CHAPTER 4

Agglomeration

Indian iron ores are characteristically friable in nature that result in generation of sizeable quantity of fines (-10 mm) every year during various stages of mining and processing in the country. The ratio of lumps to fines produced in the country is 2:3. The fines generated as such cannot be used for iron making (blast furnace/DRI units) in the country and therefore large portion of it gets exported. These fines, however, could be put to use in the domestic Iron & Steel Industry after suitable beneficiation followed by agglomeration.

National Steel Policy 2005 suggests encouragement for agglomeration (sintering and pelletisation) so as to use these iron ore fines which make up about 90% of the present exports.

Basically there are two main methods of agglomeration of iron ore fines, depending on the size and chemical composition, they are, Sintering and Pelletisation.

Blast furnace productivity has gained momentum over the years with utilisation of higher and higher proportions of quality agglomerates in the burden. It has been observed 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. Increasing percentage of flux (basicity) in sinter helps in reducing the Reduction Degradation Index (RDI). The high RDI implies high degree of fines generation and unfavorable gas distribution in blast furnace, owing to channel effect. Increasing percentage of sinter in the burden, say from 20–30% to about 60–70% (often considered to be optimum) have marked beneficial influence on furnace performance. Use of higher percentages of fluxed sinter (over 70%)

becomes difficult because it is necessary to accommodate the need of fluxes for other ingredient (lumps & pellets) of the burden. Use of over 70% sinter in the burden with lower sinter basicity is not practicable, as lowering of basicity appreciably deteriorates the sinter properties like strength and reducibility. Depending upon the quality of ore and the physical and chemical properties of sinter, it is generally agreed that, on an average of 20–70% sinter can be used successfully in the blast furnace.

Use of pellet gives rise to improved permeability in comparison to lumpy ore or sinter. This leads to better solid-gas contact resulting in higher productivity at low coke rate. At present, 15–20% pellets are used in many furnaces along with sinters & lump ore. Higher percentages of pellets are however avoided because of high cost, tendency of pellets to swell when gas pressure is developed in the pores during reduction—which ultimately leads to disintegration of pellets and difficulty to produce fluxed pellets owing to an even higher swelling tendency.

Pellet forms suitable substitute for high-grade iron ore lumps presently being used very liberally in DRI Kiln for production of coal-based sponge iron. The main advantages of using pellets in BF/DRI kilns are their uniform quality & superior chemistry which enhances production by nearly15% of their rated capacity, besides, it reduces specific consumption of coal, increases life of kilns and lowers the repair cost of refractories.

It is a fact known world over that no hot metal can techno-economically be produced without agglomerates in the charged burden. Taking into account various metallurgical/techno-economic advantages accrued by use of agglomerates, the burden mix of sinter, pellets and lumps would govern the future scenario. This strategy opens up the opportunity for utilisation of fines and slimes after beneficiation for making of sinter and pellet.

4.1 SINTERING

Sintering is the agglomeration technique of fine materials to produce clusters by incipient fusion at high temperature. The required raw material specification and the process are as follows:

4.1.1 Raw Material

Iron ore fine (size -10 +0.15 mm), coke breeze (3–6 mm in size), fine limestone/dolomite (less than 3 mm) and sand are the basic raw material inputs for sintering. Alternatively, dunite, i.e. magnesium silicate, is added to substitute limestone/dolomite & sand to maintain the sinter chemistry. Fines below 5 mm (return fines) and steel plant waste are also included in the raw material category.

4.1.2 Granulation

All the input raw materials after thorough mixing are transferred to a drum where water is sprinkled and the drum is rotated for granule/nuclei formation. The nuclei formation is essential for maintaining permeability of sinter bed. These nuclei grow as mixing of the flux, carbon and iron ore fines are continued. Time required for granule/nuclei formation is kept relatively short (3–4 minutes), to restrict the growth of the granule/nuclei to about 10 mm size. A schematic diagram of sintering process flow sheet is given in Fig-44.

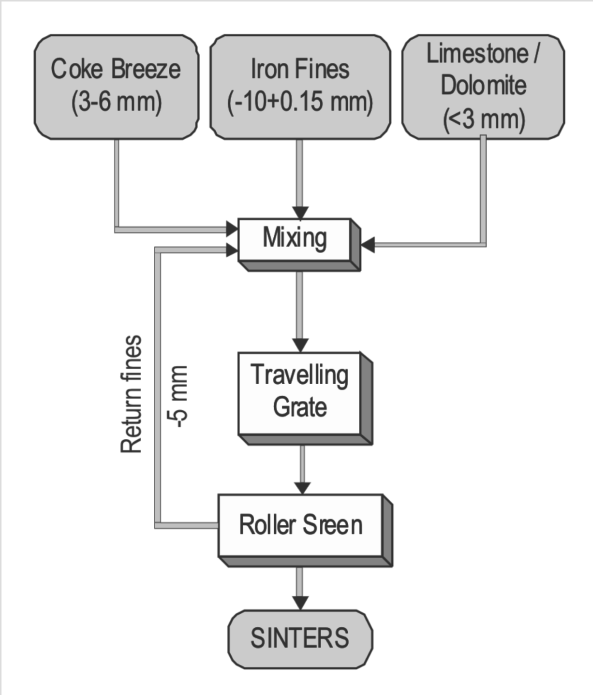

Fig-44: Schematic Flow Sheet for Sintering of Iron Ore Fines

4.1.3 Sintering Process

This granulated material is charged onto a continuous horizontal travelling grate of the Dwight-Lloyd sintering machine to form a bed of 400–600 mm deep and the top of bed is ignited by oil, or gas burners. Air is continuously drawn downwards throughout the length of grate by suction fan so that flame front gradually travels down through the bed of the sinter mix. This combustion raises the temperature inside the bed to 1250–1600°C depending upon the amount & type of fuel and suction deployed. The iron minerals are reduced to FeO and in turn combine with silica to form fayalite ($2FeO.SiO_2$). Fayalite melts at 1290°C in the bed and helps the solid particles in their bonding into big and strong agglomerate. Most of the heat generated out of combustion is consumed in drying, preheating and calcinations of materials in the lower layer of bed. When the combustion zone reaches the bottom layers of the mix, outgoing combustion gases attain maximum temperature indicating that the sintering of the mix has been duly completed. The sinter cakes discharged from the grate are broken by crushers to suitable size, then screened and oversize is cooled and stored or dispatched to blast furnaces. The undersize is recycled back for sintering as return fines. A schematic diagram of sintering machine is given in Fig-45.

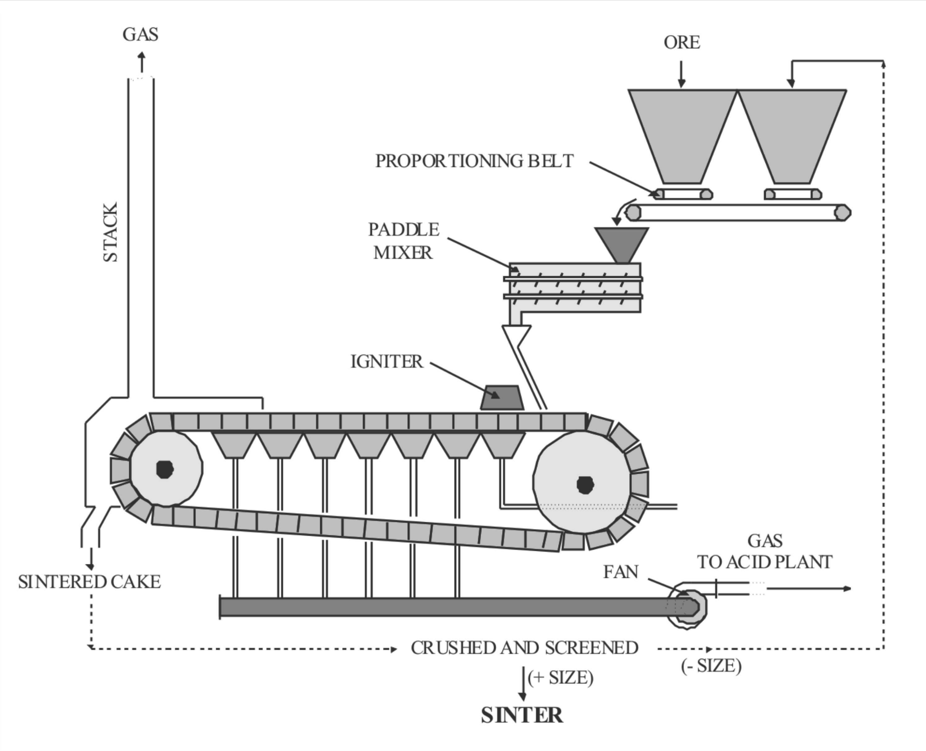

Fig-45: Dwight-Lloyd Sintering Machine

The percentage of -100 mesh (-0.15 mm) in iron ore fines used for sintering should be restricted to around 20%. Excessive quantity of very fine material affects the sinter bed permeability, resulting in high pressure drop during air suction through the bed and thereby adversely affecting sinter output and increases fuel consumption. The return fines in the sinter mix should be maximum 25%. Excess quantity of return fines reduces porosity of sinter. Moisture content in the mix should be between 7 and 12%. The quantity of coke breeze used is 6 to 8% of the ore. The quantity of flux depends upon the gangue content of the ore and is regulated to obtain self-fluxed or super-fluxed sinter (CaO/SiO_2 >2.0). The flux addition in the sinter mix improves the physical quality of sinter. It also reduces the iron content of blast furnace slag due to presence of iron in sinter in more reducible form (oxides and ferrites). Use of self-fluxing sinter in blast furnace eliminates the need of limestone in the burden. Use of super-fluxed sinters improves its reducibility without affecting its strength.

4.2 PELLETISATION

Pelletisation essentially consist of formation of green balls (12–16 mm) by rolling a fine iron bearing material (<325 mesh) with a critical amount of water and to which an external binder or any other additive is added if required. The green balls are then subjected to heat hardening to obtain pellets of desired quality required for iron and steel making. During formation of green balls sometimes coal or coke breeze is added to the feed material prior to mixing to bring down the fuel consumption during heat hardening. A schematic presentation of pelletisation process is presented in Fig-46.

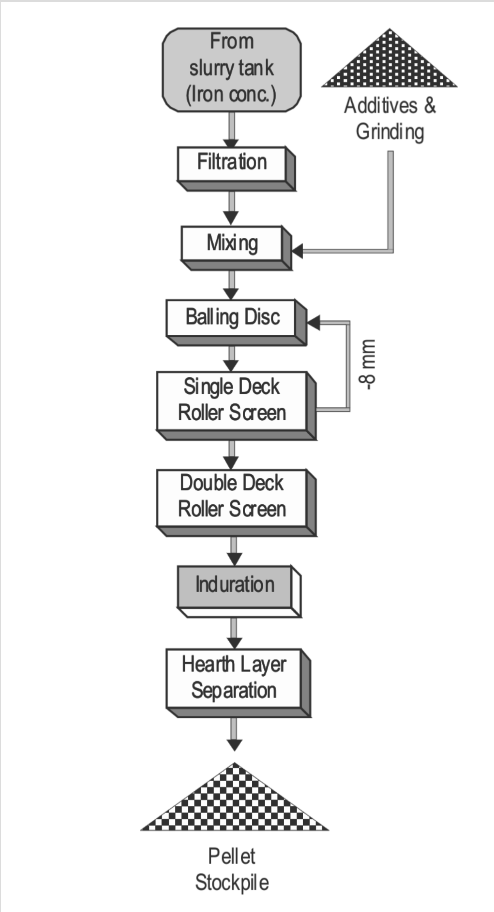

Fig-46: Schematic Flow Sheet for Pelletisation of Iron Ore Fines

4.2.1 Additives Preparation

High grade iron ore or beneficiated concentrate ground to –325 mesh (>85%), with a Blaine index of 1800 is generally mixed with various materials to form pelletising blend. The materials used are bentonite as binder, limestone and/or dolomite (0.5–1.5 %) as flux, coal or coke as solid fuel. Flux is normally used to tailor the chemistry of pellets and to produce the desired metallurgical and physical properties in the fired pellets. Fixed carbon in the form of coal/coke breeze is simply a solid fuel added to green balls to improve furnace productivity and overall fuel economy. Coal or coke besides accelerating the pelletising process is generally a less expensive source of heat than oil or gas. When added to green balls at proper levels, coke brings the inherent fuel value of a hematite green ball equal to that of a magnetite pelletising feed. Both proximate analysis and CV of coal/coke breeze dictate the quantity that can be added to mix.

4.2.2 Green Balling

The pelletising blend from the additive preparation section is fed by weigh-feeders to the pelletising discs/drum. In the pelletising disc/drum the blend is mixed with water (to maintain a moisture level of 5–8 %) and rolled to create spherical balls called green balls of 9–16 mm in diameter. Green ball formation is carried out either in a rotating disc (3.7–5.5 m in dia.) inclined at 45^0, or in a drum (typically 9–10 m long and 2.5–3.0 m in dia.) rotating at 10–15 rpm. Green pellets discharging from the discs/drum are conveyed to a double deck roller screen ahead of indurating machine. The undersize (-8 mm) green pellets are re-circulated and oversize green pellets (-18+8 mm) fed to induration furnace.

4.2.3 Quality Evaluation of Green Pellets

4.2.3.1 Drop Number : The drop number is a measure of ability of green pellets to withstand the drops encountered at conveyor belt transfer points during conveying green pellets from balling section to induration grate. The drop number of green pellets is measured by dropping 20 green pellets onto a steel plate from a height of about 300 & 450 mm until they develop cracks or crumble. The number of drops each pellet can withstand is measured and the average of 20 green pellets are taken as drop number. Normally the satisfactory drop number is 15 & 6 from a height of 300 & 450 mm respectively.

4.2.3.2 Crushing Strength : The crushing strength represents the resistance of the solid to compression. The average crushing strength of green pellets is determined by compressing individually about 20 pellets on a top pan balance until they crumble and the reading of the balance (kg) is noted at the time of breaking of pellets takes place. A crushing strength of 1.8 to 2.3 kg is considered to be a satisfactory strength.

4.2.4 Heat Hardening of Green Pellets

The green pellets meeting the above physical standards are subjected to heat hardening or induration. Basically there are three types of technologies available for induration of green pellets which are as under:

4.2.4.1 Vertical Shaft Furnace : The oldest and simplest technology of indurating green pellet is a vertical shaft furnace suitable for either magnetite or magnetite plus hematite blend of iron ore. A simple vertical shaft furnace internally refractory lined with no moving parts, heat hardens the descending green pellets by intense heat transferred from the countercurrent gas flow. The disadvantage of this process is that there is little or no flexibility.

4.2.4.2 Straight Travelling Grate : This process was developed by Dravo-Lurgi which can handle all types of pellet feed i.e., 100% hematite, 100% magnetite or a blend of both. The process consists of drying, preheating, firing, after-firing and cooling which are carried out on a single straight traveling grate. The process parameters may be adjusted to optimum induration cycle for a particular type of ore as determined after laboratory/pilot plant testing.

In the Dravo-Lurgi (Straight Travelling Grate furnace) process the indurating furnace is fed continuously from the double deck roller screen feeder which lays down the green balls across the full width of the machine on top of a protective hearth layer. Induration of green pellets takes place on the travelling grate, having a number of wind boxes. The total bed height of hearth layer plus the green balls is constant up to around 500 mm. Speed of travelling grate is variable in the range of 0.5 to 1.5 m/min. and is controlled to maintain a constant bed height. A schematic flow sheet depicting the straight grate induration process is given in Fig-47.

Initially during updraft drying the gas flow removes water from lower half of pellet bed and at the same time heats this layer to a temperature where condensation will not form in the lower layers of green pellets, thereafter gas flow reverses for downdraft drying. During drying the temperature reaches to about 200–250°C. Thereafter, the pellets are preheated to a temperature of about 750–800 °C and finally the temperature is further raised to about 1300°C to 1350°C.

At the end of firing zone most of the bed will have reached the end temperature of about 1300°C to 1350°C. The lowest layers of the bed reach the end temperature by drawing the hottest recuperation gases through the bed in the after firing zone.

Cooling is updraft to quickly lower the temperature of grate components and to recuperate the heat in pellets at the highest possible temperature. Heat for induration is

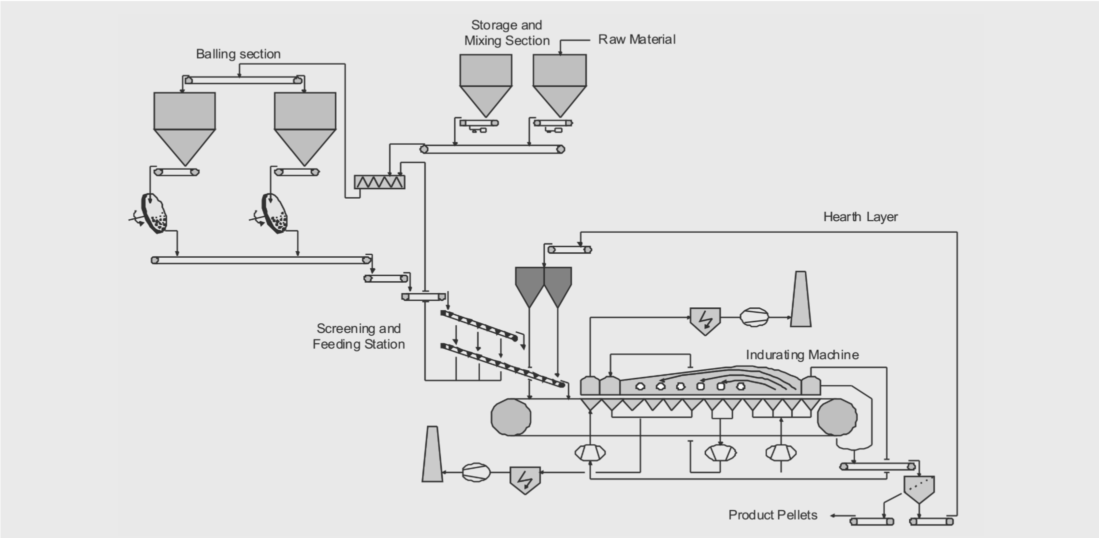

Fig-47: Straight Grate Pelletisation Process

supplied by burners firing heavy furnace oil.

Hardened pellets result from heating green balls to a temperature between 1300°C to 1350°C. With sufficient retention time at this temperature, the green ball moisture bonds are replaced with mineral bridges and slag bonds that enhance the pellet's physical properties such that stockpiling, shipping and subsequent processing can be achieved with minimum fines generation.

In some cases this treatment (Induration) causes certain chemical reactions to occur that change pellet's specific metallurgical properties. These reactions may include the oxidation of magnetite and dehydration of earthy hematites; in many cases “fluxed pellets” are produced by additions of limestone, dolomite, silica, etc. to the balling feed. These additions react with the gangue in the iron ore to enhance the performance of the pellets in certain downstream processing steps.

4.2.4.3 Grate-kiln Process : This process was developed by Allis-Chalmers for magnetite or magnetite plus hematite blend. Green pellets fed onto a travelling grate are dried and preheated to a certain temperature, discharged into a rotary kiln for firing and cooled in an annular rotary cooler. Thus, the pelletising process involves three stages i.e., preheating, firing and induration. A schematic flow sheet depicting the grate kiln (GK) pelletisation process is given in Fig-48.

The Grate Kiln process (GK System) consists of three machines in series—a travelling grate, a rotary kiln and an annular cooler. Overall, the GK System is a countercurrent gas/solids heat exchanger.

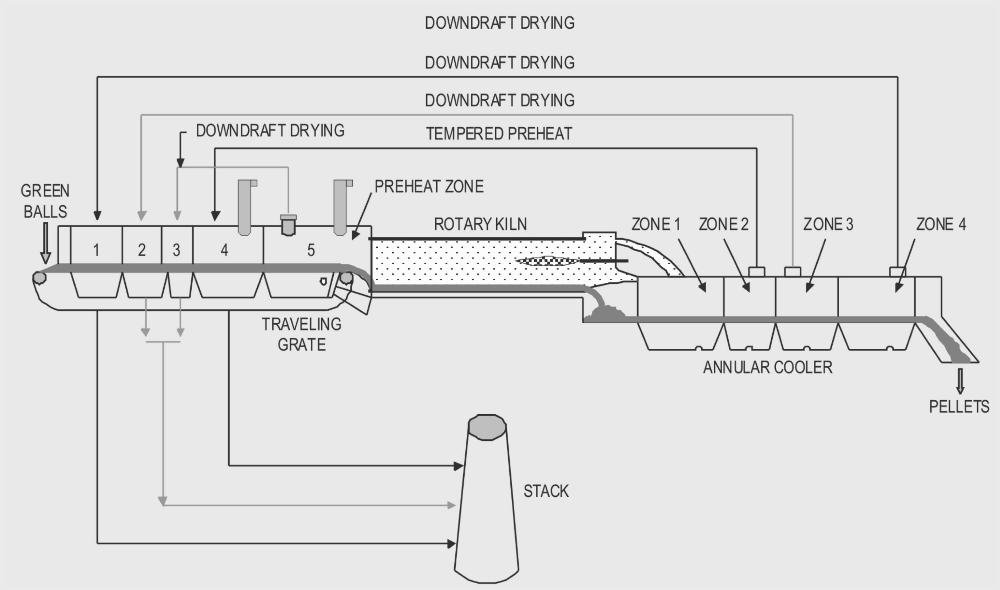

Fig-48: Grate-Kiln Flow Sheet

4.2.4.3.1 Travelling Grate : The travelling grate is used primarily to dry and preheat green balls for feeding into the rotary kiln, where they are indurated. The travelling grate provides the means for efficient heat transfer with high, medium and low temperature gases. These gases transfer heat by convection therefore intimate gas solids contact is required for effective heat transfer. Dried green balls do not have the physical properties necessary to survive direct feeding to the rotary kiln and must be semi-indurated, which is achieved in a travelling grate.

4.2.4.3.2 Rotary Kiln : The rotary kiln is a downwards-sloping cylinder in which the preheated pellets are transferred from the travelling grate for completing the induaration of pellets. The speed of rotation controls the rate of solids flow through the rotary kiln and imparts a mixing action to the pellet burden. The mixing action helps in making homogenised pellets. All of the pellets get equally exposed to the burner flame for a particular amount of time. This residence time given to the pellets is sufficient to uniformly indurate all the pellets, thereby minimising the ball-to-ball quality differences inherent in pellets. At the discharge end of the rotary kiln is a single burner, which utilises the hot recuperated (secondary) air from the annular cooler for combustion.

4.2.4.3.3 Annular Cooler : The annular cooler is similar to travelling grate except for its annular configuration. Hot pellets discharging from the rotary kiln are distributed in the annular cooler as a level bed. Ambient air is forced upwards through the conveying elements (pellets) and the bed. Thus machine parts are not exposed to high temperatures. The pellets are levelled in the annular cooler to a bed depth of 660 mm and conveyed over up to 4 cooling zones. In each cooling zone, sufficient cooling air is provided to produce the mass of air at a temperature required by the rotary kiln and travelling grate. The various cooling zones are designed in such a way that they will recover the maximum heat from the hot pellets and various ducts carry this hot air to rotary kiln/travelling grate zones. Cooled pellets are discharged through the cooler's discharge hopper on to a product load-out system.

4.3 METALLURGICAL TESTS

The International Organisation for Standardization (ISO) has standardised procedures for conducting many tests on iron ores and agglomerates that are necessary to evaluate their metallurgical performance during smelting in a blast furnace. These test procedures are basically empirical. Table-8 summarises the different test conditions employed for assessing the metallurgical behaviour of iron oxides.

A brief detail about the various tests is as follows:

4.3.1 Compression Strength

Compression strength is defined as 'the capacity of a material or structure to withstand axially directed pushing forces'. When the limit of compressive strength is reached, materials are crushed. Compressive strength is regarded as one of the principal criteria of suitability of indurated/roasted iron ore pellets for metallurgical processing. The strength of pellets depends on the extent of their oxidation. A high degree of oxidation gives the pellets structural homogeneity, prevents the formation of concentric bands and radial cracks, and promotes more extensive and complete ore particle sintering; it is one of the most important conditions in increasing strength.

Compression strength is normally measured only in the case of pellets. Sixty pellets, in the size range of 10–12.5 mm are taken and load is applied using a universal testing machine at a cross-head speed of 15 ± 5 mm/min. The test values are reported as the mean crushing strength and the percentage under 200 daN/pellet (deca newton per pellet) and 150 daN/pellet. The acceptable values are as follows:

Below 200 daN/pellet	Max. 10%
Below 150 daN/pellet	Max. 5%

Test Reducing gas %	Reducibility	Relative Reducibility	Swelling Index	Reduction Under Load	Reduction Degradation Index (RDI)
CO	40 ± 0.5	30 ± 1	30 ± 0.5	40 ± 0.5	20 ± 0.5
N_2	60 ± 0.5	70 ± 1	70 ± 0.5	60 ± 0.5	60 ± 0.5
CO_2	-	-	-	-	20 ± 0.5
Flow rate (LPM)	50 ± 0.5	15 ± 0.5	15 ± 1	85	20
Temp. °C	950 ± 10	900 ± 10	900 ± 10	1050 ± 5	500 ± 10
Reduction or time	O_2 loss 65 % or 4 hours	3 hours	1 hour	O_2 loss 80% or 4 hours	1 hour
Sample quantity required	500 ± 1 g	500±1 g	18 Pellets	500 g	500 g
Size in mm	10-12.5	10-12.5	10-12.5	10-12.5	10-12.5
Load kPa	--	--	--	50	--
Retort Dia. (mm)	75	75	75	125	75 (130 mm dia., 200 mm length 4 lifters, 30 rpm)
Property measured	Reducibility index	Degree of reduction	Degree of reduction change in height, pressure drop across the bed		Reduction degradation index (RDI), LTB index

Table-8 : Static Tests on Iron Oxides

4.3.2 Tumbler and Abrasion Index

Defined as 'a relative measure for evaluating the resistance of iron ore pellet to size degradation by impact and abrasion' (ISO 3271:1995). Index used in certificate of analysis of iron ore pellets. This is a mechanical test conducted of iron oxide pellets to assess the mechanical impact on pellets during transportation. Abrasion Index is specific to the mineral's effect on crushing and grinding equipment, more specifically to the consumable metal parts involved (cones, liners, balls/rods, etc.). It is a factor used to determine the effective rate of wear of the aforementioned consumables.

In order to determine the tumbler index, a drum with a diameter of 1000 mm and length of 500 mm with two lifters of 50 mm height is used. About 15 ± 0.15 kg of the sample (9-16 mm size pellets, or 6.3-40 mm size lump ore, or sinter of 10-40 mm) is subjected to 200 revolutions at 25 rpm. After the test, the material is screened—the percentage above 6.3 mm is designated as the tumbler index and the percentage of below 0.25 mm (or sometimes 0.5 mm) as the abrasion index.

4.3.3 Reducibility

The reducibility test essentially aims at measuring the rate of reduction of iron bed material under blast furnace conditions. It indicates the velocity at which the iron ore pellet can be reduced. The residence time in the reduction zone is set according to the ore/pellet reducibility. In order to determine reducibility, two test procedures are followed—(a) relative reducibility and (b) reducibility.

The results obtained from the first method indicate the degree of reduction as a relative rate compared with a standard sample; while in the second method, the rate of oxygen removal between 30% and 60% reduction is measured and the (dR/dt) at 40% reduction in per cent/minute is reported. Both the methods help to assess the reduction rate when the higher oxides present in any iron oxide sample under testing are reduced to FeO.

4.3.4 Reduction Under Load (RUL)

Specifies a method for evaluating the physical stability of iron ores reduced under load and under specific conditions. The specific conditions are—isothermal heating for reduction, a test portion having a specified size and placed in a fixed bed under load, a reducing gas composed of a carbon monoxide/hydrogen/nitrogen mixture, measurement of the differential gas pressure across a bed of the test portion and measurement of the change in the height of the bed.

This applies to sized ores and pellets. ISO 7992:2007 specifies a method to provide a relative measure for evaluating the structural stability of iron ores, when reduced under conditions resembling those prevailing in the reduction zone of a blast furnace. ISO 7992:2007 is applicable to lump ores and hot-bonded pellets.

The test is conducted in a vertical retort of 125 mm diameter in which the sample is exposed to reducing conditions (30% CO & 70% N_2) at temperatures up to 1100°C .The test is particularly suitable for determining the stability of pellets and other iron oxides, under these conditions. In addition to the extent of reduction, the shrinkage of the charge and its resistance to gas permeability are also measured. The differential pressure that is measured corresponding to 80% reduction gives an idea of the stability of the iron oxide during reduction.

The acceptable values of some of the properties mentioned above are as follows:

Type	Size, mm	Abrasion Index, %	Swelling Index, %	Tumbler	Reducibility, R40
Pellets	-12.5+9.5 (below 5mm, 4% max.)	5	15 (max.)	94	1.20 min. for fluxed pellets & 0.80 min. for acid pellet.
Lump ore/Sinter	-40+10 (below 5mm, 4% max.)	5	Not important	65	1.24 min. for lump ore.

4.4 INDIAN SCENARIO

The present facility in the country for processing & utilisation of beneficiated fines through agglomeration are highly inadequate in non-captive sector in particular, leading to export of large amount of fines.

The total installed sintering capacity in the country is 39 million tonnes. However, the production is 31 million tonnes (2009-10) only. Installed capacity & production of sinters (By Plants) and general specification of fines/iron concentrate is presented in Table-9.

Characteristically, sinters are porous and brittle and therefore they cannot be transported over a long distance as they cannot withstand the rigors of handling, i.e. repeated loading, unloading, etc. That is why sinter plants are integral part of ISPs and mini Steel Plants.

All the ISPs have their own sintering plants (except IISCO) to cater to their own needs and consume the entire generated fines (classifier underflow of 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 viz, Eastern Sector (Orissa & Jharkhand) and Bellary-Hospet area.

The other mode of agglomeration is pelletisation. Pellets can be used as feed for iron making in blast furnace (BF) of Integrated Steel Plants (ISP), sponge iron (DRI) units and mini blast furnace. In India, however, the pellets are being selectively used in gas-based DRI whereas the ISP on their own premise thought them unviable. This mist however appears to be fading away now. All the ISPs are considering incorporation of some portion of pellets in the blast furnace burden to replace the calibrated lumps because of its superior chemistry, quality & strength in addition to enhancement of productivity.

The installed capacity of pelletisation plant in the country is 28.8 million tonnes however production is meager 11.5 million tonnes only. Installed capacity & production of pellets (By Plants) and general specification of fines/iron concentrate is presented in Table-10.

In '000 tonnes

Name & Location of Plant	Annual Installed Capacity	Production		Iron Ore Fines Consumed		General Specification of Concentrates / Fines Used
		2007- 08	2008-09	2007-08	2008-09	
Bokaro Steel Plant, Jharkhand	6200	5349	4446	4921	4287	Fe 63.5% (max.), SiO_2 3.4%, (Av.), Al_2O_3 2.72% (Av.), Size -3 mm.
Bhilai Steel Plant, Bhilai, Chhattisgarh	6334	7229	7459	5153	5395	Fe 62.6% (min.), Size -10 mm <10% & 1 mm >75%
Durgapur Steel Plant, West Bengal	3009	2841	2766	2349	2278	Fe >63%, SiO_2 2.17 to 4.54%, Al_2O_3 2.38 to 3.03%. Size +10 mm <10% & 1 mm >75%
Rourkela Steel Plant, Orissa	3070	3444	3229	2808	2598	Fe 62.83%, SiO_2 2.48%, Al_2O_3 3.04%, Size -10 mm
Visakhapatnam Steel Plant, Andhra Pradesh	5256	NA	5033	NA	3718	Fe 64.50% (min.), Al_2O_3 3.0% (max.), SiO_2 3%, (max.), Size (-) 10 mm.
Tata Steel Ltd, Jamshedpur, Jharkhand	8000	5826	6531	5515	6091	NA
IDCOL, Kalinga, Keonjhar, Orissa	8	NA	NA	6(e)	NA	Fe 62% min., Al_2O_3 + SiO_2 8% max. Moisture 4%, SiO_2 1.5–5%.
Ispat Industries Ltd, Dolvi, Raigad, Maharashtra	2240	NA	NA	NA	NA	NA
Neelachal lspat Nigam Ltd, Kalinga Nagar, Dubori, Dist. Jajpur, Orissa	1711	782	752	672	633	Fe 63% (min.), Size +10 mm 7% max.
SISCO, Mettur, Tamil Nadu	127.5	-	NA	-	NA	NA
Jindal Steel & Power Ltd, Raigarh, Chhattisgarh	2300	NA	NA	NA	NA	NA
Jayaswal Necco industries Ltd, Raipur-493 221, Chhattisgarh	800	NA	NA	NA	NA	NA
Bhushan Power & Steel Ltd Sambalpur, Orissa	1000	NA	NA	NA	NA	NA
BMM Ispat, Karnataka	2500	NA	NA	NA	NA	NA

Source:IMYB-2009

Table-9: Installed Capacity & Production of Sinters (By Plants)

In '000 tonnes

Name & location of Plant	Annual Installed Capacity	Production		Iron Ore Fines Consumed		General Specification of Concentrates / Fines Used
		2007- 08	2008-09	2007-08	2008-09	
Kudremukh Iron Ore Co. Ltd, Mangalore, Karnataka	3500	1940	1316	1892	1559	Fe 64% , Size-10 mm SiO_2+Al_2O_3 6% (max.) S 0.05%, P 0.08% (max.)
Mandovi Pellets Ltd, Shiroda, Goa – 403 103	1800	523	297	569	308	Fe 62%, SiO_2 2 to 3.5%, Al_2O_3 1.35 to 2%, Size -10 mm
JSW Steel Ltd, Bellary, Karnataka	4200	NA	NA	NA	9581	Fe 62%, Size -10 mm
Essar Steel Ltd, Visakhapatnam, A.P.	8000	NA	NA	NA	7410	Fe 63%, Size -10 mm
JSPL, Orissa	4500	NA	NA	NA	NA	NA
Aryan Ispat, Orissa	1200	NA	NA	NA	NA	NA
BMM Ispat, Karnataka	1200	NA	NA	NA	NA	NA
Brahmani River Pellets, Orissa	4000	NA	NA	NA	NA	NA

Source : IMYB-2009

Table -10: Installed Capacity & Production of Pellets (By Plants)

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 sector. In general it was indicated by the mineral industry that pelletisation plants consume enormous amounts of fuel and energy in grinding for pellet making and involves huge capital investments. Hence, the capital and operating cost of pelletisation plants is very high. The breakeven/Economic size of the pelletisation plant is around one million tonne. This involves huge capital investment (appox. Rs 250 crore). Hence, only big players like captive plants can set up pellet plants.

Unlike sinters, 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. That is why pellets can be produced and sold everywhere.

Of late leading players like SAIL, NMDC and TATA 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	Barbill 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

Pelletisation in all likelihood will come up in a big way in India. The surplus production from ISPs could be supplied to the indigenous sponge iron plant (coal-based) which could lead to reduced use of high-grade lumps in these plants (coal-based DRI). The remaining could be exported. Recent waving of the export duty on pellet by GOI is likely to further the prospects of venturing into pellet making by the industry.

There is a positive indication from the industry to foray into pelletisation business. In view of the above, there is a need to give possible incentive for pellet making industry in the country. Along with the constraints of power supply; operating cost and capital cost involvement in pellet making were discussed in detail with the industry. The industry expects that Government provide some additional incentives such as subsidised power & water tariff, reduce royalty for pellet making industry and waive-off import duty on imported technology and equipment to enable setting up of beneficiation and pelletisation facilities. It was also opined that small mine owners should be allowed to establish beneficiation-cum-pelletisation plant as joint venture facility in order to have sufficient feed material and affordable capital investment.

The iron ore fines at the mines head that are being exported (non-captive sector), forms the ideal feed for agglomeration after beneficiation. Besides, substantial amounts of slimes accumulated in the tailing ponds of iron ore washing plant can be used for pellet making after beneficiation. Beneficiation flow sheets of which are already discussed in Chapter 3.

In the process of pelletisation of fine iron ore concentrate, enormous amount of energy is being consumed in grinding of the concentrate to desired fineness due to high work index of the ore. The major factors influencing the operating cost of pelletisation are (i) High energy consumption (about 65 kW/tonne) and (ii) high furnace oil consumption.

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

Cost of 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 Pulverized Coal @ Rs 4000/tonne	**40.00**
Bentonite 10 kg @ Rs 2000/tonne	**20.00**
Labour & Maintenance	**100.00**
Miscellaneous	**100.00**
TOTAL	**1157.50**

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. Thus, the process of beneficiation followed by agglomeration will not only conserve the limited high-grade ore but also make it possible for optimum utilisation of the available valuables from mine/process rejects which further will reduce burden of stacking of tails/rejects kept for disposal and will avoid environmental degradation caused on account of it.