

Assignment - 34.1) Classification of furnaces :-

Furnace :- A Furnace is a device in which the chemical energy of fuel or electrical energy is converted into heat which is then used to raise the temperature of material.

Furnace are classified from different points of view in order to have an idea of representative types of various industrial furnaces which comprise mainly of three main portion.

- The fire place where combustion of fuel takes place.
- The cooking chamber or furnace proper, where heat is transferred from the product of combustion to the materials under heating.
- The appliances for removal of flue gases.

Classification of furnaces based on various factors are given below

Based on the heat source :-

- (a) Combustion / flame furnaces - These are furnaces where heat is developed due to combustion of fuels.
- (b) Thermo-electric furnace - In these furnaces, heat is generated by electricity.

Based on type of fuels used :-

- (a) solid fuel fired furnaces
- (b) liquid fuel fired furnaces
- (c) Gaseous fuel fired furnaces
- (d) mixed / multi fuel fired furnaces.

Based on method of heat transfer from fuel to charge under heating :-

- (a) Furnace in which the fuel is in direct contact with the material under heating.

Ex - goldsmith's and blacksmiths open fireplaces.

- (b) Furnace in which charge is heated by products of combustion; an example is heat treatment furnaces.

- (c) Furnace in which material is heated by the way of heat transfer through a solid wall
Ex - a boiler furnace.

- (d) Furnaces in which heat transfer takes place through a liquid medium surrounding the submerged material under heating
Ex - salt bath furnaces or lead bath furnaces.

Based on use of heat saving appliances :-

- (a) Recuperative furnace.
- (b) Regenerative furnace.

Based on charging system :-

- (a) manual charging furnace

(b) mechanical charging furnace:

Based on mode of operation:-

(a) Batch furnace → Ex- cupola etc

(b) periodic furnace → Ex- annealing furnaces.

Coke ovens etc

(c) Continuous furnace → Ex- glass tank furnace
reheating furnace etc.

Based on draught:-

(a) Natural / Self draught furnace

(b) Forced draught furnace

(c) Induced draught furnace

(d) Balanced draught furnace

Based on shape of furnace:-

(a) crucible furnace

(b) shaft furnace → Ex- blast furnace

(c) Hearth furnace

Based on purpose:-

(a) melting furnace

(b) roasting furnace

(c) reheating furnace

Based on the way in which charge is handled:-

(a) shaft furnace

(b) Tunnel kiln

- (c) muffle furnace
- (d) Pusher type furnace
- (e) Bath furnace - Fixed, tilting or rotary.

Based on the Industries which use the furnaces:

- (a) steel reheating furnace
 - gas fired continuous billet heating furnace.
 - Pusher type
 - walking beam type
 - Soaking pits.
- (b) production of pig iron - blast furnace
- (c) production of iron nodules - rotary kiln
- (d) iron casting manufacture - cupola furnace.
- (e) Chemical Industry.
 - Radiant pipe still furnace
 - pot furnace
- (f) small iron & steel melts - coke fired crucible furnace.
- (g) steel making furnace
 - open hearth
 - Basic oxygen furnace / LD converter
 - Bessemer Converter
- (h) steel heat treatment furnaces
 - Reversing regenerative bogie type furnace
 - steel strip annealing furnace.
- (i) Refractory bricks and pottery
 - Coal fired beehive kiln for refractory firing
 - Continuous brick kiln

- Stroke fired tunnel kiln for refractory firing

(J) Non-Ferrous metals

- Oil fired tilting rotary furnace

- Reverberating furnace

- Small rotary brass melting furnace.

- Oil fired tilting rotary furnace.

- Oil fired tilting crucible furnace.

(K) Cement and lime burning

- Pulverised fuel fired counterflow rotary kiln

- Direct fired shaft kiln

(L) Glass melting

- Gas fired regenerative bath

- pot furnace

(m) Steam raising

- stroke fired

- Pulverised coal fired furnaces

(i) horizontal firing

(ii) vertical firing

(iii) tangential firing

- Fluidised bed furnaces / Circulating Fluidised bed furnaces.

- cyclone furnaces.

(n) Carbonisation

- Gas making

- vertical continuous

- Beehive oven

- By Product oven

(i) regenerative type (ii) waste heat type.

4.2) Furnace used in steel plant and their classification

Furnace used in steel plant :-

Various important / major furnaces installed in various units of typical Indian Integrated steel plant are listed below.

- Coke oven Heating Chamber
For producing blast furnace grade coke.

- Sintering Plant Furnace
for producing sinter to be used in B.F

- Blast Furnace
for producing iron

- Blast furnace stoves
for heating air

- Steel melting shop (S.M.S.) Furnace
Eg - L.D converter, Basic open Hearth furnace

- Rotary Kilo
for calcination of limestone & Dolomite in
Refractory material plant (RMP)

- Soaking Pits
for heating steel ingots in slabbing / blooming mill

- Reheating furnace
for heating steel slabs in hot rolling mill

- Batch Hood Annealing furnace.
(for annealing of cold rolled steel strip coils)
in Cold strip Rolling mill (CRM)

- Continuous Annealing line (CAL) furnace

~~An annealing furnace used prior to~~
(for continuous annealing of cold rolled steel strip) is CRM

- Hot Dip Galvanizing line (HDGL) furnace
(An annealing furnace used prior to galvanizing of cold rolled steel strip) is CRM
- Captive thermal power plant boiler furnace.

✓ Classification of steel plant furnaces :

Above mentioned furnace are classified based on various factor as described below

(1) Based on the purpose of the furnace :

- Metallurgical furnaces
Ex - Blast furnace, Sinter plant furnace, L.D converter etc.
- Heating Furnaces
Ex - Soaking pit, reheating furnace, coke oven heating chamber etc.
- Heat treatment furnaces
Ex - B. annealing furnace, HDGL furnace etc.
- Steam generating furnaces
Ex - boilers.

(II) Based on the type of fuel used :

- Solid fuel fired furnaces
- Liquid fuel fired furnaces
Ex - rotary kiln.
- Gaseous fuel fired furnaces

Ex - coke ovens, sinter plant, soaking pits, reheating furnace etc.

- multi-fuel furnaces

Ex - Captive thermal power plant boilers using all solid, liquid & gaseous fuels simultaneously.

(iii) Based on the use of waste heat saving appliances.

- Regenerative furnaces

Ex - Coke oven

- Recuperative furnaces

Ex - Soaking pit, reheating furnace etc.

- Waste heat boiler type furnaces

Ex - rotary lime kilns, L.D converter.

(iv) Based on draft control system

- Natural draft furnaces

Ex - B.F. stoves, coke ovens etc.

- forced draft furnaces

Ex - soaking pit

- Induced draft furnaces

- Balanced draft furnaces.

(v) Based on mode of operation of the furnaces

- Batch / periodic furnaces

Ex - coke ovens, annealing furnace etc.

- continuous furnace

Ex - rotary lime kilns, reheating furnace etc.

4.3) Fuels used in steel plant furnaces & their characteristics:

Steel plant Furnace

Fuels used in the furnace

- | | |
|---|---|
| 1. Coke oven | Mixed (B.F. + C.O.) |
| 2. Sintering plant furnace | Hearth mixed gas |
| 3. Blast furnace | B.F. grade coke |
| 4. B.F. stores | Mixed gas |
| 5. Rotary lime / dolomite kilns | Furnace oil, coke oven gas |
| 6. Soaking pits in slabbing mill | Mixed gas |
| 7. Reheating furnace in hot rolling mill | Mixed gas |
| 8. Annealing furnace in cold rolling mill (CRM) | Mixed gas |
| 9. Hot-Dip Galvanizing line (HDGL) furnace in CRM | Mixed gas |
| 10. Captive power plant boilers | Coal middling / Steam coal, B.F. gas, C.O. gas, Converter gas, furnace oil. |

Characteristic of various fuels used in steel plant furnaces.

(1) Blast Furnace gas:

Composition - $\text{CO} = 22-24\%$, $\text{N}_2 = 52-54\%$

$\text{H}_2 = 4-6\%$, $\text{O}_2 = < 1$

$\text{CH}_4 = 0.0000$

$\text{CO}_2 = 17-20\%$

Properties

Calorific value = 820-840 Kcal/Nm³

Density = 1.3-1.35 Kg/Nm³

Dust content = < 10.0 mg/Nm³

Ignition temp = 680°C

Theoretical flame temp = 1400°C

Explosive lower limit = 37%

Explosive upper limit = 71%

Gas pressure = 1000 mmwg

Gas yield = 1850-2000 Nm³/THM

Theoretical gas/air ratio = 0.70

Theoretical flue gas = 1.5

(II) Coke oven gas

Composition - CO = 6-7%, N₂ = 3-4%

H₂ = 58-60%, O₂ = < 1%

CH₄ = 23-25%, C_mH_n = 2-3%

CO₂ = 2-3%

Properties

Calorific value = 4200-4300 Kcal/Nm³

Density = 0.44-0.46 Kg/Nm³

Dust content = nil

Ignition temp = 560°C

Theoretical flame temp = 2000°C

Explosive lower limit = 5%

Explosive upper limit = 32%

Gas pressure = 700 mmwg

Gas yield = 290-300 Nm³/TDC

Theoretical gas/air ratio = 4.20

Theoretical flue gas = 4.9

(III) Converter gas

Composition = CO = 60-65%

CO₂ = 12-18%

N₂ = 20-30%

O₂ = < 2%

Properties

Calorific value = 1800-2000 kcal/Nm³

Density = 1.33-1.36 kg/Nm³

Dust content = < 10.0 mg/Nm³

Ignition temp = 610 °C

Theoretical flame temp = 1900 °C

Explosive lower limit = 20%

Explosive upper limit = 70%

Gas pressure = 1000 mmHg

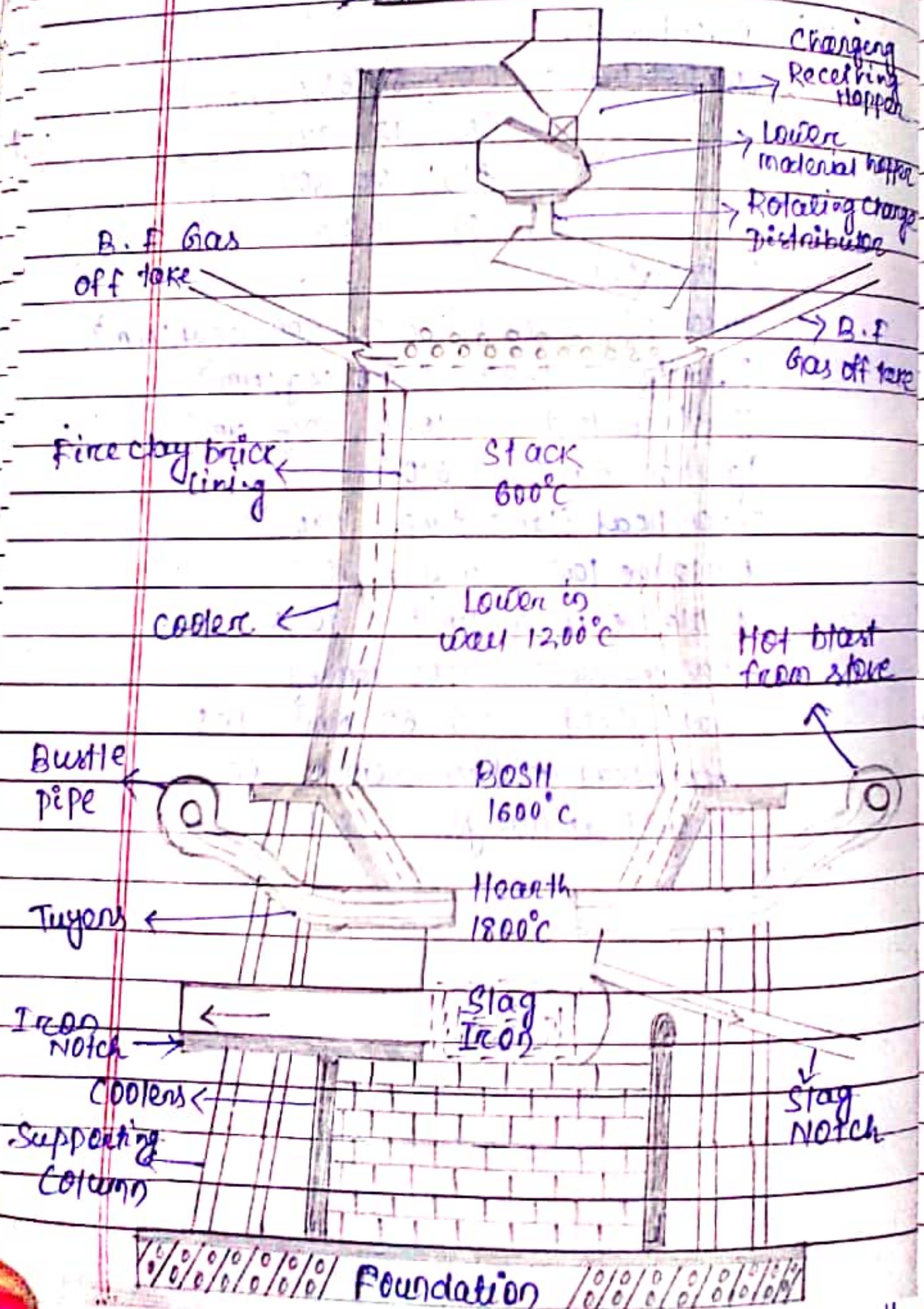
Gas yield = 50-60 Nm³/TCS

Theoretical gas/air ratio = 1.60

Theoretical flue gas = 2.3

4) Sketch the various section of the following
Furnaces.

Blast Furnace



Cupola Furnace

Pig iron
Coke &
Limestone

charging
door

charging
prat form

Tuyeres

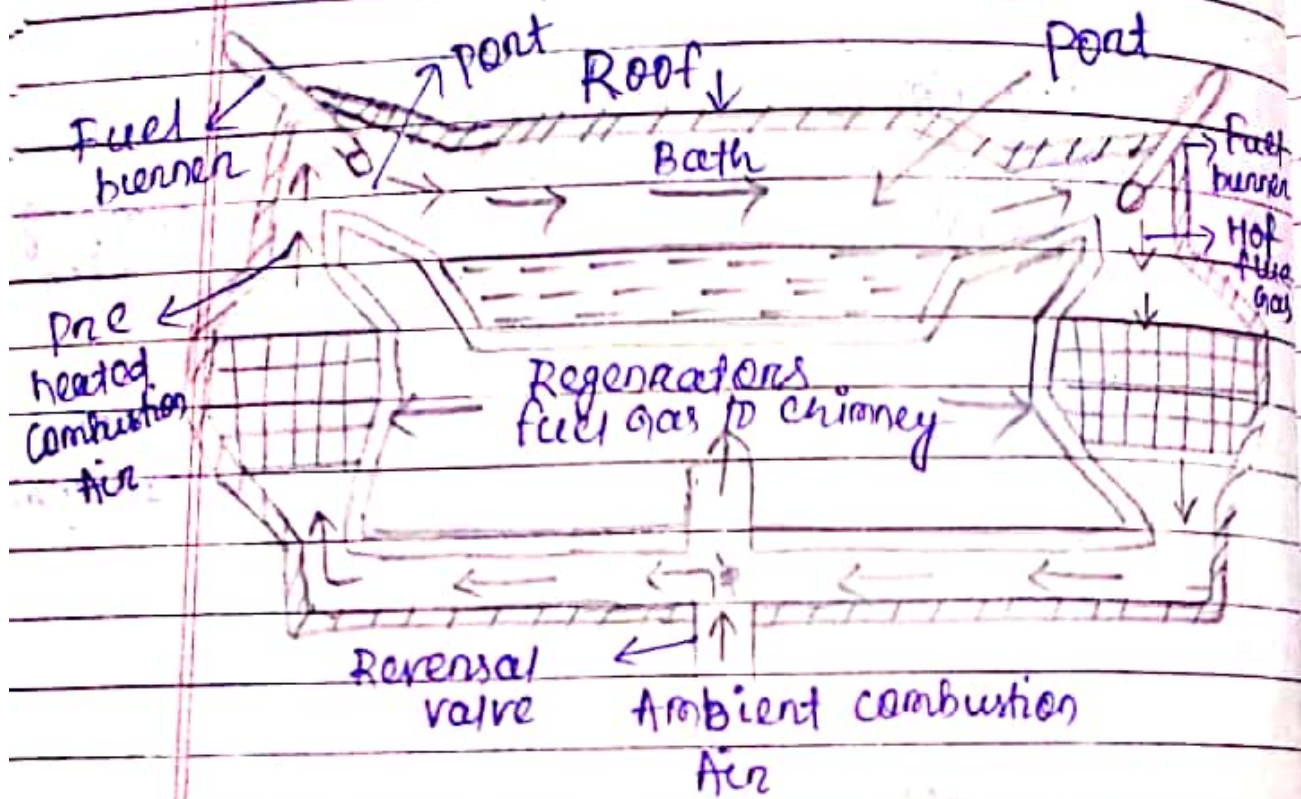
Tap
hole
for
slag

tap hole
for Cast
Iron

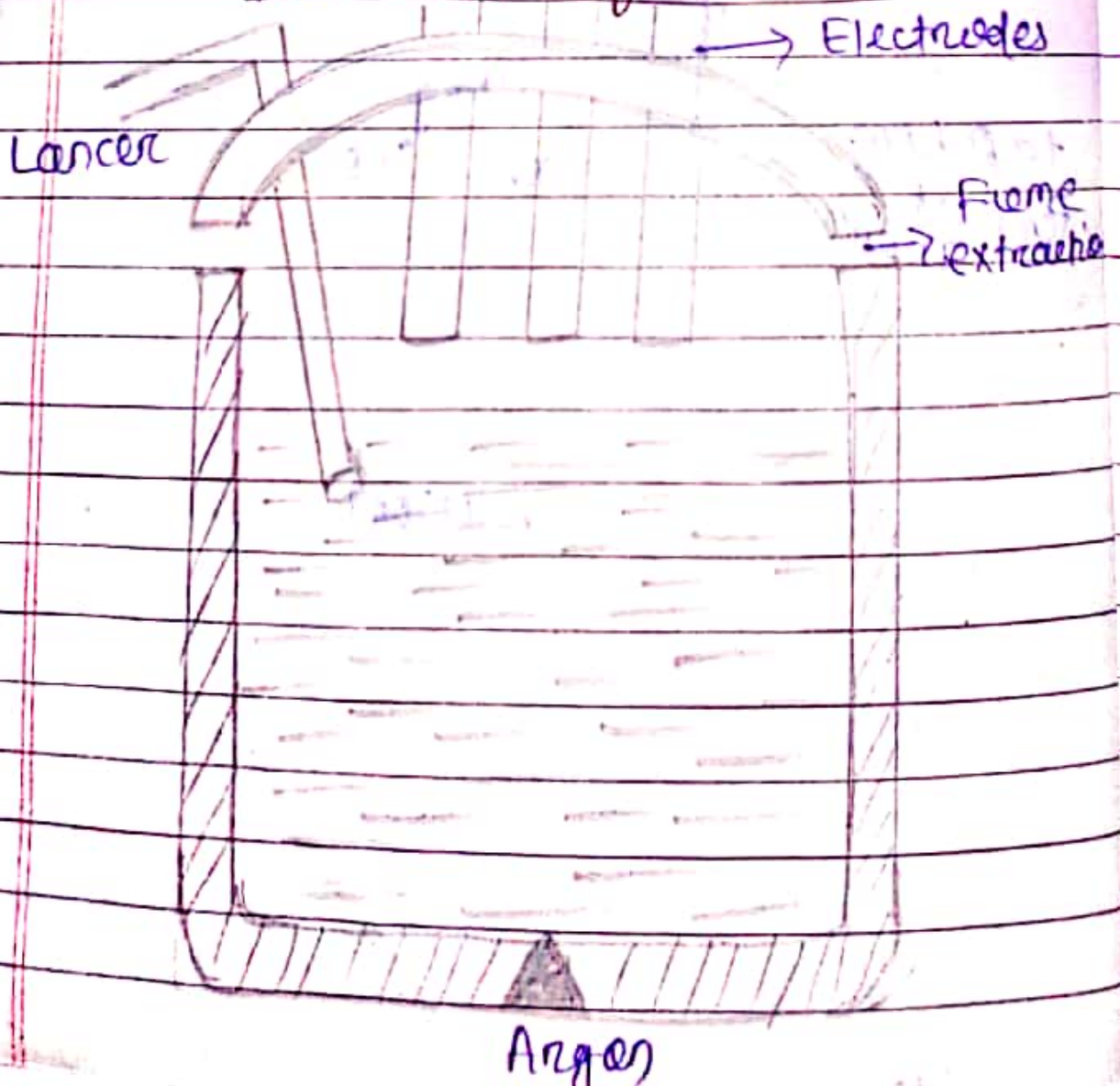
Slag
cast - Iron

Support

Open hearth Furnace



Ladle Refining Furnace



Basic Oxygen Furnace

Steel
trap
hole

Oxygen

converter
mouth

Oxygen
Lance

converter
shell

permanet
refractory
lining

Wear
out
refractory

BOTTOM

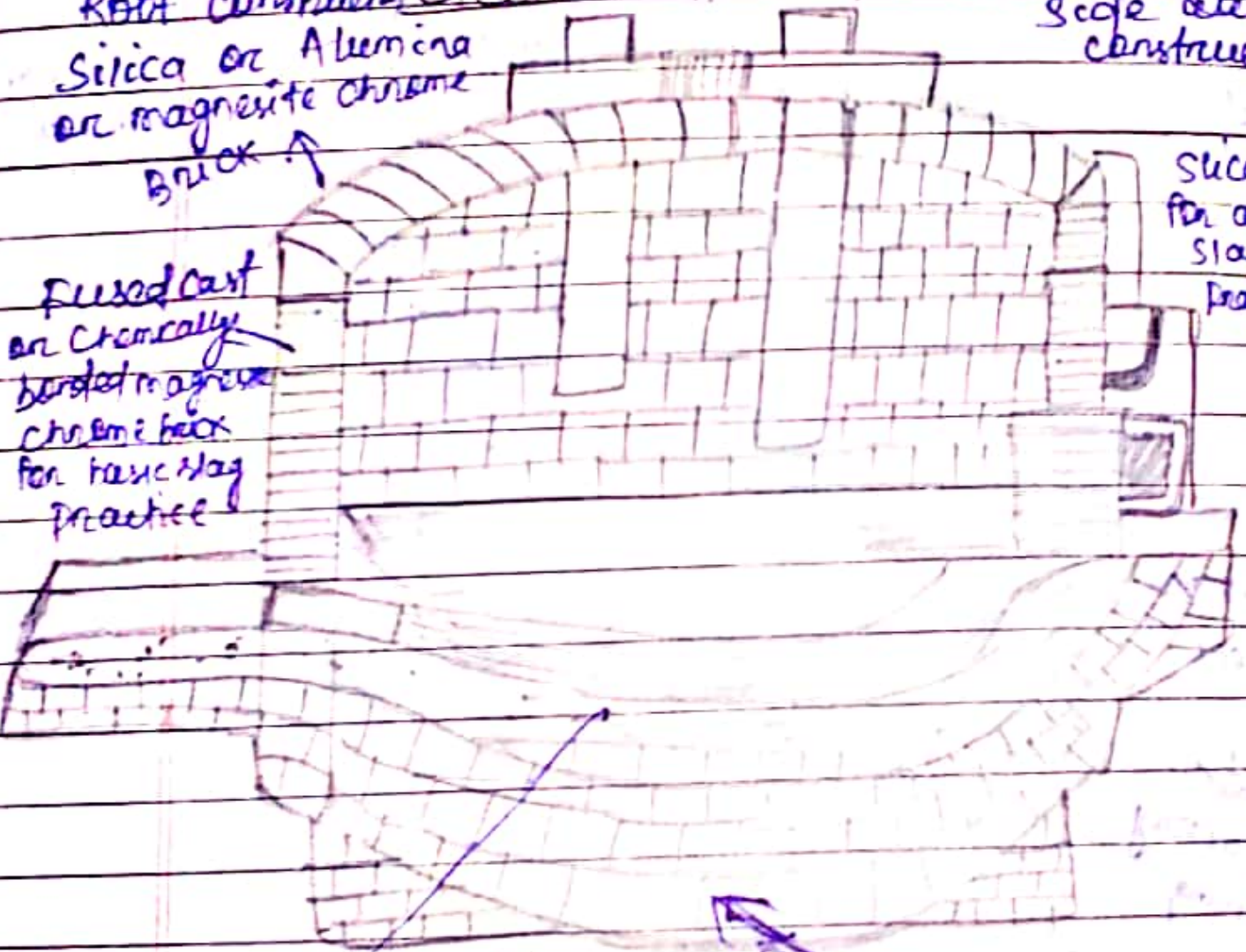
✓ Roof construction Electric Arc Furnace

Silica or Alumina
or magnesite chrome
brick

Side wall
construction

Silica brick
for acid
slag
practice

Fused cast
or Chemically
bonded magnesite
chrome brick
for basic slag
practice



[Bottom construction] Silica or magnesia brick

magnesia or Fireclay brick

5th chapter

pyroscope & pyrometer

1. Define pyroscope & pyrometer

Pyroscope

- 1) Pyroscope are the refractory material at different shapes that deforms beyond an ~~etc~~ indicate the temperature inside the kiln. Thus it is one type of temp measuring equipment. Basically they are shapes as cones and rings. They are used for one time only, it is kept inside the kiln.

ex - croton cone, Seger cone.

Pyrometer

- 1) Pyrometer is a one type of temperature measuring instrument.
- ~~2) it is measure the temperature~~
- ii) This instrument does not ~~come~~ directly contact with kiln or furnace.
- iii) it used to measure the temp of kiln & furnace.
- iv) ex Optical pyrometer, radiation pyrometer, ~~thermometer~~, Resistance thermometer, thermistor, thermocouple

(98)

Discuss various types of pyroscope.
Describe " types of cone

2 (3) used in ceramic kiln.

(2)

Discuss various types of pyroscope.

→ Mainly 2 types pyroscope are used in ceramic kiln ~~area~~ for measuring the temperature inside the kiln.

i) Seger cone

ii) Orton cone.

Seger Cone → This is invented by German Scientist Herman Seger in 1886.

→ These cones are made of purely ceramic material & fused clays, feldspar etc.

→ It is used for testing re. refractoriness of different material, refractory material.

Orton Cone

→ These & Seger cones perform German standard.

→ but re. Orton cones perform British standard.

Pyroscope: (i) Pyroscope is a type of temperature measuring equipment.

(ii) The pyroscope are made of ^{ceramic} refractory material of different shapes. Basically ~~pyroscope~~ ^{cones} are

(iii) that defines beyond or indicate the temp inside the kiln.

(iv) they are used for ~~one~~ only one time. it is kept inside the kiln.

③ Describe various pyrometer, used in Ceramic kiln

→ There are various types of pyrometer used in Ceramic kiln.

i) Optical Pyrometer

ii) Radiation pyrometer

iii) Thermocouple

iv) Resistance Thermometer

Optical Pyrometer

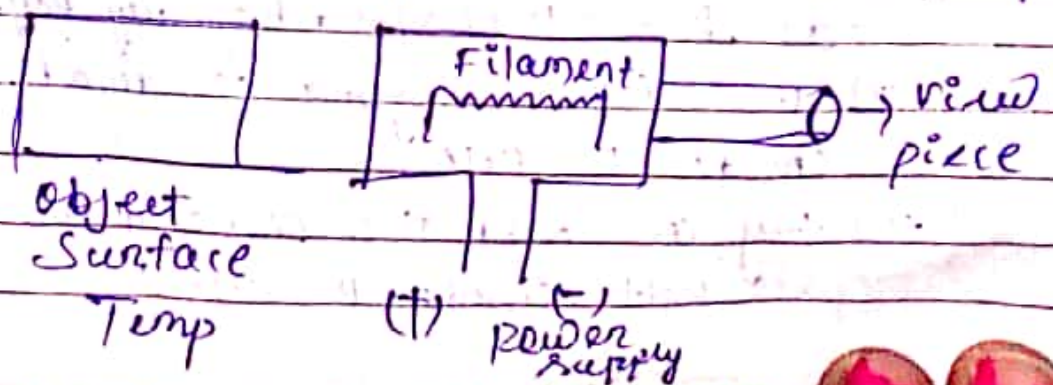
→ Optical pyrometer is a temperature measuring instrument.

→ Recording the temperature is not possible in this type of pyrometer.

→ The visible radiation from a hot body is employed to indicate the temp of the body.

→ It measures the amount of heat radiated from a object & there is no ~~direct~~ ^{direct} connection between the pyrometer & this object whose temp is to be found out.

→ In this type of pyrometer, the brightness of the object is compared to measure the temp

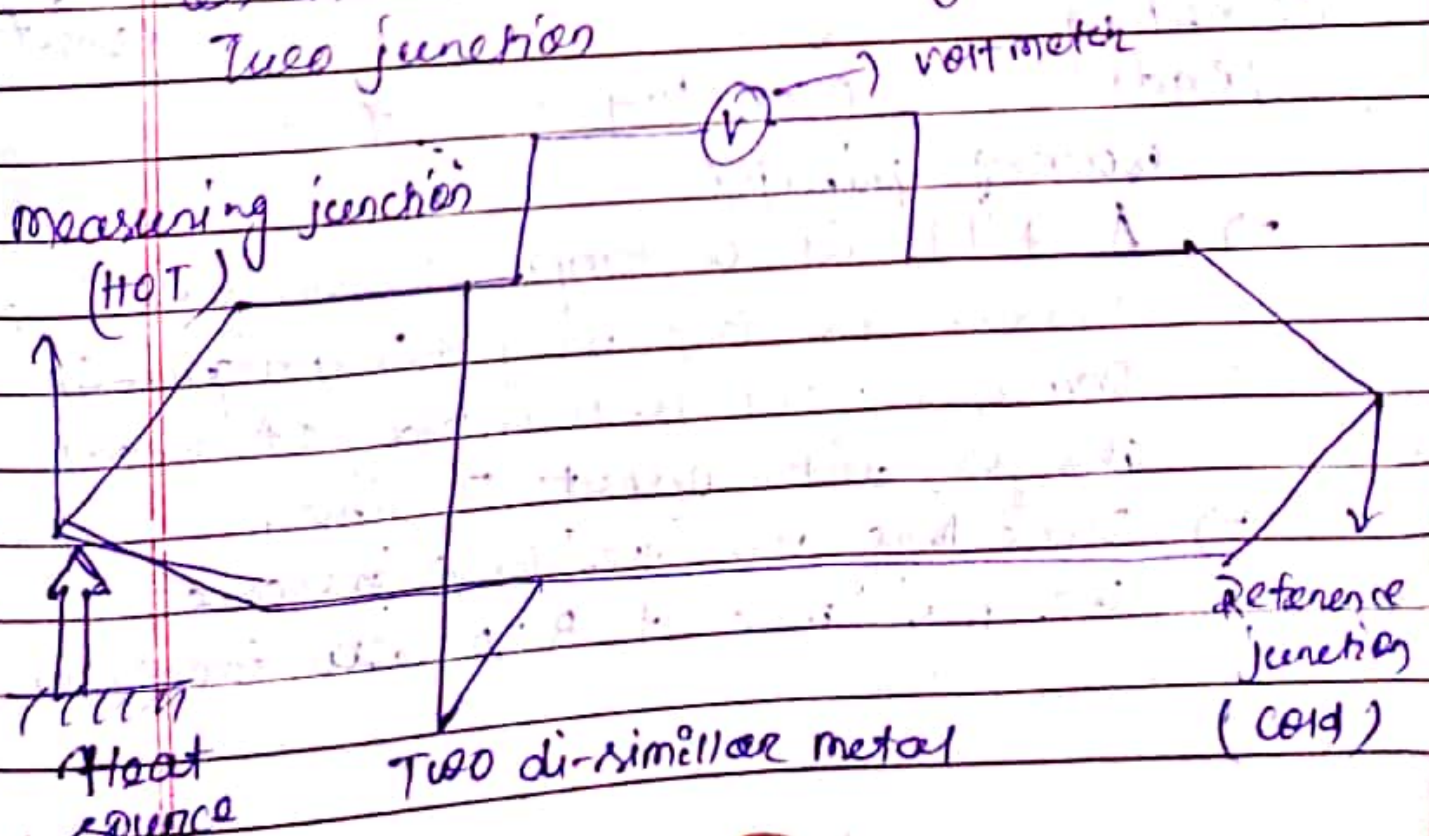


Radiation pyrometer

-) This type of Radiation pyrometer is a temperature measuring instrument.
-) This type of pyrometer is based upon the measurement of radiation energy emitted by hot body.
-) it consists of a lens to focus radiation from the body.

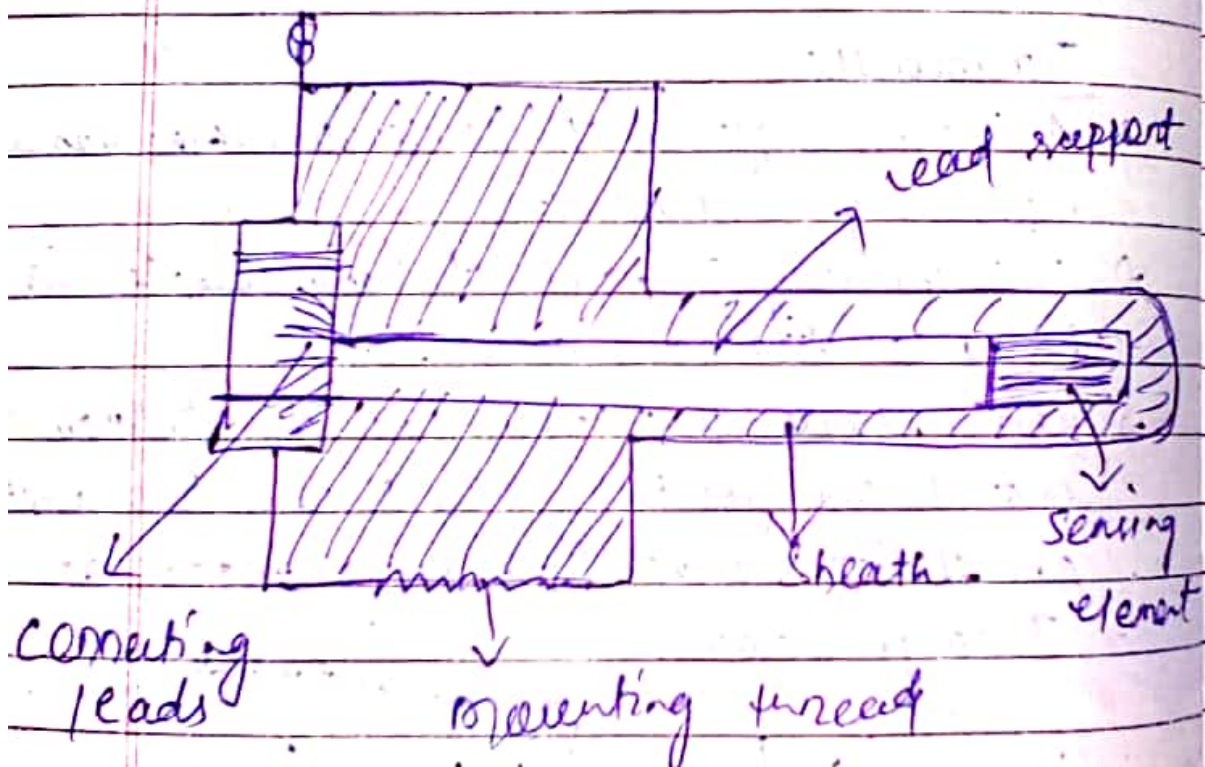
Thermocouple

-) A Thermocouple is a temperature measurement measuring instrument.
-) The working principle of thermocouple is based on Seebeck effect.
-) which states that when two dissimilar metal are joined together to form two junctions an electromotive force is generated at two junctions.



Resistance Thermometer

- Resistance Thermometer is a temperature measuring instrument.
- The instrument which measures temp with the help of Resistance is called Resistance Thermometer.
- It is also called as Resistance Temperature Detector (RTD)



Working principle

- A RTD is a temp. sensor which measures the temp using the principle that the resistance of metal changes with respect to time.
- There is a linear relationship between the temp and the resistance of RTD. When the temp increases, the resistance of RTD also increases.