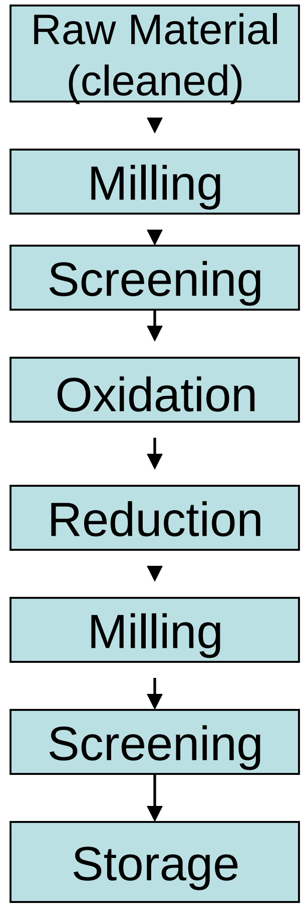
PYRON PROCESS

- Mill scale
- Reducing agent ---- Hydrogen gas



- Mill scale is basically obtained from steel mills which produce sheets, rods, wires, plates and pipes.
- The mill scale mainly consists of Fe_3O_4, and also contains oxides of tramp elements normally associated with steel, especially Si, Mn and Cr in the form of very finely dispersed oxides ----- difficult to reduce.
- The mill scale is dried and ground up to the desired particle size in a continuous ball mill. (- 100 mesh)
- Oxidation of the mill scale at 870 to 980 ^{o}C converts FeO and Fe_3O_4 to ferric oxide (Fe_2O_3).
- This process is essential to ensure uniform properties of Pyron-iron Powder.

- Reduction of ferric oxide by hydrogen is done in an electric furnace (30– 40 meter long) at 980°C . (continuous belt furnace).
- Hydrogen is supplied by NH_3 cracking plant and reduction is done at 980 °C.

$$Fe_2O_3 + 3H_2 \longrightarrow 2Fe + 3H_2O$$

- The reduction product is ground and mechanically densified to make it suitable for production of structural parts.
- Fine particle size -----small pores ------------faster sintering.

HYDRIDE DECOMPOSITION

This method of powder production is used for *precious* metals. **Hydrides** are binary compounds of metals and hydrogen.

The main steps are as follows:

(i) Hydride Formation:

In this step turnings of metals (Ti, U, Zr etc) are heated in hydrogen resulting in the formation of hydrides.

(ii) Milling:

Hydrides are brittle in nature and thus can be easily crushed and ground to fine powder.

(iii) Dehydridation:

The fine powder of hydrides is heated under vacuum at elevated temperature to eliminate hydrogen from metal, and consequently a fine metal powder is obtained.

PRECIPITATION FROM SOLUTIONS

- This method is used for **precious metals.**
- Leaching an ore or ore concentrate, followed by precipitating the metal from leach solution.

Steps Involved:

i) Formation of insoluble compounds/precipitates:

The salts of metals are converted/precipitated as insoluble **hydroxides**, **carbonates** or **oxalates** etc.

ii) Decomposition:

On heating, these compounds/ppts. decompose into metal or metal oxides and gaseous products.

*The examples of this technique are the production of uranium dioxide, platinum, selenium, silver, nickel and cadmium oxides.

THE CARBONYL PROCESS

- The only method for the manufacture of metal powder by the pyrolysis of a gaseous compound which has been used industrially on a substantial scale is the **carbonyl iron or nickel process**.
- When iron and nickel ores react under high **pressure (70-300 atm.)** with carbon monoxide, iron pentacarbonyl [$Fe(CO)_5$] or nickel tetracarbonyl [$Ni(CO)_4$] is formed, respectively.
- Both compounds are liquids at room temperature.
- $Fe(CO)_5$ evaporates at 103 ^{o}C and $Ni(CO)_4$ at 43 ^{o}C.

Precipitate Formation:

This step of the process is carried out according to the following scheme:

- The liquid carbonyles are stored under pressure in tanks submerged in water.
- The distilled and filtered liquids are conveyed to steam heating cylinders, where they are vaporized.
- The vapors of liquid are sent to decomposers.
- The decomposers are jacketed and heated, giving an internal temperature of 200-250 ^{o}C.
- These cylinders are 9-10 feet high with an internal dia of 3 feet, with conical bottoms.
- The incoming stream of vapors meets a tangential stream of ammonia gas.
- CO is removed here and precipitates of metals are formed which are then sieved, dried and may be milled to break up the agglomerates.
- The CO gas arising from the decomposition is recovered and re-used.

- Carbonyl iron powder is used for the production of magnetic powder cores for radio or television applications.
- In P/M it is used for the manufacture of soft magnetic materials and permanent magnets.
- Because of its high price and poor die filling properties, it is not suitable for the manufacture of sintered structural components.
- The carbonyl process is also well suited for the extraction of both metals from lean ores.
- The process can be controlled so as to yield a spherical metal powder.

ELECTROCHEMICAL PROCESS

These methods are based on the electrolysis of molten solutions of metals or fused salts.

The metals are electrically deposited on the cathode of an electrolytic cell as a sponge or powder or at least in a physical form in which it can be easily disintegrated into a powder.

Advantages of the process:

The technique has a number of advantages, e.g.

- The product is usually of a high commercial purity.
- A considerable range of powder qualities can be obtained by varying bath compositions.
- Frequently the product has excellent pressing and sintering properties.
- The cost of the operation may in some cases be low.

Limitations:

- Alloy powders cannot be produced.
- The product of process is frequently in active condition (presence of chemicals on powder particles) which may cause difficulties in washing and drying it (contamination/oxidation with atmospheric oxygen may occur).
- The cost of operation may be high in some cases.

Basic principle of the process and equipment used:

- The equipment used is an electrolytic bath made of steel, and lined from inside with rubber. Two electrodes are inserted in the bath.
- Cathode is made of lead while anode is made of the same metal whose powder is being produced.

- **Principle:**
- The basic principle is the electrolysis process in which decomposition of a molten salt/aqueous solution into its ions is obtained by the passage of electric current.
- The metallic ions are deposited at the cathode which can be removed with a brush and collected at the bottom.
- The electrolytic tanks have conical bottoms with a valve.
- Suction pipes are connected to these bottoms and powder is removed from the tank.
- The efficiency of the tank/process depends on the deposition rate.

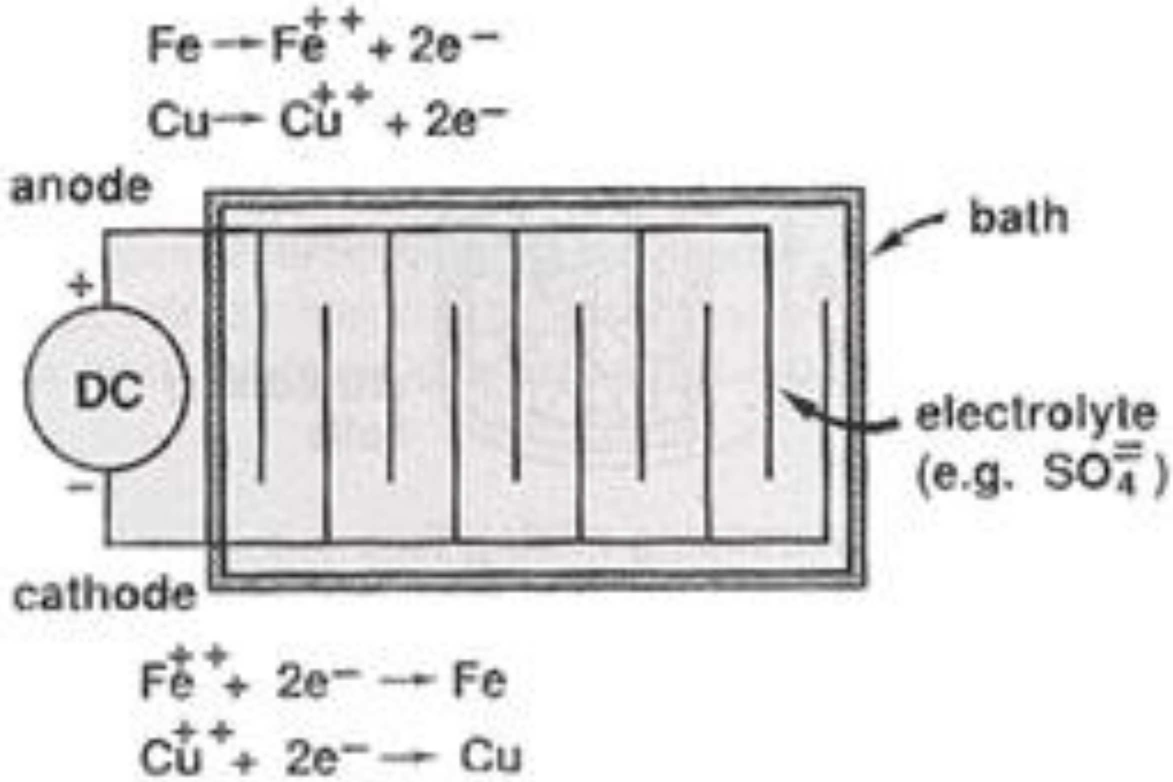


Figure: Electrolytic Cell Operation for Deposition of Powder --- Schematic.