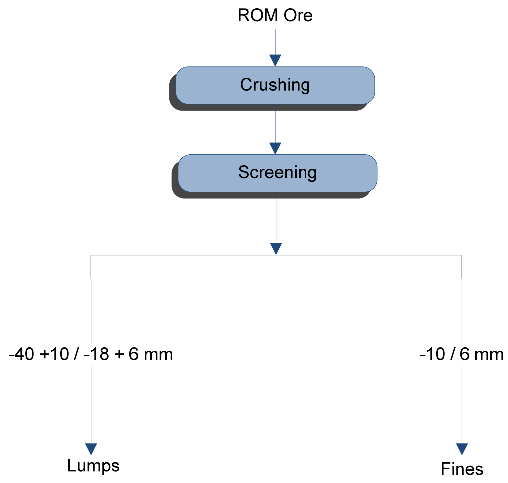

Figure 5. Dry processing.

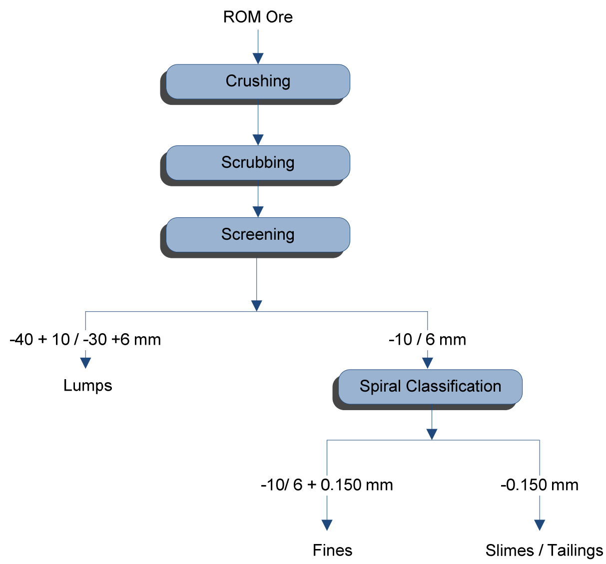

Figure 6. Wet processing.

During wet processing, the aim is to restrict alumina content in the lumps and sinter fines to 2.5-3% and 5-6% respectively. The classifier fines are not beneficiated further and used as such, mostly being of inferior grade, for sinter making.

The alumina content in Indian hematite ore is high, ranging from 1 to 7% whereas the silica content is low. Thus the alumina: silica ratio is high. The same is detrimental to blast furnace as well as sinter plant productivity and hence, not desired.

The processing/ beneficiation practice followed until now has resulted in the following:

- non-exploitation of low grade/sub-grade iron ore lying in-situ due to selective mining or stacked in the mine site due to utilisation of higher grade ore only;
- large quantities of -10/6 mm fines stacked in the mines and -0.150 mm slimes in the tailings pond amounting to millions of tonnes with considerable iron values. The ever increasing stock is causing land and environmental issues.

6.2 Challenges

India is almost self sufficient in terms of resources. But with the envisaged crude steel production capacity of 244 Mtpa and requirement of iron ore, including exports, to the tune of 500 Million tonnes by 2025-26, there is a need to exploit the resources judiciously for sustainable growth. If the dependence on high grade ore is continued, the resources would get depleted in another 15-20 years.

It is in this regard that the mining threshold has been revised to 45% Fe and 35% Fe for hematite ore and siliceous hematite ore respectively. It is now obligatory for the mine operators to exploit and utilize low grade ores which until now was not happening. In fact there is need for starting exploitation of Banded Hematite Quartzite/ Banded Hematite Jasper and magnetite ore. This will help in increasing the resource base for sustainable growth.

There has been a change over the years in the nature of feed particularly iron ore for iron making. Higher proportion of quality sinter and pellets are replacing lumpy ore in the burden with benefits such as reduction in the consumption rate of coke.

Talking about agglomerates i.e. sinter s and pellets, sinters produced after agglomeration of -10/6 +0.150 mm fines are porous and brittle. Hence, they cannot be transported to long distances. This is the reason that sinter plants are located in the steel plant premise of ISPs and MSPs. Sinters can form 20-70% of iron ore feed to the Blast Furnace. Sinter production in India is about 31 Mtpa against the installed capacity of 39 Mtpa.

On the other hand, pellets produced after agglomeration of -325 mesh fines are hard and compact. They can withstand the rigours of multiple handling and can be transported over long distances. They provide better permeability than lumps and sinters. Pellets can form 15-20% of iron ore feed to the BF apart from its usage in the DRI process.

BF-BOF/LD and DRI-EAF/IF routes will account for 66% and 33% of envisaged steel production respectively. Hence, there will be a requirement of about 75 Mtpa of pellets. The installed capacity of pellet plants is about 28.8 Mtpa and production is only 11.5 Mtpa.

Thus the challenges that need to be overcome from the perspective of iron ore beneficiation are:

- Utilisation/ Beneficiation of stacked -10 mm fines in mines and -0.150 mm slimes impounded in the tailing ponds;
- Beneficiation of low-grade/ sub-grade ore in-situ or stacked in the mines;
- Processing of ROM ore in its totality particularly for the new deposits;
- Beneficiation of magnetite;
- Beneficiation of Banded Hematite Quartz (BHQ) and Banded Hematite Jasper (BHJ).

6.3 Way Ahead

Considerable amount of ore characterisation, mineralogical studies and beneficiation test works have been carried out for different ore types from different deposits of the country. Sufficient information, data and test results are available to overcome the challenges. In fact, steps have started in this direction by way of implementation of some beneficiation and pellet plant projects. Also, some projects are in the pipeline.

The following section covers the beneficiation schemes that can be adopted for the above-mentioned iron ore materials and types.

6.3.1 Iron ore fines in size -10/6 mm

Huge stacks amounting to several million tonnes of -10/6 mm fines are available for beneficiation in various mines. In the non-captive sector, these fines have been produced by dry processing of higher grade ROM ore for production of lumps. They can be ground to appropriate size for liberation of iron bearing minerals and subjected to gravity separation (Spiral concentrator/ Upstream classifier) and magnetic separation (WHIMS/ HGMS/ SLon) for obtaining pellet grade concentrate. The blue dust can be used as required for sweetening purpose i.e. increasing the grade of pellet feed concentrate to desired extent.

In the captive sector, the -10 mm fines are being treated in the spiral classifier to obtain -10+0.150 mm sinter fines. However, they have high silica and/or alumina content. They are being presently used as inferior sinter feed material. However, beneficiation of these fines can be done through gravity and magnetic separation wherein silica and alumina content can be reduced for producing sinter grade fines and pellet fines. Thus, more than 50% of material can be recovered as sinter and pellet fines or pellet fines.

A typical flow sheet for production of sinter fines and pellet fines from -10 mm fines is presented in Figure 7.

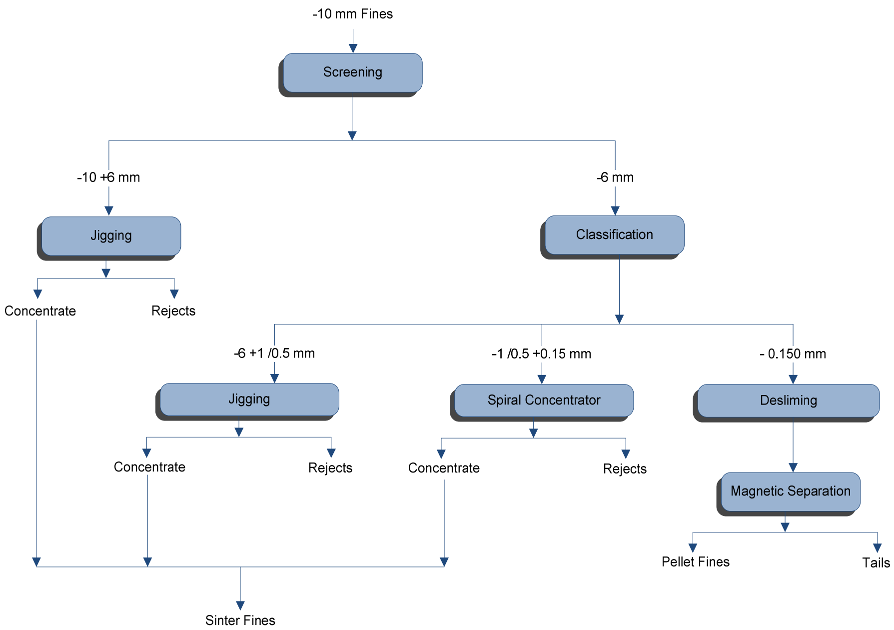

Figure 7. (-)10 mm fines beneficiation.

6.3.2 Slimes in -0.150 mm size impounded in the tailing ponds

Large quantities of slimes in -0.150 mm have been impounded in the tailings pond after wet processing of hematite ore. They contain considerable iron values as the Fe content in these tailings is over 50%. In these tailings, limonite and goethite minerals are more predominant along with silica bearing and clay minerals accounting for high silica and alumina content. However, they can be beneficiated to obtain pellet feed fines with yield up to 30%. This concentrate can be admixed with high grade fines like the blue dust to obtain the final pellet grade fines.

A typical flow sheet for producing pellet fines from slimes through magnetic separation is presented in Figure 8.

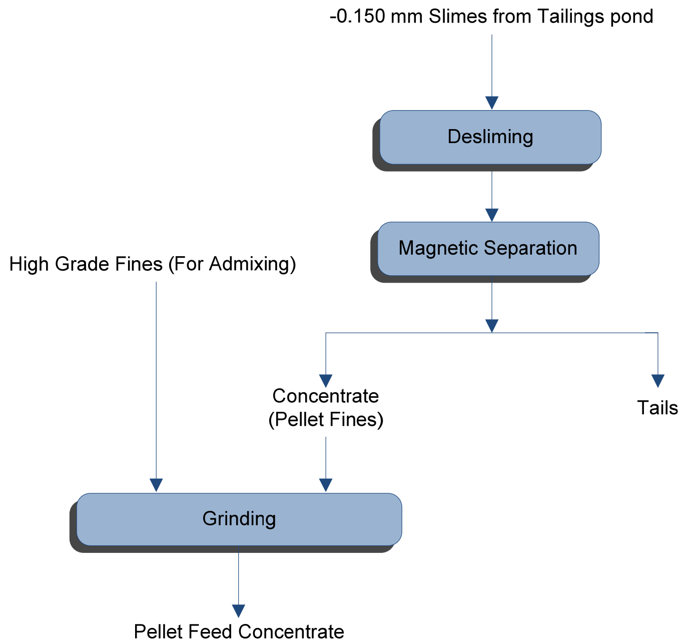

Figure 8. (-)0.150 mm Slimes Beneficiation.

6.3.3 Sub-grade ore, in-situ or stacked at the mine site

Large quantities of sub-grade iron ore is lying in-situ or stacked as rejects in the mines due to exploitation and usage of higher grade ore only. These ores contain Fe more than 45% and up to 60%. They can be beneficiated through gravity and magnetic separation after appropriate size reduction for liberation of hematite from gangue minerals. Either sinter and pellet fines or only pellet fines can be produced.
A typical flow sheet for production of sinter fines and pellet fines from sub-grade ore is presented in Figure 9.

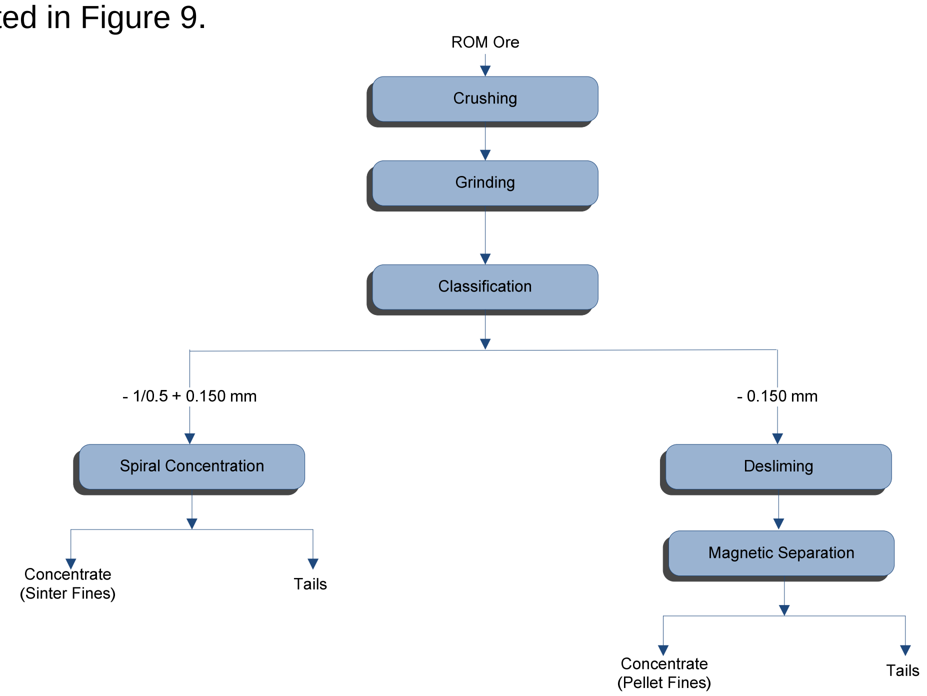

Figure 9. Sub-Grade Ore Beneficiation.

6.3.4 Total beneficiation

It is very important that the ROM ore mined at the cut-off grade of 45% Fe particularly from the new deposits is beneficiated in its totality. This will help in optimum exploitation and utilization of reserves.

In most of the cases the ROM ore can be crushed to -30 mm size in multiple stages and various size fractions can be beneficiated through gravity and magnetic separation techniques for obtaining B.F. grade lumps, sinter fines and pellet fines. The cut-off for beneficiation may be higher than the mining cut-off and will require stacking of ore below the beneficiation threshold.
A typical flow sheet for Total Beneficiation of ROM ore is presented in Figure 10.

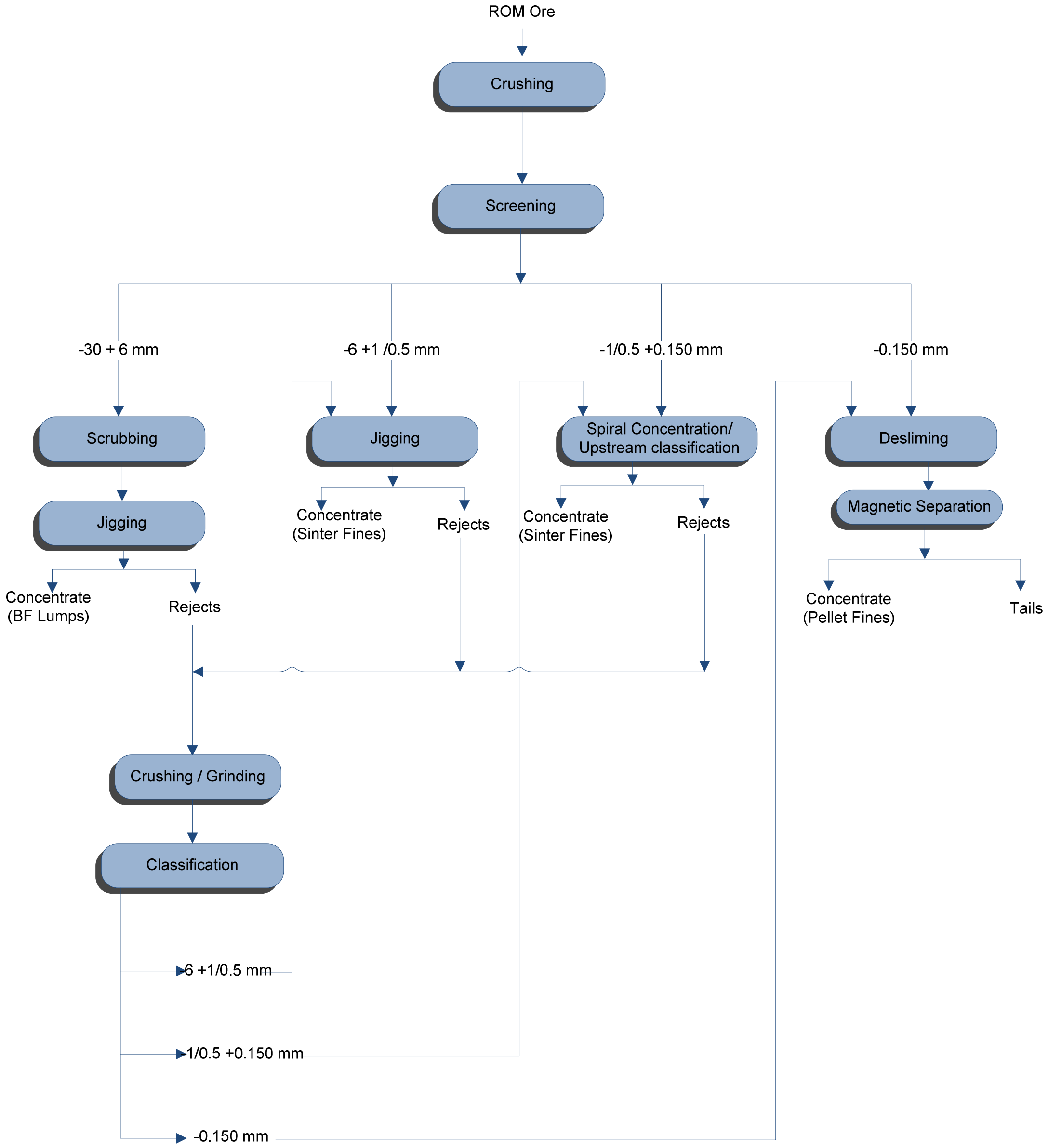

Figure 10. Total Beneficiation of ROM Ore.**+**

6.3.5 BHJ/BHQ beneficiation

BHQ/BHJ ore typically contains equal proportion of hematite and silica, about fifty-fifty percent, in the finely crystalline form of quartz called Chert. The Fe content is low in the range of 30-35%. The iron bearing hematite can be liberated after size reduction to very fine size around 100 microns. The ground ore can be beneficiated through gravity separation in spiral concentrators to obtain pellet fines.
A typical flow sheet for BHQ/BHJ Beneficiation is presented in Figure 11.

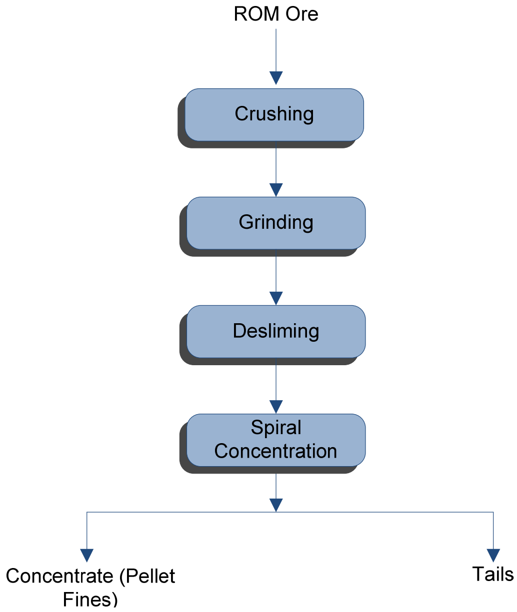

Figure 11. BHQ/BHJ Beneficiation.

6.3.6 Magnetite beneficiation

Magnetite is present in abundance and accounts for more than 37% of total resources of 28.5 Billion tonnes. It contains Fe in the range of 35-40% in many cases. The crushed and ground ROM ore can be subjected to magnetic separation for obtaining pellet fines.

A typical flow sheet for magnetite beneficiation is presented in Figure 12.

Depending on the ore and material to be beneficiated, the flow sheet for a particular project can be designed after test work. In recent times, leading companies have taken steps in this direction. Handful projects of fines and total beneficiation have been commissioned. Some slime beneficiation and fines beneficiation projects are under construction phase. A few pellet plants have also been installed. However, much needs to be done.

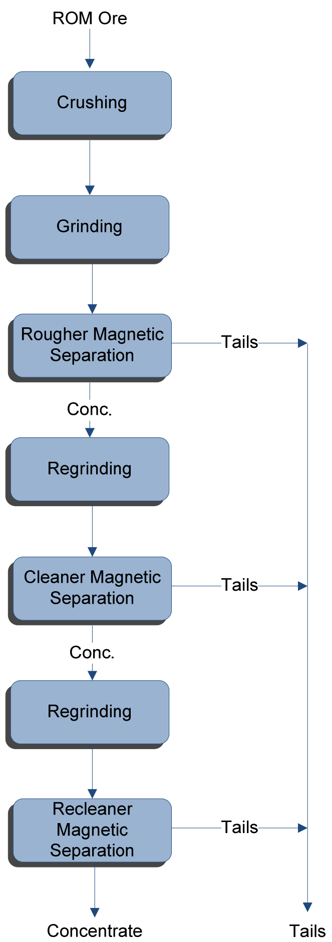

Figure 12. Magnetite Beneficiation.

7 CONCLUSION

In the background of past and current mining and processing practices, the envisaged growth of Iron and Steel Industry as per National Steel policy has thrown a lot of challenges to the Iron Ore Mining and Mineral Sector.

These challenges need to be overcome for achieving sustainable growth of the Indian Iron and Steel Industry. It is imperative that resource base is expanded and properly evaluated through detailed drilling and use of modern technology, the technological developments in the fields of drilling, blasting, excavation and hauling and transportation system are leveraged for the large scale mining envisaged and processing of low grade/sub-grade ore, stacked fines, slimes, BHJ/ BHQ and magnetite is carried out.

The approach to process/ beneficiate the ore depends to a very large extent on the requirements of the iron and steel making industry which now accepting more agglomerates in its iron making feed. The national Steel Policy envisages steel production through Blast Furnace and DRI routes in the proportion of 66% and 33%. Higher growth in the DRI sector particularly coal- based process is foreseen in India. Hence, there is great potential for use of sinters and pellets, particularly pellets. The lower grade ores, both hematite and magnetite, can be exploited for production of sinter fines and pellets fines or pellets fines only.

The following steps need to be taken up for optimum utilisation and conservation of iron ore resources for sustainable growth of the Iron and Steel Industry in India.

7.1 Exploration and Evaluation

- Converting existing hematite resources into reserves by detailed exploration followed by feasibility;
- Persistence of hematite beyond 60m, which was hitherto the limit of exploration to be evaluated;
- Adopting proper drilling technologies for reliable data generation;
- Use of surface geophysical techniques for faster coverage;

7.2 Mining

- For achieving higher productivity, use of surface miner and in-pit crushing and conveying system needs to be considered,
- Consolidate the small fragmented mines, which are not operating with modern technology and hence not extracting optimum volumes and leave behind sterilised iron ore for the future,
- Feasibility of underground mining methods to exploit large magnetite resources that are locked up in ecologically-fragile areas;\

7.3 Beneficiation & Agglomeration

- Implementation of total beneficiation concept for ROM ore to be produced at 45% Fe cut-off in new deposits;
- Immediate use of available -10 mm stacked fines in non-captive sectors and -0.150mm slimes impounded in the tailing ponds of washing plants;
- Further processing of sinter fines produced as classifier sands for reduction of alumina and better sinter productivity in the captive sector
- Utilisation of low grade/ sub-grade ore, in-situ or stacked at the mine site;
- Beneficiation of BHJ/ BHQ and magnetite;
- Augmentation of existing sinter plant capacity by ISPs;
- Augmentation in existing pellet plant capacity by the non-captive sector;
- New pellet plants by ISPs and non-captive sector;
- Push for more usage of pellets in coal based DRI plants predominant in India;

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