Principles of Roasting with Its Types

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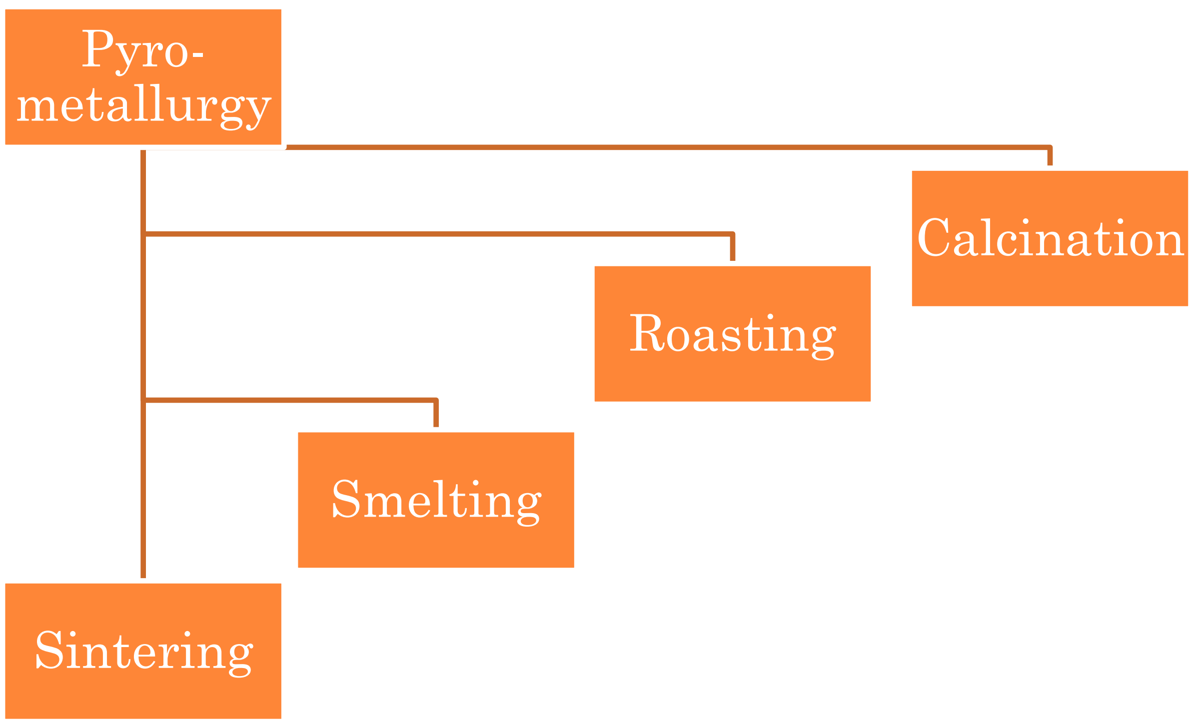
Various Metallurgical Processes

- **Hydrometallurgy** is a method for obtaining metals from their ores. It is a technique within the field of extractive metallurgy involving the use of aqueous chemistry for the recovery of metals from ores, concentrates, and recycled or residual materials
- **Electrometallurgy** is a term used for processes that refine or purify metals using electricity. It can also be a general term for electrical processes used to plate one metal with another for decorative or corrosion resistance purposes.
- **Pyrometallurgy** is a branch of extractive metallurgy. It consists of the thermal treatment of minerals and metallurgical ores and concentrates to bring about physical and chemical transformations in the materials to enable recovery of valuable metals

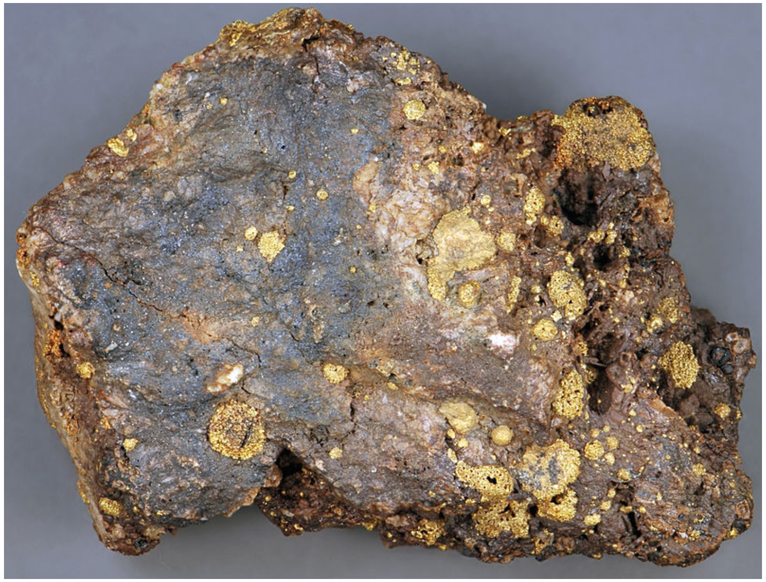
METALLURGY -PYRO

- metallurgy deals with the extraction of -Pyro minerals from ore by treating them with heat.



ROASTING

- In roasting, the ore is heated in a regular supply of air in a furnace at a temperature below the melting point of the metal.
- Roasting is a metallurgical process involving gas–solid reactions at elevated temperatures with the goal of purifying the metal component(s).
- Often before roasting, the ore has already been partially purified, e.g. by froth floatation. The concentrate is mixed with other materials to facilitate the process.
- This process is generally applied to sulphide minerals. During roasting, the sulfide is converted to an oxide, and sulfur is released as sulfur dioxide, a gas.



- For the ores Cu_2S (chalcocite) and ZnS (sphalerite), balanced equations for the roasting are:-
- $2\ Cu_2S + 3O_2 \rightarrow 2\ Cu_2O + 2\ SO_2$
  $2\ ZnS + 3\ O_2 \rightarrow 2\ ZnO + 2\ SO_2$

PROCESSES

There are several different types of roast, each one intended to produce a specific reaction and to yield a roasted product (or calcine) suitable for the particular processing operation to follow. The roasting procedures are:

- **Oxidizing roasts -** which remove all or part of the sulfur from sulfide metal compounds, replacing the sulfides with oxides. (The sulfur removed goes off as sulfur dioxide gas.) Oxidizing roasts are exothermic.
- **Sulfatizing roasts -** which convert certain metals from sulfides to sulfates. Sulfatizing roasts are exothermic.

- **Reducing roasts**, which lower the oxide state or even completely reduce an oxide to a metal. Reducing roasts are exothermic.
- **Chloridizing roasts**, or chlorination, which change metallic oxides to chlorides by heating with a chlorine source such as chlorine gas, hydrochloric acid gas, ammonium chloride, or sodium chloride. These reactions are exothermic.
- **Volatilizing roasts**, which eliminate easily volatilized oxides by converting them to gases.
- **Calcination**, in which solid material is heated to drive off either carbon dioxide or chemically combined water. Calcination is an endothermic reaction.

- **Roasting depends on following factors:**

  1. Time
  2. Temperature
  3. Avaibility of O_2 or air
  4. Physical condition

- **Criteria of selection of roasting process**

  1. Physical condition of product blast furnace smelting product should coarse or cellular reverberatory furnace – product should be fine leaching – product should be porous .

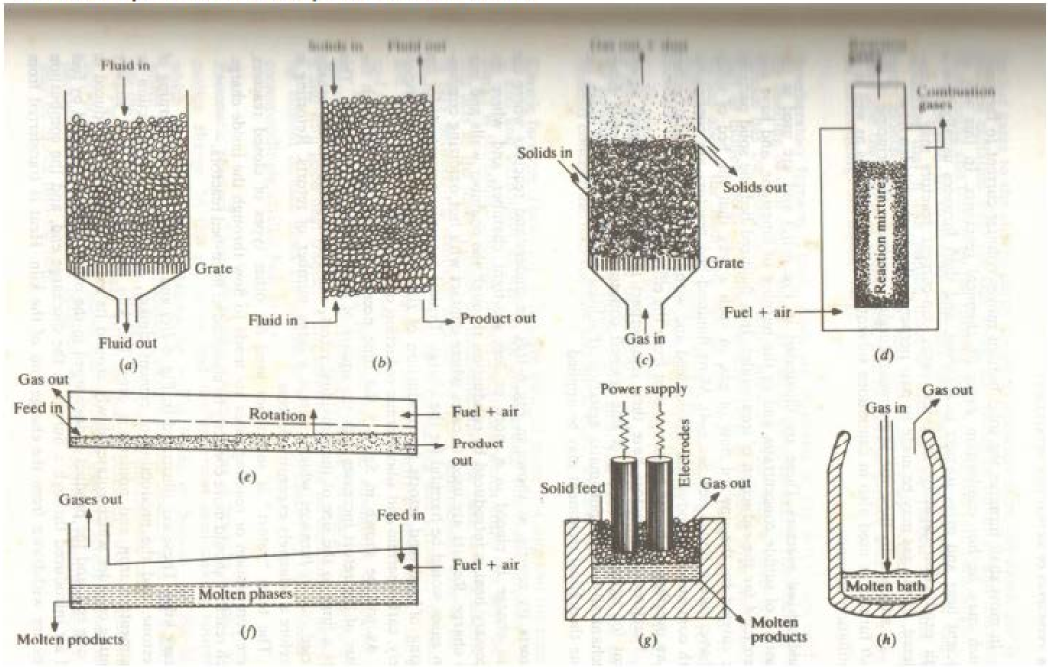
  2. Chemical composition of product
     For copper – retain some sulphur

     For Lead & Zinc - complete elimination of sulphur .

ROASTERS

- Each of the above processes can be carried out in specialized roasters.
- The types most commonly in use are fluidized-bed, multiple-hearth, flash, chlorinator, rotary kiln, and sintering machine (or blast roaster).

Various reactors: **a) Fixed bed reactor b) Shaft furnace c) Fluidized bed d) Retort e) Rotary kiln f) Reverberatory furnace g) Electric arc furnace h) Pneumatic/top blown converter**



Flash Roasting

- Preheated ore particles are made to fall through body of hot air resulting in
- Instantaneous oxidation or ‘flashing’ of combustible constituents of the ore, mainly sulphur
- Hence called flash roasting
- Ore should be of fine size
- Capacity of flash roaster > hearth roaster
- Temp. of combustion zone = 900-950^0 C

Sinter Roasting/Blast Roasting

- Fine ore & concentrate have to be agglomerated before they can be charged in a blast furnace
- Treatment of sulphide ore in a sintering machine where roasting and agglomeration take place simultaneously
- Charge = (fine ore+ moisture) as layer of 15-50 cm thick on revolving belt
- Combustion is done by burner
- Speed is adjusted - roasting should be completed before it is discharged
- Produce porous cinder called sinter
- Cooled sinter is sized to give uniform product

MULTIPLE HEARTH ROASTING

Basic principle –

Counter current flow of solid ore & the oxidizing gases.

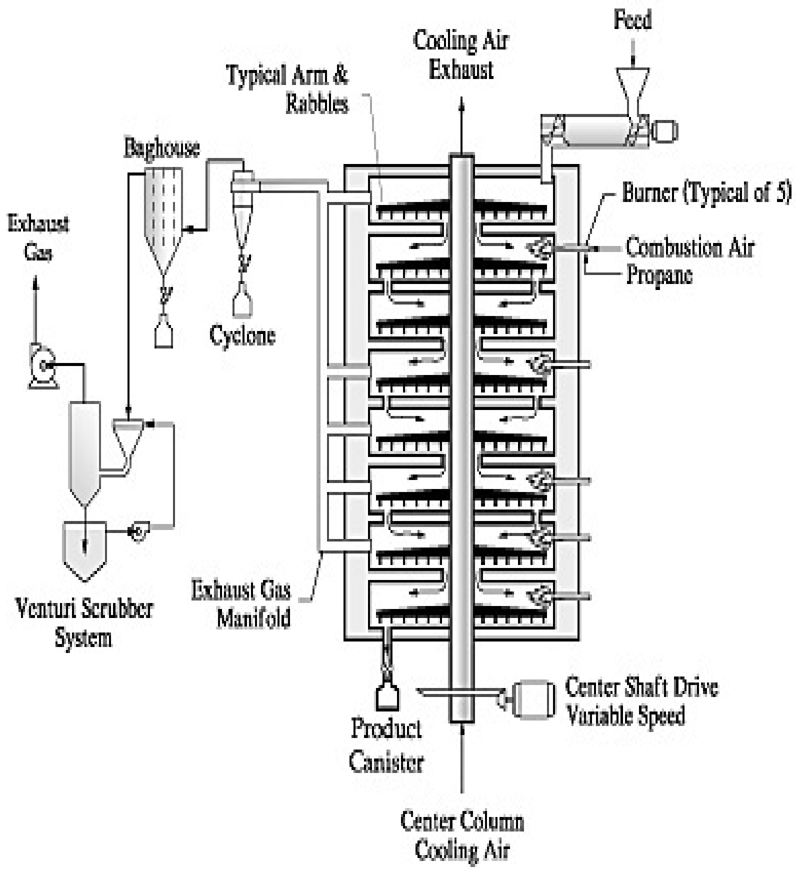
Working:

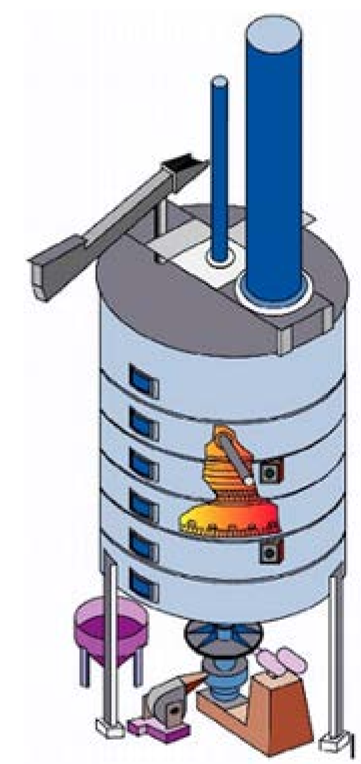
- The hearth at the top dry and heat the charge
- Ore is discharged automatically at the top hearth
- It gradually moves downwards through alternate passages around the shaft and periphery and finally emerges at the bottom
- The oxidizing gases flow upwards
- External heating of charge is unnecessary except when charge contain moisture

Drawbacks :

(1) Roasting is slow

(2) Gases are unsuitable for production of H_2SO_4 because they do not contain sufficient SO_2 and SO_3





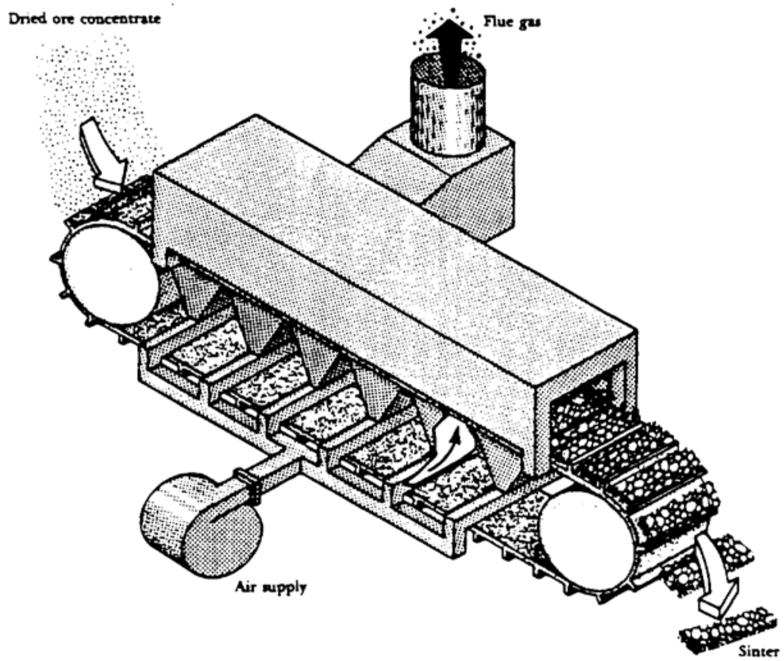
Pictorial view of multiple hearth roasting unit

Sintering Machine

Preparation Methods

Ore concentrates are often treated, or prepared, before they are smelted. Preparation methods can change the physical form of the concentrate, the chemical form, or both. Two common preparation methods are sintering and roasting.

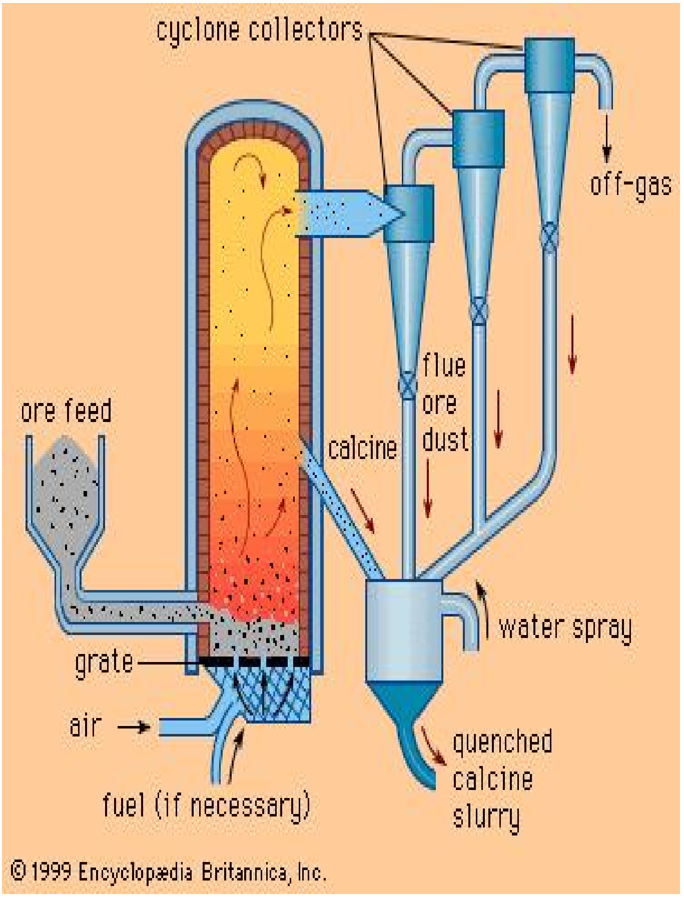
Sintering changes the physical form of a material. The dried concentrate obtained by froth flotation concentration is often so fine that it can't be efficiently treated in smelting devices such as a blast furnace. Sintering fuses the fine concentrate into strong, porous products (like charcoal briquettes) that are then crushed and sent to the smelting operations. Figure 16-2 shows a sintering machine. In this device, ore concentrate, coke, water, and other materials are fed onto a traveling grate. The combustion of the coke produces heat to fuse the concentrate.



Fluidized-bed roasting

Principle-

- Ore particles are roasted while it is suspended in an upward stream of gases
- Gas passes through bottom of the bed
- Behahaviour of the bed depends on the velocity of gas



Fluidized-bed roasting

- The ore particles are roasted while suspended in an upward stream of gas
- Finely ground sulfide concentrates in size over the range 0.005 to 0.05 cm in diameter is used
- As in the suspension roaster, the reaction rates for desulfurization are more rapid than in the older multiple-hearth processes.
- Fluidized-bed roasters operate under a pressure slightly lower than atmospheric and at temperatures averaging 1000°C (1800°F).
- In the fluidized-bed process, no additional fuel is required after ignition has been achieved.

Steps observed during roasting process

Stage-1

- When the gas flow rate is very low, and the ore bed is porous, the gas permeates the bed without disturbing the ore particles
- Pressure drop across the bed is proportional to flow rate

Stage-2

- Gas velocity increses, the bed expands upwards due to the effect of the drag forces exerted by gas stream
- The pressure drop across the bed depends on the gas velocity

Stage-3

- When gas velocity further increases a stage is reached
- Pressure drop = wt. of the particle per unit area of the bed
- Particles remain individually suspended and offer less resistance to gas flow

Stage-4

- Further increase in gas velocity lead to continued expansion of the bed
- Results in increase in interparticle distance
- Pressure drop across bed continues to decrease as the gas velocity increases

Stage-5

- Finally, the expansion of the bed is independent of gas velocity
- Outcoming gas stream appears in the form of bubbles bursting on the surface of the bed which looks like well stirred boiling liquid
- In this condition the bed is said to be fluidized.
- The fluidized bed has an apparent density distinctly different from the density of the solid and is capable of flowing like a liquid.

THE FLUIDIZATION BEHAVIOUR

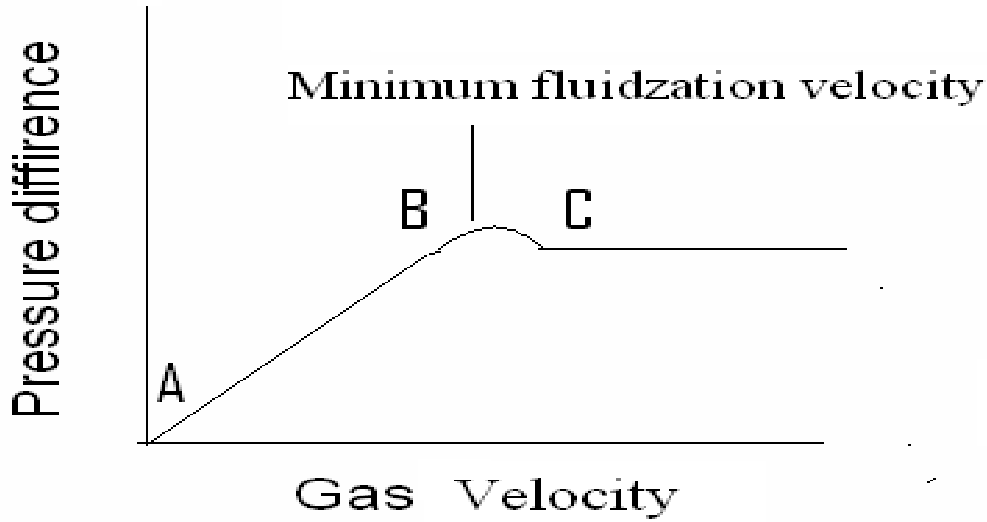


Fig. Typical Fludization curve

AB= Pressure drop cross the bed before fludization occur

BC = As pressure drp increse ,bed is rearrange and cause minimum rsistance to gas flow

point C- maximum voidage of packed bed nad minimum gas velocity is requred for fluidzation

Advantages

- High energy efficiency because it can be autogenously operated
- Useful in recovery of sulphur because the gas that it produces has high SO_2 content
- Ideal for roasting of oxide ores because the oxidizing reactions that take place during roasting is highly exothermic.

  e.g. Pyrite FeS_2, Millerite NiS, etc.

PLENARY

- Define (one type of) metallurgy process