CHAPTER 1

Executive Summary

Iron and Steel Industry's growth in India has been exceptional. The exponential growth witnessed reflects the robustness of the Industry. National Steel Policy 2005 estimated domestic steel production to grow by 7.3% annually and consumption to grow by 6.9% and projected steel production of 110 million tonnes by the year 2019-2020. However, in 2006-2007 domestic steel production grew at the rate of 10.9% and consumption at 11.6%, accordingly, the estimate for production of steel was revised in 2008 and was projected at 180 million tonnes as target to be achieved by 2019-2020.

1. Steel in India is presently produced via two major routes:

   (a) The blast furnace (BF) and basic oxygen furnace (BOF/LD) route of steel making are generally adopted in Integrated Steel Plants (ISP). These plants are large in capacity that range from 1 to 5 million tonnes per year and occupy a fairly large area of 4 to 8 sq.km.

   (b) Scrap/DRI or sponge iron and electric arc furnace (EAF) and induction furnace (IF) route of steel making as adopted in Mini Steel Plants (MSP) are small in capacity and range from 0.5 to 1 million tonne and in some cases are up to 2 million tonnes per year. These plants are usually setup in areas not exceeding 2 sq.km.

2. Pig iron and sponge iron forms the feed for steel making. Integrated Steel Plants (ISP) require large capital investment, longer gestation period and depend on metallurgical coke which is not easily available. DRI units on the other hand require limited capital investment, shorter conception period and the reductant used can be non-coking coal or natural gas. Consequently, the DRI process became popular among developing countries. Such units in large number are spread across the country and India is the largest producer of sponge iron (coal based) in the world.

3. The present installed capacity of steel making in the country is about 78 million tonnes, however, the actual production reported in 2009-10 was 65.51 million tonnes. The projection target reflected in the National Steel Policy (NSP 2008) is 180 MTPA steel production by 2019-20, which is of a threefold rise and highly ambitious. If this projected target has to be realised, the major step that would need immediate effectuation will be enhancement in iron making capacity in almost all the three routes of BF, DRI & Liquid iron process routes followed by BOF, EAF and IF for steel making.

4. National Steel Policy also assumes that around 60% (about 108 MTPA) of the new steel capacity would come up through blast furnace and BOF route, 33% (about 60 MTPA) through sponge iron & EAF/IF route and 7% (about 12 MTPA) through other routes.

5. Blast furnace route of iron making would continue to dominate the iron production in India followed by sponge iron (DRI). Lumpy iron ore (-30+10 mm) and agglomerates like sinter & pellets form the feed for the production of pig iron in blast furnace; whereas, steel scrap, lumpy iron ore (-18+6 mm) or pellets are the feed for sponge iron production.

6. In order to achieve such enhancement in steel making, the industry's key concerns, include increasing raw material insecurity, constraints in creation of new projects, expansion of existing projects and infrastructure bottlenecks require to be addressed.

7. Iron ore is the basic raw material for iron production. Hematite and magnetite are the most prominent of the iron ores found in India. Of these, hematite is considered to be the most important iron ore because of its high-grade quality & lumpy nature, which is consumed by a large number of pig & sponge iron industries in the country i.e., 98% of the total domestic consumption.

8. India is bestowed with large resource of iron ore. Iron ore occurs in different geological formations. However, major economic deposits of iron ore are found associated with volcano-sedimentary Banded Iron Formation (BIF) of Precambrian Age. Geographically, the Precambrian banded iron ore formations are distributed in five broad belts/zones, wherefrom, hematite—an enriched ore which is also the principal ore for iron making in the country is mined. The five prominent zones are:

Zone A : Singhbhum in Jharkhand and Cuttack in Orissa

Zone B : Dantewara & Durg in Chhattisgarh and Chandrapur & Gadchiroli in Maharashtra.

Zone C : Bellary-Hospet belt in Karnataka.

Zone D : Goa, Ratnagiri in Maharashtra and North Karnataka.

Zone E : Metamorphosed BIF along the West coast in Karnataka and Kerala.

9. Most of the iron ore deposits in India were explored during 1950s and 1960s with the advent of major Integrated Steel Plant (ISP) in the Public and Private Sector. Keeping in view of the availability of high-grade lumpy hematite ore in the country and then technical know-hows of iron making in vogue i.e., blast furnace route requiring high-grade lumps, exploration agencies laid emphasis on establishing resource of iron ores whose grade were 60-63% Fe. Consequently, while exploration and after preliminary classification of the various ore types in a particular deposit, zones of lower grade ores were totally overlooked. Exceptions were made where low-grade iron ore deposits were found associated with high-grade types. Exclusively low-grade iron ore deposits were, however, totally ignored then.

10. Almost all the five major iron ore belts were explored for high-grade ores only. The country has huge resource potential of low-grade iron ore in this belt too, although, exploration efforts were highly inadequate.

11. As per United Nations Framework Classification (UNFC) of mineral resources, total resources of iron ore in the country is around 28.52 billion tonnes (National Mineral Inventory as on 1.4.2010). Hematite and magnetite are the principal ores of iron. Hematite estimated to be about 17.88 billion tonnes has 8.09 billion tonnes under "reserve" category and 9.79 billion tonnes under "remaining resource" category. Whereas total resources of magnetite estimated at 10.64 billion tonnes has under reserves category a mere 0.02 billion tonnes while 10.62 billion tonnes are placed under remaining resources.

12. A close look at the gradewise share of hematite reserves in the country will reveal that a cut-off grade of + 60 % Fe has only been taken for exploration programme as against present threshold of 45 % Fe and hence reserve estimates were significantly on the lower side.

13. Almost all of the present-day production of iron & steel products comes from hematite reserves. Magnetite reserves are not exploited for domestic consumption as these are mostly in eco-fragile areas of the Western Ghats. Existing reserves of hematite merely account for around 28% of the total iron resource of the country (28.52 billion tonnes). In India, hematite reserves and resources are mostly confined to the States of Orissa (42% & 34%), Jharkhand (29% & 26%) Chhattisgarh (11% & 19%), Karnataka (11% & 12%) and Goa (6% & 5%). The balance (1% reserves & 4% resources) is spread across Maharashtra, Andhra Pradesh, Uttar Pradesh, Rajasthan etc.

14. About 2.5 tonnes of r.o.m. iron ore or 1.7 to 2.0 tonnes of processed iron ore is required for per tonne of steel production. To meet the projected steel production of 180 million tonnes (by 2019-20), the r.o.m. iron ore requirement would have to be in the order of over 500 million tonnes per annum which includes long term projected export contracts of around 100 million tonnes.

15. India is almost completely self-sufficient with regard to iron ore but with future steel production envisaged, the adverse impact that would befall on the reserves position is rather imminent. The existing reserves (NMI 1.4.2010) of hematite (averaging around 63% Fe) are the only source of iron ore and as such, and these reserves may not last beyond 15-20 years maximum at the present rate of steel production. Hence, to meet the future and projected targets, additional domestic resources have to be created.

16. With high-grade iron ore reserves under the threat of depletion despite revision of threshold value of iron ores to 45% Fe & 35% Fe (from hematite ore & siliceous hematite ore respectively), it is obligatory on the part of Mining Industry to consider exploitation and utilisation of low/lean-grade iron ores which hitherto were sidelined as waste for effective utilisation. The fresh exploration strategy would have to be drawn with cut-off /threshold grade ores as a target.

17. Future scope of exploration of low-grade iron ore in India as identified by CGPB Committee-I, is as follows:

Orissa	: Bonai-Keonjhar belt, Tomka-Daitari and Umerkote belt.
Jharkhand	: All major high-grade ore deposits contain low grade lateritic ores.
Karnataka	: Bhagalkot, Tumkur and Chitradurga districts.
Maharashtra	: Sindhudurg, Gadchiroli (Surajgarh range) and Gondia districts.
Chhattisgarh	: Siliceous hematitic ore (55-60% Fe) and lateritic hematite ore (45-55% Fe) in all 14 deposits of the Bailadila range, Dantewara district.
Andhra Pradesh	: Cuddapah, Kurnool, Karimnagar, Adilabad and Guntur districts.

18. Majority of the hematite ore reserves (over 85%) in India are of medium to high-grade. Selective mining coupled with processing of entire r.o.m. ore makes their use possible directly in blast furnace & DRI plants (coal based in particular) in the form of quality calibrated lumps. This resulted in usage of higher percentages of lumpy iron ore i.e., around 45% in iron making in India as against 15-20% lumps used globally.

19. Only processed iron ores are used in iron industry. Iron ore processing in the country is restricted to meet the physical standards, as it is inherently medium/high-grade. Therefore, all the Integrated Steel Plants (ISPs) deploy multi-stage crushing, washing and sizing of r.o.m. ore to produce lumps (-30+10 mm) and sinter-feed size (-10+0.15 mm) material. While, non-captive sector supplying lumps to coal-based DRI plants, resorts to multi stage crushing and screening to meet the size requirement. This practice generates

large amount of fines (-10/-6 mm) and slimes (-100 mesh/0.15 mm) which get unused at the mine site. Characteristically, Indian iron ores are fragile in nature and mining & processing combined, generated substantial amount of fines. The proportion of lumps & fines in general is around 2:3.

20. These stacked fines (minus 10/6 mm screen undersize), slimes and the category of available low-grade resources falling in between threshold value and saleable grade on account of selective mining during last six decades constitute the potential source for producing usable grade iron concentrate after beneficiation. This will not only utilise existing discard material for recovery of valuable but also conserve limited high-grade lumpy hematite reserves in the country.

21. Extensive R&D work was indeed carried out at various laboratories in India and at IBM's Ore Dressing Laboratory in particular on low-grade/sub-grade iron ore, iron ore fines (-10 mm) and classifier/tailing pond slimes (-100 mesh). The flow sheet developed on almost all types of ore reflects the possibility of producing concentrate suitable for sinter & pellet making (Chapter 3.7). By and large these flow sheets may offer a road map for likely process route of beneficiation. By taking advantage of the same, the existing operators must look towards beneficiation as a means to overcome the crisis of supply of high-grade ore and this is the need of the hour.

22. The capital cost of 250 tph beneficiation plant works out to be around Rs 100 crores. The cost of beneficiation in respect of fine for sinter feed will be around Rs 200/- per tonne whereas for pellet feed it would be in the range of Rs 250/- to 350/-per tonne.

23. The mining industry is currently run in fragmented lease holds and operated by captive & non-captive units producing iron ore in the ratio of 25:75. Since, creation of a beneficiation facility is capital intensive, it may not be possible for small to medium sized entrepreneurs in the non-captive sector to invest in such venture. However, a large number of small mines located nearby can form consortium to have their beneficiation facility erected. A concept of custom mill for beneficiation needs to be introduced, whereby the fines from small mines in the vicinity of the facility could be received, blended, processed in a centralised processing unit and the concentrate thus produced could be pelletised or sold to appropriate market. Such consortium would need to work on certain defined objectives: (i) consistent supply of raw material for which they must sign an MoU amongst themselves (ii) seek Government's intervention for land, power, fuel (coal) & water requirement so that they be made available at the subsidised rate; and seek relief by way of import duty waive-off on imported technology and equipment for setting up such beneficiation facilities as a measure to incentivise these small players so that they venture into such highly capital intensive project.

24. The potential areas for such activity would be Eastern Sector (Orissa & Jharkhand) and Bellary-Hospet Sector (Karnataka).

25. The beneficiated/value-added fine needs to be agglomerated before its use. Beneficiation & agglomeration of these materials for iron making is the call of the day, and India should take the right direction to meet its future objective.

26. Primary function of incorporating agglomerates in the blast furnace burden is to utilise the fines generated during various stages of mining and processing. Blast furnace being a counter current gas reactor, these fines cannot be directly used as they hamper the gas flow.

27. The present facility in the country for processing & utilisation of beneficiated fines through agglomeration is highly inadequate particularly in the non-captive sector. This has led to large amount of fines (around 70-75% of the total fines production) getting exported.

28. The National Steel Policy suggests encouragement of sintering and pelletisation so as to utilise these iron ore fines which make up about 90% of the present exports.

29. Agglomeration of iron ore fines basically involves two main methods—sintering and pelletisation.

30. Sintering is the agglomeration technique of iron ore fines in the size range of-10+0.15 mm to produce clusters by incipient fusion at high temperature.

31. Sinters are porous and brittle and that is why sintering process of agglomeration is restricted to Integrated Steel Plants (ISP) using blast furnace route & mini blast furnace of non-captive sector only. The entire ISP has their own sintering plants (except IISCO) to cater to its own needs and consume the entire generated fines (classifier underflow of iron washing plant) for sinter making. The non-captive producers deploying mini blast furnace for hot metal production use limited amount of fines for sintering after beneficiation. Nevertheless huge quantities of fines are left unused at present at various mine sites even after their export.

32. The total installed sintering capacity in the country is 39 million tonnes. However, the production is 31 million tonnes (2009-10).

33. The pelletisation is the other mode of agglomeration applicable for fines below 325 mesh size.

34. Pellets are hard and compact and therefore they can be transported over a long distance as they can withstand the rigors of handling, i.e. repeated loading, unloading, etc. Pellets are viable and therefore can be produced and sold everywhere. Pellets, therefore, will play a very important role in iron making in both blast furnace as well as coal based DRI units.

35. In India, pellets are selectively used in gas based DRI units whereas the ISPs based on certain assumptions consider them unviable. This facade however appears to be fading away now. Many ISPs have moved proposals to incorporate some portion of pellets in the blast furnace burden to replace the calibrated lumps because of their superior chemistry, quality & strength in addition to enhancement of productivity. Therefore, pelletisation in all likelihood would come up in a big way in India.

36. The installed capacity of pelletisation plant in the country is 28.8 million tonnes, however, production is meagre 11.5 million tonnes only.

37. At present, practically none of the ISPs has pelletisation facility. The present level of pellet making facility in non-captive sector however is too little and needs augmentation of its capacities besides initiating creation of new facilities both in captive and non-captive sectors. ISPs can commence beneficiation followed by pelletisation in immediate future as it has readily available huge stocks of slimes impounded in its tailing ponds. This will not only recover the loss of valuables from slimes but also help in controlling environmental degradation on account of its perpetual stacking.

38. Of late leading players in the Mining & Steel Industry have realised the importance of pellet making and have begun to incorporate pelletisation facilities which are as follows:

Owner	Source of Raw material	Pellet Plant Capacity (million tonnes)	For Use in
SAIL	Gua mine fines	4.0	ISP
SAIL	Taldih & Kalta	2.0	ISP
TATA Steel	Noamundi mines	6.0	ISP
Jindal Steel & Power ltd.,	Barbil and from various other mines	10.0	DRI
ESSAR	Orissa fines	10.0	DRI
KIOCL	Bellary & Donimalai fines	0.5 (4.0)	DRI
NMDC	Bailadila Bacheli Slimes	2.0	DRI
NMDC	Donimalai Slimes	1.2	DRI

39. Pelletisation plants in general involve huge capital investments and consume enormous amounts of energy and fuel for grinding and pellet making. Hence, the capital involved and operating cost of pelletisation plants are very high. The breakeven/ economic size of the pelletisation plant is around one million tonne. This involves huge capital investment (approx. Rs 250 crores). Hence, only big players like captive plants can setup pellet plants. However, technology needs to be tailor-made for deposit-specific Indian iron ore as economic/readily available commercialised technology may not be suitable and would need testing before its implementation

40. An estimated conversion cost for making one tonne of pellet from the beneficiated concentrate is given in table below:

Cost per tonne of pellet produced	
Particulars	**Cost (Rs)**
Power Consumption : 65 units/tonne @ Rs 5.50/ Unit	357.50
Fuel Consumption:18 kg of furnace oil @ Rs 30/kg (Purchase price less MODVAT)	540.00
Additives 10 kg of Pulverised Coal @ Rs 4000/tonne	40.00
Bentonite 10 kg @ Rs 2000/ tonne	20.00
Labour & Maintenance	100.00
Miscellaneous	100.00
TOTAL	**1157.50**

41. A close look at the market price of high-grade lumps vis-à-vis production cost of quality pellets from mine/processing rejects and slimes after beneficiation will be comparable.

42. Thus, the process of beneficiation followed by agglomeration will not only conserve the limited high grade lumpy iron ore but also will engender optimum utilisation of the available valuables from mine/process rejects. This will reduce burden of stacking of tails/rejects that are kept for disposal and will be an effective measure to control environmental degradation.

43. Blast furnace productivity did show a turnaround over the years consequent to utilisation of higher proportions of quality agglomerates in the burden. Observations revealed that 1% replacement of calibrated lumps by agglomerated products like sinter or pellet reduces the coke rate by 1.5 kg/t of hot metal produced. Depending upon the quality of ore and the physical and chemical properties of sinter, it is generally agreed that on an average 20–70% sinter could be used successfully in the blast furnace.

44. Use of pellets in iron making is advantageous due to (gives rise to) improved permeability in comparison to lumpy ore or sinter. This leads to better solid-gas contact resulting in higher productivity and lower coke rate. At present, 15–20% of pellets are used in many furnaces along with sinters & lump ore.

45. SAIL intends to incorporate pellets in their blast furnace burden and proposes burden comprising of 15% lumps, 15% pellets and 70% sinters in near future. This strategy could open up the opportunity for utilisation of low-grade iron ores, fines and slimes which after beneficiation and transformation into pellets could fine larger scope for application.

46. To meet the future target in steel production, the ISPs and DRI units whose share in the country's iron production is likely to be 60% & 33% respectively would have to depend largely on pellets to enhance their production. Assuming that ISPs on the whole make use of a minimum of 15% pellets (optimum) in their blast furnace burden, and taking into consideration the projected target steel production to be achieved, the minimum requirement of pellets would be around 25 MTPA. Further, assuming that all coal-based DRI units uses 50% of pellets in replacement of high-grade lumps, there too, the demand for pellets would be around 25 MTPA. Thus, around 50 MTPA (min.) pellets additionally would be required. This dependence on pellets will not only conserve the high-grade hematite lumps but also will enable effective utilisation of fines & slimes. The surplus production of pellets, if any, could be supplied to the indigenous sponge iron plant (coal based) and the remaining could be exported. The recent waving of the export duty by GOI could make pellet making ventures by the industry a viable proposition.

47. Small mine owners must be encouraged to venture into pelletisation business considering its future demand. The Industry has been of the opinion that to improve participation in pelletisation business incentivising such pellet making industries in the country is essential. Government of India would need to consider offering some additional incentives in respect of power & water tariff, reducing the royalty on pellet making industry and waiving off import duty so that technology and equipment for setting up beneficiation and pelletisation facilities could be easily imported. Small mine owners would need to be encouraged to establish beneficiation and pelletisation plant as joint ventures so that there is no dearth of sufficient feed material and availability of capital investment.

48. Sponge iron will have to play a key role in the immediate future for the development of steel sector as per National Steel Policy. Therefore, steel industry has to depend a great deal on sponge iron for the supply of metal in future. Therefore, thrust should be given to pellet making which will in turn replace use of high-grade lumpy iron ore in coal-based DRI units in the country.

In the light of aforesaid, it can be emphasized that, steel making necessitated the whole gamut of activities right from mining of r.o.m. iron ore at the threshold value of 45% Fe (35% Fe for siliceous hematite ore) to value addition/beneficiation of iron ore, sintering & pelletisation followed by iron and steel making through Blast furnace cum BOF/LD or DRI cum EAF/IF of processes. Pictorial presentation of iron ore from mine to metal is presented in Fig. 1.

Steel is a long term business and the raw material resources are to be planned at least for a period of fifty years with similar growth rates. As we look into our strength regarding availability of iron ore, the present level of reserves are not encouraging for the projected demand of the ore by 2019-20. As managers of raw materials it is our responsibility to see that the requirement of input is comprehensively met in quality as well as quantity. This brings us face to face with the issue of conservation and beneficiation followed by agglomeration of beneficiated fines.

To keep pace with the likely growth of the iron ore industry, quality raw material is the need of the hour, it is therefore imperative to address and implement the following aspects in a time-bound manner:

Short Term Measures

(i) Preparation of feasibility of mining of several small/low-grade deposits already identified and proved earlier; enhanced requirement and deployment of appropriate beneficiation technology would have to be ascertained.

(ii) Immediate processing of sinter fines (classifier underflow) being used for sinter making by ISPs, for making of quality sinter grade material production (reduction of alumina), after deployment of appropriate beneficiation technology.

(iii) Immediate utilisation of available stacked fines (-10 mm) in non-captive sectors and slimes (-100 mesh) impounded in the tailing ponds of iron ore washing plants and stacked sub-grade/marginal grade ore through deployment of appropriate beneficiation technology.

(iv) Improving the processing capacity of existing beneficiation facilities to produce quality product.

(v) Introduce the concept of total beneficiation of r.o.m. ore at 45% Fe cut-off (for quality lumps, sinter & pellet fines) for optimum utilisation of available reserves.

(vi) Developing new mines with total beneficiation facility.

(vii) Exploration of low-grade iron ores associated with high-grade types within the existing mine/lease area.

(viii) Augmenting Sintering plant capacity by Integrated Steel Plants.

(ix) Contemplating pelletisation facility by ISPs and non-captive sectors to accommodate additional concentrate generated from beneficiation of low-grade ores, fines & slimes.

(x) Augmenting existing pelletisation plant capacity in non-captive sector.

(xi) Encouragement for use of pellets in DRI units (coal based) and thereby discourage liberal use of high-grade lumps.

Long Term Measures

(i) Convert the existing hematite resources into reserve by detailed exploration followed by feasibility

(ii) Exploring the possibility of persistence of iron ore (hematite) at depth (beyond 50 meters or from existing pit bottoms of large working mines of hematite).

(iii) Exploration in freehold area within known iron ore belts must be taken up. Most of the freehold areas within the known iron ore belts have not been explored so far due to lack/absence of iron ore exposure/outcrop. Besides, ideal lease/relinquished areas may have to be thoroughly assessed by drilling to ascertain the availability of iron ore.

(iv) Exploration for low-grade ores (hematite & magnetite) in the country, other than the mining area already in operation needs to be put on the fast track.

(v) Evolving suitable mining technology to exploit magnetite ores, that are mostly found to occur in environmentally and ecologically sensitive areas of the Western Ghat region of the country.

(vi) Exploring beneficiation potential of hematite resource namely banded iron formation which is basically banded hematite quartzite (BHQ) or banded hematite jasper (BHJ) forming the base rock of the enriched iron ore deposits. This base rocks contains around 25 to 35% Fe.

(vii) Evolving suitable technology for utilisation of goethite-rich iron ore in iron making. Beneficiation of low-grade iron ore will generate a substantial goethite-rich iron reject (Fe 50-55%) which may cause huge environmental problem on account of its stacking.

Having known the reserves & resources of iron ore (hematite & magnetite), practical ratios of lumps v/s fines during mining, properties & grades of the country's ore, demand & supply of ores to domestic steel plants at present & in future etc., there is no need to have any debate over, whether Indian Industry should go for massive expansion of beneficiation & agglomeration plants or not. For protecting individual industry as well as to serve the national interest over a longer period effectively, it will not be out of place to say that Statutory Regulations be brought to ensure full utilisation of the mined ore which automatically will lead to adoption of latest efficient technologies of beneficiation & agglomeration (pelletisation in particular).

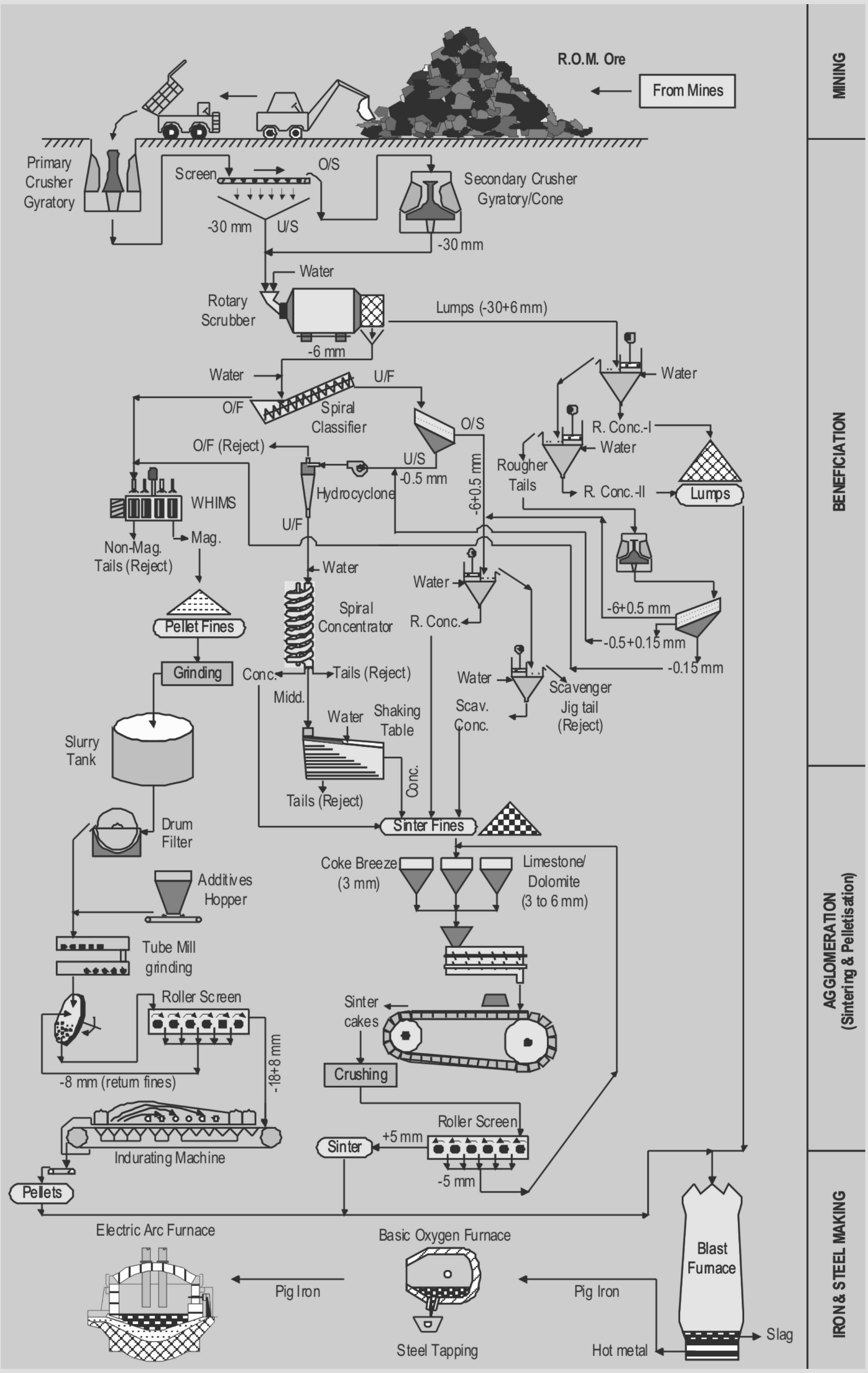

Fig-1: Iron ore—Mine to Metal