

SINTERING MACHINE

OR

DWIGHT LLOYD SINTERING MACHINE



• Important parts of the machine

1. Storage bin
2. Mixer drum
3. Feeder
4. Leveller
5. Band of pellets and rails for its moven.
6. Drive Mechanism
7. Sinter breaker.
8. Screen
9. Cooler
10. Spillage collector
11. Windbox.
12. Dust Extractor
13. Exhaust fan/blower
14. Ignition hood.

i. Storage Bin :-

Raw Materials Like Iron Ore, (-10mm, +100mm) ore fines, coke breeze (-3mm), flux, reclaimed flux dust, return fines, etc are generally used for Sintering.

These may be stored in separate overhead Bins from where weighed amount of these are delivered to the mixer to prepare the feed mix.

ii. Mixture drum :-

The raw material are moistened and thoroughly mixed and mixer to prepare a desired homogenous feed for Sintering. After initial Mixture the moist charge is rolled in a drum to nodulise the fines and thereby decrease the size range of the particles and improve permeability of the Sinter bed.

iii. Feeder :-

After mixing the green mix is laid evenly across the whole width of the pallet with minimum compaction. It is necessary to have a continuous uninterrupted flow of charge on the pallets when the machine runs.

● Charge Levellar :-

For smooth working it is necessary to have uniform thickness of the bed on the pallets. A flat plate is fitted immediately after the feeder to level off the charge. The thickness of the bed is in the range of 30-45cm (300-450mm) and now it is 45-60 cm.

● Ignition hood :-

The top layer of this green mix is heated to the sintering temperature ($1200^{\circ}\text{C} - 1300^{\circ}\text{C}$) by a gas or oil burner. One or more rows of burners are fitted into the hood over the entire width of the pallet. The proper ignition depends on the amount and distribution of the solid fuel (coke) in the mix. Since cost of solid (coke) fuel can amount to nearly 80% cost of the sintering production.

● pallet :-

The pallets has to support the mix during its travel from feed end to discharge end. It must also stand high temp develop during Sintering.

The grate (जाल) bars laid at the bottom of the pallets should provided maximum openings without allowing excessive fine materials being pulled through into the wind boxes during Section.

The side wall of the pallet have a maximum depth of about 60 cm (for 30-45 cm bed) and 70 cm (For 45-60 cm) it walls tapers outward to ensure free face of the Sinters cake at the discharge end.

The rollers are attached on each side of the pallet to for smooth running on the rails.

Drive Mechanism :- The pallets move from feed into discharge end on the upper rail track and after discharging the Sinter cake. return back to the feed end in overhung fashion on the lower rail track.

The Speed of Sintering machine is around $1.5 - 2.5 \text{ m/min}$.

- Sinter Breaker :- Because of Straight line movement of the pallets feed end to discharge end the Sinter cake is practically a one whole piece.

At the discharge end when the pallets change the direction of their movement one by one the Sinter cake breaks in slabs of nearly the same dimensions as that of pallets.

These big piece come in contact with Sinter breaker as a series of pronges and claws mounted on a shaft. the lump of cake size are broken by this Sinter breaker in to suitable size.

The breaking of the Sinter is done in hot condition after breaking the Sinter is screened at the oversize (BF size) is cooled fully so that it could be carried out to the blast furnace through conveyor belt. The fines are also collected and can be suitably recirculated to the Sinter Machine.

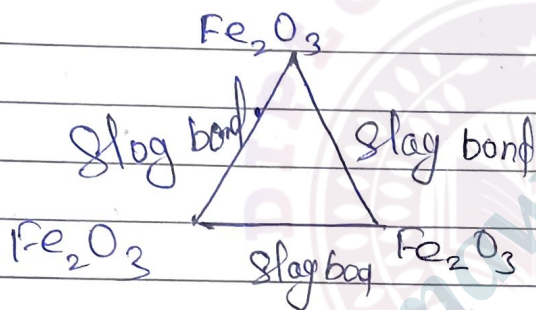
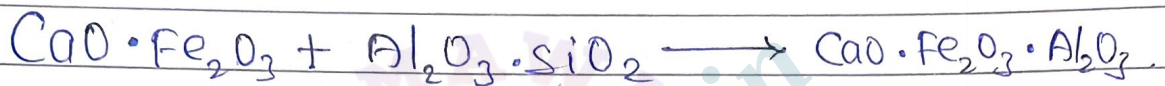
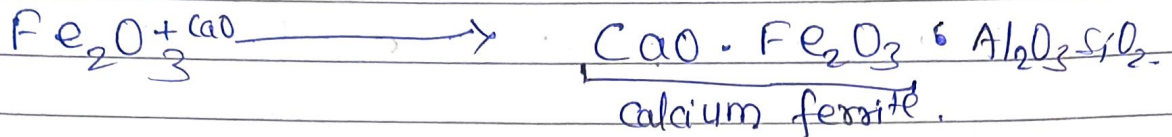
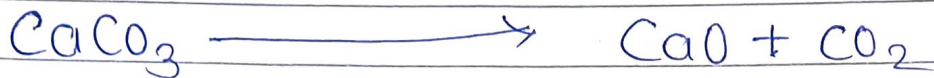
• **Spillage Collector :-** In spite of all care the material do spill over due to the vibration of moving machine and these must be collected and reused again. The machine is covered on the sides and a longitudinal bunker is installed below and a bottom track such that the Spillage from the top track and Sinter fines or lump sticking to the grate can be directed to the conveyor all this to the Sinter Screen for further processing.

• **Wind box, Dust extractor, Blower :-**

Wind box are connected to the entire length of pallets and it is connected below the pallet uniform suction through this windbox can be done with the help exhaust fan. The dust coming with the exhaust gas are collected in the dust extractor with are feeded just after the waste gas main.

The exhaust/waste gas may be cleaned before taking them off into the atmosphere through stack or chimney.

Mechanism of Bonding



Silica ferrite of calcium & Aluminum (SFCA)

- Sinter me slag bond banega.

Types of Sinter.

There are mainly three types of Sinter.

① Acid Sinter or no flux Sinter:-

The Sinter mix does not contains any flux. flux is added in the BF separately.

2. Flux Sinter :- The amount of flux added in the mix is such that the basicity of the mix is equal to that of the slag to be

produce. in the furnace, Seprate addition of flux Could be required only in proportion to the lumpy ore charged in the blast furnace.

~ The extra flux is added to take care of Impurities of Ore as well as coke & ash in BF.

Super flux Sinter :- In this type of Sinter an additional flux is added to the mix to produce for the desired final Slag basicity Taking into account the impurities content of both ore as well as coke.

• Advantage of Sinter •

- ① Agglomeration of fines into hard, strong, and porous lump which gives better bed permeability.
- ② Elimination of moisture and other volatile matters on the Sinter stand with a chipper fuel.
- ③ Super flux Sinters save much more coke in the B.F.
- ④ Increase the Sinter percentage —

In the blast furnace burden
Increase the permeability of the
B.F resulting Increase in the productivity.

(5) Utilization of Solid waste generate
with in Steel work.

(6) Elimination of 60-70% of
Sulphur and arsenic if
percent during Sintering.

(7.) Lime rich bosh slag hinder
reduction of silica, absorbed
vapourised Silicon and Sulphur to
produce low Silicon and low Sulphur.

(8.) Increase the Softening temp. and
narrowing down of the Softening
range.

• Quality of Sinter.

- (1) Size and Size Range
- (2) physical behaviour at room temperature
- (3) physical behaviour at high temperature.

(1) Size and Size Range:- Higher fines
and Increase Size range of particles
increases the packing density which
in turn decrease the permeability.

2. physical behaviour at Room temperature:-

- Tumbler Index — Increase of CaO by SiO_2 , increase of CaO by Fe decrease in Limestone. Sizing addition of burned lime increase in bed depth etc. Have been Used to Increase the tumbler Index.

SINTERING PROCESS

LEAC - NOTES

Sintering.

→ है एक Agglomeration process - fine particles -

- Heat - जिससे fines bond - चिपक जाते हैं।

* generally - particles - Surface - दो Bond

i. diffusion (Low temp)

ii. Second (temp high) - particles - Surface -
Slag layer - due to flux - जिससे particles -
slag or glass ऑक्साइड में चिपक जाते हैं। (blue - कार्य)

Agglomeration → Sintering → ज्यादा Economical Use
→ pelletizing → low Economical & Use.

Why Use SINTERING.

→ fines को direct furnace charge.

→ fines " " charge permeability ↓

→ B.F Work नहीं कर पाएगा.

Advantages of Sintering.

→ इसका बस - Advantage - सिर्फ Fines → के Use

→ Adv - ये भी → pre - calcination - due to flux -

→ जिसको पुरा करने के लिए Heat की भी जरूरत पड़ती है।

→ जो बाद में नहीं पड़ती. (BF में)

→ जिससे हमें Coke ↓

→ And इसमें Reduction बहुत Fast होता है. Easily.

→ Flame temperature को हम Control कर

Dwight - Lloyd Sintering Machine.

दो Scientist का Name.

सॉर - Raw Materials - Hopper (Bunkers) में होते हैं -
जिसमें हम conveyers belt की सहायता से Granulator
फिर Mixer में डालते हैं - Hopper की Help से
- Dwight - Lloyd Machine में Charge करते हैं - फिर
→ Mixer में हम Moisture भी डालते - As - w) binder.

pellet size = 8-16 mm

* pelletising *

pelletising is a method of agglomeration or particle size enlargement in which material fines are processed into pellets and granules.

∴ pelletising is a process which involve mixing of very finely grounded particles of iron ore fines having a size less than 100 mesh with additives bentonite (binders) and then shaping them into a spherical balls having size in the range of 8-16 mm in diameter by a pelletiser and hardening the balls by firing with the fuel.

There are 4 stages involved in the production of iron ore pellet :-

- ① Raw material preparation
- ② formation of green ball and pellet
- ③ Indurance of pellets.
- ④ colling storage and the transport of pellets.

(1) Raw Material material preparation :- During the process of pelletisation iron ore concentrate from the iron ore beneficiation plant is dried and heated to around 120°C .

The dried material is fed to the ball mill or grinding concentrate ground iron ore of size 80% less than 45 microns (325 microns) with moisture content of around 9-10% is required for the pellet production.

Suitable binder (Bentonite) is added to the concentrate which is thoroughly mixed in a mixer.

(2.) Formation of green ball and pellet :- Green pellet with size range of (8-16 mm) are prepared in a balling drum or in a disc pelletiser.

~ Disc pelletiser is preferred for the production of quality green pellet.

- The disc pelletiser is an inclined pan around (5-7.5 m) of diameter rotate at around (10-15 RPM) Rotation per min.

The inclination of the base is around 45° . The prepared mix is fed into the disc at a controlled rate in the disc, the material is

due to the continuous rotatory motion formed into modules. One fines are lifted upward in a disc and the material rolled down to the bottom of the disc.

This rolling action first forms small granules called seeds (Nuclei) during the rolling action the balls encounter fresh feed more and growth takes place more by layering as the pellets grow in size and migrate to the periphery and to the top of the disc. Pellet growth is controlled by the small amount of water sprayed in the disc and the disc rotation speed with the growth of seeds their frictional drag against the disc decreases and the centrifugal force acquired by them increases and consequently they move out of the nucleation zone.

These pellets are called green pellets as they do not have required strength.

The green pellets are then screened and the required size material is sent to the induration plant.

3. Induration of pellet

During the induration the motion hardening of pellet is carried out by the application of heat. Induration of greenball pellets consists of three main steps.

- (1) Drying of green pellet ($150 - 300^{\circ}\text{C}$)
- (2) preheating of green pellet ($600^{\circ} - 800^{\circ}\text{C}$)
- (3) firing ($1200 - 1300^{\circ}$)
- (4) cooling of hot pellet.

(1) Drying of green pellet :- The green balls are dried by passing hot air through the bed of the balls laid on a grate. The temperature of hot blast is around $(150-300^{\circ}\text{C})$ depending on the moisture content of the green ball and the nature of the Ores from which the balls is made.

(2) preheating of green pellet :- In the preheating stage partial oxidation of magnetite and Sulphide if present occurs along with the calcination of carbonates and hydroxide the temperature of preheating is around $500-1100^{\circ}\text{C}$.

The solid bonding slag bond and grain growth commences in the preheating period. These are completed in the fixing stage.

(3). Firing :- For firing. the temperature is below the melting point of the major oxide phase presence but within the reactive Range of the gangue Components and additives. The temperature of

firing is around $(1250^{\circ} - 1350^{\circ}\text{C})$.

Liquid formation by chemical combination of various acid basic constituent. Consequently the development of slag bond occurs during firing.

The strength of the pellet is developed initially at the shell and progress towards the centre with time at the firing temperature.

Firing Units:-

Three different type of pellet firing machine that are in the commercial use:-

(1) Vertical shaft furnace:-

3. The travelling grate :- These are essentially modified adaption of Dwight alloyed sintering machine in which the green balls are feed at one end of continuous travelling machine and hardened and cotted pellets are discharged from the other end. The length of grate is divided into 4 different zones.

(1) Drying (2) preheating (3) firing (4) cooling.

The hot air from the Colling zone is circulated in a complex manner to carry out preheating by down draught on up draught.

firing is done by the Combustion of fuel gas (BF gas, Coke Oven gas, LD gas) The hot air from the firing zone is circulated to drying zone.

NOTE 1 - A protective layer (Hearth layer & side layer) layer of previously fired pellets on the bottom as well as on the sides of the bed.

The temperature therefore need not be raised to the firing temperature level near the bottom on the walls and the danger of over heating the metallic pellets is hereby eliminated.

NOTE 2 - Higher temperature of firing leads to excessive slag formation and less porous pellets, quality, detrimental to the B.F. operation.

NOTE 3 - No solid fuel (coke) is incorporated along with pellets.

• pellets Colling and handling.

The pellet are cooled and Screened after the induration the oversized pellets are crushed and are sent along with the undersize to the stock house bins where they are reprocessed.

• Advantages of pellet.

- i. Iron Ore pellet is a kind of agglomerated fines which has better tumbling index when compared with Iron ore.
- ii. pellet have good reducibility due to high porosity (20-30%) and Sinter have (10-18%). Normally pellets are reduced considerably faster than Sinter as well as ore.
- iii. pellets have a Uniform Size generally in the range of (8-16mm)
- iv. pellets are of Spherical shape (permeability) and open porous which gives good bed permeability.
- v. pellet have high and uniform mechanical strength and can be transported to long distance without generation of fines.

pellet — Iron Ore fines
Sinter — Iron Ore, flux, coke,

	% Fe	Contain
(1) pellet	—	65-67%
(2) Sinter	—	63-65%
(3) Ore	—	60-62%

Difference between pellet & Sinter.

Sinter	pellet.
(1) Sinter Size 10-40 mm	(1) pellet Size 8-16 mm
(2) Raw Material: -10mm to 100mesh	(2) -100mesh (-325 mesh)
(3) Sinter porosity 10-18%	(3) pellet porosity 20-30%
(4) Reducibility less (65%)	(4) Reducibility more (70%)
(5) Swelling less	(5) Swelling more.
(6) RDI less	(6) RDI More.

RDI - Reduction Degradation Index.

SCHEMATIC DIAGRAM OF BLAST FURNACE

Diplomawallah.in

BASIC TERMS TO KNOW

INTRODUCTION

The source of iron is its ore that is hematite (Fe_2O_3) and Magnetite (Fe_3O_4). Chemically pure iron ore contains 70-73% Fe.

But the available ore contains 50%-65% Fe and the rest is impurities (Al_2O_3 , P_2O_5 , SiO_2 , MnO , TiO_2 moisture etc.).

The gangue materials are insoluble in liquid iron and possess very high melting point. Their temperature is decreased by addition of flux and they form slag.

$$\boxed{\text{Flux} + \text{Gangue} = \text{Slag}}$$

Flux is in the form of limestone (CaCO_3), Lime (CaO), dolomite ($\text{CaCO}_3 \cdot \text{MgCO}_3$) is added. The Lime and magnesia (MgO) are bases where silica and alumina are acids and their ratio is called basicity.

$$\boxed{\text{Basicity} = \frac{\text{Base}}{\text{Acid}} = \frac{\text{CaO} + \text{MgO}}{\text{SiO}_2 + \text{Al}_2\text{O}_3} = \frac{\text{CaO}}{\text{SiO}_2}}$$

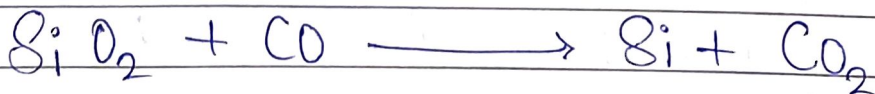
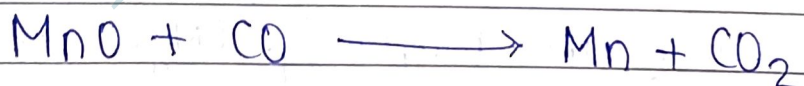
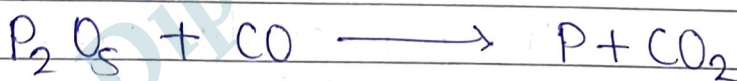
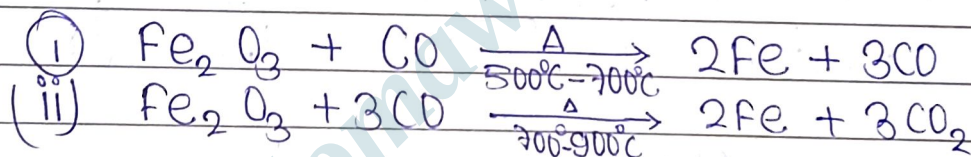
NOTE:- It is the ratio of CaO and SiO_2 if it is called $\checkmark$ ratio.

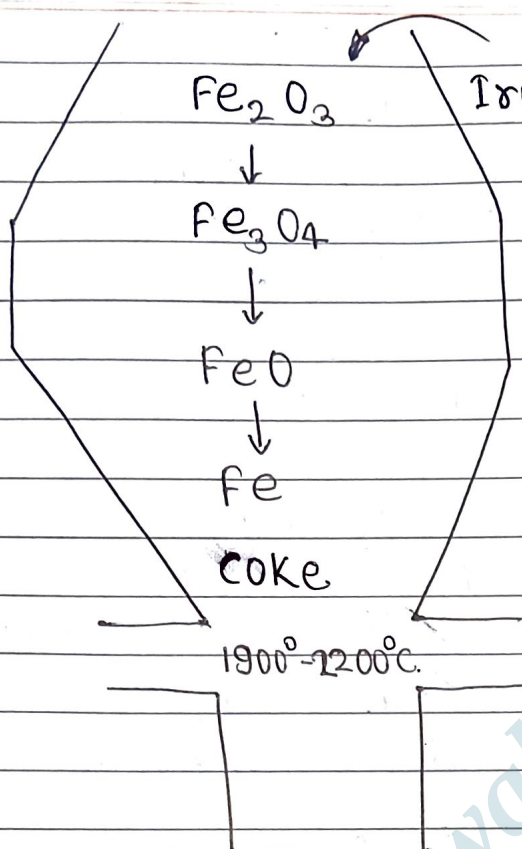
Iron bearings Materials :-(Lump ore, Sinter, pellet)

$$\text{Basicity} = \frac{\text{CaO}}{\text{SiO}_2}$$

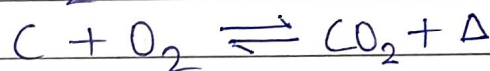
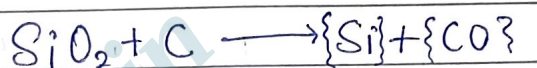
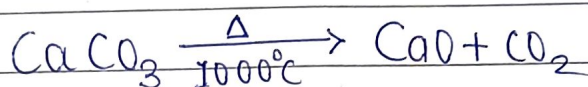
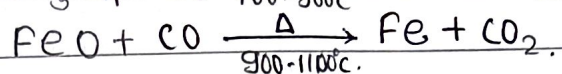
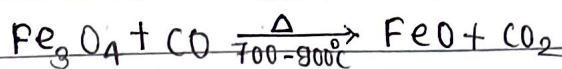
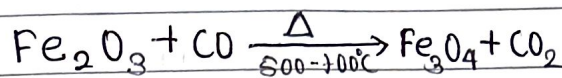
To meet the thermal and chemical requirement use coke along with coal and oxygen in the form of air.

- ① Iron bearing material - Iron Ore (जो Iron के ऐसा Material)
- ② Coke
- ③ Flux, Limestone, dolomite.





Raw Materials
Iron Ore, coke, flux.



5 Metal Impurities:-

$\text{Fe} \rightarrow \text{C}, \text{Si}, \text{Mn}, \text{P}, \text{S}$

Solid raw material at room temperature are charged from top.

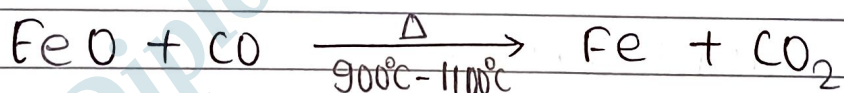
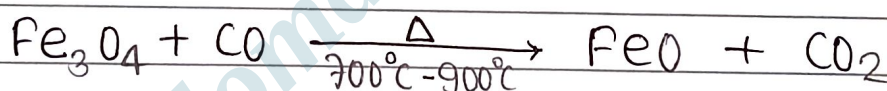
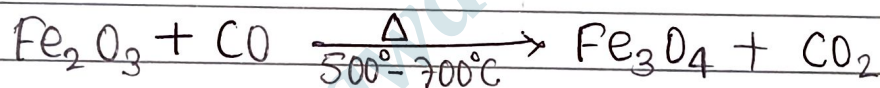
Solid raw material - (Iron ore, coke, flux)

* preheated air around $1000-1200^\circ\text{C}$ is blown through tuyers pipe inserted into the furnace through its wall.

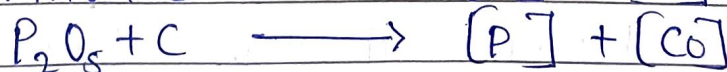
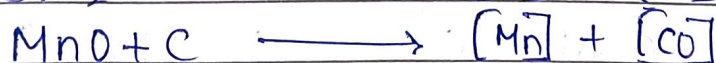
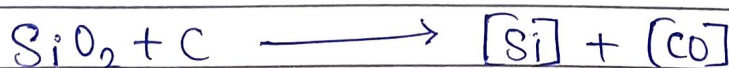
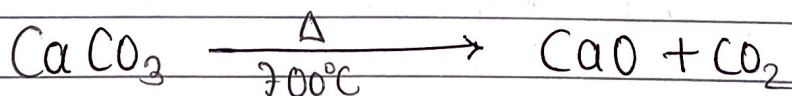
Exothermic Carbon Combustion of Coke by oxygen from air gasifies carbon into CO and also provides heat.

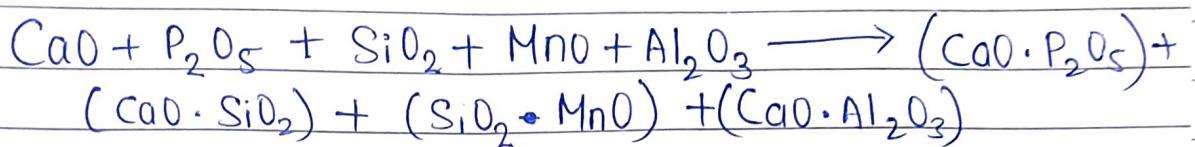
The highest Zone of the furnace (1900°-2000°) is at the tuyers level.

As the hot reducing gas travels upward it heats up solid charge as well as participate in various reaction at different zones of the furnace.



Calcination of CaCO_3 for making flux





*. The Output from the furnace are:-

- ① Hot metal or Molten Metal
- ② Molten Slag.
- ③ Blast furnace slag. (CO , CO_2 and N_2)

The hot metal is tapped out from top hole several times a day in to either open ladles or torpedo and transferred to the S.M.S. (Steel Making Shop) for further refining.

The Molten slag is tapped from time to time through the slag ~~hole~~ hole (slag notch) in to the slag ladle and is used as feed stock for manufacture of slag cement etc.

The top gas is known as blast furnace gas if it has a considerable fuel value since it contains CO .

The gas is cleaned and stored and then mostly utilized in the blast furnace shop itself for preheating of air and running turbines to drive air blowers.

—: Hot metal Composition:—

(i) C = 4 - 4.5 %

(ii) Si = 0.5 - 1.5 %

(iii) Mn = 0.04 - 0.06 %

(iv) P = 0.17 - 0.25 %

(v) S = 0.04 - 0.1 %

(vi) Fe = 92 - 94 (Rest)

Specific gravity
of blast furnace
= 1.02

—: Blast furnace Slag Composition:—

(1) CaO = 32 - 35 %

(2) SiO₂ = 28 - 32 %

(3) Al₂O₃ = 18 - 22 %

(4) MgO = 4 - 6 %

(5) MnO, CaS, P₂O₅, TiO₂ = (Minor)

Campaign life = 15-20 years

P₂O₅ - Phosphorus pentoxide

TiO₂ - Titanium Dioxide

—: Blast furnace gas composition:—

(i) CO = 20 - 30 %

(ii) CO₂ = 10 - 20 %

(iii) N₂ = 50 - 60 % (Rest)

(iv) H₂ = 2 - 3 %

Iron Density - 7.8 gm/cm³ = 7800 kg/m³

Slag Density - 2.5 gm/cm³

Coke Density - 3.7 gm/cm³

- Blast furnace gas exit temp - 200-250°C
- Blast furnace η Chlorotic Value 800-900 kcal/m³
- Blast furnace is a counter current reactor.

★ Blast furnace Construction :-

It is circular in crosssection and around 30-32m height. The Outer Shell is made of steel (50-70 mm) Inside the shell there is refractory Lining. The steel shell is welded construction rather than the earlier form of rivetted construction.

The tall structure have recently been made free standing i.e - Only Support is provided by the foundation.

The furnace interior is broadly divided into different Sections:-

(i) Stack (17 m) :- It is the upper (Section) portion of the blast furnace, whose walls slopes going outwards as goes downwards.

The charge gets heated from 200°C at the Stack line level, to nearly 1100-1200°C by the time it descends to the bottom of the Stack. Stack is also know as shaft.

In order to ensure free fall of the charge material as it expands progressively with progressive rise in temp the cross section of the furnace is uniformly increased to almost double the size from the stack line to the mantle level.

Since so much the iron oxide reduction occurs in stack the success of the blast furnace process depends on the counter current solid interaction in the stack.

- (2) Belly :- It is a cylindrical portion below the stack and above the bosh region the furnace walls are parallel to some extent in this region.
- (3) Bosh :- It is below the belly and slopping inward going downward the charged material being to soften and fuses as they come down into the bottom of the stack. (बोझा, षज्ज)
Melting of the burden except coke takes place in the bosh region.

The furnace walls in this region are tapered down in order to reduce the crosssectional area with the resultant decrease in the volume of a charge. The burden permeability in this region is mainly maintained by the solid coke.

The gangue and flux combine to form slag.

(Bosh contains unreduced FeO and primary slag)

The coke of adequate strength and size should be used for efficient operation. Any unwanted degradation of coke leads to the decrease in permeability in the bosh region and adversely affects the operation of the blast furnace.

• Tuyers •

Immediately above the hearth, tuyers are located through which hot air blast is blown for fuel combustion.

The no. of tuyers vary with the size of the furnaces, usually it is even no. between 24-42 and are uniformly spaced all over the periphery.

• Bustle pipe •

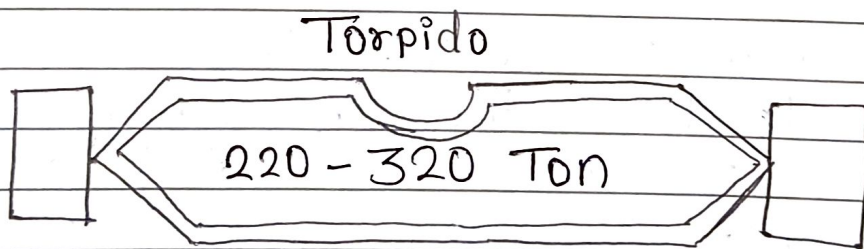
Air from hot blast stove is supplied to a huge circular pipe encircling the furnace at the bosh level.

This is called bustle pipe. The individual tuyers are connected to this bustle main.

• Hearth •

It is a reservoir to collect liquid metal and slag, the walls of the hearth are parallel and the hearth is the smallest cross-section of the furnace.

The entire charge is molten in the hearth and the slag and metal are tapped out from the hearth in separate ladders.



The cross-section of the furnace below the tuyers decreases, since liquid are dense without pores and

voids thus leading to decrease in volume. In the hearth wall taphole are located at around 0.3 - 0.6 m above the hearth bottom, whose diameter is around 12-15 cm.

• Tap hole and slag hole •

In some old furnaces another hole is provided for the removal of slag called slag hole, slag notch or cinder notch.

Both the holes are kept sealed by refractory, clay. For tapping the clay seal is opening by a mechanical drill machine. After tapping the iron notch and slag notch is again sealed by refractory clay. (refractory material)

For small capacity furnace there is only one taphole is provided by for large capacity modern blast furnace provided with two or four to (4) tapholes are provided

• Up takes (OFF takes) •

The gasses from the furnace top are carried out of the furnace by large vertical pipes called uptakes normally 4 in number. Two adjacent uptakes are joined together to form one single duct and the two such ducts thus form are connected to form only one duct which carries the gas downcomers in to the gas cleaning system.

• Downcomer •

The down coming pipe which delivers the gas from uptakes to gas cleaning system.

• Bleeder •

Bleeder valve is a safety device which opens automatically to release extra pressure developed inside the furnace and thereby eliminate the danger of explosion. Some furnaces have separate bleeders for each uptakes.

• Blast furnace Refractory •

Between the Outer shell and inner working volume of the furnace there is a thick refractory line which protect the steel shell.

The lining life determines the One non-Stop Campaign life.

The Campaign life was 5-7 yrs in 1960 and is now about 15-20 yrs and even more, Such a long life has been possible due to improved quality of the refractory lining as well as better furnace operations.

The measures causes of failure of the lining are as following:-

- (1) Carbon monoxide attack
- (2) Action of Alkalies and other vapours.
- (3) High temperature.
- (4) Abrasion by moving solid charges.
- (5) Attack by Molten Slag and metal.

All these factors may not equally important in all zones of the furnace.

- Thermal Conductivity refractory - Silica, graphite, fire clay Silica 600°C में Expand करेगा 600°C से कम होगा तो contract करेगा (गिर जाएगा).

- Neutral Refractory - Zirconia

- Hearth में Carbon का Refractory का Use करते हैं।

Foundation of a furnace.

The foundation is the base structure of a furnace, designed to support its weight and ensure stability under high temperatures, vibrations and operational stresses. It is a critical component for the safe and efficient functioning of the furnace.

The foundation of the furnace is laid with concrete and steel. The foundation must be strong enough to support the weight of the furnace and withstand the high temperatures generated during operation.

Mantle or Columns :

- The mantle or columns are the structural support framework of a furnace, typically forming the outer skeleton or a load-bearing structure.
- They are designed to withstand the immense (असीमित) weight and stress generated during furnace operations.

Importance :-

- Without a properly designed mantle or column system, the furnace structure can collapse due to high thermal expansion, mechanical stresses, and dynamic loads.
- They ensure longevity and operational safety.

Bell and Hopper in a Blast furnace

The bell and hopper are essential components at the top of a blast furnace, used for charging raw materials like iron ore, coke, and limestone into the furnace while minimizing gas loss.

1. Bell and hopper System

- Hopper: A funnel-shaped structure at the top of the blast furnace that holds and guides the materials.
- Bell: A cone-shaped device ~~beneath~~ beneath the hopper that controls the entry of materials into the furnace.

Advantages of Bell and Hopper System

- Reduces material segregation for consistent operation.
- Prevents energy loss by sealing gas inside.
- Maintain furnace pressure, improving efficiency and productivity.

GAS CLEANING PLANT

- The Co Content of the blast furnace gas may be around 20-30% by Volume.
- It has Calorific Value around 800-900 kilo Calory per m^3 (KCAL/ m^3)

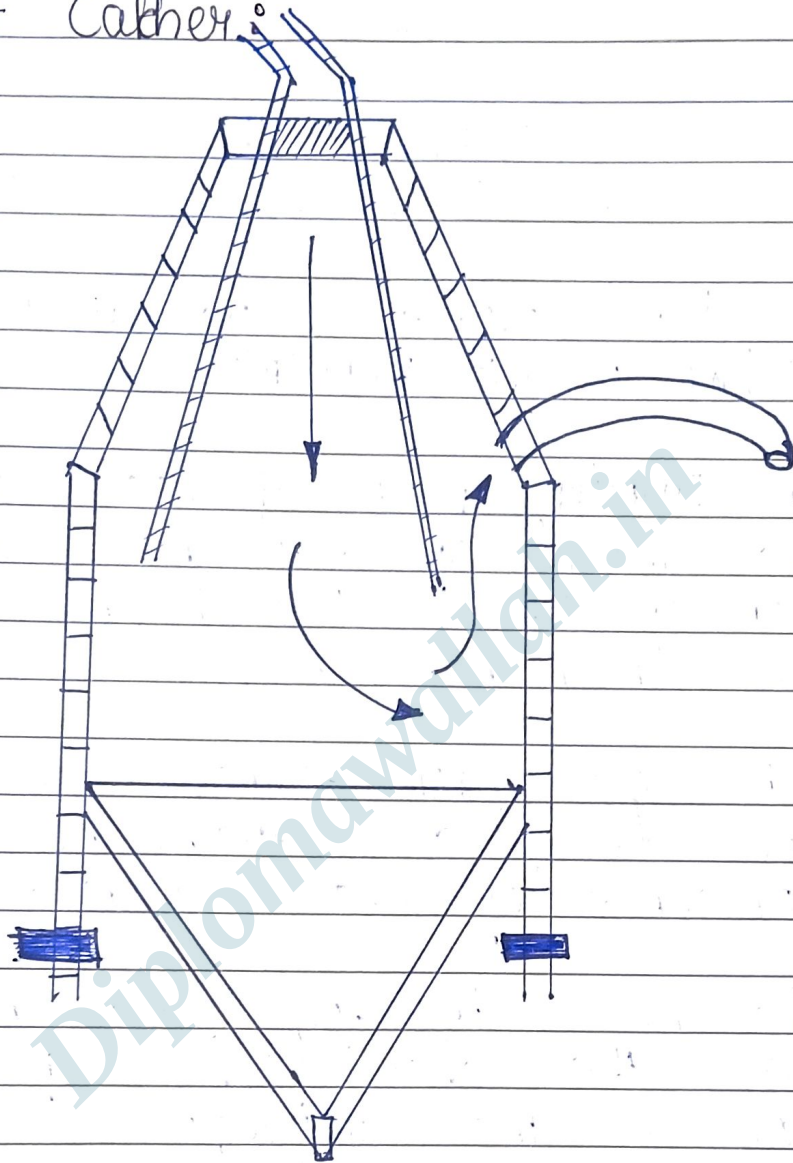
The quantity of gas produce depends upon the amount of fuel burned for one ton of coke. nearly $4000 m^3$ of the gas may be produce.

- The gas from furnace can not directly be used as a fuel, because the presence of dust content.

The gas is therefore clean before its use the chemical heat of the cleaned gas is the utilized.

The average dust content may be in the range of 10-30 gm/ m^3 .

• Dust Catcher



The blast furnace gas which is coming through the down comer directly sent in to the dust catcher which removes a much of the flux dust.

The dust catcher operates on the principle that, the dust is contained in the gas by virtue of its

Velocity, and hence if velocity is zero. The dust particles will be eliminated from the gas.

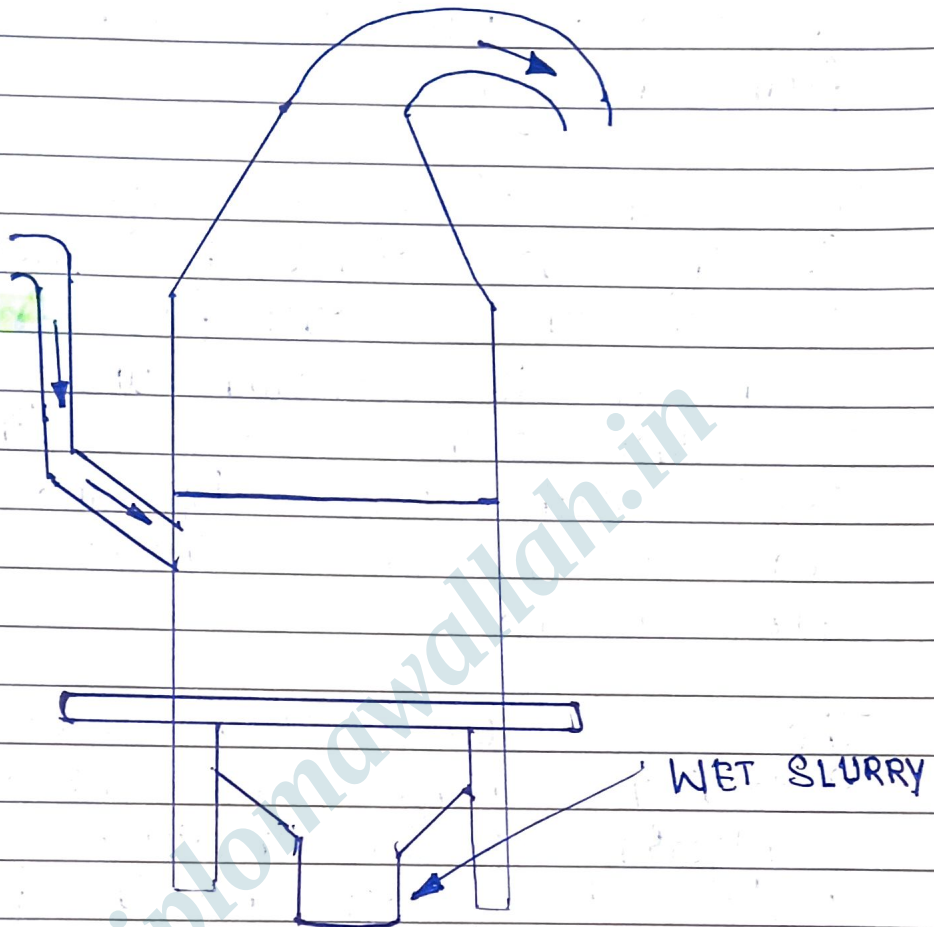
- ✓ The state of zero velocity is achieved in the dust catcher by simply reversing the direction of dust flow from vertically downward to vertically upward direction. The dust catcher is a cylindrical steel shell with conical top and bottom and it is lined inside from fire bricks.

The gas comes down vertically and suddenly changes its direction to vertically upward direction. Since the outlet is located nearly at the top of dust catcher.

The brings the gas to a point of zero velocity and coarse dust fall in the bottom of the dust catcher where it is periodically removed.

The efficiency of dust catcher is usually 60 - 75%.

• WET SCRUBBER :-



It consists of a tall cylinder with a conical top and bottom, the gas enters in this at a point near the bottom and leaves through centrally located outlet at the top, water is fed from top in the form of one or more rows of water spray.

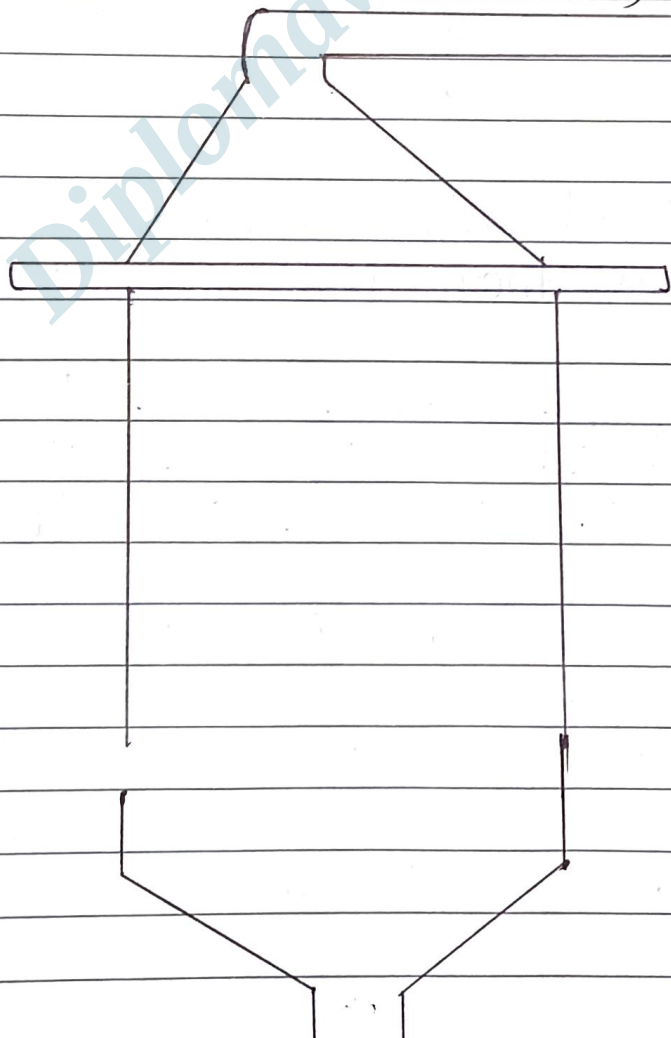
Inside the cylindrical shell several layers of wooden packing with perforated (small holes) are

fitted to break off the gas flow into small jets and thereby bring intimate contact of gas and water. The dust content in the gas sticks to the wooden packings and is washed down by water.

The slurry then formed is collected at the bottom and is continuously removed from the solid for recirculation.

The dust content of the outgoing gas is $0.5 - 1.5 \text{ gm/m}^3$.

● ESP (ELECTRO STATIC PRECIPITATOR) [CORONA EFFECT]



∴ ESP

It is based upon the principle that under an action of high applied static voltage, the dust particles in a gas phase acquire electrostatic charge and are attracted to an electrode of opposite polarity. (Corona effect) where they are collected and washed out by flowing water from the top, the unit consists of either tubes or plates as one electrode and wires centrally located in each tube / plates and other electrode.

One wire $\longrightarrow$ Discharging plate.
Other plate $\longrightarrow$ Collecting plate.

- Rectified high voltage is applied across these plates or electrodes.
- The gas enters from the bottom and rises upward through a system of such cells (CE)
- The dust particles on ionisation get attracted towards opposite charge plate (CP) and are washed down by water flow over the surface of the tubes or plates

- The slurry is formed, collected and is removed from there into a thickener for separating water from the solids for recirculation.

The dust content after ESP is about 0.01 gm/m^3

- Ventury Washer.

● GAS HOLDER:-

It is used to store cleaned gas. The gas is stored in a huge gas holder of capacity (100000m^3) or 10000000 Ltr and is distributed from there in the plant wherever necessary.

● UTILISATION OF BLAST FURNACE GAS.

In general cleaned blast furnace gas may be used in the following work:-

- ① preheating the (blast furnace gas) blast (hot air) for blast furnace through the Hot blast stoves.
- ② firing of reheating furnaces, in an integrated Steel plant.
- ③ firing of an open hearth furnace (steel making furnace) by mixing it with Coke Ovens gas.
- ④ For heating Coke Ovens chamber (batter).
- ⑤ For power generation (For Steam based PG).

NOTE :- Nearly 25-40% of the total gas generated is consumed in preheating the blast in the modern Blast furnace for firing of Hot Blast stove.

• HOT BLAST STOVE •

Diplomawallah.in

● Construction :-

The Stove is a tall cylindrical Steel Shell with height 20-36 m, diameter 6-8 m, lined with insulating bricks, firebricks inside.

It has a dome shaped top.

The Interior of the stove has a combustion chamber and a heat regenerator unit.

which consist of refractory bricks arranged as a checker works.

The checker works has observe maximum heat at a faster rate while heating and should deserve heat equally rapidly to the incoming cold blast.

The larger is the Surface area exposed as flues the faster is the heat exchange with the gas. The checker bricks are supported by cast iron or steel column.

The wall separating the Combustion chamber from the checkers is also heavy duty fire bricks construction.

The dome is subjected to maximum temperature and hence needs to be properly insulated and lined with heavy duty firebricks.

The top portion of the checker bricks have to stand higher temperature with progressively decreasing value downwards, the quality of checker bricks used also vary accordingly.

The top 3-6 m of checker is made of higher alumina bricks or semi silica bricks while the remainder are good quality fire bricks.

Now the modern trend is use to silica completely as a checker bricks or silica is top portion (Near Dome) and the rest bottom portion of firebricks.

The bricks lining including checkers are expected to last 15-20 years.

• Working :-

During the heating cycle the cleaned B.F gas is burnt with air in the combustion chamber. (Blast furnace gas chamber from the gas holder).

The hot product of Combustion later heat of the checker bricks. In this case the Stove is said to be on gas and is maintain on gas until the checkers bricks are heated to the Certain temperature.

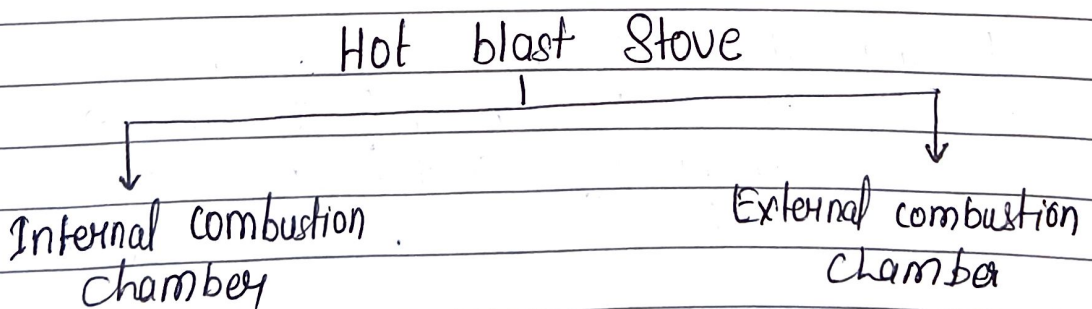
This required 2-4 Hrs - now firing is stop and cold blas is passed at room temp is blown through the Stove in the reverse direction.

The air blown is by turbo blowers gets heated in contact with hot checker bricks and then flows in the Blast furnace through bustle pipe.

In this case The Stove is said to on blast.

This colling cycle of the Stove which blast 1-2 Hrs Since colling is faster then heating a colling and two on heating.

The thermal efficiency of Stove where is between 75-90%.



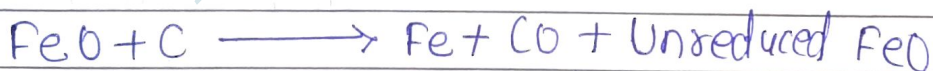
IMPORTANT POINT

- i. checkers के वजह से इसका नाम Heat generator पड़ा
- ii. checkers को Heat करने के process को ON gas कहते हैं, इसे Heat होने में $1\frac{1}{2}$ - 2 Hrs (90-120 min) लगता है,
- iii. Checker का दूसरा नाम heat regenerator है,
- iv. Combustion gas (Blast furnace gas).
- v. cold heat (on Blast) - 45-60 min.

Bosh - $76-79^\circ$

Stack - $81-85^\circ$

Tuyers zone - Runway or Recovery.



Tuyers Zone (Raft temp) = $1900-2000^\circ\text{C}$

→ Exothermic - जो reaction Heat produce करे उसे Exo

→ Endothermic - जो reaction Heat को absorb करता है

Pig Casting Machine (PCM)

Pig Casting machine is used in the metallurgical industry to cast molten metal, usually from a blast furnace, into shape that can be further processed. The term "pig" comes from the shape of the cast metal, which resembles a pig's tail when arranged in a casting bed. This machine is used for casting metals like iron and steel.

Working of Casting machine:

1. Molten Metal flow: The molten metal is poured from a furnace into a holding ladle, which then delivers the metal to pig casting machine.
2. Mold System: The pcm has a series of molds, which are typically made of sand or metal. These are arranged in rows to cast the molten metal into shapes.
3. Casting: The molten metal is poured into these molds. It solidifies as it cools down, forming "pig iron" bars or ingots.

4. Cooling and Election: Once the metal cools, the Cast object or "pigs" are removed from the mold. These can be further processed in Steel mills or used for other applications.

Liquid products Disposal

In Metallurgy Liquid product disposal refers to handling and managing excess or waste liquids generated during the metal processing stages.

1. Slag: This is a by-product of the Smelting process, and it's typically removed from the molten metal. Slag can be cooled and sometimes used in construction materials like Cement.

2. Wastewater: During cooling or washing processes, wastewater can accumulate. It must be treated to remove harmful chemicals before being disposed of or reused.

3. Molten Metal Spillage: If any molten metal is accidentally spilled,

it must be safely handled. Special Equipment is used to quickly contain and collect the molten metal to prevent accidents or loss.

Essentials of Blast furnace process:

The blast furnace process is a key method used in the production of Iron Ore from Iron Ore. It involves the reduction of iron ore (mainly hematite, Fe_2O_3) into molten iron (pig iron) using a combination of heat and chemical reactions. Below are the essentials of the blast furnace process.

Raw Material Used:

Iron Ore: (usually hematite or magnetite):
This is the source of iron.

Coke: A carbon rich material derived from coal, used as both fuel and reducing agent.

Limestone: Acts as a flux to remove impurities like silica from the iron ore.

Air (oxygen): Supplied through blast air to create the necessary heat for the chemical reactions.

Basic Structure

The blast furnace is a large vertical structure where the reactions take place. It's divided into several sections.

Top Section: Where raw materials (iron ore, coke, and limestone) are added.

Middle Section: Where the main reduction reactions occur.

Lower Section: Where molten iron and slag are collected.

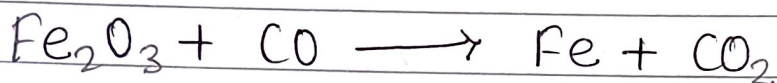
Working process:-

The blast furnace operates through the following steps.

Charging: The raw materials (iron ore, coke, and limestone) are fed into the top of the blast furnace.

Blast of Hot Air: Hot air (around 1200°C) is blasted into the furnace through tuyeres at the bottom. This air helps fuel the combustion of coke, producing heat and carbon dioxide, monoxide.

Reduction Reaction: The Carbon monoxide from coke reduces the iron ore (Fe_2O_3) into molten iron (Fe) in the middle section of the furnace.



Formation of Slag: The limestone reacts with impurities in the iron ore (mainly silica, SiO_2) to form slag, which is a waste product.

Separation: The molten iron (pig iron) sinks to the bottom of the furnace, while the slag floats on top. These two are separated and drained from the furnace.

Outputs of the Blast furnace process:

Pig Iron: Molten Iron are removed from the furnace. It can be further processed to make steel or other alloys.

Slag: The waste material formed by impurities, which can be used in road construction or cement production after cooling.

Gases: Gases like CO_2 , CO and nitrogen are released, which can be treated and used for energy recovery.

Importance of Blast Furnace:

The blast furnace process is the most widely used method for extracting iron on an industrial scale. It produces high amounts of pig iron, which is further refined to make steel or used in casting products.

Blast operations -

Blowing in procedure:-

The process of starting a newly lined furnace is called blowing in. This operation involves four main steps, viz. drying, filling, lighting and operating until routine practice is achieved.

There is no standard practice of blowing - in.

Each plant follows its own method. The main steps are briefly discussed below.

The main four steps are:

- i. Drying.
- ii. filling
- iii. Lighting. / firing.
- iv. Operation until normal production of stabilised.

Drying :-

The new lining of a furnace contains a significant proportion of moisture. The moisture must be slowly and completely removed before the temperature of

the furnace is raised. This operation is known as drying. During Drying the furnace is slowly headed. Blast furnace dry can be done by any one of, wood or coke fire & hot blast from the hearth.

filling:- At the end of drying depending upon the method use for drying the furnace is cleaned off.

Filling of the furnace.

After the furnace drying process is complete, the filling of the furnace beings.

This process starts from the bottom (hearth) and is done step by step to prepare the furnace for operations

Steps in filling:

1. Start with wood and shavings:

- The hearth is filled with wood and shavings Soaked (saturate) in oil to make it easier to ignite.
- The filling reaches the tuyere level (air Injection area).

2. Add Timber and Coke

- On top of the wood, timber and coke are added until it fills up to the bosh level (middle section of the furnace).

3. Add Limestone

- Limestone is added along with coke.
- Limestone helps remove impurities by forming slag when heated.

4. Layer with Ore and coke:

- A lighter mixture of iron ore, coke and limestone is added.
- At this stage, the ratio of ore to coke is kept low (about 0.5 to 0.6) to prepare the furnace for full operation.

5. Final filling:

- More layers of iron ore, limestone and coke are added from the top of the furnace to complete the filling process.

Steps 3 & 4 : Lighting and operating the blast furnace

1. Lighting the furnace:

- After filling, the furnace is lighting by inserting red-hot bars through the tuyeres, slag hole, or iron notch.

2. Initial Burning:

- For the first 24-36 hours, burning is done using natural draught.
- Then, a light blast is gradually introduced to enhance combustion.

3. Gas Emergence:

- When enough gas begins emerging from the furnace top, the blast is gradually increased over 6-7 days until normal levels are reached.

4. Handling tap holes:

- Tap holes are left open initially for gases to escape.
- They are closed once gas emission reduces significantly.

Slag and hot metal Management

1. Draining Slag:

- When enough slag accumulates, it is drained out to maintain furnace operations.

2. Charging fresh Burden:

- As material descend in the furnace, new layer of iron ore, coke, and limestone are added to keep the furnace full.

3. Increasing Iron Ore ratio:

- The ratio of iron ore is gradually increased for efficient metal production.

4. First Cast:

- Once the hearth is full, the slag and hot metal are drained out.
- Overcharging and tapping Schedules are established to ensure smooth production.

Routine Operation Establishment:

- Time frame
 - It takes about a week to establish normal operation where both metal and slag meet the required composition and production schedule.
- Strict procedures:- Overcharging and tapping are done at regular interval to maintain quality & efficiency.

4. Banking : The temporary or shutdown of blast furnace is known as banking.

The furnace to be shut down due to shortage of raw material breakdown other maintenance work, supply issue in market etc and show on since the furnace can not be put on or off.

readily the furnace needs to be prepared for such a temporary shutdown so that when production is to be resume it can be done with minimum of efforts and wastages.

Banking is done by reduction in combustion rate, covering the fire with excess coke, luting the all air inlets the fire is thereby maintained inside the furnace for future use.

During banking operation, the blast is taken off, the blow pipes are dropped and the tuyere openings are plugged with special refractory mass, to prevent air from drafting through.

Thus, hearth heat is preserved and the furnace could be returned to operations with a minimum effort.

The stock level is inspected every day when the furnace is banked.

A slow downward movement of the stock indicates slow consumption of coke by air that is infiltrating in. A rapid drop in stock level can lead to deficiency of coke at the time of restarting the furnace.

The furnace is restarted by replacing the tuyeres and notches and charging sufficient coke to fill up space created by the sinking of the stock.

The rest of the practice normally takes course similar to blowing in practice.

It may take a week to bring back the furnace operation to normaly.

Blowing out

- Blowing out is the complete shutdown process when significant damage occurs after several years of operation.
- Involves cooling the furnace and removing materials.

Blowing out is the process of stopping the operation when business conditions deteriorate and production is no longer required.

Common method of blowing-out is given below:

- charging is stopped and the stock is allowed to descend until minimum of it remains inside. The last cast is carried out as completely as is feasible. Towards the end, the remaining stock is quenched with water and the furnace becomes cold. The furnace is cleared off the quenched material, by raking operation.

— Starting the furnace after blowing-out, takes less time and less efforts than starting a 'banked furnace'.

— However, the costs in connection with blowing out, raking out and cleaning preparatory to starting exceed the cost of banking.

Fanning

Sometimes, full production capacity of the furnace is not required for reasons like - less demand for iron, raw materials shortage etc.

In such cases, production is decreased by reducing the input blast.

If the blast is reduced to a value less than 25% of the normal volume then this technique is known as fanning.

During fanning a positive pressure is maintained in hot blast system.

Fanning is far better than total shutting off the blast, because by adopting fanning, normal production can be restored in a short period, without any difficulty.

Back drafting

- To perform various maintenance functions such as the replacement of tuyeres or repairing cables,
 - it is necessary to take the furnace off blast for short period, often it is less than two hours.
- In such instance the furnace is not banked but is back drafted.

The blast is put off and the baffle pipe is put under negative pressure to force furnace gases to flow in reverse direction in to the stove where it is burned. Air may be drawn in through the bleeders downwards to achieve this.

In Simple Words:-

Temporary operation mode to allow for minor repairs while maintaining blast furnace functionality

→ problems in blast furnace.

Irregularities in blast furnace operation.
their causes and remedies -

The Irregularities in the blast furnace operation may arise due to the faulty mechanical devices like coolers, valves etc..... or due to the faulty mechanical operations, like charging, tapping etc on due to the abnormal process inside the furnace with respect to physico chemical changes.

Some common irregularities blast furnace operation are as follows:-

Hanging :- If uniform descend of the burden in the furnace is interrupted either by wedging or brazing (Furnace) of the stack or by scaffolding it known as hanging.

It may be caused due to the different reason :-

- ① Solidification of previously fused slag.
- ② Excessive blast pressure, resulting in counteracting the downward movement of the stock.

③ Condensation of the alkali vapour in the upper part of the stack thereby cementing the charge resulting in impervious mass.

④ The decomposition of large amount of carbon due to carbon deposition reaction or Newmann reversion reaction in the void and decrease the permeability of the burden.

Remedies :- Add limestone of larger size which on disassociation generates CO_2 which in turn forces the solution loss reaction to take place and improve the permeability of the bed.

2. Reduction is blast pressure distribute the gas flows slowly but more uniformly.

3. A persistent hanging can be cured by blowing down the furnace to bosh level and filling it with coke blank.

Scaffolding :- Scaffolding is the large mass of material that gets stuck to the furnace wall, usually as a single block, particularly in the top portion of the Bosh.

- Jumping :- A sudden change in pressure of the blast is called jumping of the B.F.

- Slipping :- Slipping is defined as the sudden sinking of the stock caused by a collapse of the hanging, wedging, Scaffold etc....

-- large mass ka girna..... is called as Slipping. [Explosion hone ka chance rakhta hai]

- Chilled hearth :- This is a very serious irregularity since it affects tapping adversely. It may result because of low fuel input, excessive moisture in the blast, water leaking in from the tuyers.

Cause of chilled hearth.

- ① Slipping ke wajh se (Reason of slipping)
- ② Tuyers of leakage.
- ③ Excess of Hummidification.
- ④ Decreasing by the coke rate.

● **pillaring** :- It is blast is Unable to penetrate right up to the Centre of the furnace. It may lead to the formation of a cold central column of the stock with an annular hot zone all around it.

This is know as pillaring.
(Dead man zone ko pillaring bolte hain).

● **Salamender** :-

Salamender is formed by the Erode of refractory in Hearth region and formed Accumulating Iron in Hearth and Solidify this is known as Salamander.

● Channeling :- Distribution of burden is not uniform.

permeability difference ho jayega. Iron ore, coke का विमानन सही से नहीं होगा! तो Blast Air किसी एक साइड से निकल जाता है, जिस तरह Permeability कम हो उसे Channeling.

- preferential flow of ascending gases through certain areas of the burden, because of their relatively much better permeability, is known as 'channeling'.

Channeling upsets - preheating of the charge, and reduction processes (gas-solid interaction) - and thereby decreases the productivity directly.

This basically arises because of improper distribution and wide size range of the charge materials in the furnace.

Use of a more uniformly sized burden and proper charging of B.F can minimize channeling.

Introduction

Direct reduction includes a family of processes in which iron ore (in the form of fines, lumps or pellets) is reduced to the solid state either by solid or by gaseous reducing agent. Reformed natural gas as well as the primary source of energy.

The final product from all DR process is a solid which has to be melted during steel making in a manner similar to scrap.

For gas based processes, the reactor used are shaft furnaces, fluidized bed or reflow while for coal based DR, rotary kiln, rotary hearth furnace and multi hearth are employed.

• Alternative Route of ironmaking •

1. Sponge Iron Making (DRI)
2. Smelting reduction (SR)

Introduction

Blast furnace recycle steel in the form of scrap have been main source of iron. However blast furnace hot metal production has decreased over the year owing to problem associated with availability of high grade metallurgical coke with increase efficiency in steel making as well as continuous casting process scrap generation has also decrease.

All these factors are contributed towards the development of alternate technologies to produce iron. Today process are available to produce iron solid iron in the form of sponge iron is called direct reduction (DRI). As well as to produce hot metal without high grade coke that is via smelting process.

DIRECT Reduced iron Making (DRI)

• Sponge iron Making •

Sponge iron is term given to the product i.e. obtained by reduction of iron oxide ore in solid state.

Solid or by gaseous reducing agent. (Natural gas, Hydrocarbon, CO, H_2 gas)

Reformed natural gas or non coking coal is generally employed as the primary source of energy.

Solid state sponge iron is mixture of reduced metallic iron, unreduced iron oxide and gangue constituent of original ore.

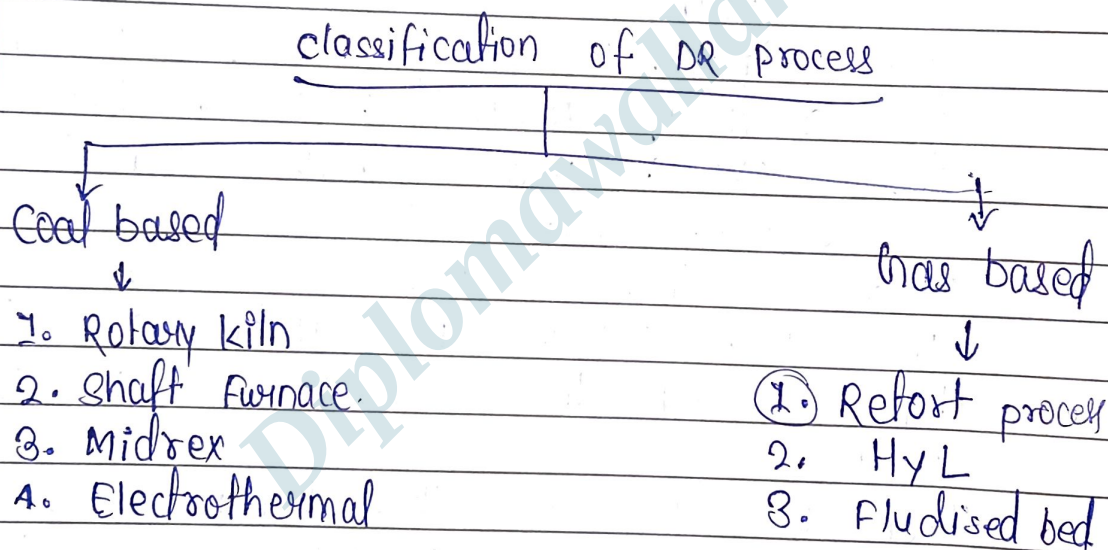
Much of the oxygen associated with the iron oxide is eliminated there by raising the content of metallic iron..

Iron ore is in the lump form and the removal of oxygen from the solid iron oxide lattice leaves the remaining mass after the reduction more porous & hence the term of sponge iron.

The term directly reduced iron originates from the fact that iron oxide is directly reduced by the reductant (Reducing agent) -

Solid Sponge Iron is also called as metalised ore because the metallic content goes of considerably in this. The final product from old DRI process is a solid which has to be melted during steel making in a manner similar to Scrap.

Classification of Direct Reduction (DR) process:-



• Advantages of DR Process.

1. Elimination of dependency of coke
2. Lower capital investment as compare to B.F.
3. Easier process control
4. Easy transportation.

Disadvantages of DR process

1. Final product is Solid and its sequentially melting.
2. Low productivity in term of unit volume of reaction.
3. Low carbon content in final product. which raise to difficulty during Iron making.
4. pollution.

• Uses of Sponge Iron.

1. Electric arc furnace as a substitute for Scrap (100% Scrap)
2. Basic oxygen furnace (BOF / LD) also known as LD furnace is used as coblant or as a substitute for Scrap (15-20% Scrap).
3. Induration furnace.
4. Open hearth furnace as a charge for melting (accept 100% Scrap).
5. Cupola furnace as substitute for cold pig Iron.

TECHNICAL DATA TON PER DAY

Technical data 350 tone per day

- No of tuyers = 4, 8-SR (Support roller).
- kiln movement = Hydrothrust
- kiln length = 72 - 76 m (Inner Diameter)
- kiln length = 4.8 - 4.35 (Outer Diameter).
- kiln inclination = 2.5% of kiln Length. (L)
- Lining = High Al_2O_3 Castable.
- Shell thickness = 25 - 30 mm.
- kiln RPM = 0.35 - 0.75 (Rotation per minute)
- Temperature = 800 - 1050°C
- No. of Shell Air fan = 9
- Gas Velocity = 8 m/s.
- Retention time = 12 - 13 Hrs.
- Refractory thickness = 230 mm.