SINTERING AND PELLETISATION OF INDIAN IRON ORES

By

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IRON ORE SUPPLY DEMAND SCENARIO IN INDIA (2000 -2040)

	2000	2010	2020	2040
Finished steel consumption	28	61	120 – 150	400 – 530
FSC per capita (kg)	30	50	90 – 110	260 – 340
Iron ore requirement	43	100	200 – 250	700 – 900
Iron ore exports	33	120	?	?
Iron ore expansion needed	-	-	20 - 70	480 - 680

NEED FOR BENEFICIATION

- High grade iron ore less than 10% of the total reserves.
- ROM iron ore with Fe less than 58 – 60% discarded as waste.
- After beneficiation iron ore availability can improve by about 50%.
- Steel community and the country demand technological solutions for utilising low grade ores.
- The technology task that would be imperative:
  1. Utilisation of low grade iron ores after beneficiation.
  2. Reduction in slime loss by recovery of iron values from slimes.
  3. Development of proper technology to agglomerate recovered micro fines (sintering or pelletising)

NEED FOR BENEFICIATION

- **With advanced beneficiation techniques, the products from ROM would be (approximate wt. %)**
  - **High grade lumps 10 %**
  - **Sinter fines 45 %**
  - **Micro fines 55 %**

AGGLOMERATION (Sintering & Pelletising)

- **Common methods of burden preparation related to the performance improvements of iron making (blast furnaces & direct reduction process)**
- **Growth of steel industry with depleting resources of high grade ores have led to a very strong demand for both pelletising and sintering of iron ores.**

PELLETISATION

- **Process objective is to transform fine iron ore concentrate into pellets suitable to feed Blast Furnace or Direct Reduction plant or COREX.**
- **Pelletisation was invented to make use of Blue dust and ultra fine concentrate generated in the Iron ore beneficiation plants.**
- **Pellets have the benefit of lower gangue on account of beneficiated ore.**

NEED FOR PELLETISATION

- **Steep rise in the prices of raw materials for DRI & Pig Iron production**
- **Catering to the iron ore demands of all the DR/ Steel plants in the country**
- **Good productivity, product quality and reasonable campaign life is very important amongst fierce competition and low grade iron ore availability.**
- **To meet ever increasing demand for iron ore with growth in Steel i.e. 110 million tones by 2020**
- **Improved productivity and efficiency of the rotary kiln & Blast Furnace with superior reducibility behaviour of pellets compared to lump ore.**

ADVANTAGE OF USING PELLETS IN DR KILNS

- 20-30% increase in production from rotary kiln
- Reduction in specific consumption of coal
- Longer campaign life due to less accretion
- Refractory repairing cost will reduce as there will be no accretion and no fused lump formation,.
- Metallization will be better compared to lump ore.
- There will be very much less fines in the product as against with lump ore.
- No need for crushing and screening of iron ore and resultant fines disposal problem
- No losses in handling iron ore as PELLETS will not break during transport or handling.

ADVANTAGE OF USING PELLETS IN BLAST FURNACE

- **Improved productivity**
- **Reduced specific consumption of Coke especially with PCI (widely practiced in most of the Chinese Mini Blast Furnaces)**
- **The charge mix is 40: 60 ratio instead of 100% sized ore**
- **0-5 mm fines can be utilized & charged instead of rejecting.**
- **Lower blast pressure required can be met by indigenous Centrifugal Fans in series due to Pellets of 10-20 mm instead of High Blast Pressure by Turbo Blower because of 10-40 mm lump ore**
- **No losses in handling iron ore as pellets will not break during transport or handling.**

TYPES OF PELLETISATION PROCESS

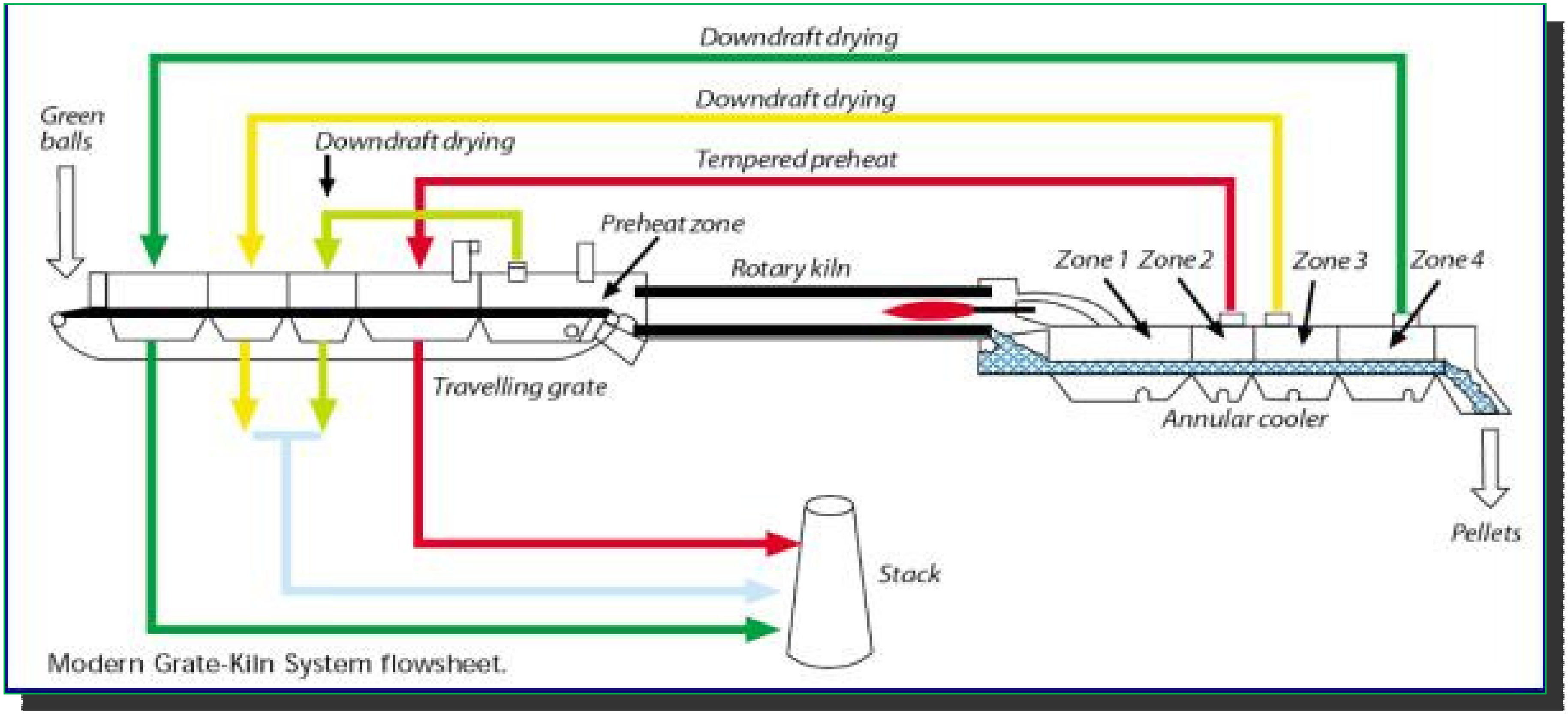
1. **Grate kiln process**
2. **Travelling grate process**.

Choice of one over the other will be based more on economics rather than the technical aspects

GRATE KILN PROCESS

- **Process adopts three equipment viz. grate, rotary kiln and annular cooler.**
- **Green balls are first dried and preheated on the straight grate followed by hardening in a counter flow manner in rotary kiln and air cooling in an annular cooler**
- **The grate has two or more wind boxes to provide for the gas draft**
- **Heat for drying and preheating is supplied by the gases discharged from the rotary kiln, and hot air from the cooler is utilised in the rotary kiln**
- **The pellet bed on the grate is only 150 -200 mm deep, and no protective layer is required on the grate since it is subjected to low temperatures.**
- **The firing in rotary kiln lasts longer and the material is cooled bycooling air passing through a relatively deep bed (0.8 – 1.0 m) of pellets.**

GRATE KILN PROCESS FLOWSHEET



Modern Grate-Kiln System flowsheet.

CURRENT TRENDS IN GRATE-KILN PLANTS

- **CFD designs** Computational Fluid Dynamics analysis helped to reduce pressure drop in the system reducing power requirement
- **Balling drum size** Size has been increased to 5 m dia with an output of over 200 TPH of net green balls
- **Higher availability** Use of specialty alloys for Grate parts and annular cooler parts leading to higher reliability and reduced maintenance cost
- **Fuel reduction** Computerised Heat & Mass balance has been developed in close interactions with existing high efficiency Grate-Kiln plant operators
- **VFD drives** for the fans Variable Frequency Drives are expected to save 20% power and help to achieve exact control of process

FUTURE DEVELOPMENTS IN GRATE KILN PROCESS

Predictive Control Systems

OCS software combines expert system, fuzzy logic, adaptive model structure, neural networks, statistic functions etc. If incorporated OCS software can predict the pellet qualities in advance or can produce pellets meeting desired norms like fuel consumption, pollution norms etc. OCS software optimises the plant performance on a continuous basis, correlates changes continuously and makes corrections online

TRAVELLING GRATE PROCESS

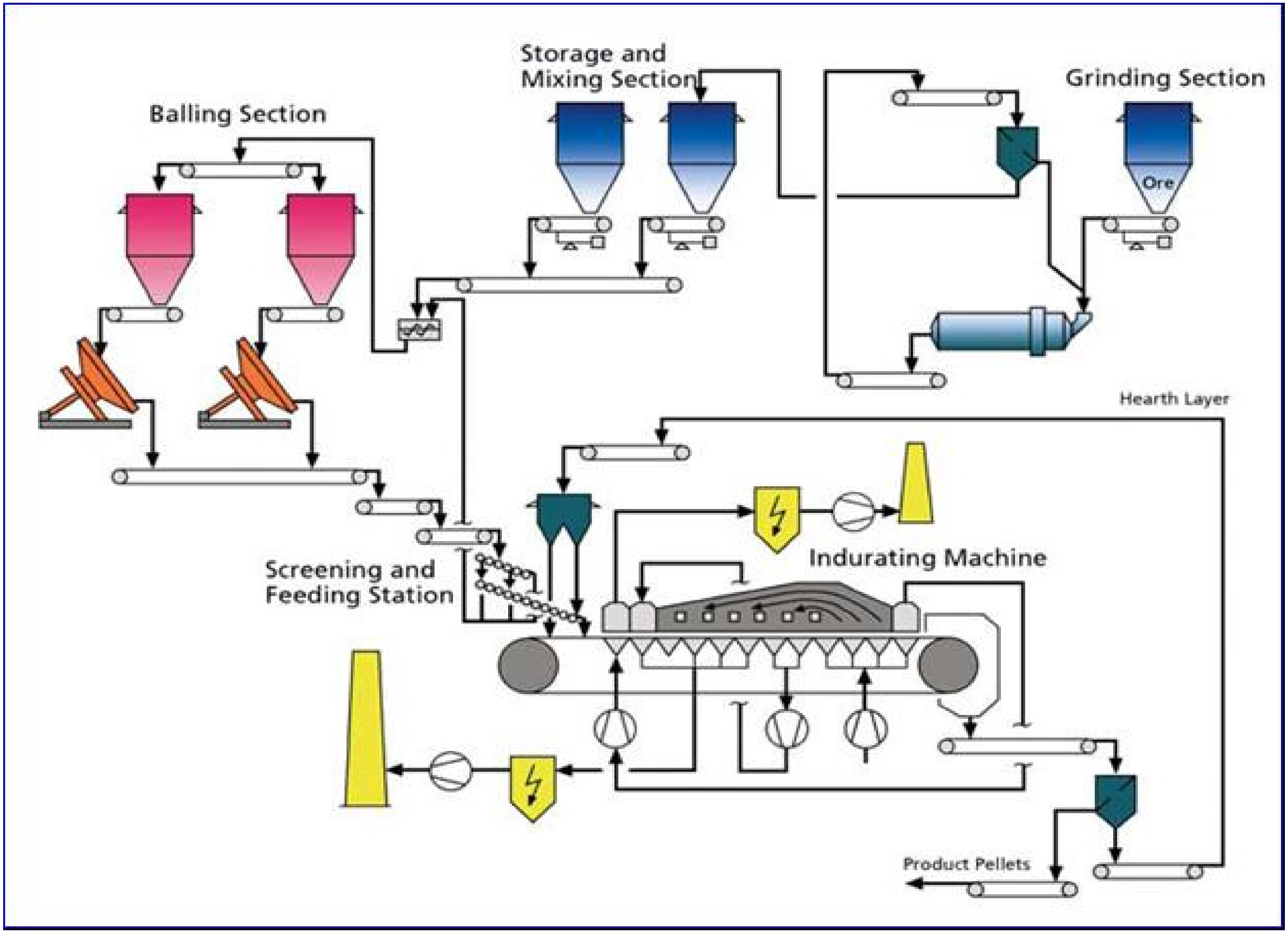
- **Travelling grate machine used for induration of green pellets resembles the well-known sintering machine of Dwight Lloyd design.**
- **Travelling grate machine is having completely closed hood with many interconnected thermal zones for recirculation of [tpvrdd gas leading to maximum heat recovery.**
- **The machine consists of three main parts;**

  a. **Upper part comprises the heat energy and air supply system in a stationary hood above the entire grate length with burner system in the firing zone.**

  b. **Bottom part is composed of the stationary wind boxes connected with gas mains.**

  c. **Central part is movable and consists of pallets, composed of a frame and a supporting structure into which grate bars are inserted. The pallets are connected to the wind boxes by means of sliding seal bars in a gas tight manner.**

TRAVELLING GRATE PROCESS FLOWSHEET



COMPARATIVE ANALYSIS OF TRAVELLING GRATE AND GRATE KILN PROCESSES

Item	Travelling grate	Grate Kiln
Heat hardening cycle	Drying, preheating, induration and cooling are done on a single grate	Drying and preheating on a grate, induration in rotary kiln and cooling in annular cooler
Grate bars	Grate bars subjected to high temperature; side and bed layers necessary	No side or bed layers necessary. Bed depth is nearly half
Pellet movement	Pellets remain stationary throughout the process	Pellets tumble continuously in rotary kiln
Burners	Large number of burner along the length of induration furnace	Single burner is used for the kiln
Fans	Several fans operating in series with multiple fan controls	Less number of fans with single fan control
Number of passes	Multiplicity of passes	Grate generally of two pass design
Pellet grades	Both BF & DR grades	Both BF & DR grades
Largest Machine	768 m2 (CVRD) AND 744 m2(Samarco) with capacity of 6 Mtpa each	LKAB-3, GIIC-Bahrain and Tildon-2 with capacity of 4 Mtpa each
Installed capacity	About 193 Mt	About 113 Mt

SINTERING PROCESS

Sinter making is a method of fusing iron ore fines into larger particles suitable for charging into the blast furnace.

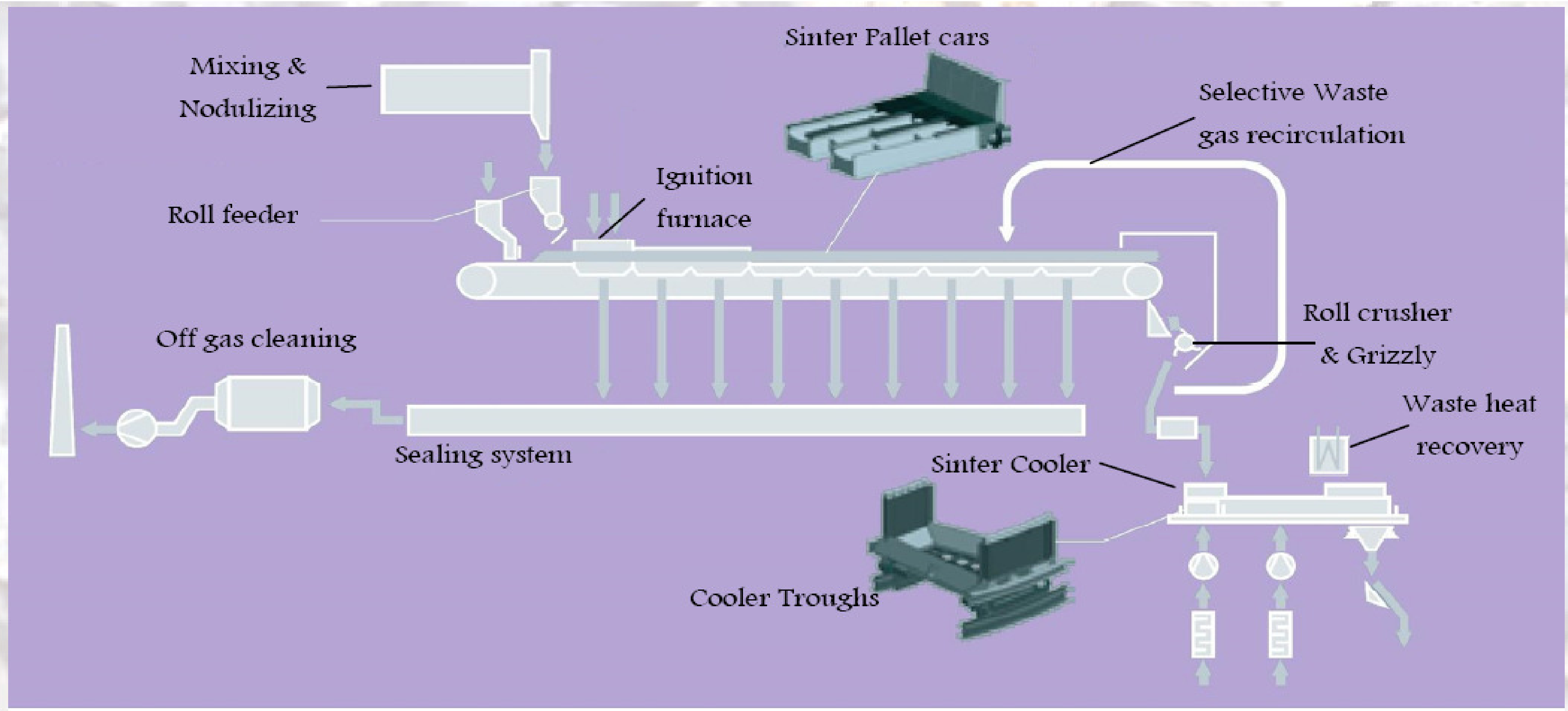
- **Predominant source of iron in many blast furnace processes.**
- **This technology was developed for the treatment of the waste fines in the early 20th century. Since then sinter has become the widely accepted and preferred Blast Furnace burden material.**
- **Presently more than 70% of hot metal in the world is produced through the sinter. In India, approximately 50% of hot metal is produced using sinter feed in Blast Furnaces.**
- **Large sinter strands 6 m wide and with a sintering area of > 400 m2, are capable of producing 30–45 t/m2/day.**

SINTERING PROCESS

The major advantages of using sinter in BFs are

- **Use of iron ore fines, coke breeze, metallurgical wastes, lime, dolomite for hot metal production**
- **Better reducibility and other high temperature properties**
- **Increased BF productivity due to higher softening temperature and lower softening –melting temperature range.**
- **Improved quality of hot metal**
- **Reduction in coke rate in blast furnaces.**

SINTERING PROCESS FLOWSHEET



SINTERING TECHNOLOGY IMPROVEMENTS

- **High intensity mixing and nodulizing**
- **Ignition furnace for optimum maintenance and operation**
- **Travelling Grate with longer lasting pallets**
- **Minimized off-gas volumes with effective sealing.**
- **Reduction in off-gas cleaning capacity through Selective Waste Gas Recirculation**
- **Discharge station for long service life**
- **Direct charging to cooler with maintenance-free cascade classifier for natural segregation and improved cooling efficiency and reduced emissions**
- **Efficient sinter cooling and installation of heat recovery system**
- **Energy savings together with reduced emissions**
- **Sinter plant control systems**

HYBRID PELLETIZED SINTERING

HPS is characterized by micro pellets with high mechanical strength, measuring between 2 mm and 8 mm. HPS feed consists of iron ore as pellet feed fines, return fines and iron and steel work remnants, filter dust, additives and binders like limestone, dolomite, bentonite and coal dust. These micro pellets are fed onto a sinter machine to produce sinter cake, which is then broken down and smelted in a blast furnace.

SINTER PLANT PERFORMANCE IN SOME TYPICAL ASIAN STEEL PLANTS

Parameter	Japan, Korea, Taiwan	China, Mill A 2009	China, Mill B 2009
Area (m^2)	450	495	450
Productivity ($t/m^2/hr$)	1.55	1.4	1.4
Yeild (%)	87	76	89
Fe, %	57.10	58.3	58.20
FeO, %	6.65	7.95	8.35
Al_2O_3, %	1.80	1.65	1.25
MgO, %	1.40	1.60	1.65
Basicity Ratio	2.15	1.90	1.90
Tumbler Index (+6.3 mm, %)	78.2	81.2	77.2

FUTURE OF SINTERING AND PELLETISING

- The future of sintering and pelletising is directly related to the future of the iron making processes that use sinter and pellets, mainly the Blast furnace and DR process.
- The future of these processes in turn depends upon steel production and consumption, which have been on an upward trend.
- Environmental interest
- Commitments to minimise CO2 emission mainly by striving to minimise overall energy consumption.

Environmental emissions of agglomeration processes

Process	SO_X, gm/t	NO_X, gm/t	CO, kg/t	CO_2, kg/t	Particulate, gm/t
Sintering	1670	640	38	220	260
Pelletising, hematite ore	200	500	1	30	130
Pelletising, Magnetite ore	100	200	<1	25	125

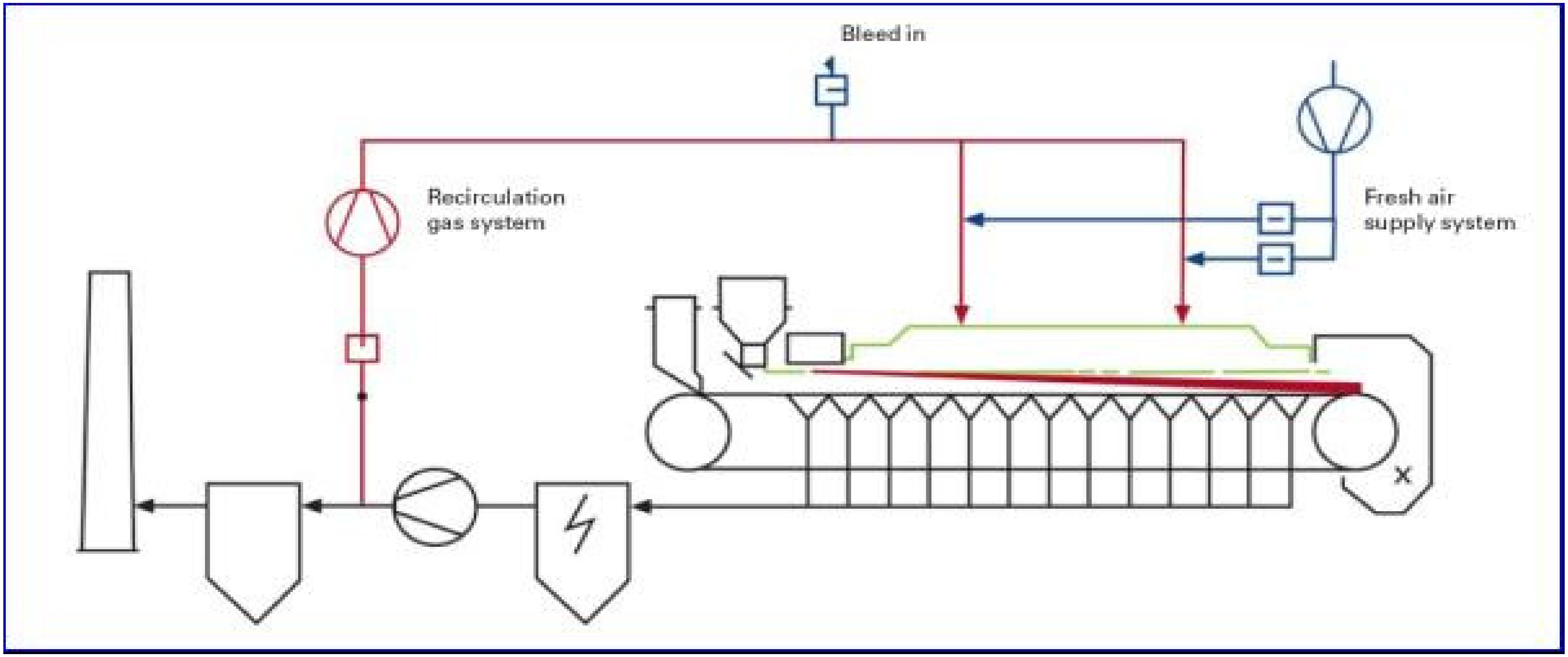
Emission Optimized Sintering (EOS®) for lower costs

Iron ore sintering creates substantial off-gas volumes, and treating these in order to meet increasingly stringent environmental standards is expensive. EOS® uses recycling technology to reduce off-gas volumes by 40 to 50 %, resulting in smaller secondary gas treatment systems. This means:

- **Lower capital investment**
- **Reduced operating costs**

Conventional sintering uses ambient air to transport heat within the sinter bed, requiring a high air flow rate. However, EOS® takes advantage of the fact that only a part of the oxygen in the air is consumed for coke combustion. Therefore a part stream of the offgas is recycled via the hood, enriched with ambient air to an oxygen content of 13–14 % and used as intake process air. This reduces off-gas volumes by about 40–50 % without affecting the sintering process

Typical flow sheet of a sinter plant with EOS® system



CONCLUSIONS:

- **Indian economy is growing at 8-9% currently and likely to grow at rates >10%.**
- **Steel demand and supply will grow in the same way riding piggyback on the growing infrastructure.**
- **India is likely to develop a steel making capacity of 120-150 MTPA by the year 2020 and around 400 MTPA by the year 2040.**
- **Since good iron ore deposits are depleting fast beneficiation technologies will have to be adopted to meet iron ore demand.**
- **Agglomeration technologies such as pelletisation and sintering will have to be added to Indian steel plants so that concentrates can be used and the agglomerated products used in iron making to produce iron and steel economically and in eco-friendly way. Existing sinter plants need to be upgraded to use concentrate.**
- **The Agglomeration technologies are constantly being upgraded to meet stringent environment standards. The same need to be incorporated in existing units to make these more eco-friendly.**

THANK YOU