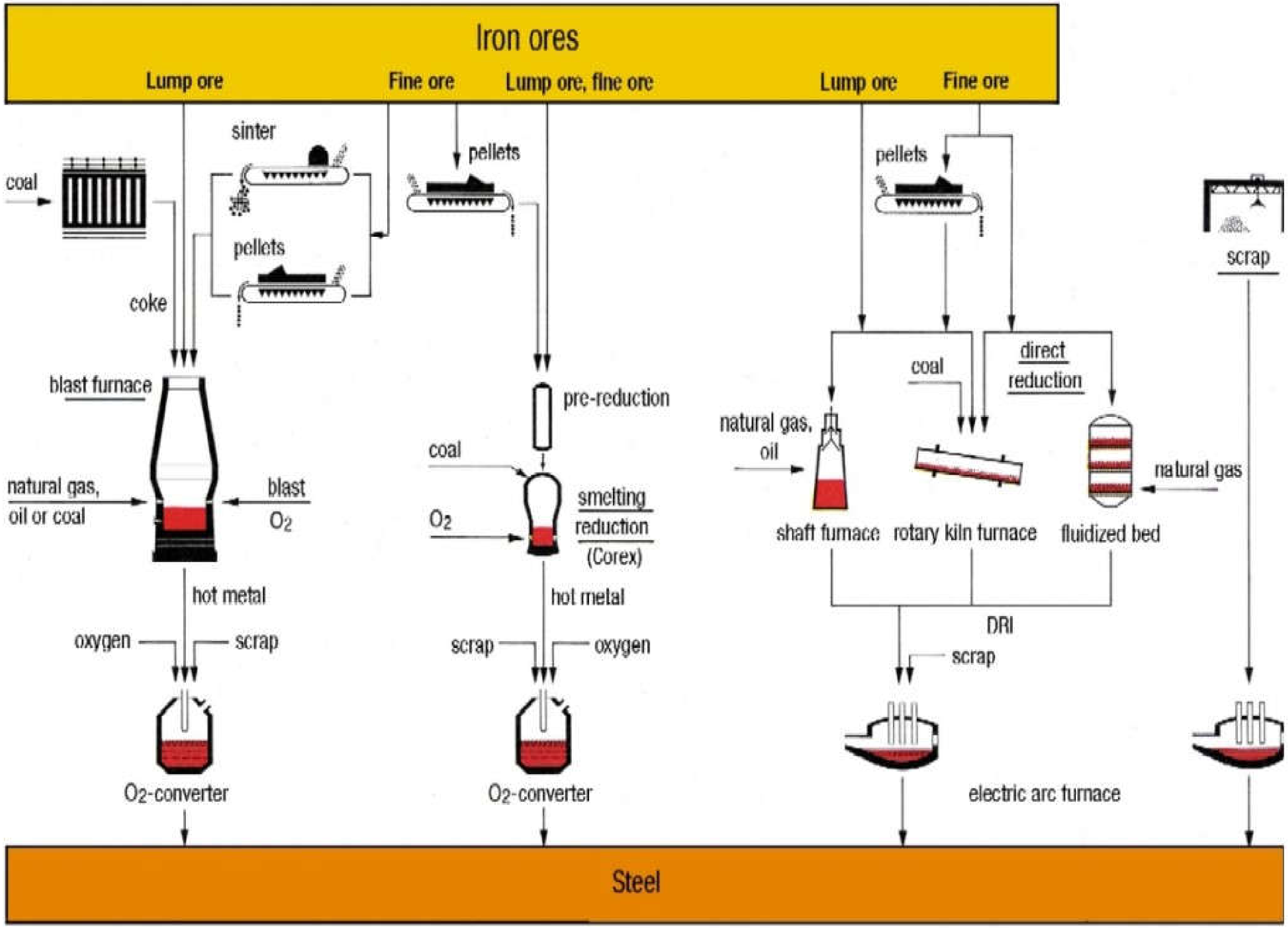
FUTURE OF PELLET INDUSTRIES
VIEW ON RESOURCES AND TECHNOLOGY

AGMMP-2024

D L Saralaya

IRON ORE TO STEEL



TYPES OF IRON ORE

Magnetite

Hematite

Goethite

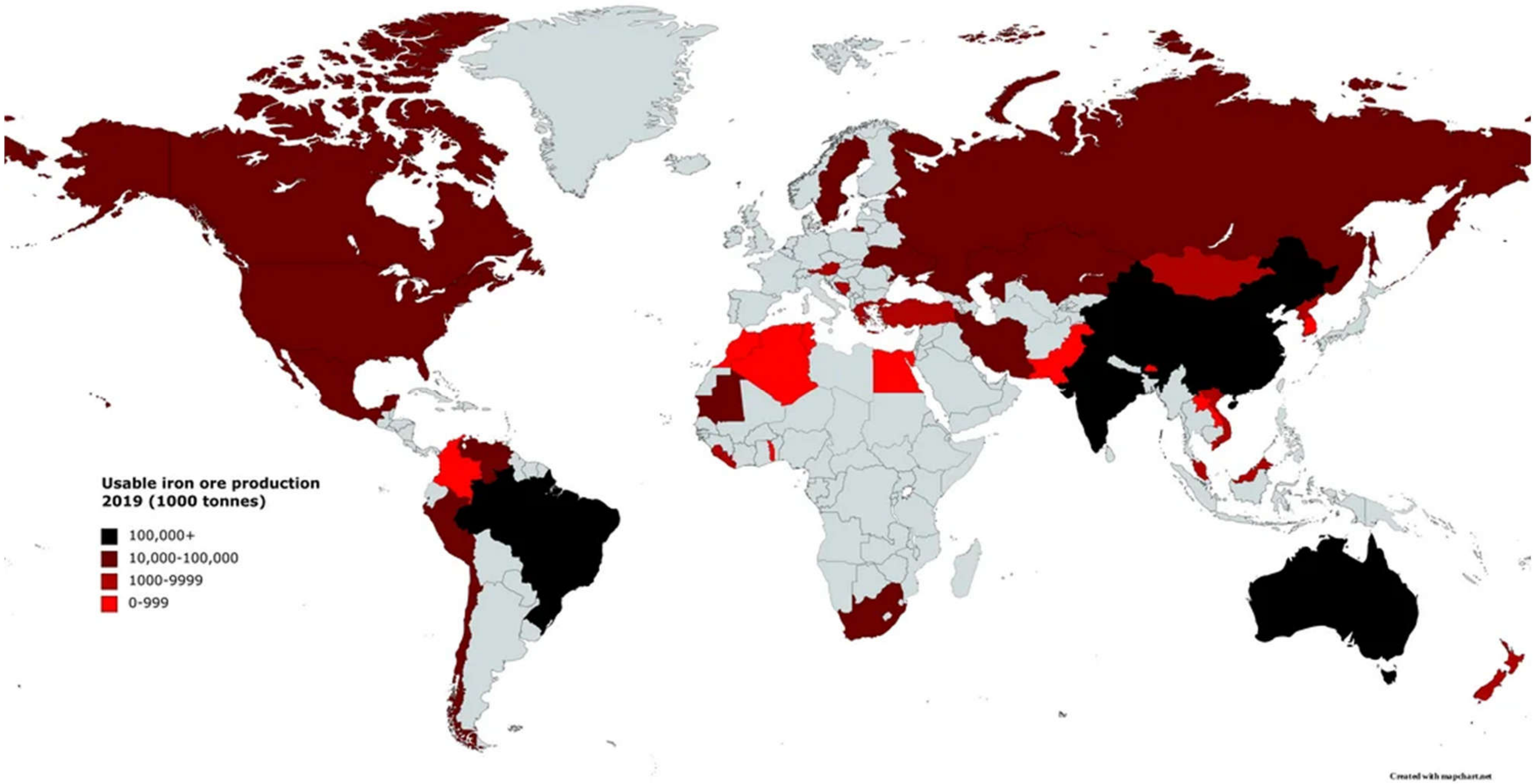
Limonite

Siderite

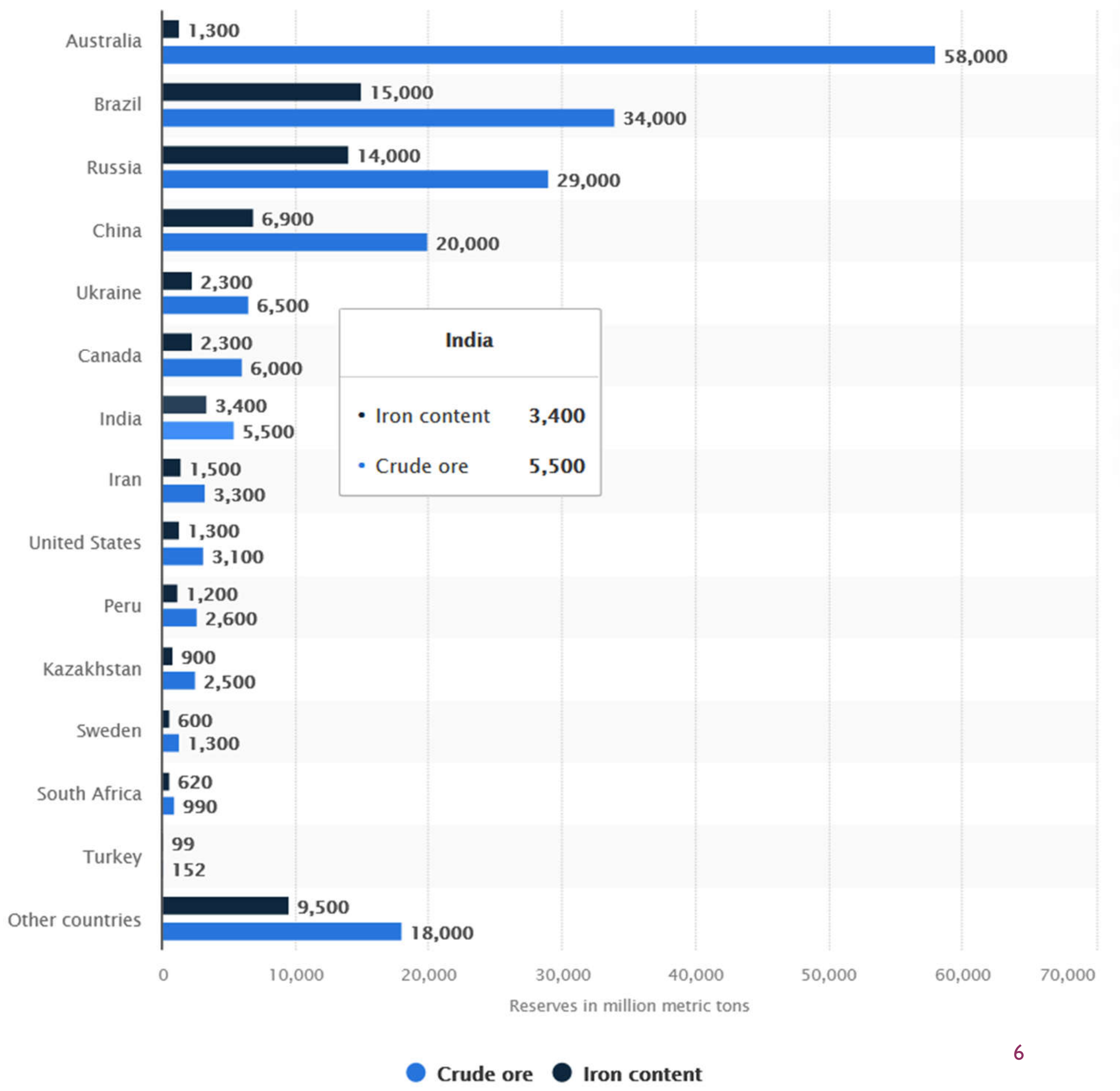
Taconite

IRON ORE RESOURCES

IRON ORE DISTRIBUTION IN WORLD

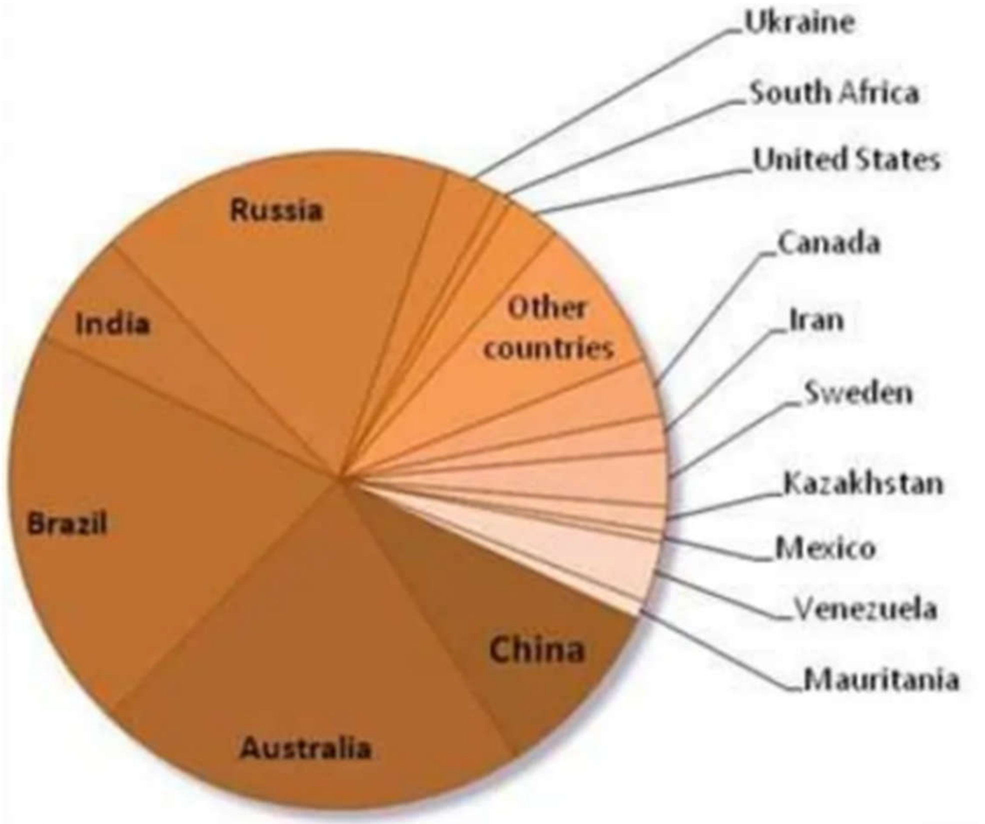


WORLD'S IRON ORE RESOURCES



WORLD'S LARGEST CRUDE ORE RESERVE

- Australia – 48 billion tonnes
- Brazil – 29 billion tonnes
- Russia – 25 billion tonnes
- China – 20 billion tonnes
- Ukraine – 6.5 billion tonnes
- Canada – 6.0 billion tonnes
- India – 5.5 billion tonnes



IRON ORE RESOURCES IN INDIA

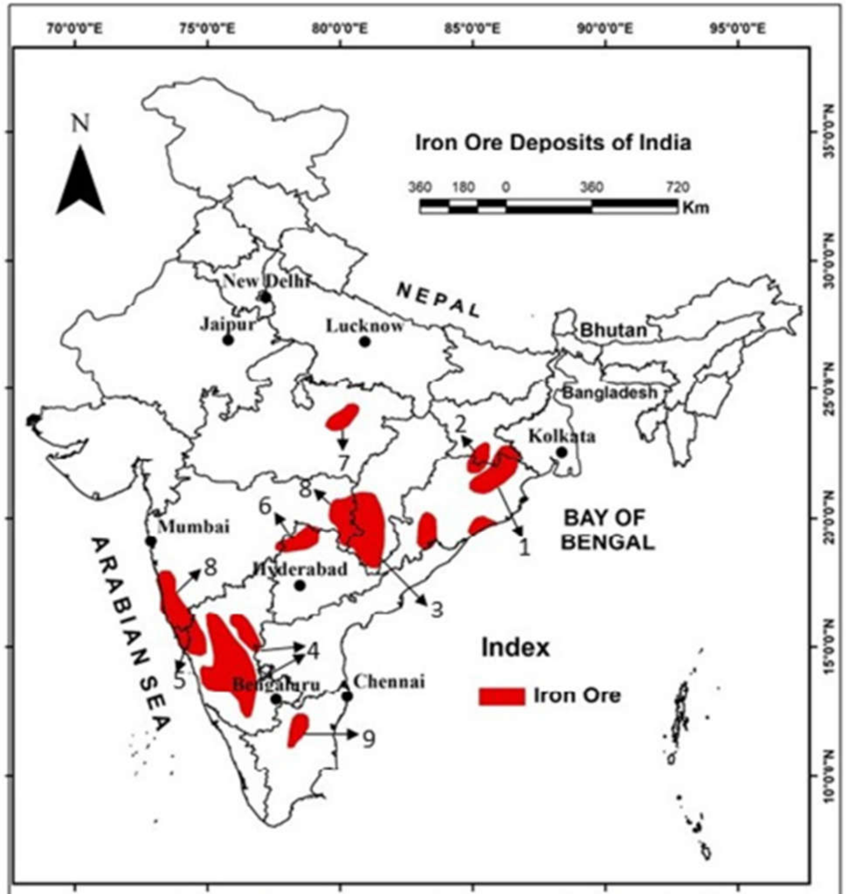
India ranks seventh among the countries which possess abundant iron ore resources.

As per NMI Database:

Category	Hematite	Magnetite
Reserves / Resources	24,057 Million T	11,227 Million T
Reserves	6,209 Million T	202 Million T
Remaining Resources	17,848 Million T	11,024 Million T

Of the main iron ores in India, about 60% Hematite ore deposits are found in the eastern sector, while around 93% magnetite ore deposits occur in the southern sector, particularly in Karnataka

DISTRIBUTION OF IRON ORE IN INDIA



Distribution of Iron-ore deposits of India (after GSI, 2011)

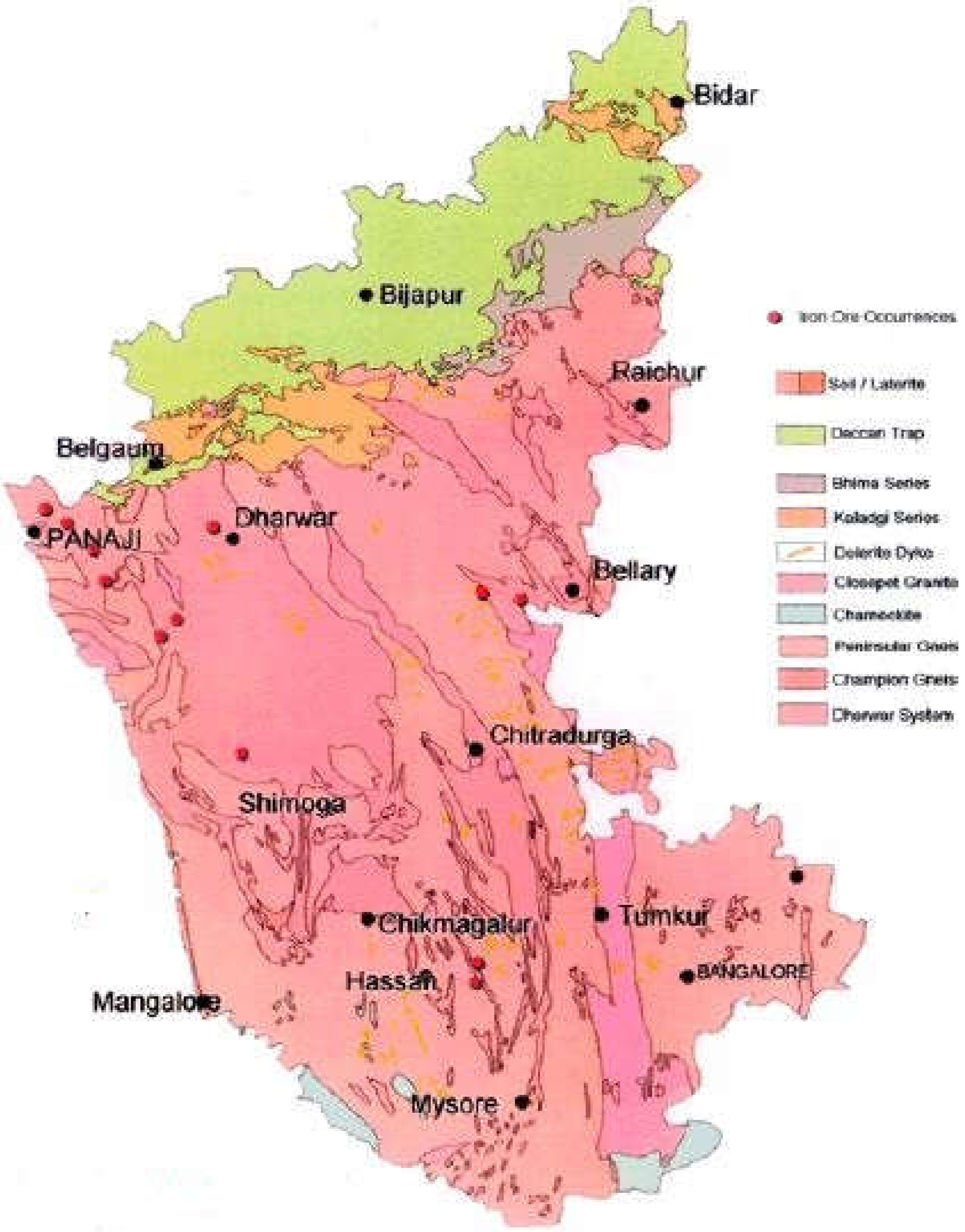
1. Sundergarh, Kendujhar, Mayurbanj and Cuttack districts of Odisha, 2. East and West Singhbhum districts of Jharkhand, 3. Bastar and Durg districts of Chhattisgarh, 4. Bellary, Hospet and Chikmagalur districts of Karnataka, 5. North and South Goa, 6. Adilabad district of Telangana, 7. Jabalpur and Sarguja districts of Madhya Pradesh, 8. Chandrapur and Ratnagiri districts of Maharashtra and 9. Salem and Trichinapally of Tamil Nadu.

State	Hematite Reserve (MT)	Wt%
Odisha	9,409	39 %
Jharkhand	4,710	20 %
Chhattisgarh	4,592	19 %
Karanataka	2,835	12 %
Goa	1,197	5 %
Other	1,197	5 %
Total	23,940	100%

IRON ORE RESERVE IN KARANATAKA

- Karnataka has very rich iron ore deposits of around 2,835 million tonnes.
- Iron ore is mainly distributed in the districts of Bellary, Chikkamagaluru, Bagalkot, Chitradurga, Tumakuru, Shivamogga, Dakshin Kannada, Uttara Kannada and Gadag.
- GSI has estimated a reserve of about 1,876 million tonnes of iron ore with about 65% of the total in Sandur belt.
- Large deposits of Lateritoid Hematitic iron ore in association with Manganese ore form prominent ridges of the Sandur schist belt.

IRON ORE DISTRIBUTION KARNATAKA

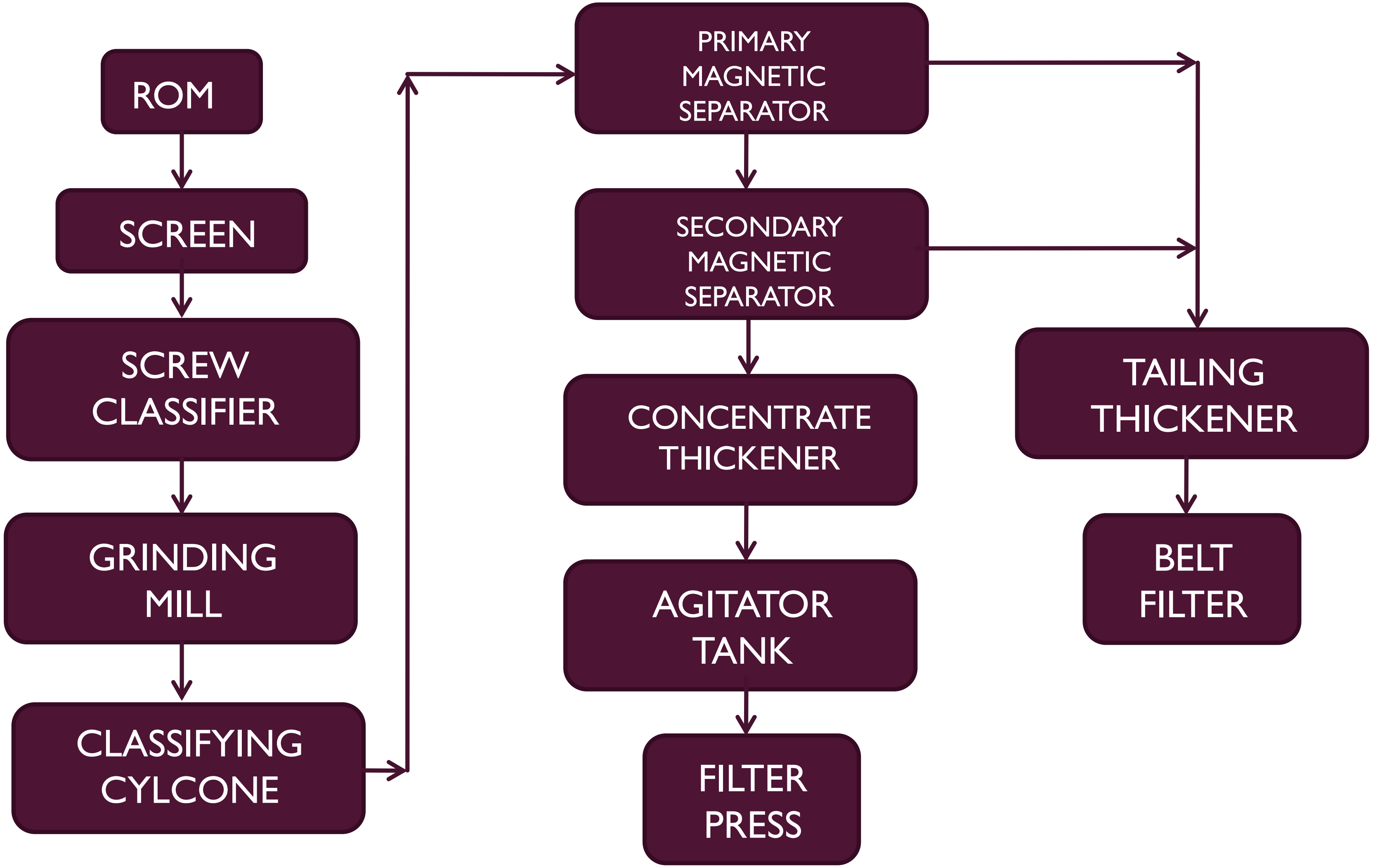


BENEFICIATION

BENEFICIATION PROCESS

- Beneficiation is a process of enriching Fe content by separating the gangue from iron bearing minerals.
- Impurities in the ROM iron ore are interlocked and have to be liberated before they can be separated.
- A wet beneficiation plant for producing high-grade iron ore concentrate requires Screens, Grinding Mills, Classifiers, Hydro-cyclones, Magnetic Separators, Agitators, Filters and Thickeners in the process route.

BENEFICIATION PROCESS FLOWSHEET



NEED OF 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.
- Improved productivity and efficiency of the rotary kiln & Blast Furnace with superior reducibility behaviour of pellets compared to lump ore.

ADVANTAGES OF PELLETISATION

- Pellets are superior to iron ore lumps in the subsequent iron making processes such as Blast furnace, DR furnace etc.
- Pellets with a nominal 64- 67% Fe, uniform porosity and better size help in faster reduction and higher metallization rates than the conventional iron ore lumps.
- The inherent higher mechanical strength and abrasion resistance of pellets enhance the production rate of sponge iron by approx. 20% under identical operating conditions.
- Pellets are of spherical shape with a size range of 9-16 mm.
- Pellets are not vulnerable to degradation during transportation due to their high abrasion resistance

ADVANTAGES OF PELLETS IN BF

- Improved productivity
- Reduced specific consumption of Coke especially with PCI
- 0-5 mm ore fines can be utilized & charged instead of rejecting
- Lower blast pressure required
- With the pellets of 10-20 mm Centrifugal Fans in series can be used in BF , instead of high Blast Pressure Turbo Blowers for10-40 mm lump ore
- No losses in handling iron ore as pellets will not break during transport or handling

ADVANATAGES OF PELLETS IN DR KILN

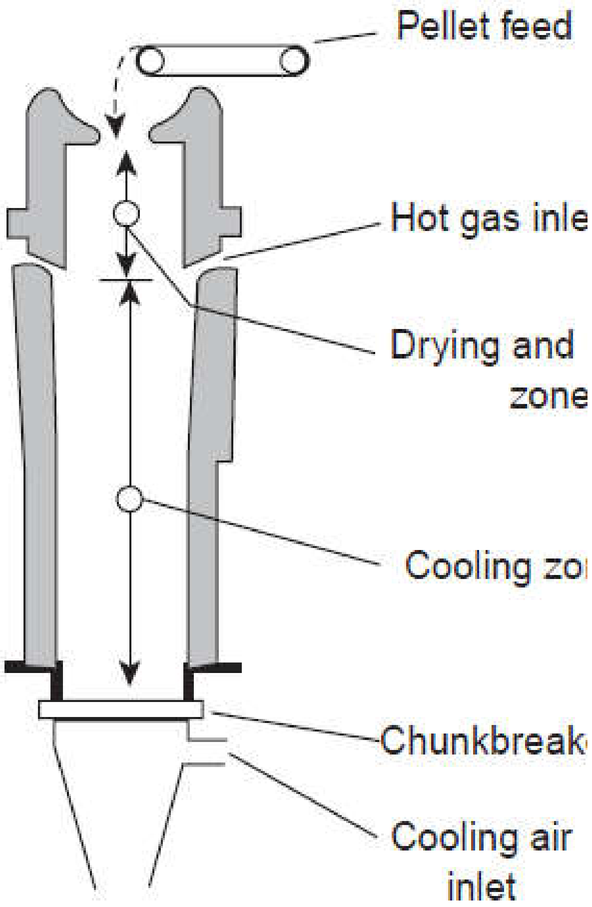
- 20-30% increase in production from rotary kiln
- Reduction in specific consumption of coal
- Longer campaign life due to less accretion
- Refractory repairing cost will reduce as there will be no accretion and no fused lump formation
- Metallization will be better compared to lump ore
- Fines generation will be drastically reduced in the product.
- Eliminating the needs of its crushing andscreening of iron ore and resultant fines disposal problem
- No losses in handling iron ore as Pellets will not break during transport or handling

PELLETISING TECHNOLOGY

TECHNOLOGIES OF PELLETISING

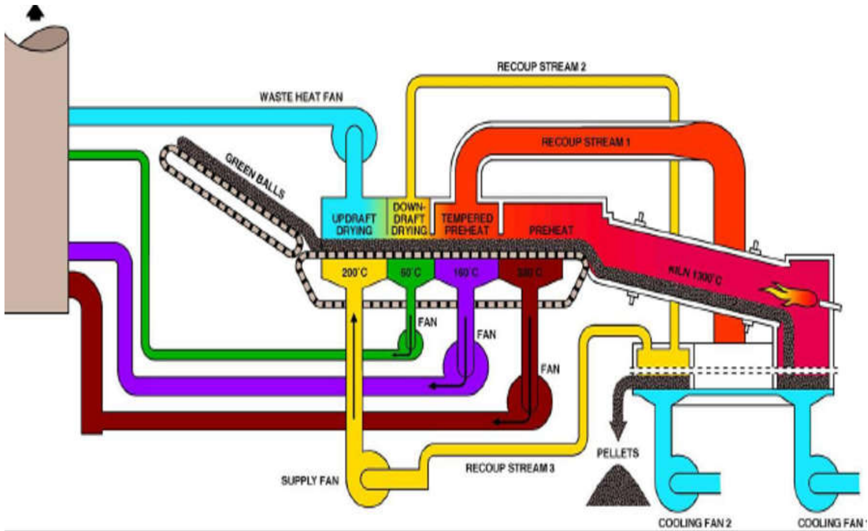
- Shaft Furnace
- Grate Kiln
- Straight Travelling Grate
- Circular Grate

SHAFT FURNACE



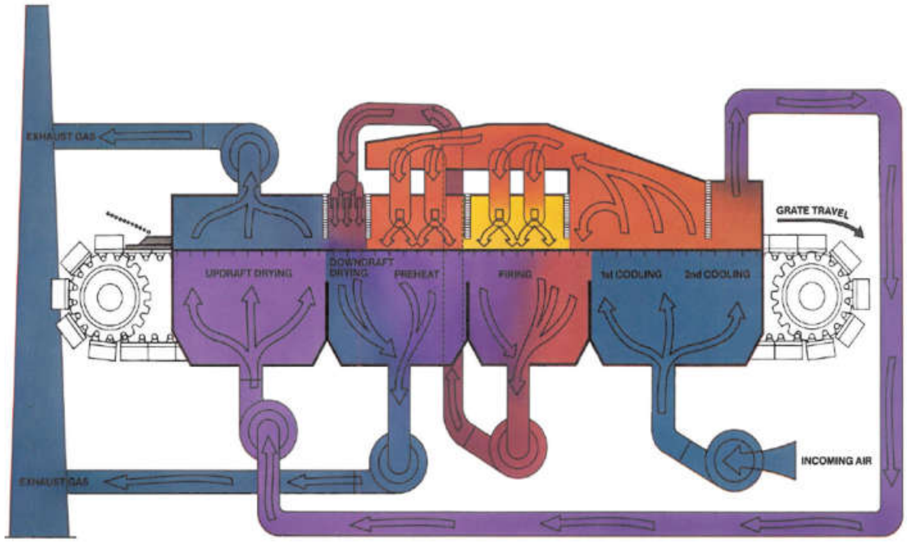
- Simple Construction, a small number of moving parts, refractory lining of total furnace with bricks of optimum ceramic quality differing in various zones
- Intensive heat exchange between gases and solids due to countercurrent flow.
- A disadvantage of the shaft furnace is the little chance of influencing individual process stages and thus causing a lower flexibility.

GRATE KILN



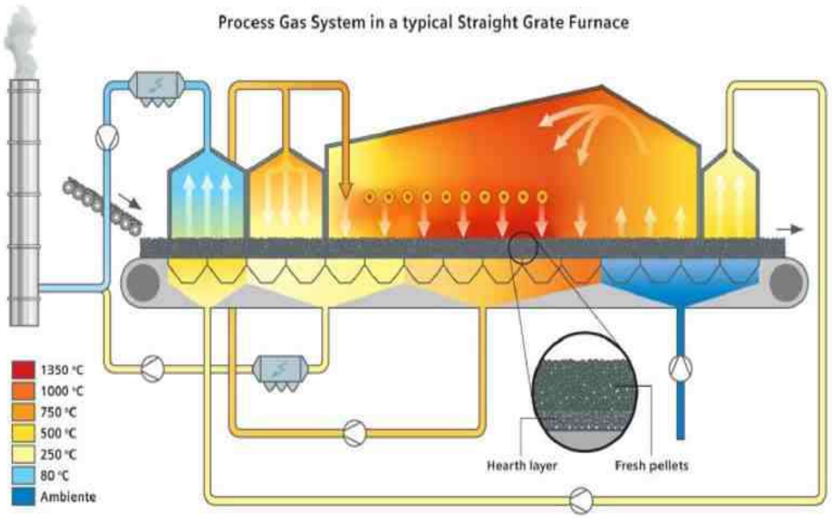
The Allis-Chalmers process employed in the travelling grate-kiln-cooler is again best suited for either magnetite or magnetite + hematite blend of iron ore. Green pellets, fed on to a travelling grate are dried and preheated to a certain temperature, discharged into a rotary kiln for firing and cooled in an annular rotary cooler. Thus, the pelletizing process involves three stages. The main advantage of this process is uniform heat hardening of pellets due to continuous rotation of kiln. The inherent disadvantages of this process are low flexibility of temperature profile and low fuel efficiency due to a single burner at the end of the kiln besides one straight travelling grate and two rotary equipment to maintain.

STRAIGHT TRAVELLING GRATE



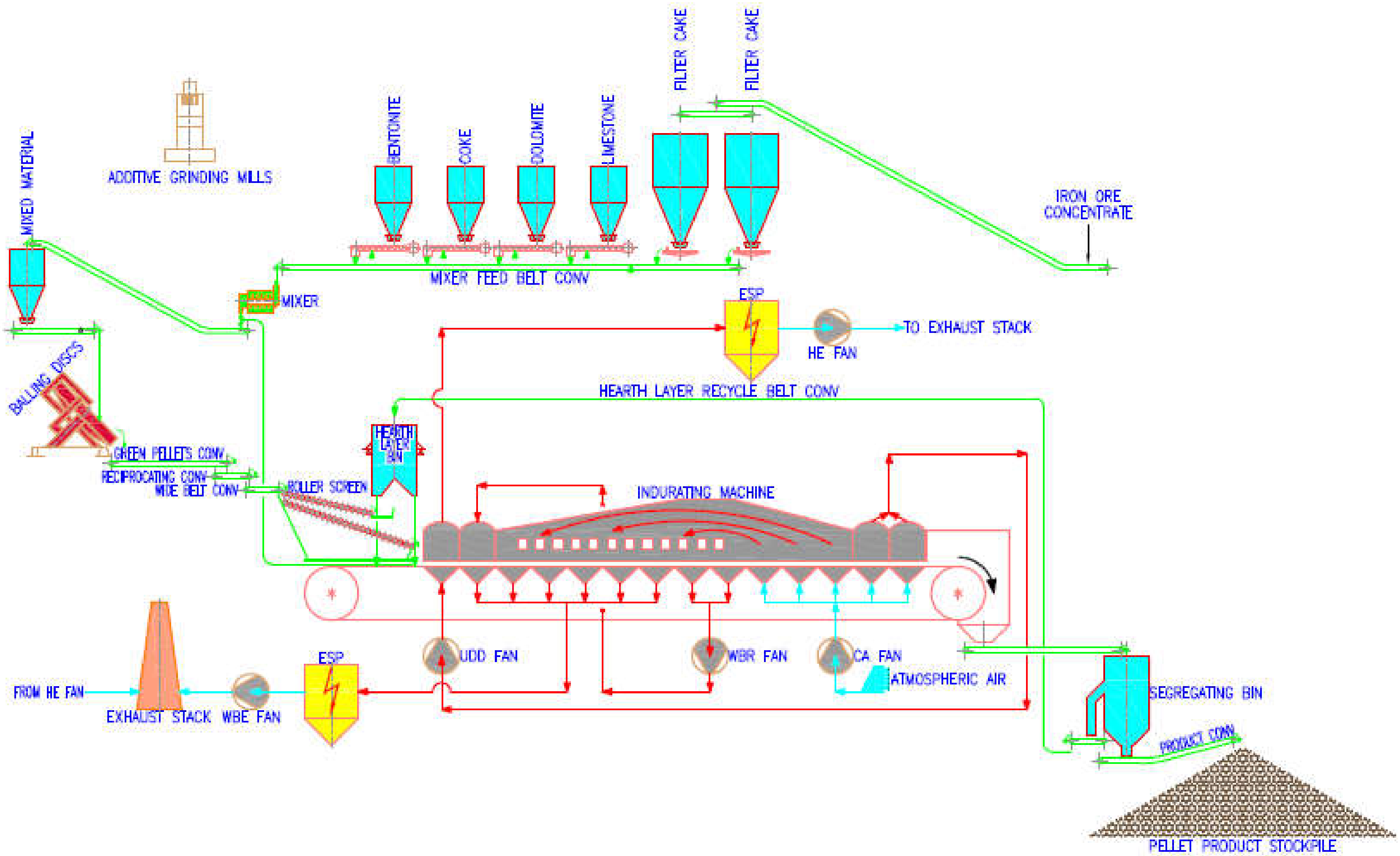
The straight travelling grate process is rather versatile and can handle all types of pellet feed whether 100% hematite, 100% magnetite or a blend of both. Entire process comprising drying, preheating, firing, after-firing and cooling are carried out on a single straight travelling grate. Advantages of this process are its simplicity, no rotary equipment, and highest possible fuel efficiency inherent to furnace design equipped with several pairs of burners in the firing zone besides flexibility.

CIRCULAR GRATE



Circular grate plant is similar to dip rail sinter cooler. The induration cycle of a circular grate plant is the same as in a straight-grate system. In straight grate systems where one-half of the induration grate is returned empty to the charging station and in the circular grate design, the cars rotates in the circular form in the circular furnace comprising of drying, preheating, firing, after-firing and cooling zones.

PELLETISING PROCESS FLOWSHEET



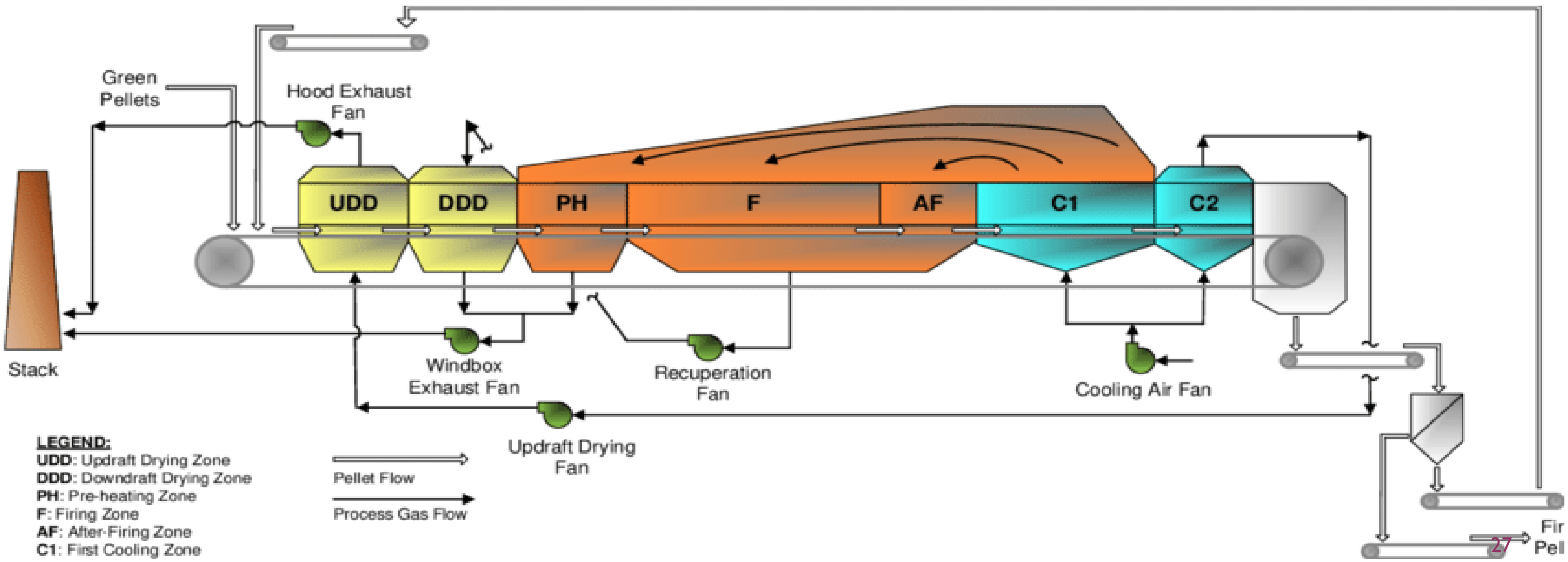
INDURATION

Induration of green balls involves thermal treatment in the following stages:

- Drying of green balls.
- Heating of dried pellets & oxidation of magnetic pellets up to induration temperature.
- Firing at induration temperature.
- Cooling of indurated pellets.

INDURATING ZONES

UPDRAUGHT DRYING	DOWNDRAUGHT DRYING	PRE HEATING	FIRING	AFTER FIRING	COOLING ZONE



REACTIONS AT DRYING ZONE (180 -350 ^{0}C)

Reaction	Remarks
During drying the moisture contained in the green balls is evaporated by warm gases. The water contained in the green balls will be in a variety of combinations: •Water Contained in the **interstices** between the particles i.e in the pores and capillaries •In case of **porous ore,** water may also be in the pores of the individual ore gain. •Water may be chemically **combined** as hydrate, e.g in limonite or in other materials accompanying the iron oxide. •Water may be **incorporated** in to such binders which tends towards the formation of gels, e.g clays or bentonite. •Water may be **chemically combined** as hydrate in such in such binders, which lead to hydrate formation, e.g. Ca $(OH)_2$, Mg $(OH)_2$. •Water may present as **crystal components** in existing or added salts.	Only part of the water contained in the green balls evaporate at 100 ^{0}C . Salts and hydrate combinations loose their water at higher temperature only.

REACTIONS AT PRE HEATING ZONE (500 -1000 ^{0}C)

Reaction	Remarks
During preheating, various reactions proceed in parallel and successively according to component composition Evaporation of crystal water Decomposition of hydrates, carbonates, sulphates. Roasting of sulphur from sulphide components. Conversion of iron oxides from siderite, limonite, pyrite as well as mainly magnetite into highest oxidation stage, the hematite Gasification of solid fuel such as coal, coke etc.	$CaCO_3$ -> $CaO + CO_2$ $MgCO_3.CaCO_3$ -> $MgO + CaO + 2CO_2$ $C + O_2$ -> CO_2 $CO_2 + C$ -> $2CO$ $2Fe_3O_4 + ½ O_2$ -> $3Fe_2O_3$ (550 ^{0}C) in presence of excess oxygen

REACTIONS AT FIRING ZONE (1200 -1350 ^{0}C)

Reaction	Remarks
During induration stage, the pellet charge is heated to an optimum temperature for each ore type and this temperature is maintained for a controlled period. The said temperature is to be below the melting temperature but within reactivity range of gangue components and additives. In general, firing is achieved under a defined oxidation atmosphere. Two thermal bonding types are decisive. •Change of **crystalline structure** during firing either by crystal transformation and growth upon oxidation of magnatite to hematite or by crystal growth when hematite is used only.	$Fe_3O_4 + O_2$ -> Fe_2O_3 $Fe_2O_3 + C$ -> $Fe_3O_4 + CO$ $Fe_2O_3 + CO$ -> $Fe_3\ O_4 + CO_2$ $C + CO_2$ -> 2 CO $Fe_3O_4 + CO$ -> $FeO + CO_2$ $FeO + SiO_2$ -> Fayalite (melts at 1205 ^{0}C) Fe2O3 + CaO -> $CaO.2Fe_2O_3$ (calcium differite); $CaO.Fe_2O_3$ (calcium ferrite); $2CaO.Fe_2O_3$ (dicalcium ferrite)

REACTIONS AT FIRING ZONE (1200 -1350 ^{0}C)

Reaction	Remarks
The reaction of slag forming constituents which are either present as gangue in ores or concentrated or added before the ball formation such as bentonite, quartz or basic additives, Basic components react with acid components and under certain conditions also with iron oxide.	$CaO + SiO_2$ -> $CaO.SiO_2$ (Ortho silicate) Fe_2O_3 -> Fe_3O_4 (reservation of hematite at high temperature 1350 ^{0} C)

R&D ROLE IN PELLET MAKING

Contribution by Centralised R& D Centre

- Pilot Plants in R & D Centre – Plant wise feed ore testing
- Centralised Process parameter guiding for all plants
- Implementation of R & D tests in the Operating Plants
- Plant efficiency and optimisation guidelines
- Pellet quality benchmarks

MAKE IN INDIA PELLET TECHNOLOGY

Need of Pellet Technology & Machine from India

- Pellet Technology – Material balance, Gas Balance & Furnace Sizing for Indian Conditions
- Design of Pellet making machines in India
- Manufacturing facility for large scale Casting & Machining
- Medium scale pellet plants complete design solutions

ENVIRONMENT – PELLETS IN IRON & STEEL

- Lower Emission Rate
- Emission in sintering process are much higher than compared tp pelletising process

Process	SOx(gm/t)	NOx(gm/t)	CO(Kg/t)	CO_2(Kg/t)	Particulate matter(gm/t)
sintering	1670	640	38	220	260
Pelletising hematite	200	500	1	30	80-85
Pelletising magnetite	100	200	<1	25	125

CO2 EMISSION

Target to reduce CO_2 emission in Steel Making

- Optimum CCS in Pellets
- Replacing Sinter to Pellets in BF burden
- Plasma Burners in Pelletisation
- Centralised Large scale Beneficiation
- Alternative fuels

THANK YOU

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