Date
07/01/2019

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Iron Making (Introduction Class)

* conventional iron making is done in blast furnace. So, it is also known as blast furnace iron making.

Raw materials → iron ore
→ coke (metallurgical coke)
↓
coking coal
→ flux.

* To produce 1 tonne of pig iron from indian raw material (since ~~raw~~ material from indian raw materials.) about 1.75 Tonne of ore (haematite) is required.

*
↦ 0.8 – 0.9 Tonne of coke is needed.
↦ 0.450 Tonne of flux either limestone or dolomite.
↦ Manganese ore. (needed acc. to the sulphur load) sulphur is generally less than (0.45%)

Phosphorus mainly comes from ore and sulphur enters the blast furnace from fuel used.

Raw material → Quality requirement
→ Suitability to B.F.
→ Burden testing.

Units of B.F :—

① → B.F. design.
② → B.F. refractory
③ → construction of B.F.
④ → B.F. Accessories.
⑤ → B.F. layout.
⑥ → Agglomeration technique → ① nodulising. ② Brequating ③ Turnilising ④ sintering.
→ B.F. operation —

① Blowing in → process of starting the B.F. → It takes 6 months to start → And last upto 10-12 years

② Blowing out → Shutting down the B.F. gradually → It takes 6 months to stop.

Products of B.F → ~~It~~ molten pig iron
→ slag.

→ B.F. irregularities

Causes/remedy of irregularity —

Productivity of a blast furnace — It is defined as tonnes of pig iron per unit useful volume of B.F. in m^3 per day.

Productivity is ideally around 2.5 ton/m^3/day corrugated Mild steel sheet

Coal washery → remove si and Al from coking coal.

POSCO Paradip port

PSU have~~s~~ productivity in the range 1.1 to 1.3.

Modern trends in blast furnace —

Poplar tree or equiliptus tree

Alternate to blast furnace —

① Sponge iron → made up of 2 process
→ Coal based → (Rotary kiln) process
→ gas based

Iron have porous appearance on surface.

→ India have larger producer of sponge iron.
→ Thermal conductivity is very poor and yield is very less.

② Molten Iron using non-coking coal —

(i) COREX Process — JINDAL Steel Plant Bhilai
↳ coal Red^n

(ii) FINEX Process —

Sintering → Insepient fusion → just before melting

Natural lump

Productivity → Tonne/m^3/day.

- Stoichiometric Mass and Enthalpy balance → to predict coke rate or oxygen demand

Iron ore — 4.6% avg. of iron ore in earth's crust.

① Haematite → Fe_2O_3 → $\frac{2}{\cancel{5}} \times \cancel{100}^{20}$ ⇒ 40%.

② Magnetite → Fe_3O_4 → $\frac{3}{\cancel{4}} \times \cancel{100}^{25}$ ⇒ 75%.

③ Hydroxide → $Fe_2O_3 \cdot (H_2O)$ → limonite.

④ Siderite → Fe_2CO_3

⑤ Pyrite → FeS_2

⑥ Pyrrhotite → FeS_2

⑦ Ilmenite → $FeO \cdot TiO_2$ → ore of Ti → Fe is side-product

↓

Found in Kerala beach sand.

Firstly crush it and then agglomerated and then it can be used as iron ore.

Classification of ore —

Based on

① Gangue content → Main gangue is Si and Al

ⓐ Silicious ore → Main gangue is Si

ⓑ Aluminous ore → " " " Al.

ⓒ Argillaceous ore → contains more of clayey matters.

(d) Calcarious ore → consists of limy matter.
(e) Titaniferous ore → TiO_2 is present as impurity like rotile, cluminete.
(f) Bituminous ore → consist of coaly matters.

② Based upon the geological origin :-

(a) Sedimentary → These consists of alternate layers of iron oxide and silica and have diff. names in different country.

In India → BHQ → (Bended Haematite quartz)

In South Africa → calcio rock

In Brazil → Itabrite

In USA → Taconite

Prop of BHQ → (a) ~~Pro~~ porous, frezile and less pure.

Minnette ores – In western Europe and UK and also known as alabama ore in USA. It is also known as iron stone in UK.

In powder form → known as 'blue dust' in India & Brazil.

(b) Igneous → deposited by volcanic eruption. These are mainly magnetite

(c) Laterite → These are found in tropical condition (tropical means alternate dry and wet season). In wet season, leaching action takes place. Due to leaching action, Silica and lime are leached away leaving behind iron ore and alumina.

(d) Replacement → Circulating water removes limestone, depositing $FeCO_3$ which after weathering converts into FeO

③ <u>Based upon structure and Texture</u> —

(a) Based on structure

(A) Oolitic structure → consists of concentric layers.

(B) Lateritic ore → consists of intermingled mass of iron hydroxide, aluminium hydroxide and other mineral.

(C) Banded ore → Consists of alternate layer of iron mineral and silicates.

(D) Hard Massive ore — These are fine grains and offers great resistance to crushing

(E) Soft ores — These are also massive but loosely held.

(F) Powdery ore — Can't be directly used and can be used after agglomeration.

(*) World Reserve of Iron ore —

(1) USA (2) USSR (3) Australia (4) Brazil (5) India
~~Aus~~

Indian Reserve → 85% Haematite
→ 8% Magnetite.
→ 7%. Rest.

43% of reserve is concentrated in orissia in the district of kyjhar, mayurbhar, bolani and ~~co~~ cuttack, jharkhand.

Goa → noabandi, barsoa, barajamda, kiriburu.

M.P. → ~~baitadila~~ Baila-Dila in bastar district
Dalli-Rajhara hills in durg district

Maharastra → Ratnagiri and chandrapur district
↓
Maharastra Electro Smelt limited.

A.P → Anantpur and Karnol district
Telangana → Warangal, Karimnagar, Aladabad

Tamil Nadu → Selum and Trichi districts
Karnataka → Bellary – Hospit corridor (100 Km in length), chikmanglur district, simoga, chittal durg, Tumkur district Kudremukh (expoted iron to iron through 'manglore port).

Goa → Blue dust is present.

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Evaluation of iron ore :-

(i) Richness → 'Fe' content of the ore.

* Australian ore contain 68% Fe.

For 1 Tonne of Pig iron → 1.4 – 1.5 T of ore.

* India → 55–60% Fe. 1.75 – 2.0 T of ore.

* UK → 30 – 35% Fe 3.0 T of ore.

(ii) Location →

(a) Geological location :- If iron ore deposits is in the form of hill like (Kirigeuru or hatigueru) then It is easier to mined and transport to nearest railway ~~St~~station.

criteria to set iron & steel plant
① Barren land
② Proximity of raw material

(i) * If it is deep inside the earth crust then open case mine has been created and the ore should be raised to ground level.

(b) Geographical location →

- Proximity to raw materials
- Transportation

(iii) Gangue Content :- Mainly silica and alumina, there could be some alkali oxide, there could be phosphorous.
If it is high in alumina, the liquideous temperature will increase. So amount of coke needed will increase.

(iv) Nature of Gangue and pre-treatment required:-

(a) Volatile Alkali oxides may enter brick joints and may damage the lining.

(b) Volatile elements/ impurities like As, Zn, can't ables to escape from blast furnace as it brought down by burden.
So, volatizing roasting is necessary to remove As and Zn before charging it to blast furnace.

whatever be reduced joins to pig iron.
" " oxidised " " slag.

Lead joins the pig iron and settles at the bottom. This reduces effective cross section of the hearth.

(c) Phosphorous — All the phosphorous present in the burden joins the pig iron (P_2O_5 is reduced).

(d) Sulphur — Sulphur can be removed in blast furnace.

Evaluation of cooking coal —

Non coking coal is dense and freile hence cannot be used in blast furnace.

Coking Coal — Certain type of coal show coking properties.

Coking prop. — When these type of coal is heated in absence of air for temp. 1100°c – 1300°c for 6 to 8 hrs. Then after cooling the product consists of a tough and porous mass.

① High Calorific Value.
② Minimum 85% fixed carbon
③ Volatile contents should be less than 2%.
④ Ash Content Should be less than 10%
⑤ Sulphur Content should be preferable should be around 1%.

Coking coal Reserves in India —

It is mainly located in Jharia and Ranigunj field and now it is extended to Ramgarh, west & east bokaro, Karnpura, Sissergarh, Patherdih, Sughdiha
coal washery

Evaluation of flux :—

Limestone or Dolomite (cheaper)
($CaCO_3$) ($CaCO_3 \cdot MgCO_3$).

Available lime — SiO_2 or Al_2O_3 (Main gangue

$$CaCO_3 \longrightarrow CaO + CO_2\uparrow$$
$$CaO \cdot SiO_2 \longrightarrow CaO \cdot SiO_2.$$

Available lime — %age of lime (flux) available in the burden after neutralizing acid radicals (silica or Alumina) present within itself.

Basicity of Burden ⟶ It is defined as the ratio of Basic oxides in the burden to acid oxides in the burden.

$$B = \frac{\text{Basic oxides}}{\text{Acid oxides}} = \frac{\%\,(CaO + MgO)}{\%\,SiO_2}$$

Scanned by CamScanner

Percent Avalable lime = % (CaO + MgO) − (% SiO_2

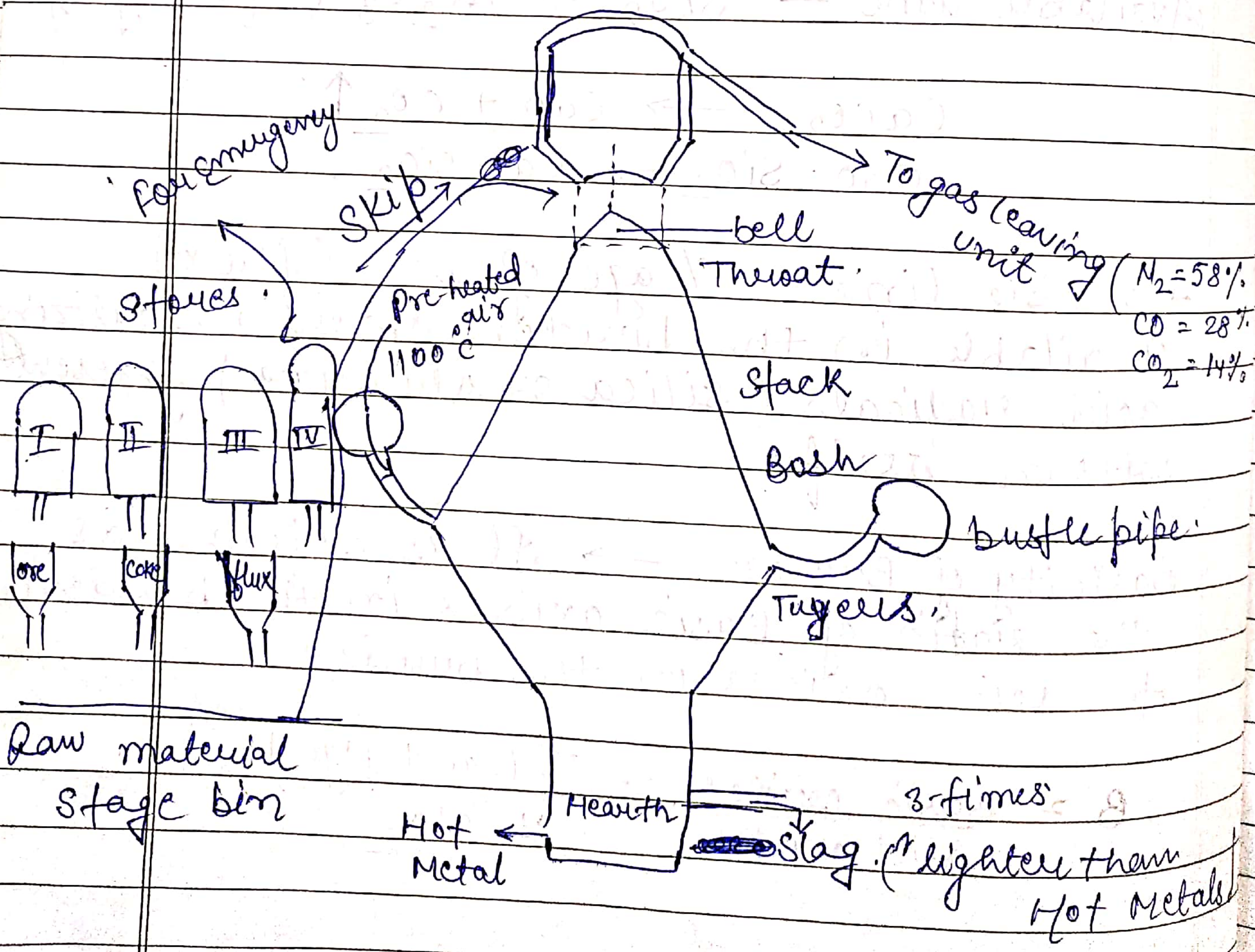
B = Basicity of the burden ~~flux~~
flux.

Major location of ~~steel plant~~ —

(I) Birmitrapur – orissa
(II) satna (MP).
(III) Bhavnathpur (Palamu dist.).

} Major Contain dolomite

Plant Layout (Iron & steel plant) :–



Percent Available lime = % (CaO + MgO) − (% SiO_2 × B)

B = Basicity of the burden flux.

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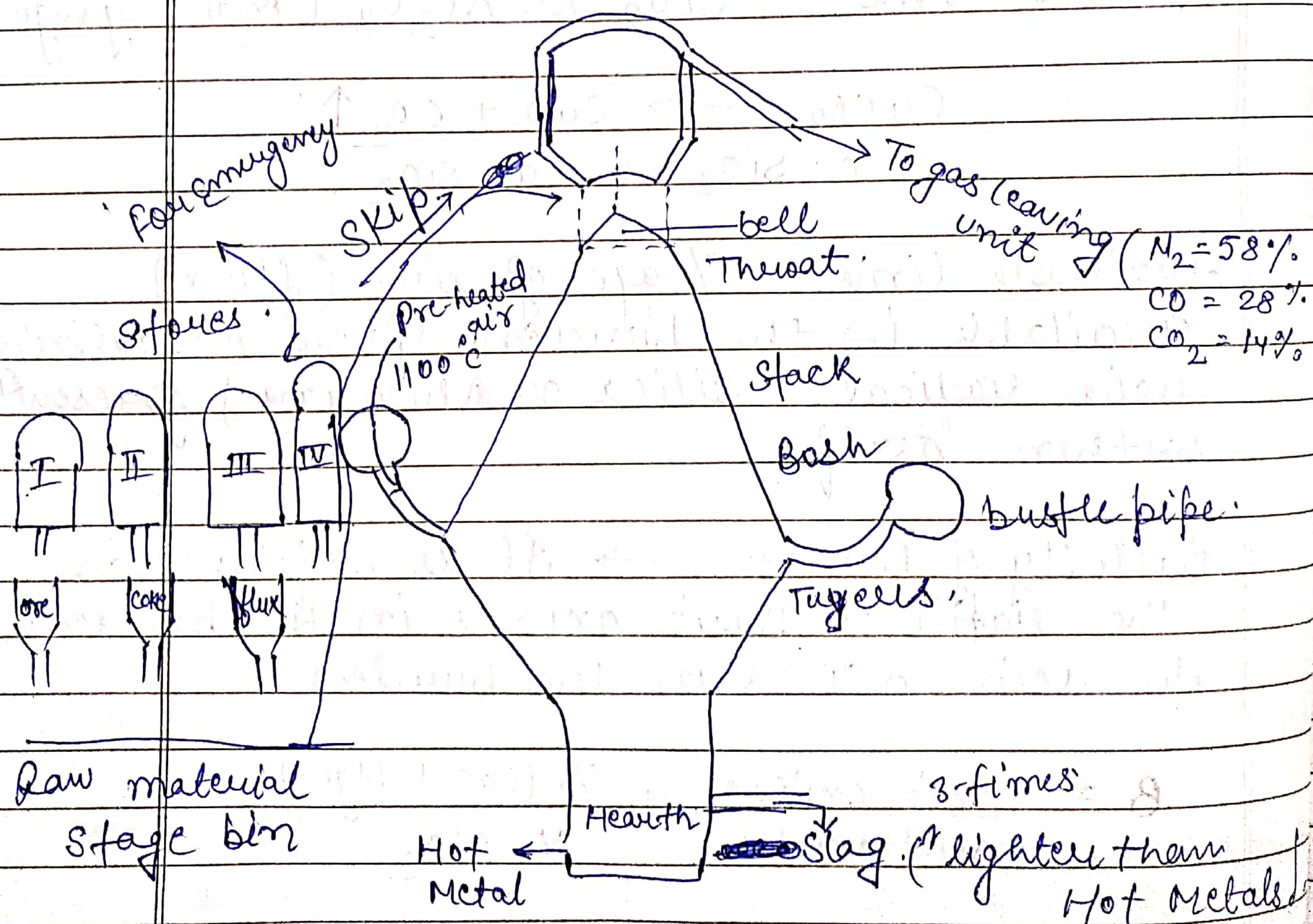
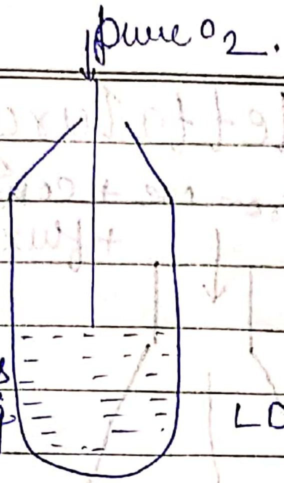


SMS → Steel Melting Salt .
Skin Purse



Casting ←

Conventional Casting | Countinuous casting

Linz and Dolo

LD Converter of Steel Making.

Steel Making is controlled oxidation of impurities.

Casting

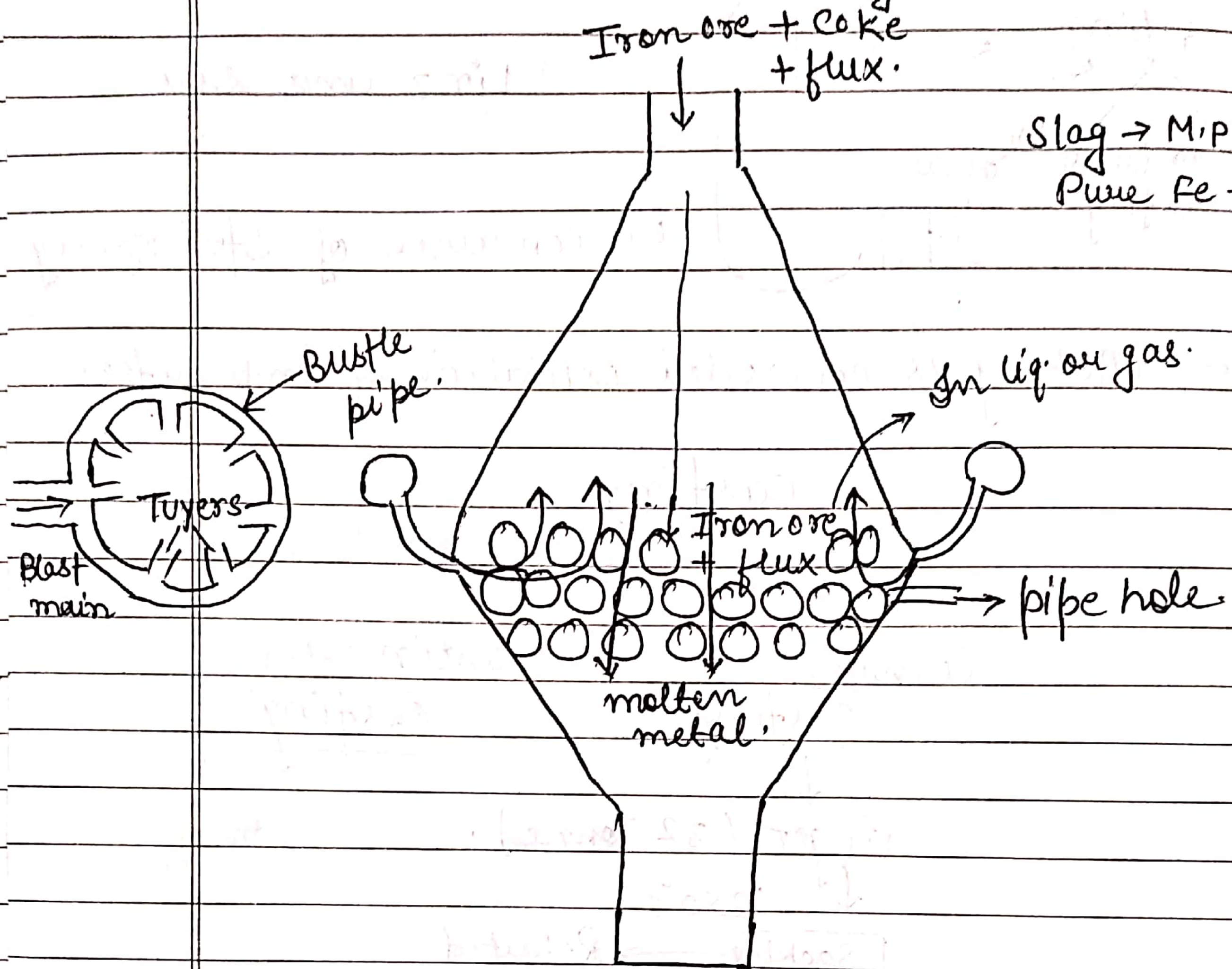
Conventional Casting | Continuous casting

Conventional Casting
↓
Ingot (32 Tonne).
↓ 1250°c.
Sacking Pit → Reheated in
↓
Rolling Mill → Slabbing mill → Blowing mill
↓
Hot rolling mill → HRCF →

→ Pickling line is basically a tank consists of dilute H_2SO_4.
↓
Coiled back
↓
Coold rolling mill → Anneling → cold rolling

Mettalurgical Coke

Slag → M.P → 1250°
Pure Fe → 1539°



⊛ Reason of outward taper of Blast furnace –

① To facilitate easy descent of raw material

② To provide space for thermal expansion of raw material during descent.

⊛ Reason of inward taper of B.F :–

① Inward taper is due to sudden volume contraction of the burden. So iron ore and flux both convert into either liq. or gas but coke is the only raw material which remains solid till it reaches combustion zone. In the combustion zone, coke reacts with hot blasts and suddenly disappears.

Function of coke in blast furnace :-

(1) Provide exothermic heat —

$$C + O_2 \rightarrow CO_2.$$

Auxiliary fuel injection along with the blasts:-

(a) Pulverised Non-coking coal. (size -200 mesh (#)).

mesh Number — No. of opening per ~~unit~~ linear inch.

(b) Injecting hydrocarbons and natural gas subjected to availability.

(c) Injection of furnace oil (

$$C_x H_y + \left(\frac{x+y}{4}\right) O_2 \longrightarrow x CO_2 + \frac{y}{2} H_2O$$

(2) Generate Reducing gas —

Since CO_2 is not stable at high temp (2000°C)

$$CO_2 + C \longrightarrow 2C + O_2$$

Boudard rxn,

Baudard rxn

Reverse Rxn takes place in the upper stack Region.

Reversion.

Naumann' Rxn:

when moisture (H_2O) is knowingly introduced along with the hot blast.

Red Hot coke + steam $\longrightarrow$ $CO(g) + H_2(g)$

$$C_{(s)} + H_2O(g) \longrightarrow CO(g) + H_2(g)$$

Benefits – Addition CO and H_2 are generated which acts as a better reducing agents.

③ Spacer role of coke –

$$Fe_2O_3 + CO = F_3O_4 + CO_2$$

$$F_3O_4 + CO = FeO + CO_2$$

$$FeO + CO = Fe + CO_2$$

flux is added at 850°C

$$CaCO_3 \rightarrow CaO + CO_2$$

$$CaO + SiO_2 \longrightarrow CaOSiO_2$$

coking coal is brittle → on applying load it will break down into smaller pieces.

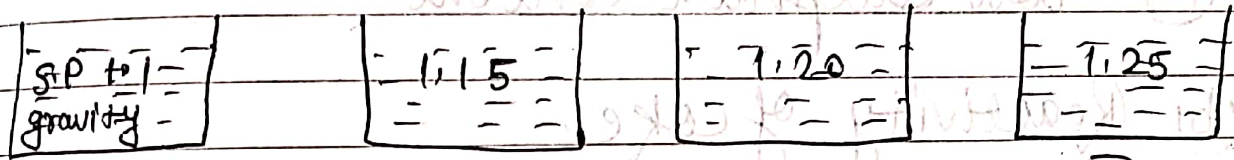
100-110 m tall B.F.

Raw material which is still solid is only coke.

→ Coke provides necessary space for the gases which go up and molten metal & slag to trikle down. This spacer role of coke cannot be subtituted by any other fuel.

Beneficiation of coking coal — (coal washing or coal washery)

Pulverised coking coal (−200 #)



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Heavy Media Separation

Very fine silica sand is introduced in the bath which consist in waters which remains in colloidal form.

If the average burden size of blast furnace is +13 mm then coke should be be +53 mm

Under size coke / rejected coke are called coke breeze.

Quality Requirement of coke —

Q why ash content increase in coking coal.

→ volatile matter content escapes out during heating but % of ash content

(a) Chemical Composition —

(i) High fixed C.
(ii) High calorific value.
(iii) low ash content
(iv) low sulphur content.

(b) Reactivity of coke.

Reactivity → How fast

Reactivity depends upon the surface area of coke exposed to the blast. It also depends on porosity of the lump coke

(c) High temp. stability —

As coke descent, it is gradually heated to very high temp. The coke must retain its original size. i.e. it should not disintegrate into smaller piece.

Coke Strength :—

① **Shatter Test**

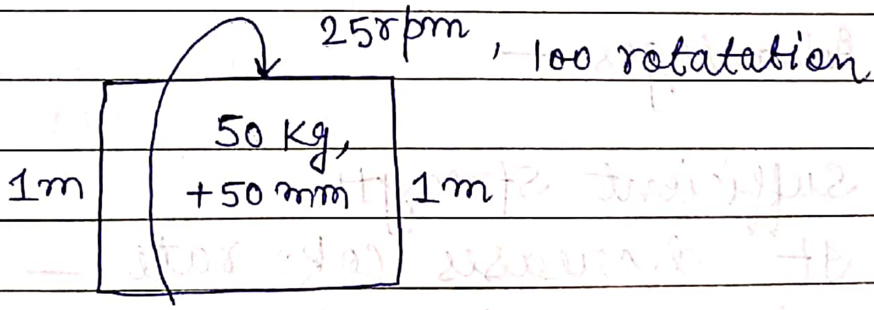
50 Kg, +50 mm

4 times ↓ 6m

50 Kg of Coke of the size +50 mm then it is dropped from a height of 6m, 4 times and then we do sieve analysis

%age of coke retained in +40 mm screen. This %age is taken as shatter index. (Normally shatter index is 97%).

② **Resistance to Abrasion** — The test is known as abrasion test or micum test.



50 Kg of +50 mm Coke is taken inside a rotating drum of equal length and dia of 1m and then it is rotation at 25 rpm. for 100 rotation. Then the material is taken out and sieve analysis is done. %age retained in +40 mm sieve should be more than 90% and % passing −10 mm should be less than 5%.

Alternate fuel —

Coke is very scarce and certain amount of coke is needed ~~to~~ due to spacer rule.

Other Alternative fuels for 1st two purposes —

① Natural gas, oil, pulverised coal, coal slurry.

Alternative to metallurgical coke —

① Ferro coke – Iron ~~ore~~ fines are mixed with non-coking coal and then carbonized. Thus obtaining a lump having sufficient strength.

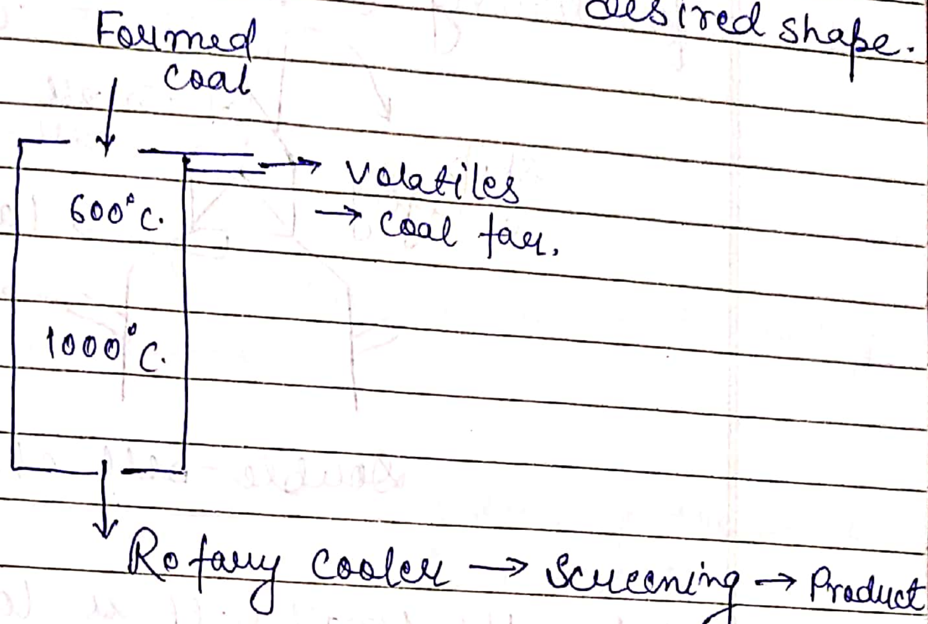
Advantages —

① Sufficient strength.
② It decreases coke rate — It further decreases coke rate and are reduced in the lump mass.

③ Formed Coke —

Non coking-coal → drying (2-3% moisture) → Pulverising

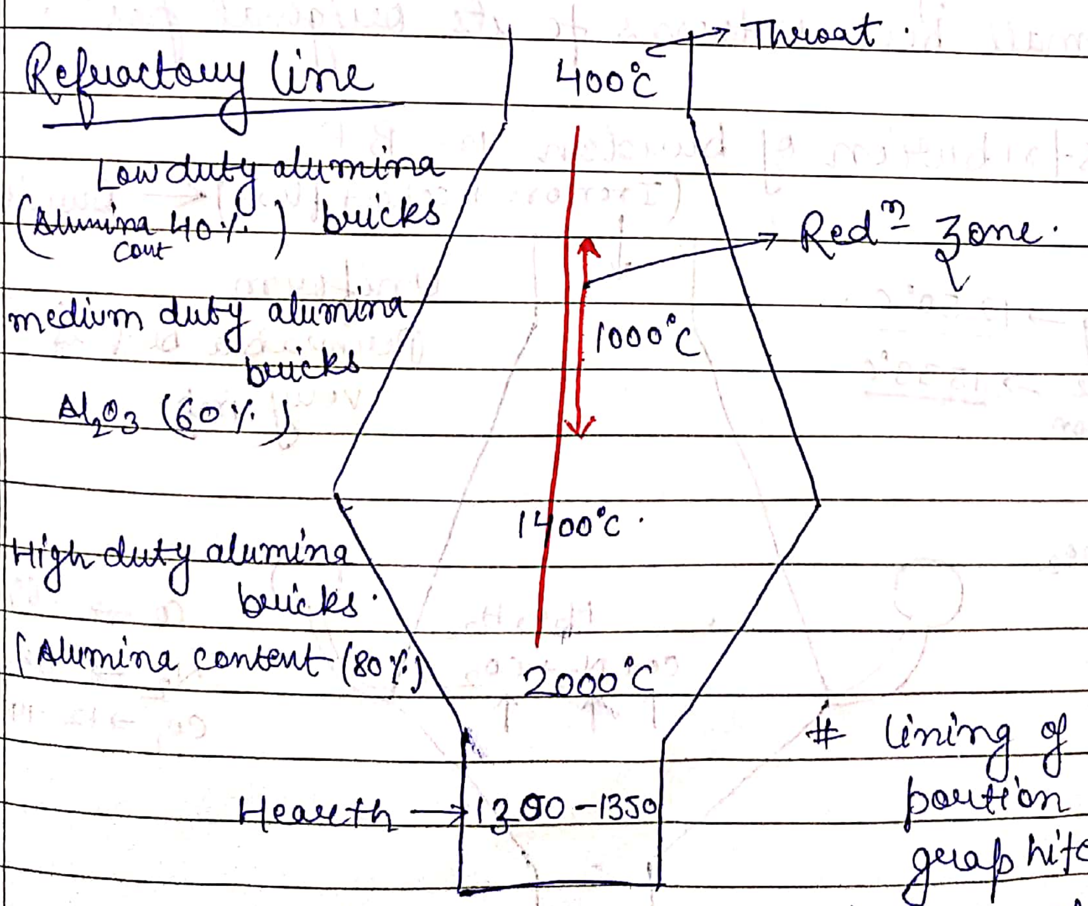
Kneading (Resolar coal Tar binder added) → Pressing → Formed into desired shape.



Vertical Retort

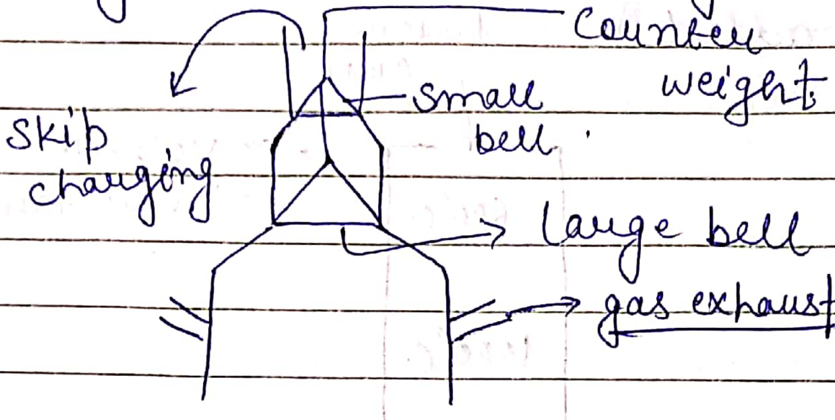
Bi-product are SO_2 and Ammonia

Refractory line



lining of Hearth portion with graphite blocks with min^m no. of joints to avoid leakage.

Fire-clay bricks are used for the lining for lining. (Skew brick lining).



Double-bell charging system.

When the small bell is lowered, the burden is fallen over the large bell. When the burden fallen over the large bell increases, then large bell is lowered and simultaneously small bell returns to its original pos^n.

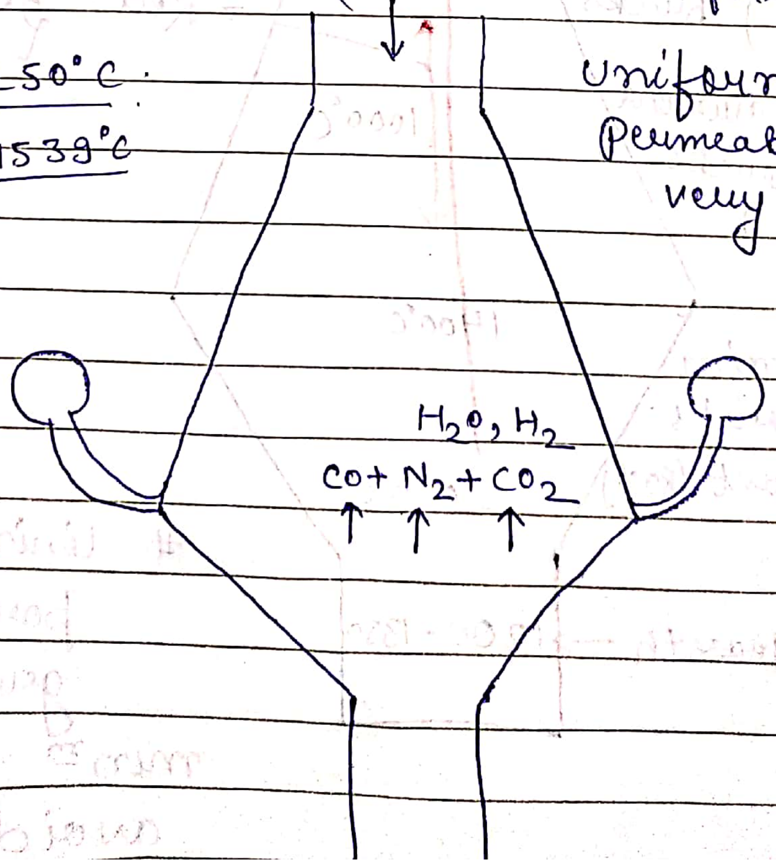
Distribution of burden in B.F.

(Iron ore + coke + flux.) ← Burden

Uniform permeable bed is very imp.

M.P. of slag → 1250°C.
" " pure Iron → 1539°C

At 900°C.
$CaCO_3 \rightarrow CaO + CO_2$.



$CO \rightarrow 26\%$
$N_2 \rightarrow 58\%$
$CO_2 \rightarrow 12-14\%$

(*) Most important reactions in blast furnace —

(i) Reduction of iron oxide :-

(ii) Progressive heating of burden :-

(a) Maximum contact between iron ore and reducing gases may be allowed.

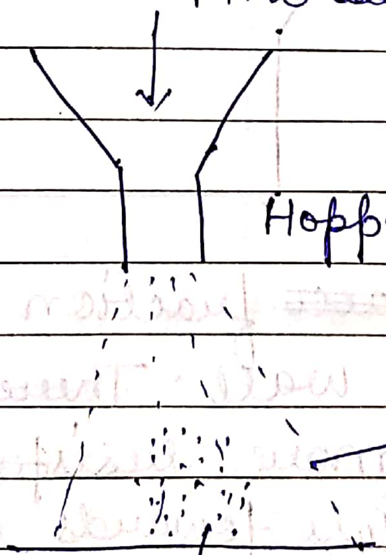
→ least resistance to the passage of upward gases.

Coarse size burden material

→ more resistance " " . . .

Find size

Fine ~~coarse~~ grains, and heavy coarse grains.

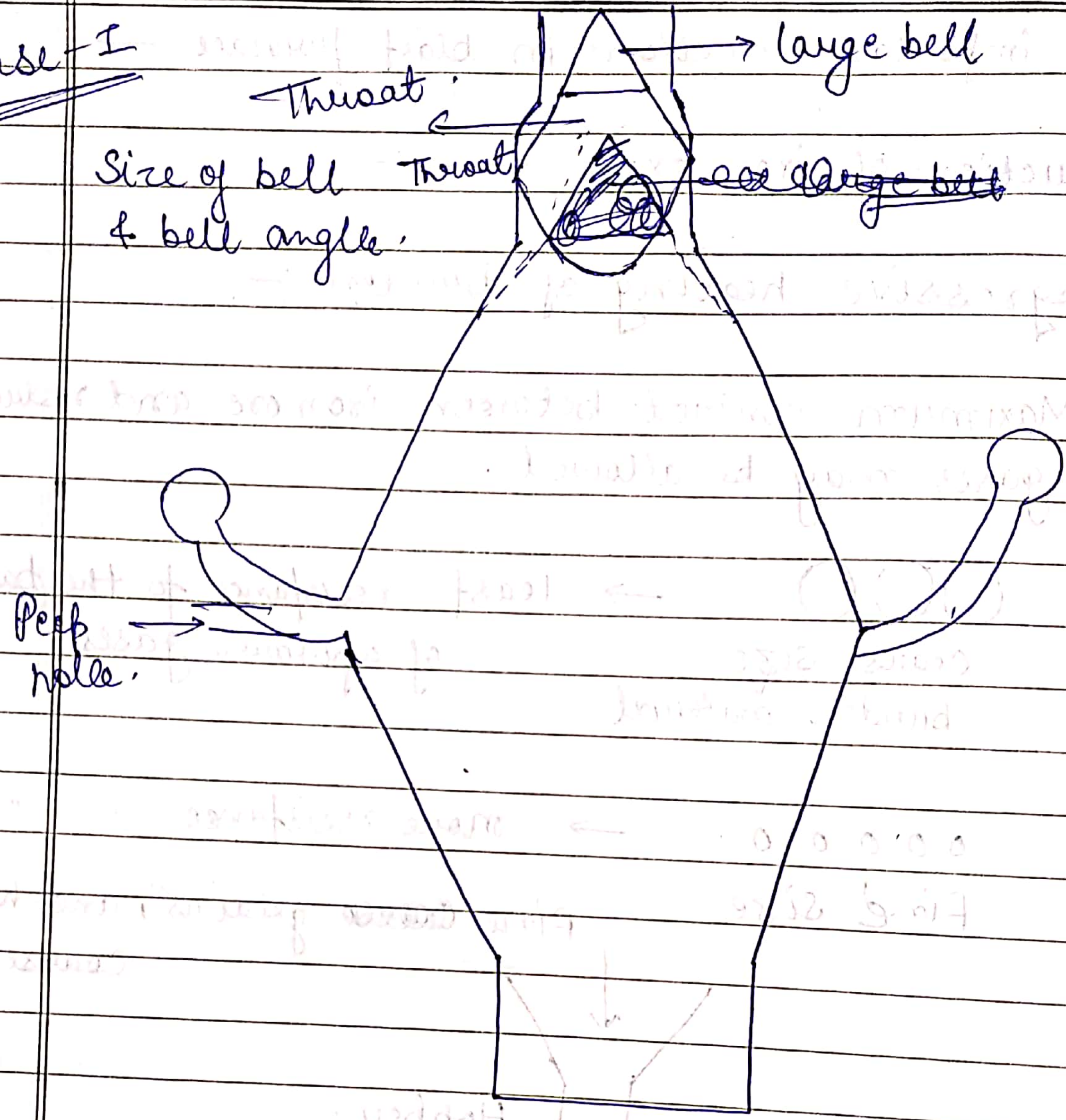


Hopper.

→ larger grains.

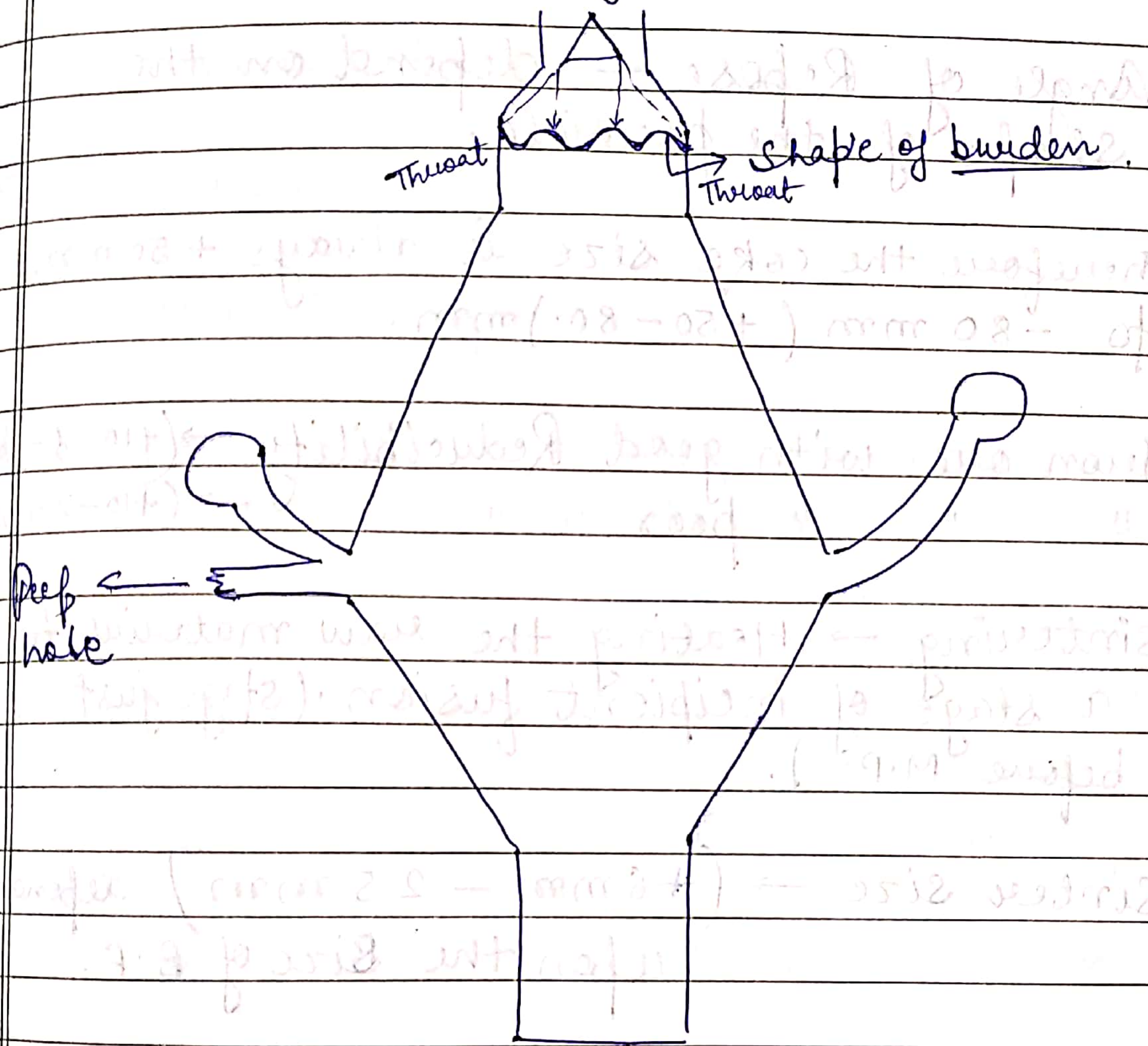
→ Fines.

Case-I



Since higher ~~acc~~ fraction of burden accumulate towards the wall. Therefore the blast encounter more resistance towards the wall and less towards centre.

Case II. Bell angle is more stip and opening is larger.



* To prevent damage to throat wall lining, iron rings are injected.

* To obtain uniform distribution of burden at throat level, deflectors and baffales are weilded with the iron rings.

Specific gravity of burden material —

Specific gravity of coke 1·1 and specific gravity of iron ore is 5 – 5·5. depending upon its quality.

Since, Specific gravity is different. Therefore their distribution in the burden is diff.

(*) Angle of Repose — depend on the shape of the particle.

Therefore the coke size is always +50 mm to −80 mm (+50−80.) mm.

Iron ore with good Reducibility → (+10−37) mm
" " " poor " → (+10−25) mm

Sintering → Heating the raw material to a stage of incipient fusion. (stage just before M.P.).

Sinter size → (+6 mm − 25 mm) depending upon the size of B.F.

Palletes → (+6 mm − 15 mm)

Charging Sequence —

The charging sequence does not have a fixed sequence ~~but~~. it varies from plant to plant.

The commonly following sequence is —

CN O(n−1)

CCC·OOO

Testing of burden material for suitability of to blast furnace —

Burden Preparation —

(I) Preparation of ore :—

Desirable Properties.

(a) Physical properties. – (i) Close range size.
(ii) Ability to withstand the weight of the burden.
(iii) Non-decrepitating.
↓
means it should maintain its strength even at higher temp.
(iv) Low Swelling.
(v) Should be stable under mildly reducing conditions.
(vi) High fusion temp with narrow range.

(b) Chemical Properties —

(i) High Fe-content.
(ii) Low gangue content.
(iii) Proper burden chemistry for effective de-sulphurisation
(iv) Proper burden chemistry for clean separation of metal & slag.

Preparation start. Mine site

(4′ - 5′ long) in the shape of bolders.

$\boxed{\text{ROM}}$ → Run of Mine.

↓ Size Reduction.

$\boxed{\text{Jaw Crushers}}$

↓

$\boxed{\text{Gyratory Crusher}}$ / Cone Crusher

Roll crusher

Size → (+12 mm - 37 mm)

↓

lump iron ore.

fines are generated. → Plant site Agglomeration (sintering).

(rich in Fe).

Pelletizing Plant

Briquetting Plant

Nodulising "

HBI → High Briquet Iron (Goa)

Indonesia Malasia.

Fe_2O_3 + C → direct Reduction.

+ CO → Indirect "

DRI → Direct Reduction Iron or Sponge Iron.

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↓

Grinding

Benefication of iron ore :

↓

by reducing gangue content

Benefication of iron ore.

(I) Size reduction.

(II) Separation of gangue.

(a) Gravity Separation method.

— Heavy media balls.

— Tabling.

— Spiraling / classifiers.

— Heavy media cyclone.

— Jigging. → pulsating motion of liq.

(b) Froath floatation →

(c) Magnetic Separation → sepⁿ of gangue from magnetite ore.

(d) Electrostatic Separation.

↓

based upon the diff. of electrical conductivity betⁿ ore particles & gangue particles.

gangue is mostly silica or clayey metal.

Preparation of Coking Coal :— (+50 mm size of coking coal is accepted.).

Preparation of flux :—

flux either limestone or dolomite (cheaper). is used in its raw form. The size redⁿ is carried out upto the level of iron ore lump size.

calcined form → used in steel making.

Steel making is an autogenous process.
The calcination temp is around 900°C.

$$CaCO_3 \rightarrow CaO + CO_2 .$$

$$CaO + C \rightarrow 2CO .$$

In the colder part of B.F or upper stake stage, the reverse rxn takes place ; Neimam Rxn —

$$2CO \longrightarrow CaO + C .$$

In the upper portion of Bosh, CaO reacts with SiO_2 to form slag $CaOSiO_2$ (M.P. 1250°C).

Burden Preparation :-

(II) Agglomeration

Agglomeration is the process of increasing the size of fine which is acceptable to blast furnace.

The processes are :-

(i) Sintering
(ii) Pelletizing
(iii) Nodulising
(iv) Brigqueting

Scanned by CamScanner

(*) Red Smoke is the indication of sintering plant

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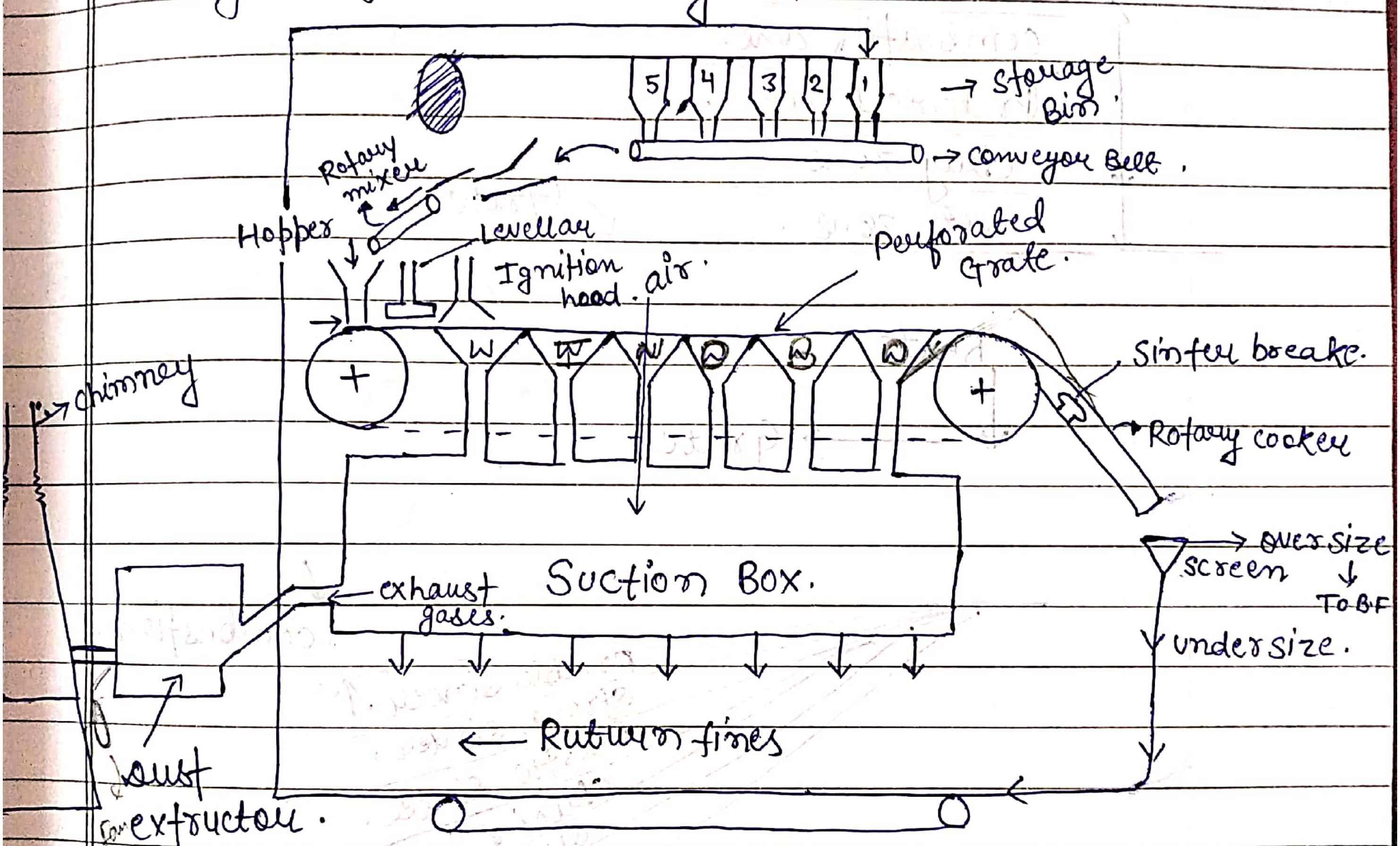
(1) Sintering :- Sintering is the process of heating iron ore fines to the stage of insipient fusion. Thus increasing the size of fine which is acceptable to blast furnace.

Dwight Lyod Sintering Machine.



1. Return fines
2,3 - Iron ore fines.
4 - Coke breeze.
5 - flux (limestone / Dolomite)
W = wind box.

Bed depth is maintained by levelar

(*) Red Smoke is the indication of sintering plant

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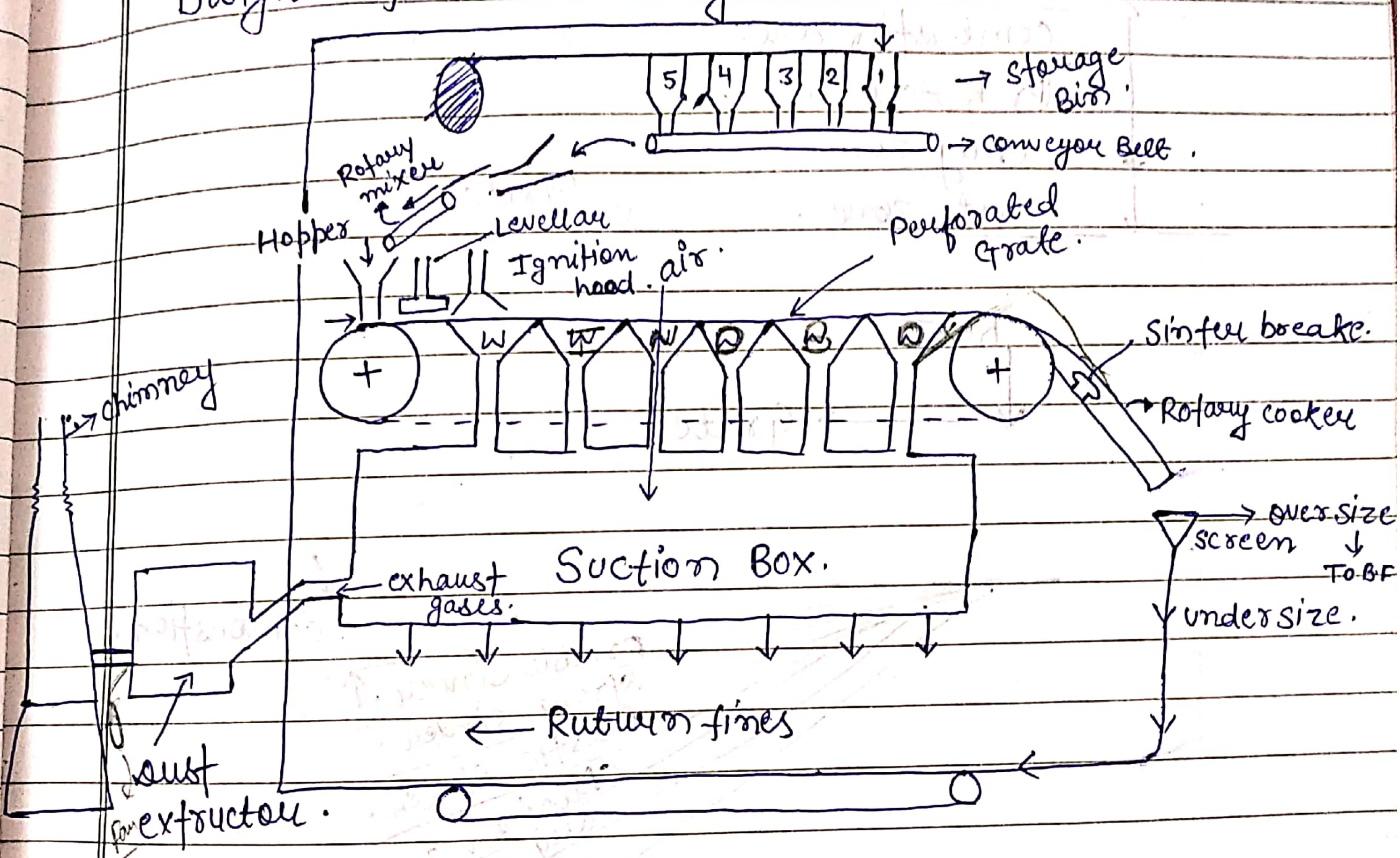

1. Return fines
2, 3 - Iron ore fines.
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W - wind box.

Bed depth is maintained by Levelar

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* Coke breeze is undersize ~~ore~~ coke which is not suitable for B.F.

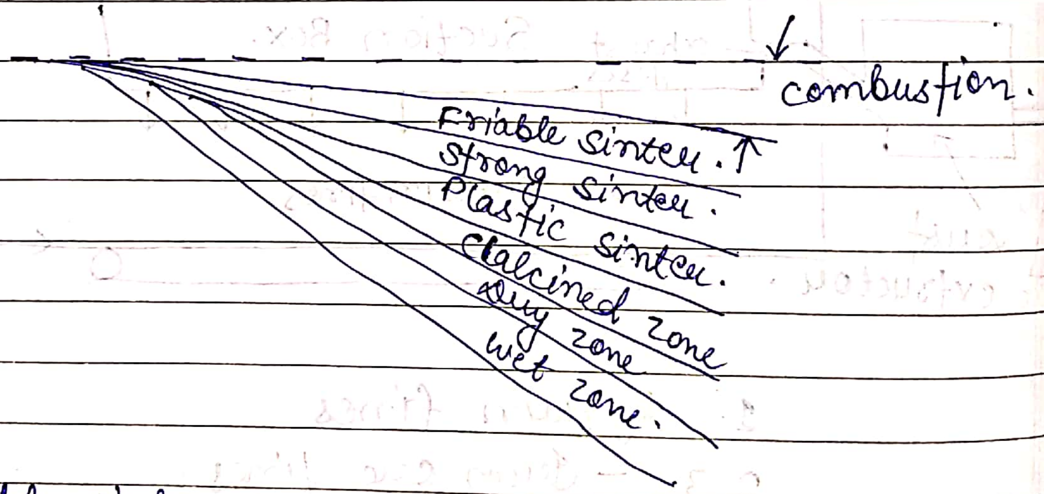
* Depth of bed is divided in different zones —

Cold air

- Cold sinter
- Heat sinter
- Combustion zone
- Preheated zone
- Dry zone
- Wet zone

Grate

Heat ↓ → Grate



Friable sinter means weak sinter.

Depth of the bed is very critical as it may cause problem to suction of air

Parameter which control the sintering process:—

1. Depth of the bed —
2. speed of travel of grate.
3. Fuel content (coke breeze is used as fuel).
4. Flow rate of air / volume of air sucked per min.
5. Uniformity of the bed.
6. Nature of iron ore fines. — If iron ore fines contains iron carbonates then volatile content may increase.
7. Nature of coke.

Classification of Sinters :—

1 Acid Sinters:— If no flux is incorporated. (Bin 5 is absent.).

2. Self-flux Sinter:— If the amt of flux incorporated in the mix is equal to basicity of the slag in the blast furnace then it is called self-flux sinter.

3. Super flux Sinter !— If entire requirement of flux (sinter + lump ore) is incorporated in the mix. then it is called super flux sinter. In this case, basicity of the mix is much higher than the basicity of the Blast furnace slag.

While doing this, the strength of the sinter should not be compromise.

Mechanism of Bonding :-

Recrystallisation bond or diffusion bond

Slag bond.

Slag bond :- When formation of a low melting slag takes place at the contact point b/w two ore particles, the bond formed is called slag bond.

Re-crystallisation Bond :- This kind of bonding takes place due to re-crystallisation at the contact point b/w two ore particles. Re-crystallisation is a diffusion process so this is also known as diffusion bond.

Pelletization —

involves
- Green ball formation
- Drying
- Endwation.
- Firing
- Cooling
- Screening.

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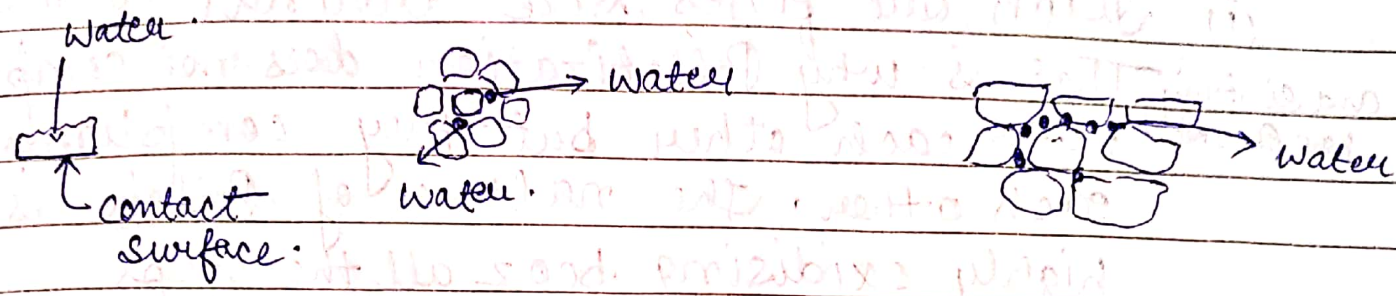
Mechanism of bonding :—



(i) Pendular state. (ii) Funnicular state. (iii) Capillary state.

* The bonding in this case is due to surface tension of water present in the void or contact surface.

(i) Water is present b/w the contact surface b/w two adjacent (Pendular State)

(ii) Water is present in some of the void. (Funnicular state)

(iii) Water is filled in all the voids. It will have max^m green strength bcoz it possesses critical amt. of water.
Capillary state
If amt. of water exceeds the critical val. then a water film will form over the surface of particle. and they it will become plastic resulting into reduction in strength.

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sintering (#-200)

Raw Material for Pelletization :-

(i) Iron ore fines size around (100 mesh.)

and sintering have (#-200) That is why Pelletization does not compete with each other but they compliment each other. The nature of Pellete is highly oxidising bcoz all the steps will be carried out oxidising atmosp. In case of sintering 5-20% of metallic iron is present.

(ii) Water.

(iii) Binders :-

(a) Organic Binders → starch, Dextrin
(b) Inorganic " → $FeSO_4$, Alkali chloride, Alkali carbonates, ~~Bentonit~~

(c) Bentonite → 0.1 to 0.2% of binders are commonly used.

Mechanism of Ball Formation :-

1 → Nucleation
2 → Transition period.
3 → Growth → Assimilation, Layering.

① Nucleation :- Nucleation starts at a point where surplus amt of water is present. As the rotation continues, adjacent particles will stick to the nucleii.

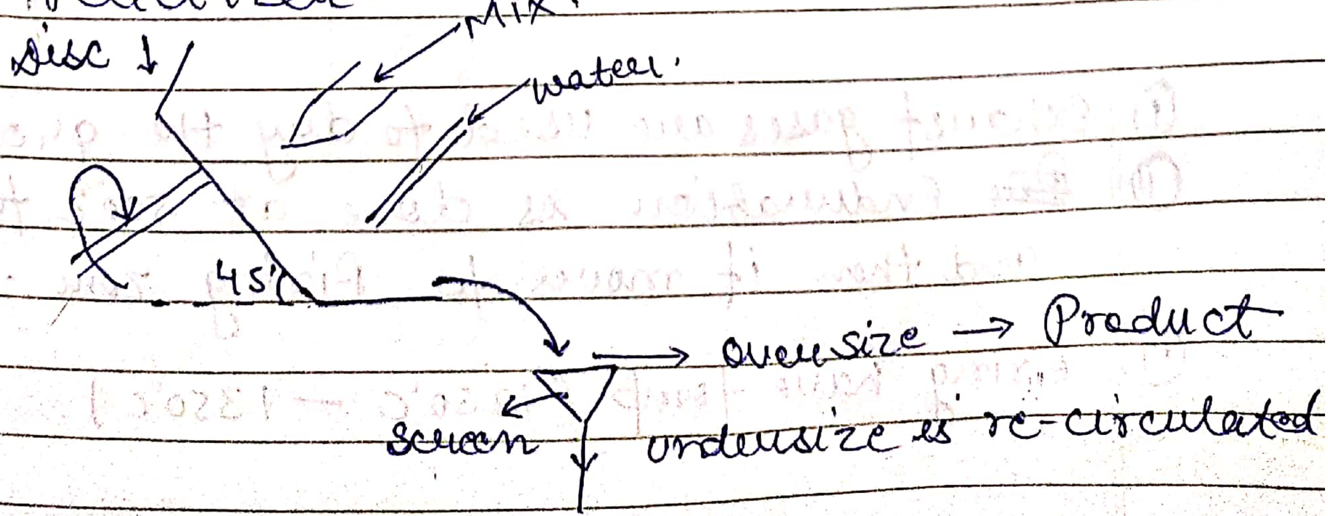
② Transition period :- The nucleii will grow only when conditions are favourable. otherwise it will break down and dissolve in the mix. Nucleii formation will start again at other point where surplus water is present and will grow if the conditions are favourable.

③ Growth.

(a) Assimilation :- Growth by Assimilation takes place when adjacent particles strick to the growing balls. No fresh add^n of charge is made.

(b) Layering :- Growth by Layering takes place when fresh charge is added continuously the growth takes place by Layering. i.e. a fresh layer sticks to the original balls.

Disc Pelletizer :-

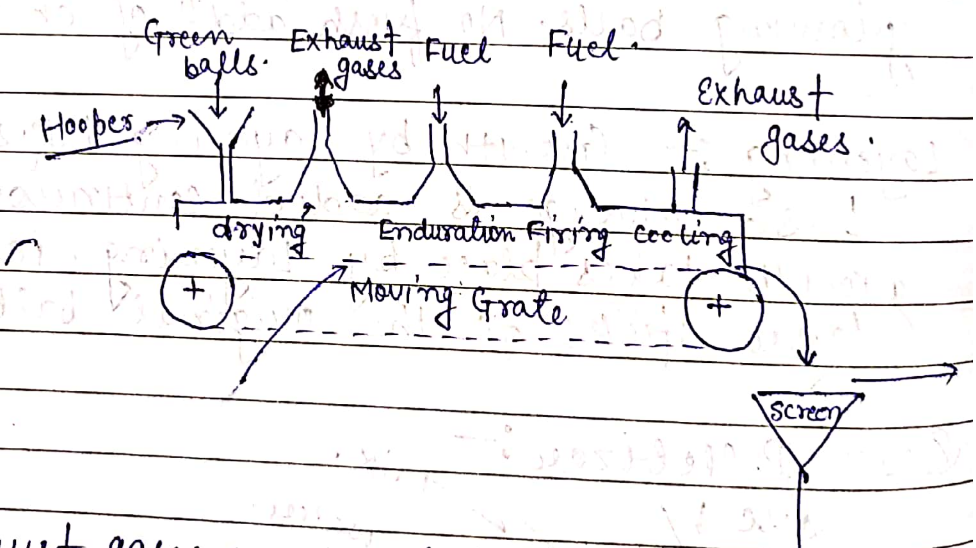


Enduration is pre-heating.

Parameters affecting the Green Ball formation :-

(I) Angle of inclination of Disc — diameter of the disc.
(II) Depth of Disc
(II) Nature & size of feed.
(III) RPM of Disc
(IV) Position of entry of mix.
(V) " " " " water.
(VI) Rate of addition of mix.
(VII) Flow rate of water.
(VIII) Angle of inclination of disc edge.

Pelletization :-



(I) Exhaust gases are used to dry the green ball
(II) ~~Pre~~ Enduration is done at 500°c to 600°c. and then it moves to firing zone.
(III) Firing have temp (1250°c — 1350°c).

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(iv) Then the fired balls are cooled and then it is subjected to screen and oversize are desired products and undersize product are re-circulated.

(v) Size in range of (5mm – 20 mm)

(vi) Pallete are suitable to used in mini blast furnace

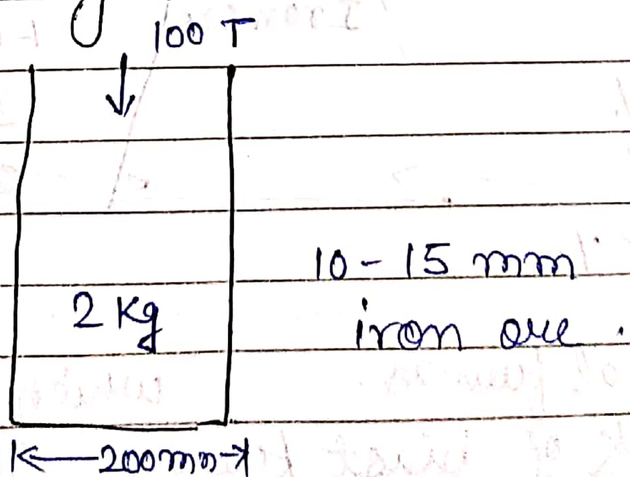
Testing of Burden Materials :–

1) Room temperature Physical properties.
(2) Reducibility.
(3) Physical behaviour at high temp.

Cold strength — impact strength — Shatter Test

Abrasion strength — Tumbler strength or Micum test.

(C) Compression strength –



with the help of a piston, a load of 100 tonne is applied. After this, the sieve analysis

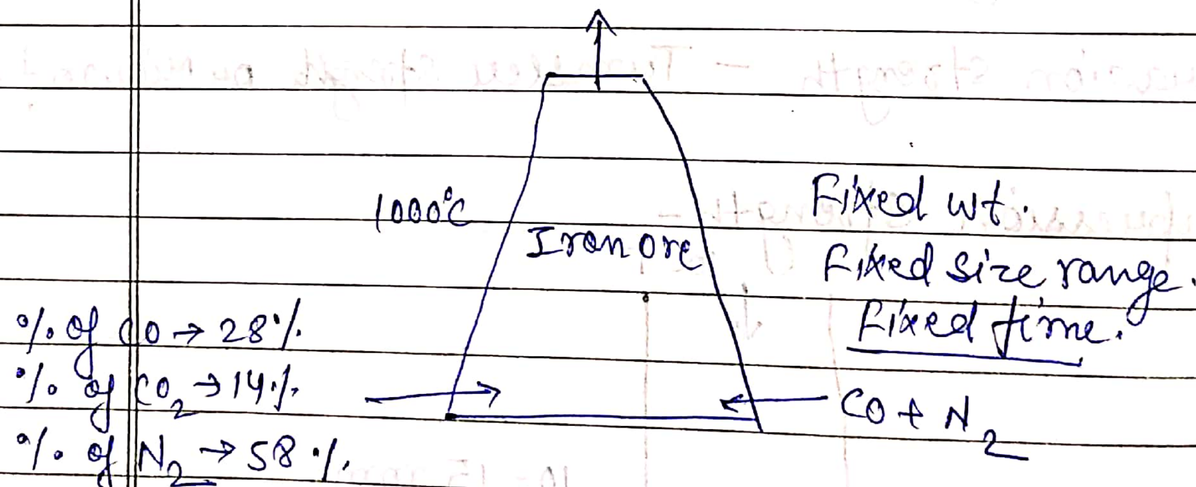
is done if +5 mm at least 75%
then it is said to be 'OK' and if it is
20%, it is friable and will break
into fines.

Porosity – Porosity of natural lump ore.

The Porosity of the natural lump ore can
be found out with the help of
archimedes principle.

Theoretical density or X-ray density $\leftarrow \rho = \dfrac{1.66 \times 10^{-27} \times Z \cdot M_A}{a^3} \; kg/m^3$

(*) Effective no. of atom for (diamond cubic) = 8. (2)



Vertical furnace. which resembles the
stack of blast furnace.

composition of

CO_2 does not take part in red^n here.

Fbb ~~J~~ Diamond Cubic ← Struc → FCC + 4 atoms at tetragonal posn

Sieve Analysis

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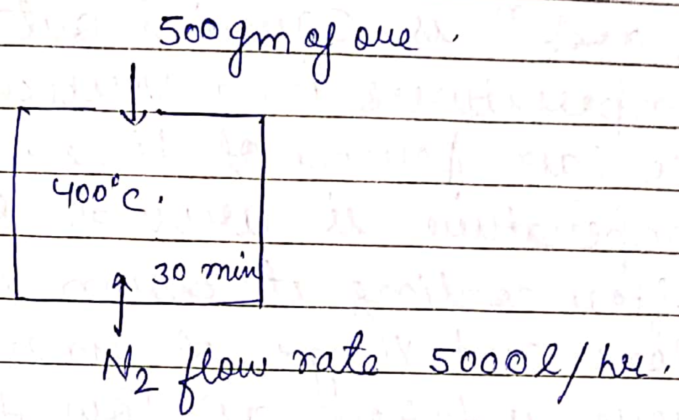
* From the weight loss, we found the reducity.

Physical behaviour at high temp —

① Decrepitation —



– 0.5 mm —— 0.05 – 1.1 %

When iron ore is charged into the B.F. at stroke line. The temp. prevailing around 400°C. So, the iron ore is exposed to 400°C suddenly. Therefore iron ore experience a ~~the~~ thermal shock. Due to this, iron ore breaks down. This is known as Decrepitation.

If % of material of size range – 0.5 mm passes to 0.05 – 1.1%.

The Blast volume is 2500 nm3

0.4 – 0.5 tonne of slag..

Top gas volume is 3200 n-m 3. and 80 kg of dust.

If the porosity of iron ore is 10% or more then decrepitant tendency is low.

Low Temp. Break down Test (LTBT):-

The red^n is carried out at lower temperatures in a vertical furnace for a certain period of time.
Temperature is around 800-850°c.
After cooling it down, sieve analysis is done and %age of fines passing 0.5mm sieve is taken as low temp break down Index.

Hot Compression strength :-

Hot compression strength can be obtained by conducting compression test inside the furnace maintained at given temp.

Swelling Index:-

Iron ore is subjected to a temp. of 1000°c the composition of gas being 50% CO and 60% N_2 and the flow rate of the reducing gas 1000 litre/min.

The swelling is measured by dipping iron ore in mercury.

Causes of swelling —

1. Reduces Bed Permeability
2. Reduces strength

(#) fluidization velocity

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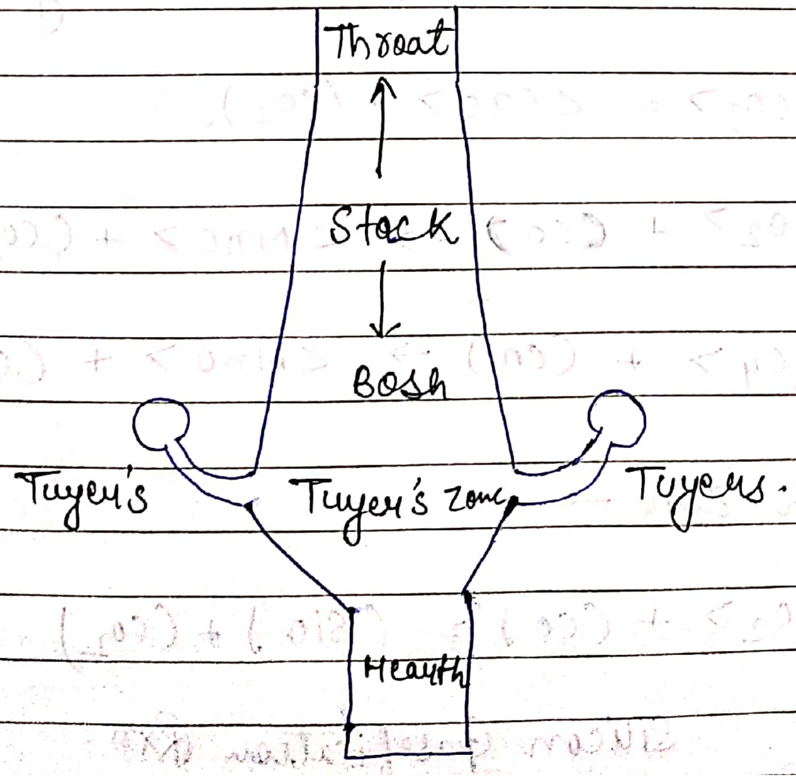
Softening of material :—

The iron ore should not soften before 1200°c. otherwise the burden will become ~~speedy~~ sticky and hence will not desend quickey / smoothly. This ~~a~~ will also effect the permeability of the burden. So, an experiment is permofered and if the shrinkage is 2.5% then the temp is 1200°c and if the shrinkage of volume is 25% then it gets melted.

High temp. Permeability :—

The Permeability of the bed can be measured ~~by~~ through Pressure drop measurement across the bed height.

Blast furnace Reactions :—



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Ⓐ Tuyer's zone :-

① $\langle C \rangle + (O_2) = (CO_2)$

② $(CO_2) + \langle C \rangle = 2(CO)$ → super heated steam

③ $\langle C \rangle + (H_2O) = (CO) + (H_2)$.

④ $(C_xH_7) + \left(x + \frac{y}{4}\right)(O_2) = xCO_2 + \frac{y}{2}(H_2O)$

⑤ $\{SiO_2\} + \langle C \rangle = (SiO) + (CO)$.
coke ash (silicon-gasefication Rxn)

Ⓑ Stack reactions —

$\langle Fe_2O_3 \rangle + (CO) = \langle Fe_3O_4 \rangle + (O_2)$.

900°C – 1000°C.

$\langle Fe_3O_4 \rangle + (CO) = \langle FeO \rangle + (O_2)$.

$\langle FeO \rangle + (CO) = \langle Fe \rangle + (CO_2)$

Temperature remains constt. during the solidificatio

$\langle CaCO_3 \rangle = \langle CaO \rangle + (CO_2)$.

$\langle MnO_2 \rangle + (CO) \rightarrow \langle MnO \rangle + (CO_2)$

$\langle Mn_3O_4 \rangle + (CO) \rightarrow \langle MnO \rangle + (CO_2)$.

Ⓒ Bosh zone —

$\langle SiO_2 \rangle + (CO) = (SiO) + (CO_2)$

Silicon Gasefication Rxn.

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At high temp., p is gas

$(SiO) + \langle C \rangle = [Si] + (CO).$

$(SiO) + (CO) = [Si] + (CO_2).$

$\langle P_2O_5 \rangle + (CO) = 2[P] + 5(CO_2).$

$\langle MnO \rangle + (CO) = [Mn] + (CO_2)$

$\langle Cr_2O_3 \rangle + (CO) = [Cr] + (CO_2)$

$\{FeO\} + \{SiO_2\} = \{FeO \cdot SiO_2\}$ → iron silicate

$\{FeO \cdot SiO_2\} + \{CaO\} = \{CaO \cdot SiO_2\} + \{FeO\}$
↳ calcium silicate).

* $\{CaO \cdot SiO_2\}$ is more stable than $\{Fe \cdot SiO_2\}$

(D) Hearth Reactions :–

$\{CaO\} + [FeS] = \{CaS\} + \{FeO\}$

$\{FeO\} + \{SiO_2\} = \{FeO \cdot SiO_2\}$

$\{FeO \cdot SiO_2\} + \{CaO\} = \{CaO \cdot SiO_2\} + \{FeO\}.$

$\{FeO\} + [C] = [Fe] + (CO).$

$[FeS] + [Mn] = \{MnS\} + [Fe].$

* Phosphorus comes in rxn through iron ore.
Sulphur " " " " fuel.

If silicon is very high → [illegible] pig iron (cast iron).

Burdening

Acid Burdening

used when SiO_2 & Al_2O_3 content of burdening low.

If SiO_2 & AlO_3 content is low, liquidous temp. will be low. So, coke rate should be low.

The combustion zone & Bosh temp is low. Therefore silicon gasification rxn will be slower. Therefore pig iron will have a low silicon and high sulphur.

Basic Burdening

used when SiO_2 & Al_2O_3 content of bendening high.

If SiO_2 & AlO_3 content is more, liquidous temp will be high so, coke rate will be high.

Bosh Higher temp is very high. silicon gasification rxn will be faster. Therefore more and more silicon is produced and [illegible] the pig iron.

Condition for De-phosphorisation (Removal of phosphorous).

$$2[P] + 5\{FeO\} + 3\{CaO\} = \{3CaO \cdot P_2O_5\} + 5[Fe]$$

dissolved pig iron

$$K = \frac{a_{\{3CaO \cdot P_2O_5\}} \cdot a^5_{[Fe]=1}}{a^2_{[P]} \cdot a^5_{\{FeO\}} \cdot a^3_{\{CaO\}}}$$

If silicon is very high → foundary grade pig iron (cast iron).

Burdening

Acid Burdening

↓

used when SiO_2 & Al_2O_3 content of burdening low.

If SiO_2 & AlO_3 content is low, liquidous temp. will be low. So, coke rate should be low.

The combustion zone & Bosh temp is low. Therefore silicon gasification rxn will be slower. Therefore pig iron will have a low silicon and high sulphur.

Basic Burdening

↓

used when SiO_2 & Al_2O_3 content of bendening high.

If SiO_2 & AlO_3 content is more, liquidous temp will be high so, coke rate will be high.

Bosh Higher temp is very high. silicon gasification rxn will be faster. Therefore more and more silicon is produced and join the pig iron.

Condition for De-phosphorisation (Removal of phosphorous).

$$2[P] + 5\{FeO\} + 3\{CaO\} = \{3CaO \cdot P_2O_5\} + 5[Fe]$$

dissolved in pig iron

$$K = \frac{a_{\{3CaO \cdot P_2O_5\}} \cdot a^5_{[Fe]=1}}{a^2_{[P]} \cdot a^5_{\{FeO\}} \cdot a^3_{\{CaO\}}}$$

$$\frac{a_{\{3CaO \cdot P_2O_5\}}}{a^2_{[P]}} = K \cdot a^5_{\{FeO\}} \cdot a^3_{\{CaO\}}$$

$$D_P = \frac{\{\% P\}}{[\% P]} = K \, a^5_{\{FeO\}} \, a^3_{\{CaO\}}$$

D_P = Dephosphorising Index.

For high D_P — (i) K should be high → At lower temp, the value of K is high. Therefore a lower temp is preferable for removal of P.

(ii) Activity of FeO in the slag should be High.

(iii) If % age of FeO in the slag is more than 15% then it is called oxidising slag.

If % age of FeO is less than 5% then it is called reducing slag.

Hence oxidising slag is needed for high D_P.

(iv) Activity of CaO is high in the slag. Therefore basicity of the slag should be high.

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Since reducing condⁿ prevails in blast furnace. Therefore %age FeO is very low in the slag. Temperature in the hearth is also very high. Therefore Phosphorous cannot be removed from Blast furnace.

De-Sulphurisation —

$$[FeS] + \{CaO\} = \{FeO\} + \{CaS\}$$

$$K = \frac{a_{\{FeO\}} \cdot a_{\{CaS\}}}{a_{\{CaO\}} \cdot a_{[FeS]}}$$

$$\frac{a_{\{CaS\}}}{a_{\{FeS\}}} = K \frac{a_{\{CaO\}}}{a_{\{FeO\}}}$$

$$D_S = \frac{\{\%S\}_{\rightarrow \text{slag phase}}}{[\%S]_{\rightarrow \text{metal phase}}} = K \cdot \frac{a_{\{CaO\}}}{a_{\{FeO\}}}$$

Desulphurising Index

For High D_S — (i) High basicity slag is needed.

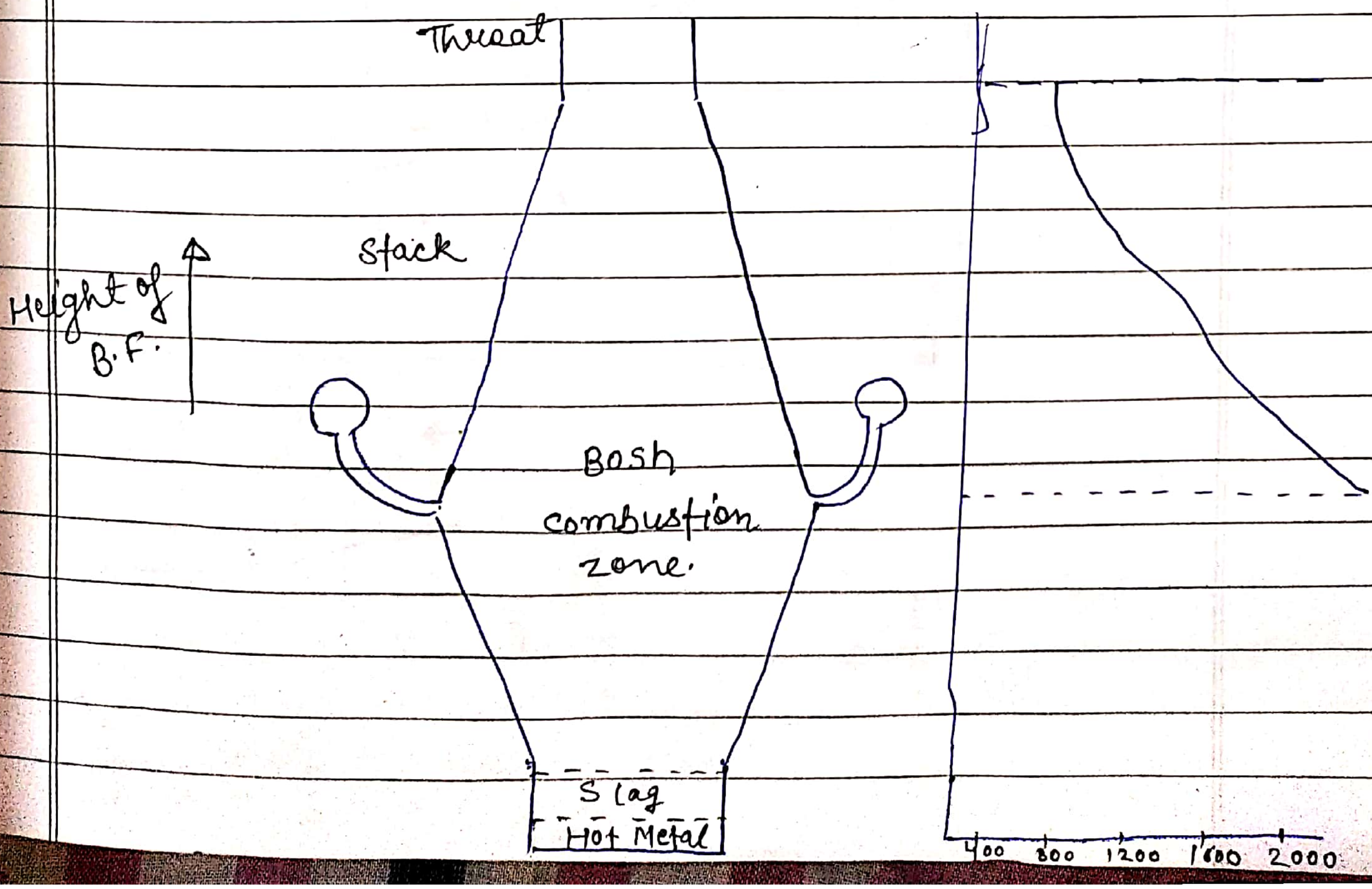
(ii) Activity of $a_{\{FeO\}}$ is low. That means reducing slag is needed.

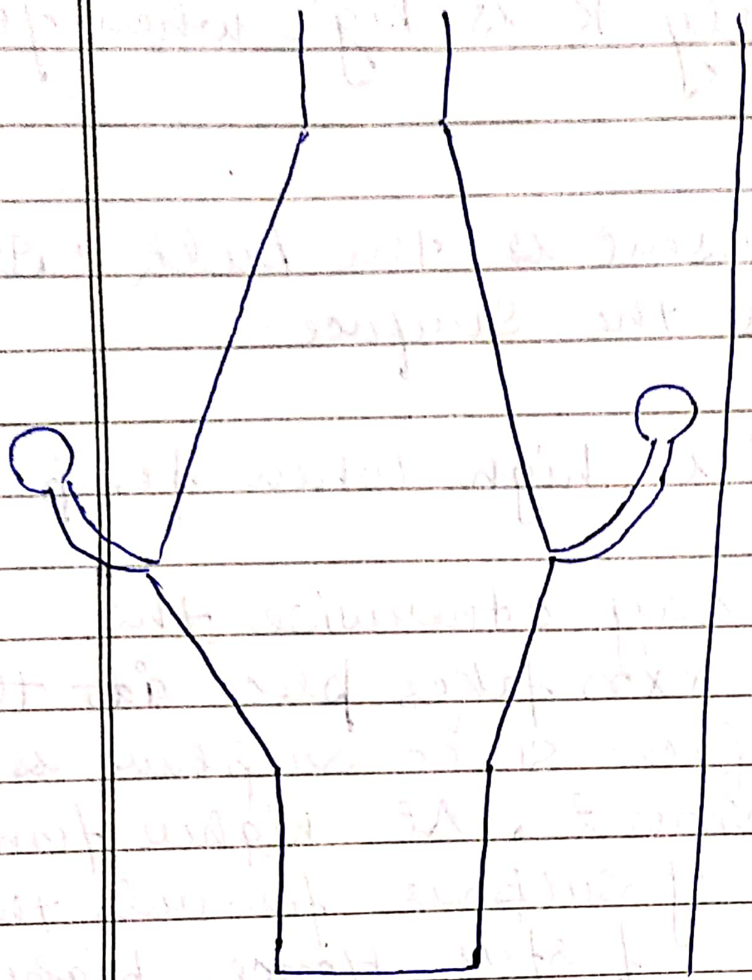
(iii) Thermodynamically 'K' is high when temp. is low.

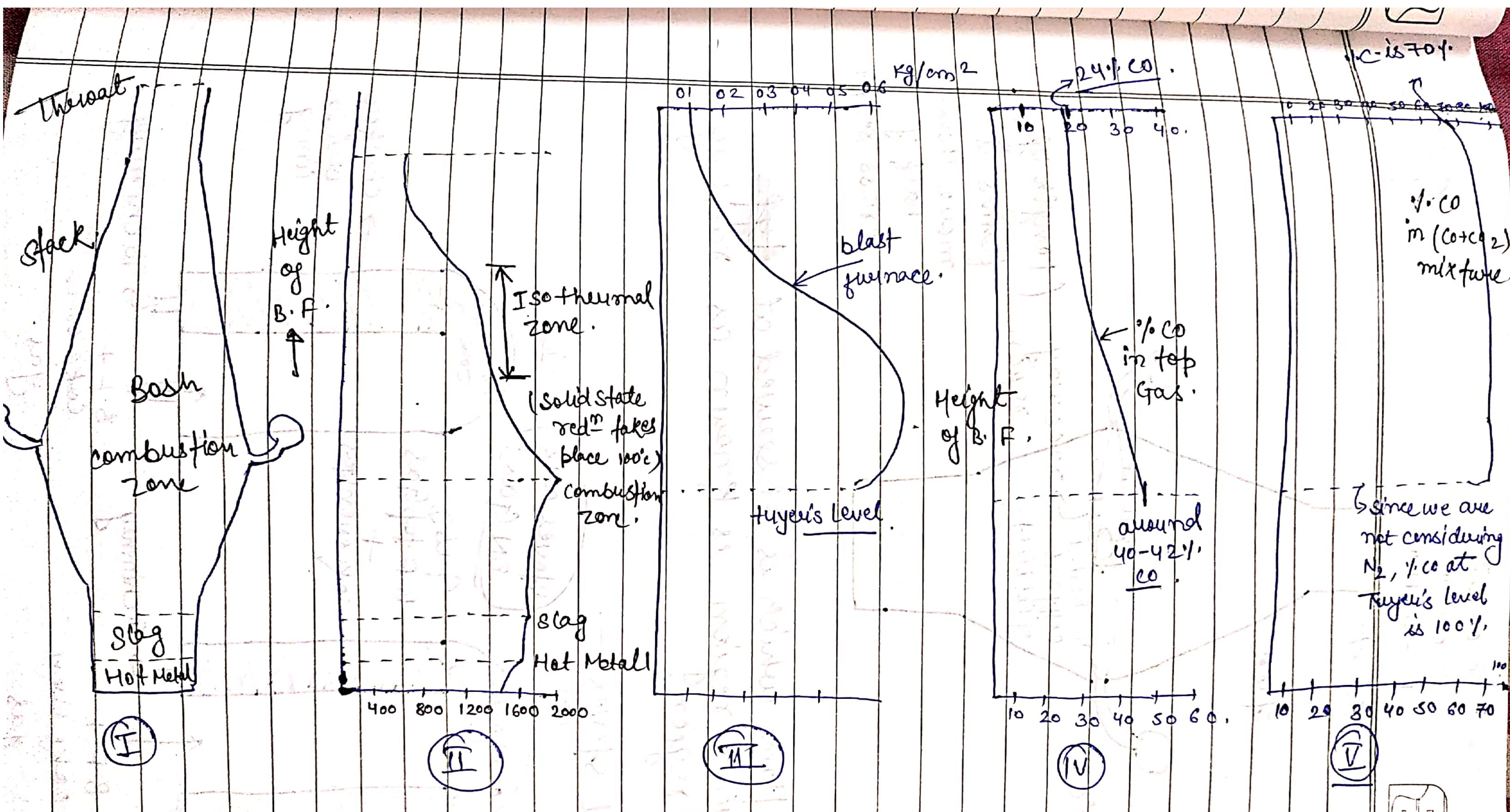
If sulphur is present in the bulk. It comes towards the surface.

Thermodynamically 'K' is high when temp. is low.
but Kinetic factors say otherwise the de-sulphurisation rxn takes place at the Metal-Slag interface. Since sulphur is a surface active element, At higher temp, rate of diffusion of sulphur towards the interface will be faster. Hence higher temp. is preferred for the removal of sulphur.

Thermal Profile of B.F. :-

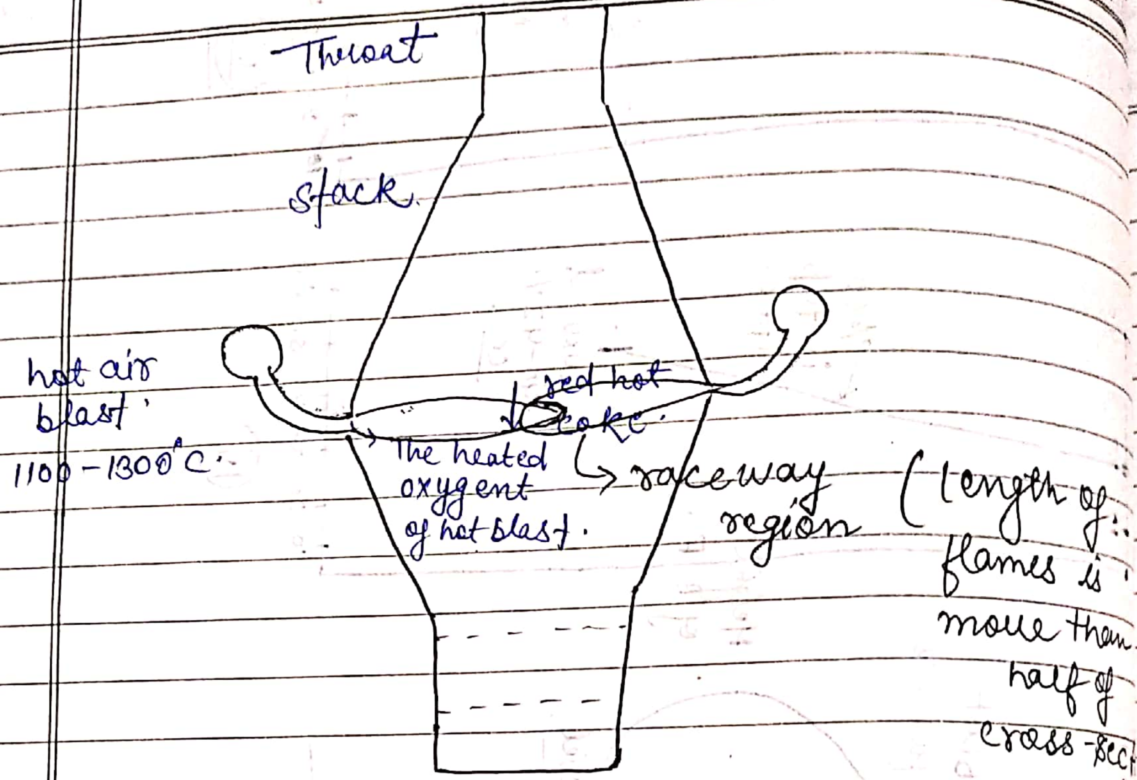






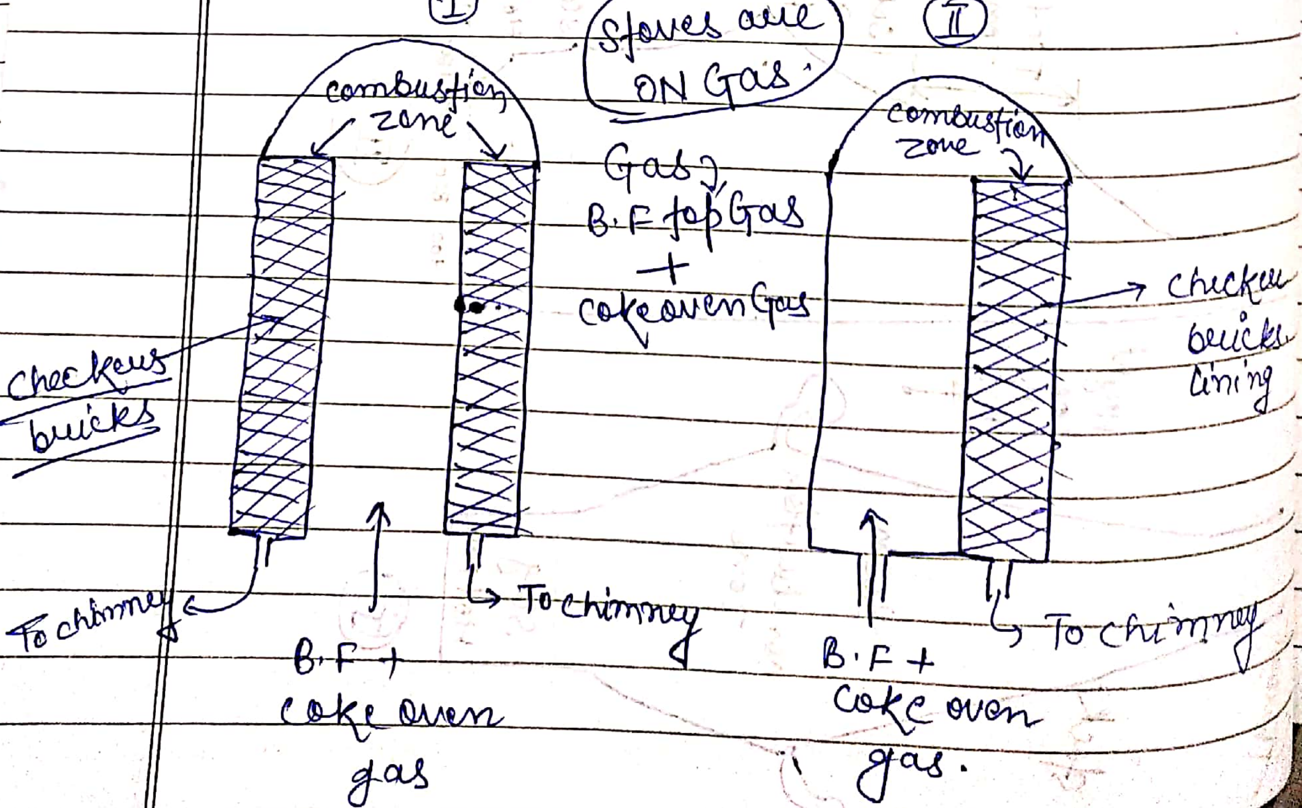
Throat
Stack
Bosh
combustion zone
Slag
Hot Metal
I
Height of B.F.
Isothermal zone.
(solid state redn takes place 1000°c)
combustion zone.
slag
Hot Metal
400 800 1200 1600 2000
II
Kg/cm2
01 02 03 04 05 06
blast furnace.
Tuyer's Level.
III
24% CO.
10 20 30 40.
Height of B.F.
% CO in top Gas.
around 40-42% CO.
10 20 30 40 50 60.
IV
% C is 70%.
% CO in (CO+CO2) mixture
since we are not considering N2, % CO at Tuyer's level is 100%.
10 20 30 40 50 60 70
100
V

Fe-O-eq"
Fe-O-C "
Fe-O-H "



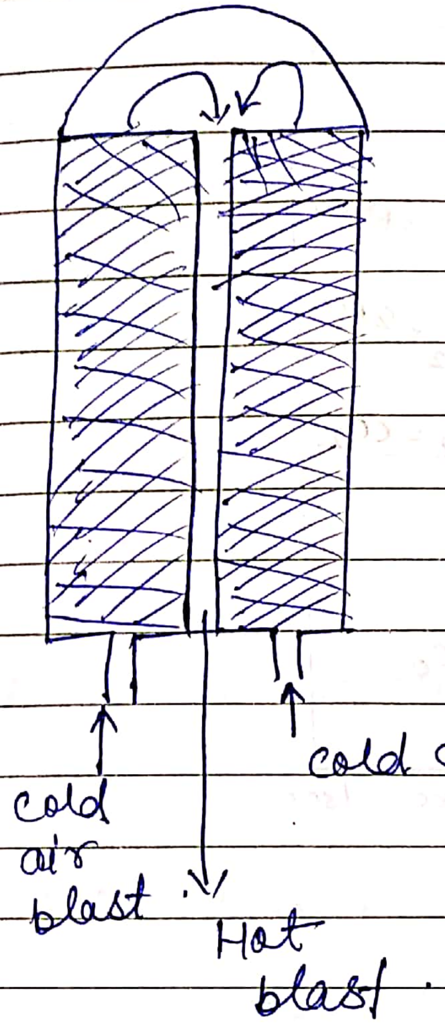
The flame which is obseived at ~~tuye~~ tuyer's region is known as raceway region.

Hot stoves —



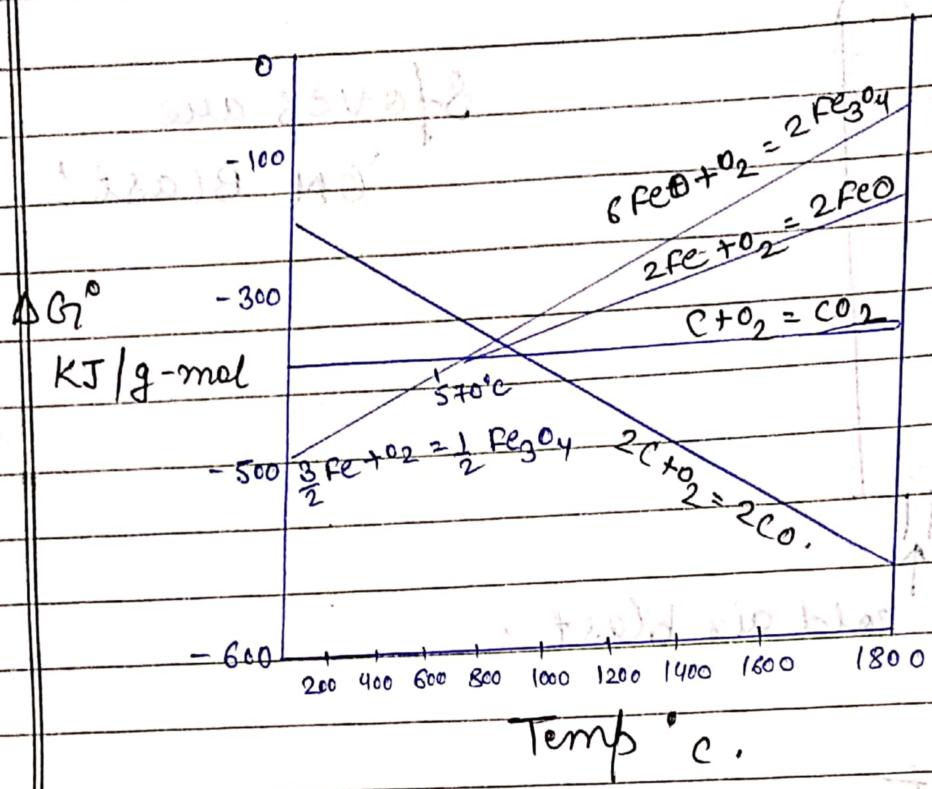
Checker bricks lining gets heated.

Waste heat Recovery boilers → to generate steam → to generate power



Stoves are 'ON BLAST'

Two stoves are always "On Gas".
1 " " " "ON Blast".
4th stoves are under reserved.



~~The Temp is~~

\# Below 570°C → $Fe_2O_3 \rightarrow Fe_3O_4 \rightarrow Fe$
Above 570°C → $Fe_2O_3 \rightarrow Fe_3O_4 \rightarrow FeO \rightarrow Fe$

Since reliable ΔG° (Std. free energy of formation) are not available regarding the formation of Fe_2O_3. Hence Fe_2O_3 is not being indicated here.

In case of $2C + O_2 \rightarrow 2CO$.

$\Delta S^\circ \rightarrow$ inc. $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$

$y = c + mx$.

$\Delta S \rightarrow +ve$.

$m \rightarrow -ve$

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(*) It is theoretically possible to reduce Fe_2O_3 at 710°C.

(*) Since steel making temp i.e. 1600°C, there is great diff of std. free energy. So, both can be separated during steel making (by adding flux).

(*) Since P_2O_5 and FeO have nearly same ΔG° below ~~at~~ 1000°C. So, whenever we reduce Fe, P_2O_5 will also be reduced and joins the pig iron.

CO equilibria.

$$\langle C \rangle + (O_2) = (CO_2).$$

$$\Delta G^\circ = -395170 - 0.84T \text{ J/mole} \rightarrow$$ Sol^n loss reaction

$$(CO_2) + \langle C \rangle = 2(CO).$$ or Boudouard reaction

$$\Delta G^\circ = 171156 - 175T \text{ J/mole}.$$

← Naumann reversion reaction takes places at upper stack region.

Now adding the 2 rxn.

$$2\langle C \rangle + (O_2) = 2(CO).$$

$$\Delta G^\circ = -224014 - 175.84T \text{ J/mole}.$$

Now, This CO is utilise for red^n of iron oxide.

$$\langle Fe_2O_3 \rangle + (CO) \longrightarrow \langle Fe_3O_4 \rangle + (CO_2)$$

$$\langle Fe_3O_4 \rangle + (CO) \longrightarrow \langle FeO \rangle + (CO_2)$$

$$\langle FeO \rangle + (CO) \longrightarrow \langle Fe \rangle + (CO_2)$$

Thus $\frac{P_{CO}}{P_{CO_2}}$ for the red^n of diff. oxides at diff. temp. can be found out.

Temp °C	1900	1460	1180	980	820	670	530
$\frac{P_{CO}}{P_{CO_2}}$	$10^5/1$	$10^4/1$	$10^3/1$	$10^2/1$	$10/1$	$1/1$	$1/10$

Temp °C	410	300
$\frac{P_{CO}}{P_{CO_2}}$	$1/10^2$	$1/10^3$

\# Thus we find P_{CO_2} is negligible above 1000°C and P_{CO} is negligible below 400°C. This is the reason why throat temp is maintained at 400°C.

Date 07/02/19

$$2\langle Fe\rangle + (O_2) = 2\langle FeO\rangle$$

$$\Delta G^\circ = -527310 + 128.75\,T \ \text{J/mole}.$$

$$2\langle C\rangle + (O_2) = 2(CO).$$

$$\Delta G^\circ = -224014 - 174\,T \ \text{J/mole}.$$

$\Delta G^\circ = ?$ $\quad \langle C\rangle + (O_2) = (CO_2) \rightarrow \Delta G^\circ = -395170 - 0.84\,T$ J/mole

for Rxn $\langle FeO\rangle + (CO) = \langle Fe\rangle + (CO_2)$.

$\cancel{2(CO)}$. $2\cancel{\langle FeO\rangle} = 2\langle \cancel{Fe}\rangle \cancel{+ (O_2)}$.

$\cancel{2(CO)}$

$$\frac{1}{2}\times 2\cancel{\langle C\rangle} + \frac{1}{2}(O_2) = \frac{1}{2}\times 2(CO).$$

$$-\ \cancel{\langle C\rangle} + (O_2) = (CO_2)$$

$$\frac{1}{2}O_2 = CO - (CO_2)$$

$$2\langle Fe\rangle + \frac{3}{2}(O_2) = 2\langle FeO\rangle + CO - (CO_2)$$

$$2\langle FeO\rangle + CO_2)$$

$$\langle Fe\rangle + \frac{1}{2}\cancel{(O_2)} = \cancel{2}\langle FeO\rangle.$$

$$\langle C\rangle + \frac{1}{2}\cancel{(O_2)} = \cancel{2}(CO)$$

$$-$$

$$\langle Fe\rangle - \langle C\rangle = \langle FeO\rangle - (CO).$$

$\langle Fe \rangle - \cancel{\langle C \rangle} = \langle FeO \rangle - (CO)$

$\cancel{\langle C \rangle} + (O_2) = (CO_2)$

$+$

$\langle Fe \rangle + (O_2) = \langle FeO \rangle + (CO_2)$:

$-① - ⑪$.

$\Delta G^\circ = 751324 + 45.25\,T$ J/mol.

$\frac{-① - ⑪}{2} + ⑪$.

$\langle FeO \rangle + (CO) = \langle Fe \rangle + \langle C \rangle + (O_2) + (CO_2)$
$- (C) - (O_2)$.

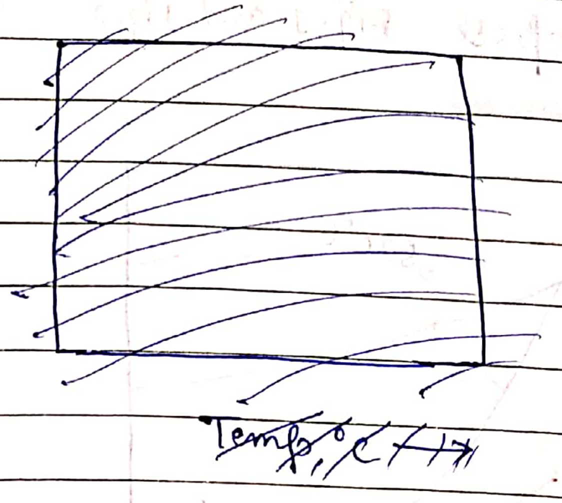
$\langle FeO \rangle + (CO) = \langle Fe \rangle + (CO_2)$.

$\Delta G^\circ = -19508 + 21.755\,T$ J/mol.

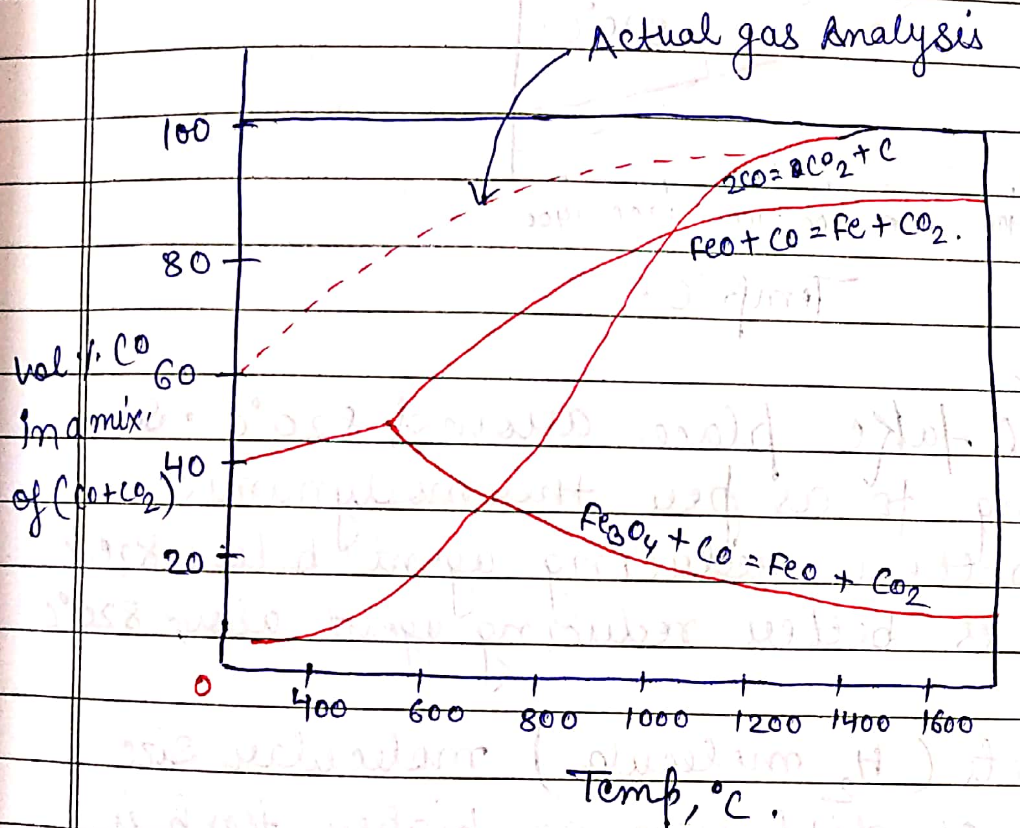
$$K = \frac{p_{CO_2} \cdot a_{\langle Fe \rangle} = 1}{p_{CO} \cdot a_{\langle FeO \rangle} = 1}$$

$$\frac{p_{CO}}{p_{CO_2}} = \frac{1}{K}.$$

$\frac{p_{CO}}{p_{CO_2}}$ ratio is same as volume ratio

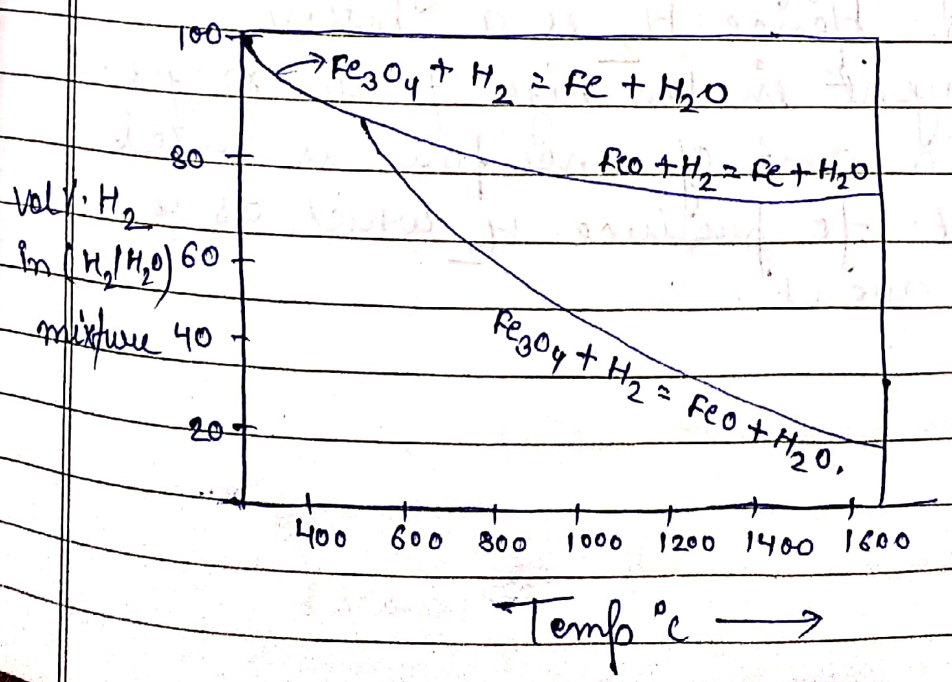


Temp, °C



Actual gas Analysis
100
80
60
40
20
0
vol % CO in mix. of (CO+CO₂)
2CO = CO₂ + C
FeO + CO = Fe + CO₂.
Fe₃O₄ + CO = FeO + CO₂
400
600
800
1000
1200
1400
1600
Temp, °C.

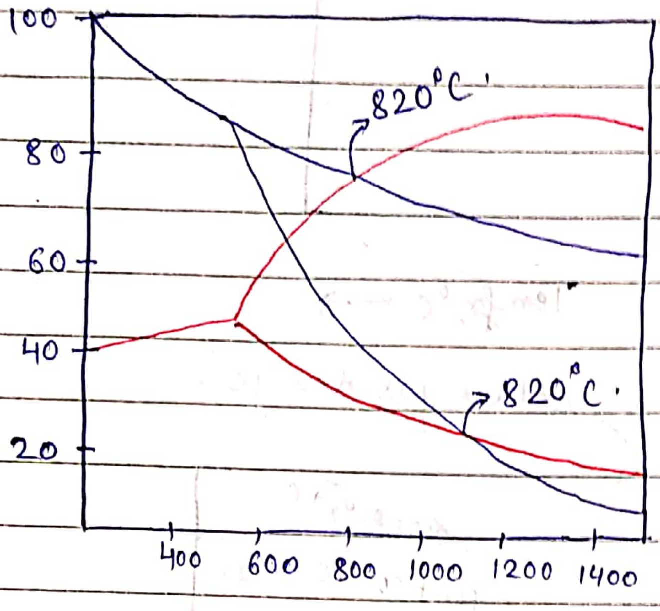
Fig. 1.



100
80
60
40
20
Vol % H₂ in (H₂/H₂O) mixture
Fe₃O₄ + H₂ = Fe + H₂O
FeO + H₂ = Fe + H₂O
Fe₃O₄ + H₂ = FeO + H₂O.
400
600
800
1000
1200
1400
1600
Temp °C

Fig. 2.

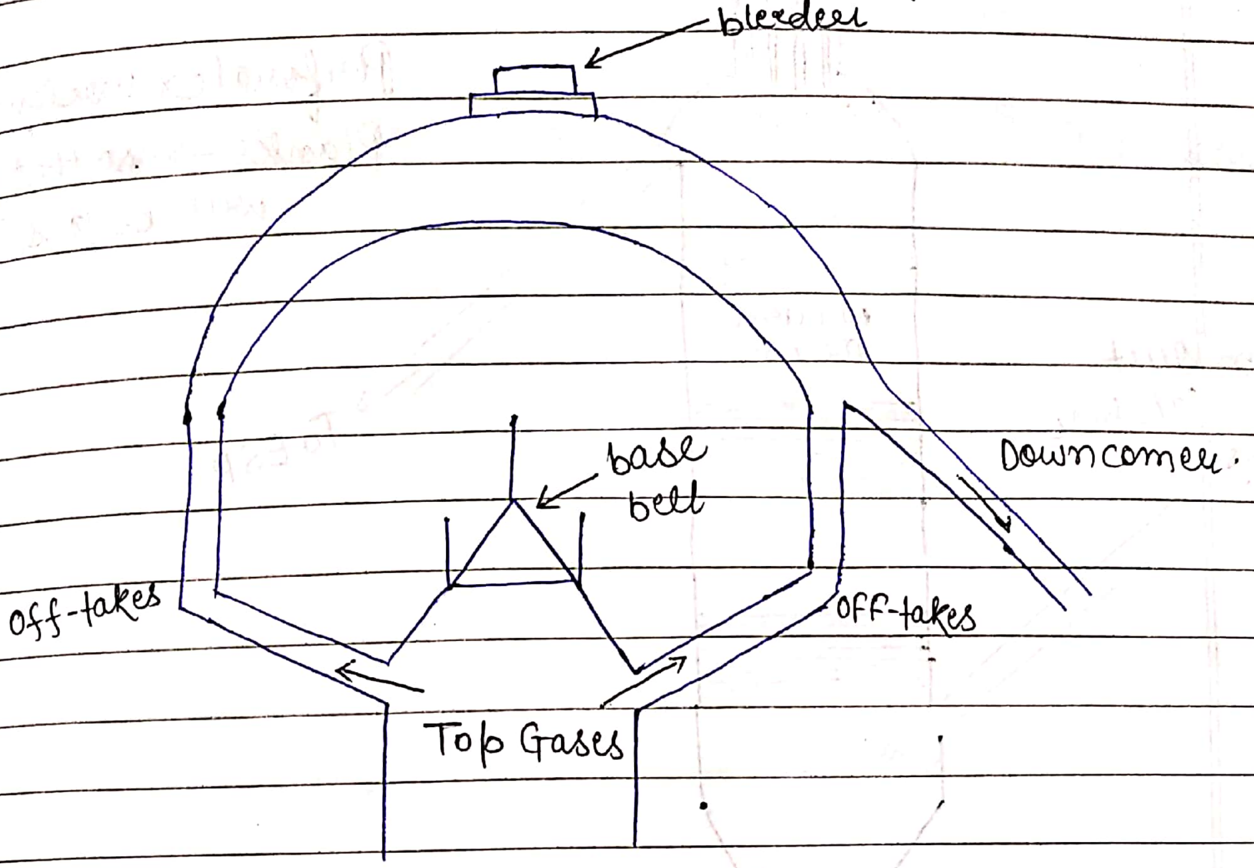
Let superimpose Fig. 1 and Fig. 2.



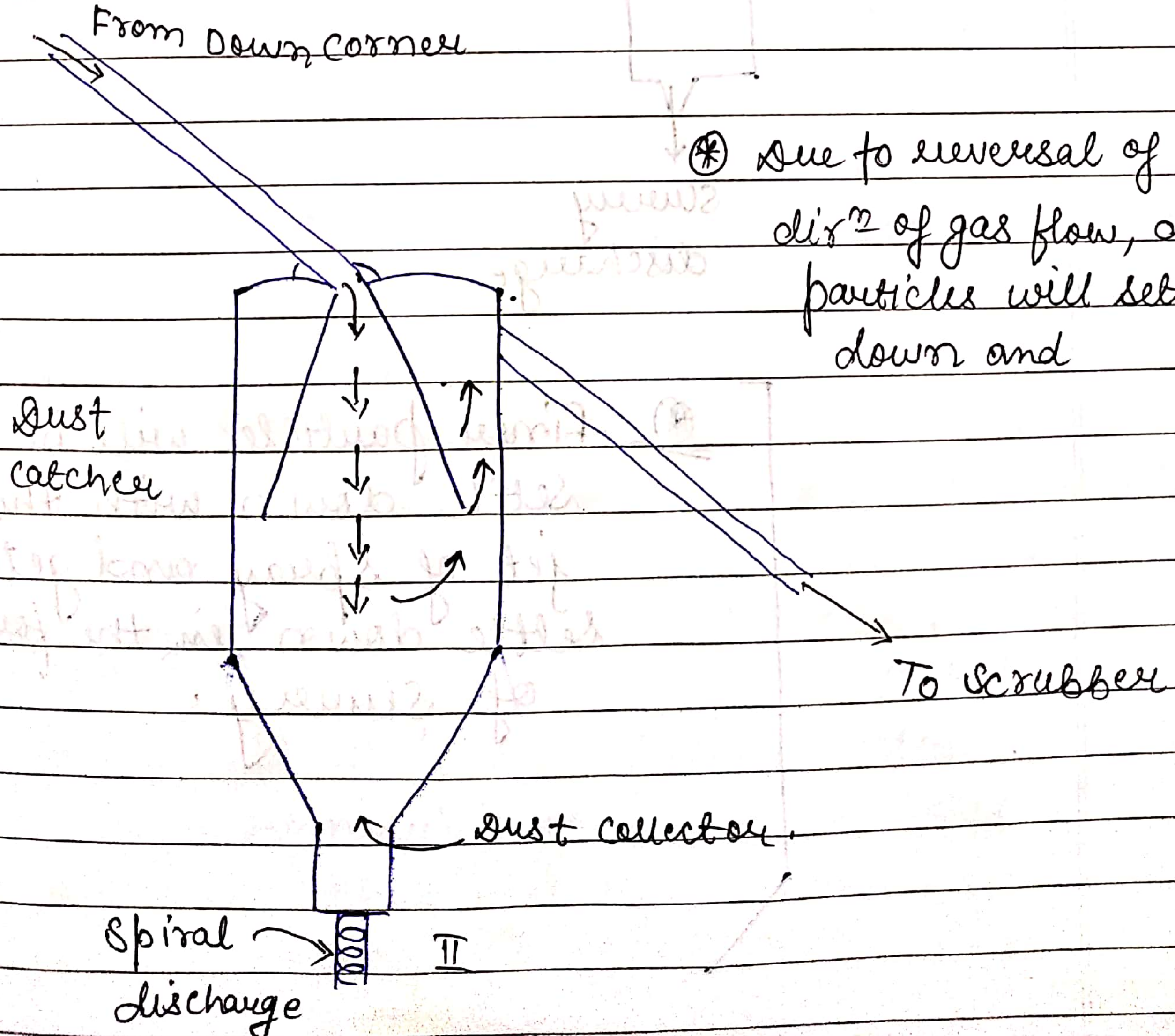
cross over will take place around 820°C : So, according to as per thermodynamic CO is better reducing agent below 820°C and H_2 is better reducing agent above 820°C

Due to its (H_2 molecule) molecular size its rate of diffusion at higher temp is quite high. Hence H_2 is a better reducing agent in the high temp. ranges. Thus certain amt of moisture is added to the blast to produce H_2 which as a reducing agent.

Blast Furnace Top Gas Cleaning Unit :-

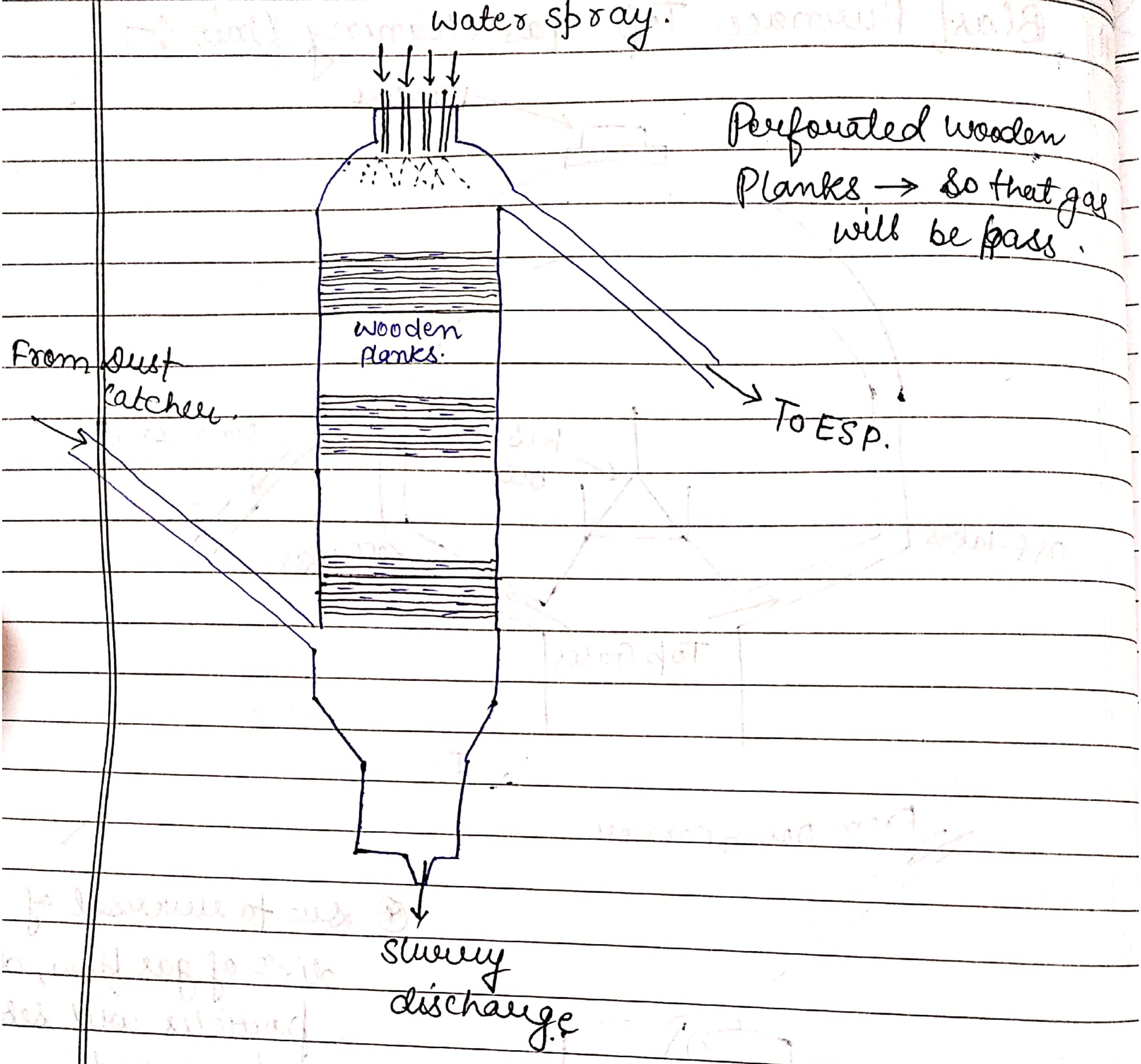


I.

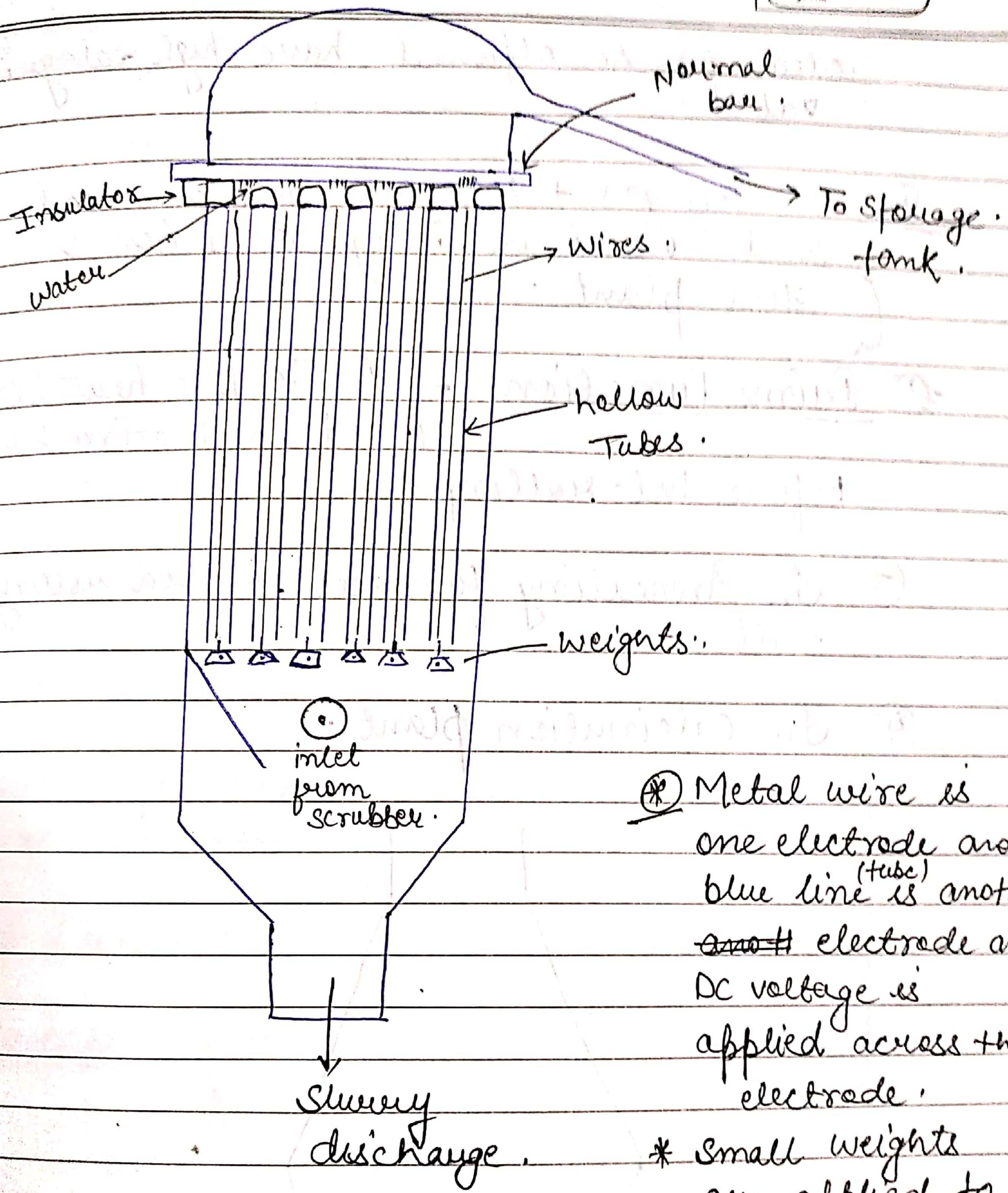


II

* Due to reversal of dirn of gas flow, dust particles will settle down and



(*) Finer particle will be settle down with the jet of spray and gets settle down in the form of slurry.



* Metal wire is one electrode and blue line (tube) is another ~~anoth~~ electrode and DC voltage is applied across the electrode.
* Small weights are applied to wire to prevent the attachment of electrode.

Imp terms —

bleeder — It is like a safety value used for removing of gases in case of choking.

cleangas so obtained have high ~~calogenic~~ Calorific value.

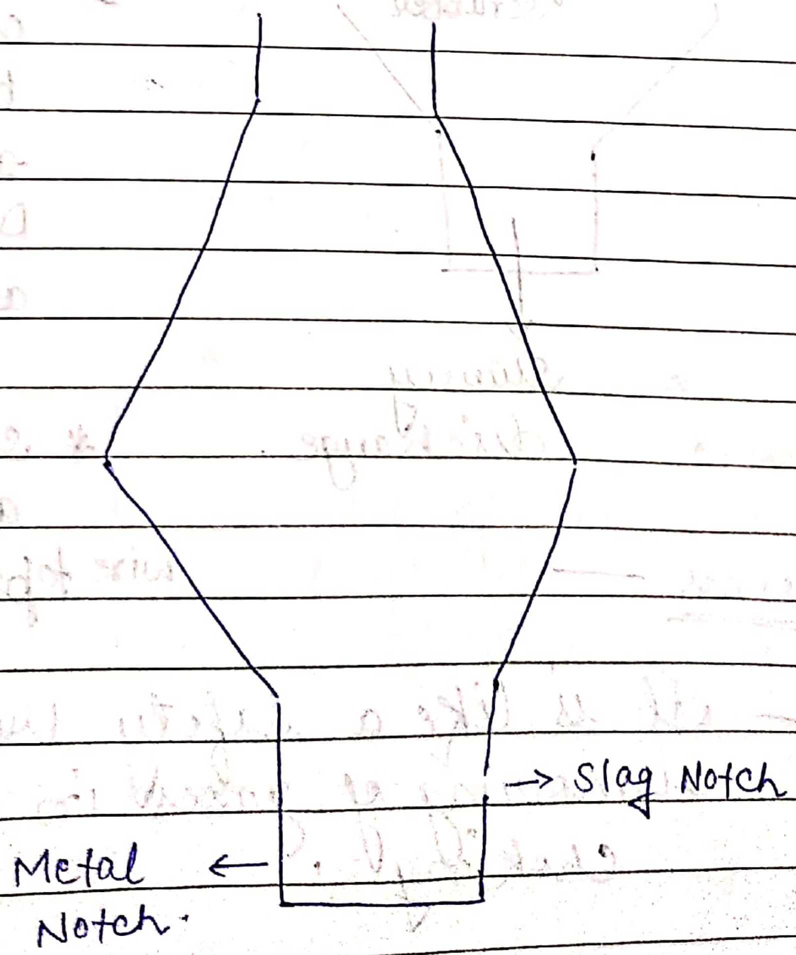
(*). B.F. Top gas + coke oven gas is mixed and used in integerated iron & steel plant.

Prime function — ① To pre-heat blast

② In reheating furnace before hot rolling.

③ In Annealing furnaces in cold rolling mill

④ In calcination plant.



wt of pressure
Bell less
changing

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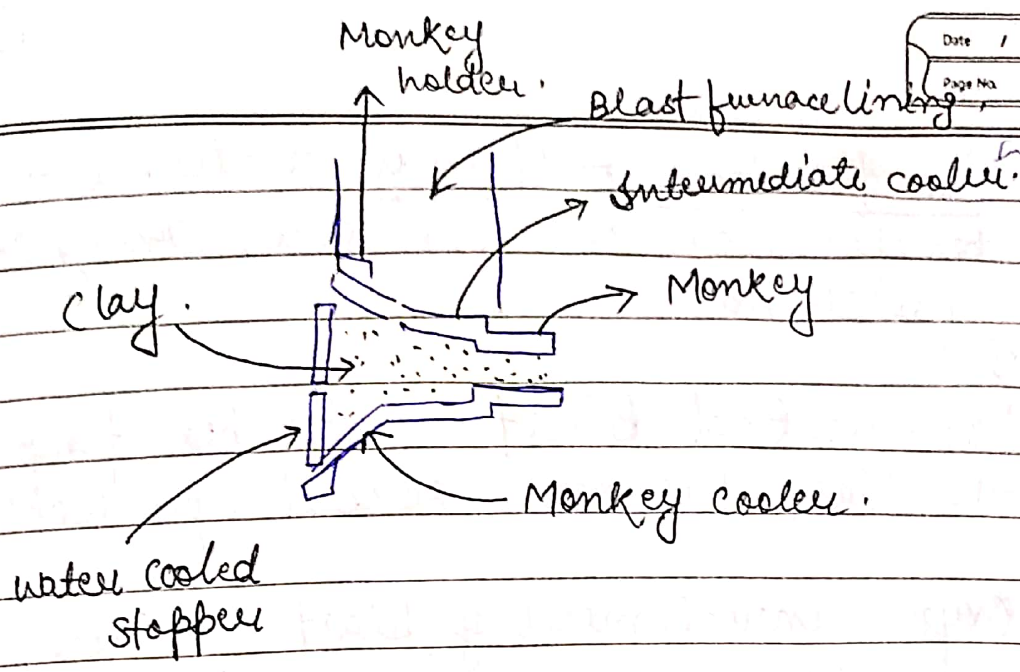


Monkey cooler is made up of Cu consisting of three concentric frustum of cones.

with the mud gun, the vacant space is filled with clay.

Specific gravity of clay is 3 times more than S.g. of pig iron.

Modern trends in B.F. :-

<u>Purpose</u> — ⓐ To increase productivity of B.F.
ⓑ To decrease coke rate.

① <u>Use of Large Capacity B.F.</u> :— <u>limitation</u> :- Coking coal should not be strong enough to withstand high capacity load.

② Uniform size range of burden :— <u>uses</u> — It gives good permeability.

(3) Pre-treatment of raw material - beneficiation of iron ore, coking coal washing

(4) use of Pre-heated Blast → Pre-heat temp. of the blast has been raised upto 1300°C.

(5) Oxygen enrichment of blast → Safe enrichment → level of oxygen in 25°C. This will inc. the ~~coml~~ temp. in the combustion zone.

done simultaneously

(6) Humidification of blast → Knowing introduce certain amt. of moisture in the blast

$$C + H_2O \rightarrow CO + H_2$$

We produce addn amt of reducing gas H_2
But this rxn is endothermic hence it balances. oxygen enrichment of blast.

(7) Auxiliary fuel injection. → Auxiliary fuels like pulverised coal, coal slurry, furnace oil, & natural gas can be injected along with the blast provided sulphur content of this fuels is low. This way coke rate can be reduced.

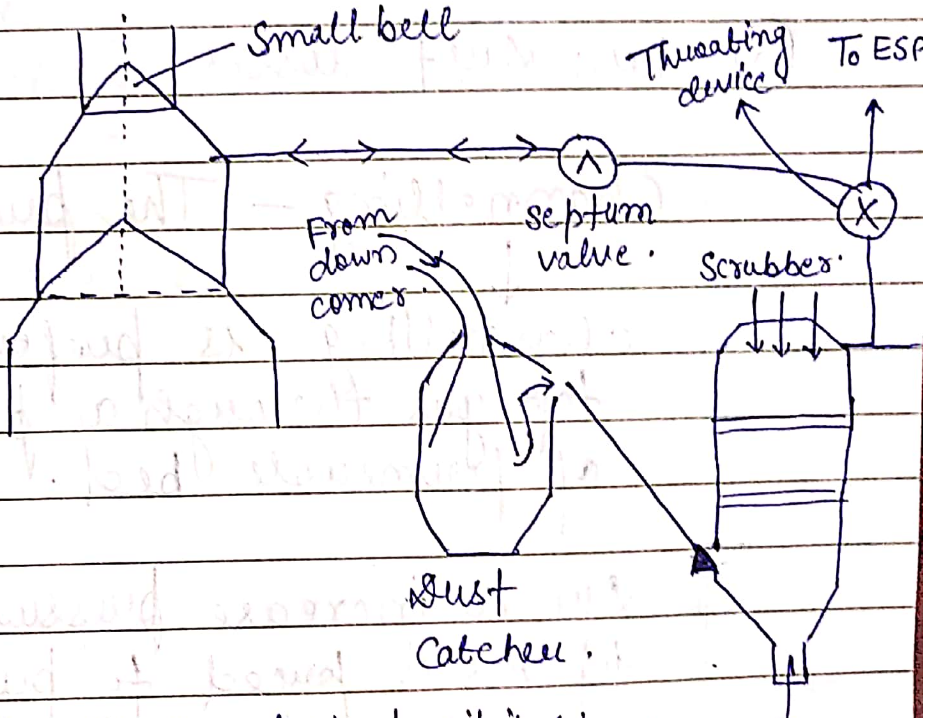
(8) Introduction of CO, CO_2 mixture in the lower stack region.

This may cause increase in p_{CO}/p_{CO_2} ratio which may result in the increase red^n rate of iron oxide in the lower stack level.

(9) Use of pre-reduced burden :- Iron ore is partially reduced by blast furnace top gas before charging it into the blast furnace.

* pre-reduction may cause loss of strength of iron ore

High top pressure :—



ESP → Electro static precipitation.

→ we are increasing the pressure in the particular top of the B.F. then its modification is called High top pressure.

$$p_{gauge} = 0.6 \ Kg/m^2.$$

In India, the ht. of guge pressure → 1 Kg/m²
In foreign " " " → (2-4) Kg/m²

Advantages —

① Residence time of the top gas increases. This results in higher reduction efficiency of iron oxide. Thus utilisation efficiency of Co increases.

This ultimately results in red^n of coke rate.

② Sensible heat is preserved. (i.e. heat associated with Co)

③ Low dust losses.

Channelling — The problem of Channeling

channelling is preferential flow of top gas through a particular section of permeable bed.

Due to increase pressure of top gas, top gas is forced to pass through even narrow openings. Thus making the red^n more uniform.

Boudard Reaction —

$$CO_2 + C = 2CO$$

This is an eq^m reaction where $P_{total} = P_{CO} + P_{CO_2} = 1\ atm.$

size

Due to increase pressure, P_{total} is more than 1 atm. Hence the reaction will take place in reverse dirⁿ.

$$2CO \longrightarrow CO_2 + C$$

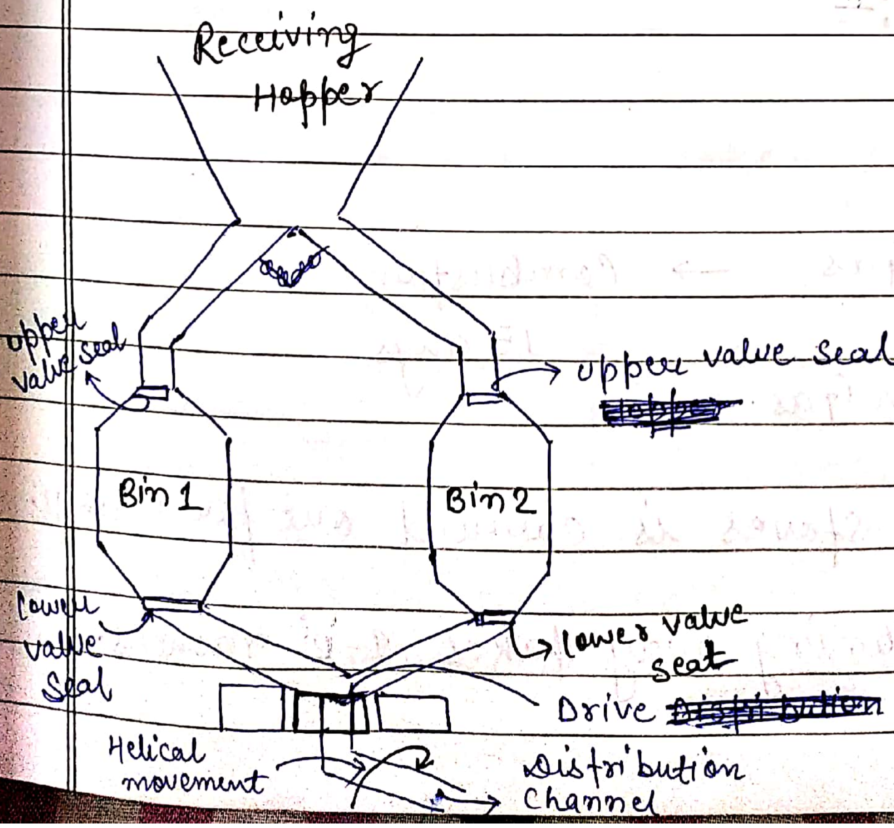
Naumann Rxn.

Since extra 'c' is deposited, this extra carbon is available for combustion / reduction in the lower part of the blast furnace. Thus it results in redⁿ of coke rate.

limitation — Since free-carbon is deposited in the voids of the permeable beds. This may cause channeling.

Due increase in internal pressure, it will restrict the fall of large bell and consequently to small bell.

Bell-less Charging :—



Receiving Hopper → burden is charge.

Upper value seal → Regulate the discharge of burden

Helical movement ensures uniform distribution of burden in the B.F.

limitation – After some time, seal should be worn out.

To replace seal, one should be kept closed, and other should be open.

After some time, the bins also need replacement but compare to bells changing system, the height is less by 30m. Hence more convenient.

Blast Furnace operations :–

I: Blowing In :– Starting a newly lined Blast Furnace.

(A) Drying :–

Stoves

B.F. Top Gas → Combustion
\+ 15 days.
coke oven Gas.

Drying of stoves is carried out for 15 days.

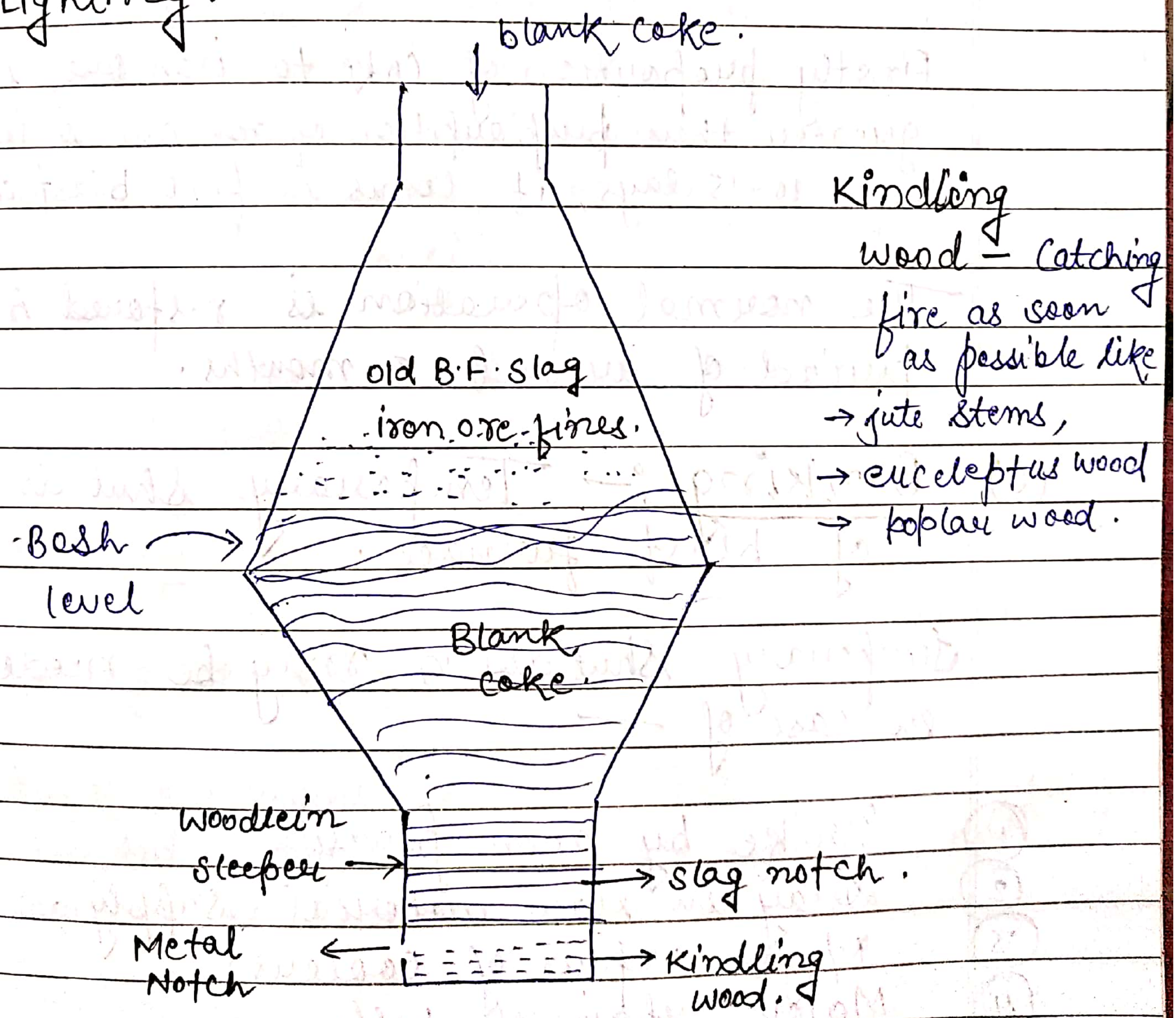
Drying of lining may takes 1-2 months.

During this drying operation, all the coolers are checked and gas cooling unit is checked, bells are checked. Similarly weighing machines are checked. Skip hugs are checked. Then B.F are allowed to cool which may take say 15 days.

Metal and slag dumped system are also chekked in this period.

Pick Casting system → It used only in case of surplus production.

3) Lighting –



When the gas stops escaping from Metal Notch & slag notch then we drill drops down the bell.

Ratio of charging material : iron ore. 22-25% oxygen escapes out
coke → 20% ← coke → 80% ash ↑.
50% ← limestone → 50% CO_2 ↑.

At the top 3200 N/m^3 of top gas (O_2)
80 kg of dust.

wt. ~~vol~~ of slag → 0.5 – 0.6 Tonne.
Vol. of slag is 3 times more than of pig iron.

Firstly proportion of coke to iron ore is greater then proportion of iron ore is increased. So, in 10-15 days, it comes in full blast condn.

— The normal operation is restored in a period of around 3-months.

(C) Banking :— Temporary shut down of blast furnace.

Temporary shut down may be needed in case of —

1. Strike by men-power.
2. Delay in raw material supply.
3. Major repair of coolers.
4. Major repair of bells.

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How to do Banking ?

→ ~~step out~~ all the liq. product should be taken out.

→ Proportion of coke in the charge is increased.

After this, only coke blank is charged. when coke blank reaches bosh level it is covered with iron ore core. prior to this all the entry point of air into the blast furnace is block (Tuyeres is block). After removing all the metal & slag (Metal & slag Notch is blocked.) Everyday the descent of coke blank is monitored carefully.

II Blowing Out :— Permanently shut down of B.F. ~~of~~ for re-lining after 10-12 years

III. Fanning :— This is done to reduce the production rate. This is done by reducing the blast rate.

IV. Back Draughting :— This is normally needed when repair of coolers are carried down. This is done in 2 ways —

① Suction is applied outside the Tyyers (bustle pipe) to create a negative pressure inside the B.F.

Blast Furnace operation :→

Irregularities, causes & remedies.

(I.) <u>Hanging</u> :– If the downward descent of the burden is slower then the problem is known as hanging of the burden.

<u>Causes</u> :– (a) Insufficient taper of stack.
(b) Sticking of slag particularly from sinter's with the burden.
(c) Fusing of slag (which is carried mostly by sinters) with burden ~~mat~~
(d) deposition of alkali vapour in the voids.
(e) deposition of carbon in the void due to Neumann reaction.
(f) Sticking of fine ore particles around coke surface.
(g) High blast pressure.

Remedies →(a) Reducing the proportion of sinters in the burden.
(b) Removal of alkali matter during pre-treatment of ores.
(c) By increasing the addition of flux (dolomite & limestone). Dissolution of which will generate extra CO_2.
(d) Using uniform size burden & of proper strength

Sol^n loss Rxn
↳ $CO_2 + C = 2CO$

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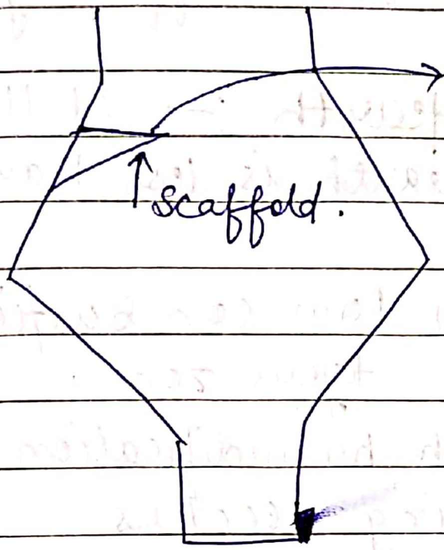
(c) Using proper ~~high~~ blast pressure.

(II) Scaffolding :-



This is due to the deposition of alkali vapour into the lining in the lower portion of stack

Formation of scaffold particularly in the lower portion of stack.

Lining → Alkali Almino silicate forms and deposited in the wall. It have a lower M.P. Scaffold is formed by stiching of ore to Alkali material.

If it is detected in the beginning, the scaffold can be removed by addⁿ of silicous matter but if the problem is detected very late then it needs some shock treatment. ~~Soft~~

Shock treatment given to b.f is known as jumping of b.f. For this, the blast is stopped and immediately it is restarted thus shock waves are created inside the B.F. This may cause the scaffold to fall down.

III Slip :- If the descent of burden is more than normal then it is called slip. Slip is an after result related to removal of hanging and scaffolding.

IV Chilled Hearth :- Chilled Hearth means temp. of hearth is less than the normal.

Causes - (a) Low combustion temp. in the tyers zone.
(b) High humidification of blast.
(c) leacking coolers.
(d) Dropping of solid materials due to slip

V Coke ejection from the slag notch due to falling of coke from combustion zone

VI Flooding —

Flooding is excess entry of liq. pig iron and slag into the hearth suddenly.

Causes :- This happens due to insufficient permeability of the coke bed in the lower bosch region. through the permeable bed, blast has to go up and liq. products has to come down, if the void is not sufficient enough, liq. products will start accumulating in the coke bed itself. when the weight of the liq. products is very large, it falls into hearth suddenly, resulting into flooding of hearth.

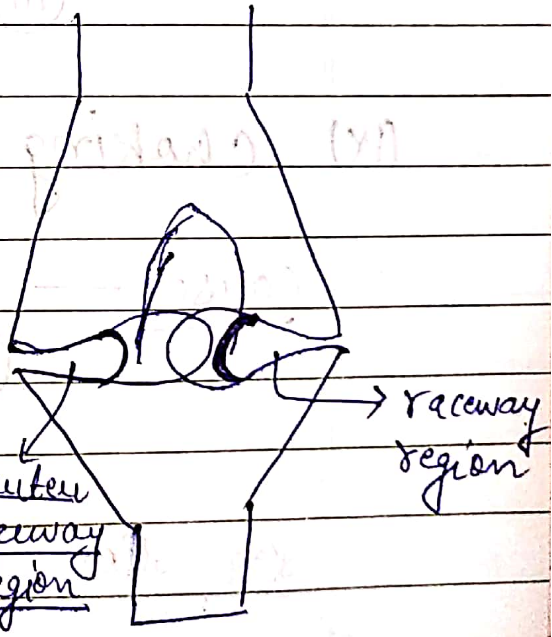
Remedies (i) coke should be of uniform size. impact strength and abrasion strength of the coke should be sufficient enough to retain its size upto bosch region.

VII. Pillering :-

Pillering is a formation of a pillar like structure in the central portion of B.F. just above the combustion zone.

Causes:

Pillering problem occurs due to shorter raceway region if the raceway region does not extend beyond the central portion of combustion zone, the central portion of the B.F. in this region is colder This results in the solification of ~~pr~~ liquid products coming down. Subsequently a pillar like structure forms in the central portion.



Remedies → Increasing the blast Pressure is the sol^n

VIII Channeling :— Preferential flow of top gases through a particular portion of permeable bed.

Causes — ① Non-uniform size of burden.
② Deposition of carbon in the void due to Neumann reversion rxn.

Remedies
(i) Uniform burden size.
(ii) Increasing the proportion of flux.
(iii) Reducing blast pressure

(IX) Choking of uptakes & downcomers :—

Causes — ① High Dust losses.
② Faulty design of uptakes & down comers.

Remedies ① Use of proper burden size with ~~powder~~ proper strength.

(X) Leaking coolers —

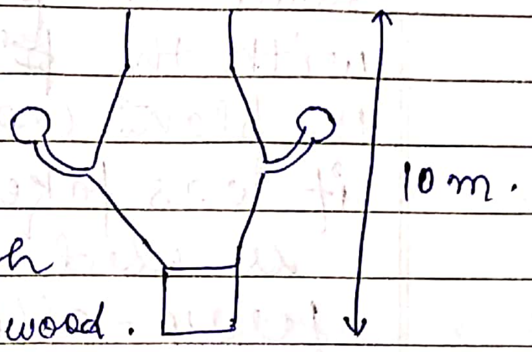
(XI) Break out — The leaking of liq. products from the hearth is known as break out.
This is highly hazardous.

Prevention :- when the lining of the hearth is carried out, every care is taken so as to have a min^{m} no. of joints

Alternate to Blast Furnace :-

1. Low Shaft furnace :-

Wood charcoal → Alternate fuel is used in low shaft furnace. It is made through a destructive distillation of wood.



This type of furnace was first implied at Bhadravati (Visvesvaraya) Iron and steel plant, Karnataka.

In this case, oxygen enrichment of blast is compulsory for effective heat transfer.

For this eucalyptus trees were to be plane in and near the bhadravati region. It takes 7 years to ~~growup~~ grow up. But this type of trees sucks lots of water due to this ground level of water drops down.

It is successfully implement in brazil due to its tropical Rain forest Area.

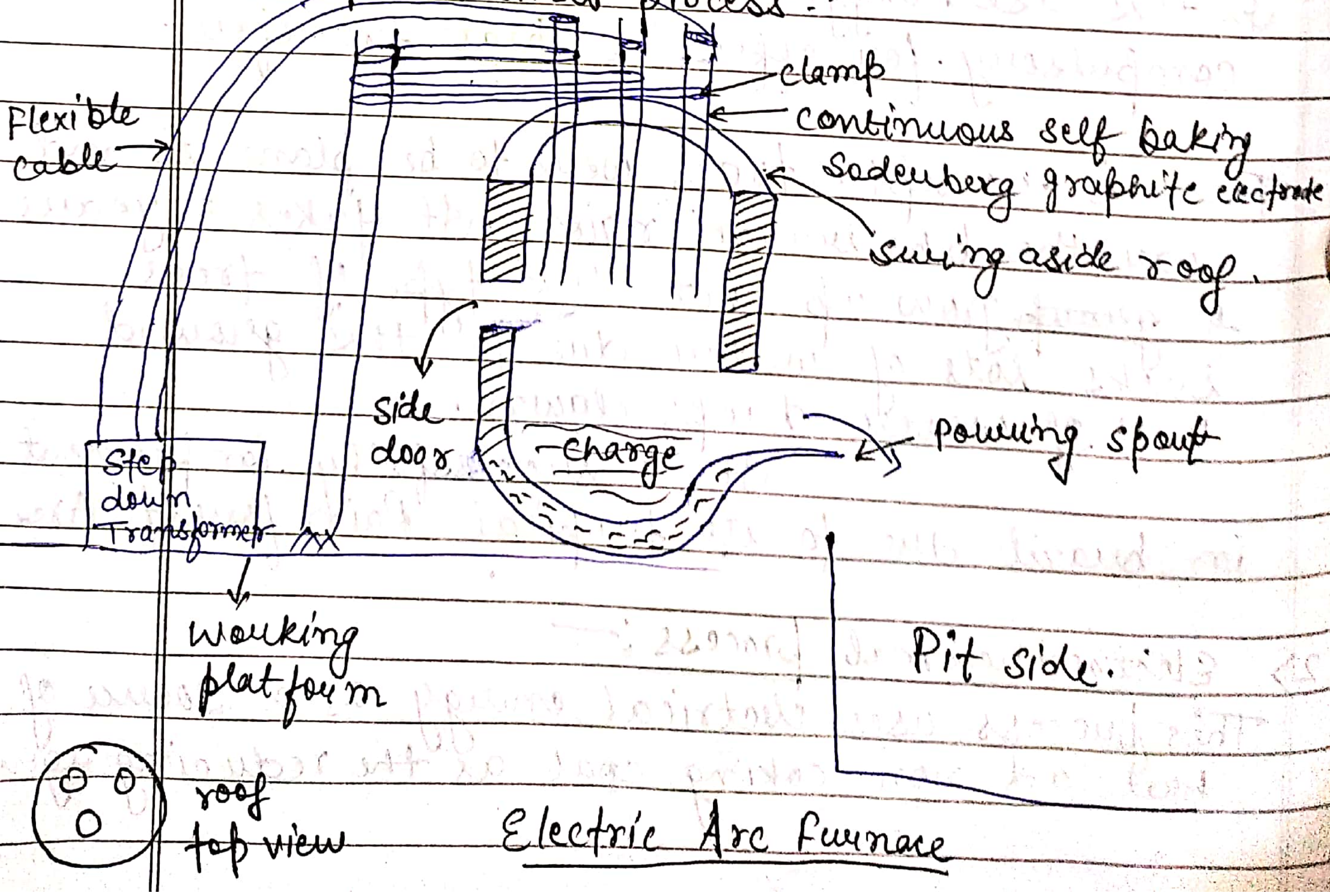
2) Electrothermal process :-

This process uses electrical energy as a source of heat and non-coking coal as the reducing agent

The plant was established in Maharashtra named Maharastra Electro-smelt ltd.).

This process has been failed bcoz cost of production was quite high due to costly electrical energy as a result the product could not compete with the ~~p~~ market price and so the plant was closed down and later it was taken by SAIL. Now the plant is used for the production of ferro-alloys. (Eg. FeCr (Ferrochrome) → raw material for production of SS
FeSi, FeMn (Ferro Silicon, Ferro Manganese) (deoxydiser in steel making).

Electrothermal process:—



Electric Arc Furnace

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charge → iron ore + Non coking coal + flux.

Classification is done based on the rating of Transformer.

Soderberg is a brand name for soderberg graphite powder.

graphite
↳ Electrode is continuously consumed. but the length of electrode should always be maintained.

charge is done by removing the electrode and roof

Drop bottom basket charging.

Electrodes are lowered and are made to touch to charge.

To maintain a constant arc gap, a circuit is based upon either constant impedence or constant resistance b/w the electrode tip and charge surface.

The Movement of each electrode is independent of each other.

Near the electrode tip temp is 3000 °C.

Direct Red^n → Reduced by solid carbon.
Indirect " → " " CO.

Pyrometary

Mini Blast Furnace

→ Useful vol starts from 150 m^3 & height 20m-25m
Raw material
80% Pallets
20% lump ore (haemetite).

→ Coke (medium quality coke serve).

→ Flux (dolomite & limestone).

B.F. chemistry adjusted in such a manner that a solid state redn is complete in compact shaft zone and top gas CO/CO_2 ratio above 2 such process, chemistry is not possible without the use of enriched Blast

COREX Process

Coal Redn Process
Non-coking coal is used
(i) POSCO steel, Pohang Korea
(ii) Saldanha steel (Pretoria → S.A. taken by Arcellor-Mittal)
(iii) JSPL, Tornagalu, Vijay Nagar, Dist - Bellary, Karnataka
(V) ESSAR steel, Hazira

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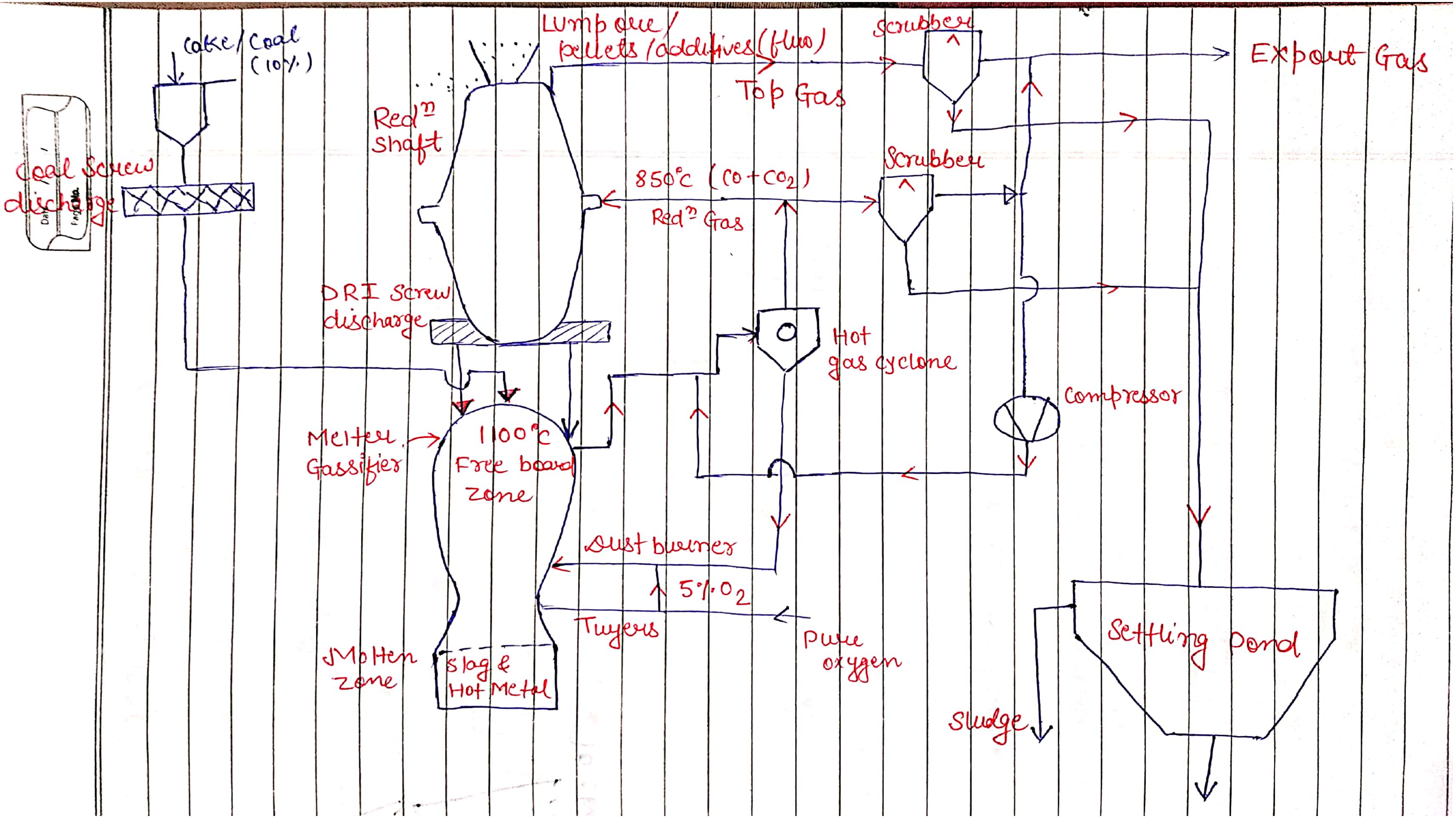
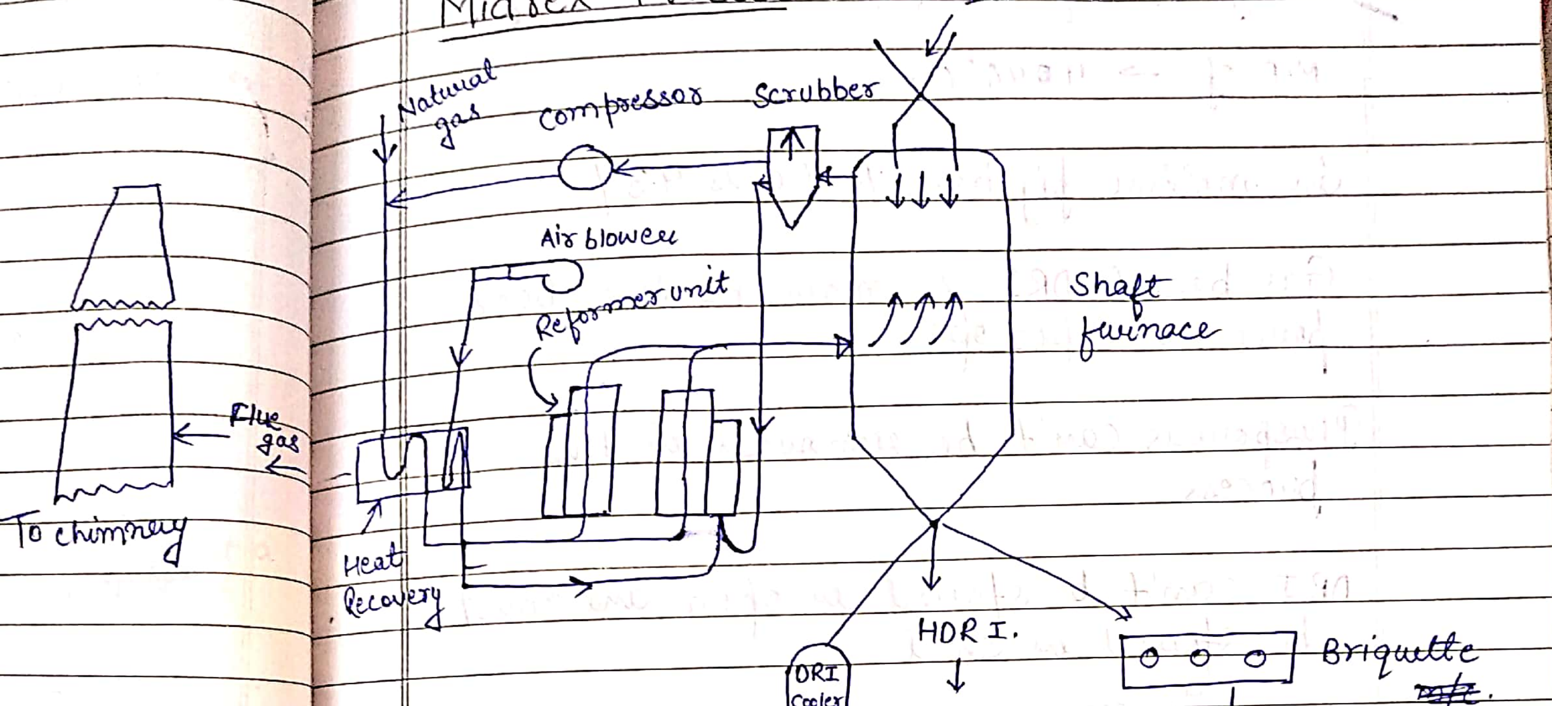

Coke/Coal (10%)
Coal Screw discharge
Lump ore/ pellets/additives(flux)
Red^n Shaft
Top Gas
Scrubber
Export Gas
850°C (CO + CO2)
Red^n Gas
Scrubber
DRI Screw discharge
Hot gas cyclone
Compressor
Melter Gassifier
1100°C Free board zone
Dust burner
5% O2
Tuyers
Pure oxygen
Molten zone
Slag & Hot Metal
Settling Pond
Sludge

Midrex Process :-



HDRI → Hot directly Reduced Iron

EAF → Electric Arc Furnace.

HBI → Hot Briquetted Iron.

Main Natural Gas → Methane.
" Reducing " → H_2 Not CO.

Flue gas are spent combustion gases.

Temp. of 950°c is maintained at the Red^n Shaft. And ~~H_2~~ CO is better reducing agent at high temp.

Q. why blast furnace pig iron consists 4% of C.

M.P. of → 1146°C.

In molten pig iron, % of C is 4.3%

Gas based DRI is more reactive bcoz pores are kept open.

Phosphorous can't be removed in this process.

DRI can't be stored in open and must be stored in shed.

Scrap में बहुत Phosphorous है, if it is contact with moisture, it catches fire immediately.