

Extractive Metallurgy – Samenvatting hoofdpunten

Overview of metallurgical processes

Primary production = start with ore

Secondary production = start with scrap

3 types of metallurgical processes:

- Pyrometallurgy: high temperature. E.g. iron, steel, lead, tin copper (85%)
- Hydrometallurgy: chemical reactions in aqueous solutions normally below 100 C. E.g. zinc (80%), copper (15%)
- Electrometallurgy: chemical reactions through charge transfer
 - Electrowinning (copper, zinc)
 - Electrorefining (copper, zinc)
 - Molten salt electrolysis (aluminium, magnesium)

Pyrometallurgy

Solid state - preparation:

- Drying: remove water, physical process
- Calcination: carbonates/hydrates to oxides
- Roasting: sulphides to oxides/sulphates
- Pelletising and sintering: agglomeration of fine materials, physical and chemical process

Liquid state:

- Smelting: chemical extraction process
 - $\text{CuFeS}_2 + \text{O}_2 + \text{SiO}_2 \rightarrow \text{Cu}_2\text{S} + \text{FeS} + \text{SO}_2 + 2\text{FeO} \cdot \text{SiO}_2$
 - $\text{Fe}_2\text{O}_3 + \text{C} \rightarrow \text{Fe}_3\text{O}_4 (+\text{C}) \rightarrow \text{FeO} + \text{C} \rightarrow \text{Fe} + \text{CO}$
- Converting: selective oxidation via air blowing
 - $\text{Cu}_2\text{S} + \text{O}_2 \rightarrow 2\text{Cu} + \text{SO}_2$
 - $2\text{C} + \text{O}_2 \rightarrow 2\text{CO}$
 - $2\text{Si} + \text{O}_2 \rightarrow \text{SiO}_2$
- Pyro-refining or fire-refining: impurity removal at high temperature
- Molten salt electrolysis
 - $\text{Al}_2\text{O}_3 \rightarrow 2\text{Al} + 3/2\text{O}_2$
 - $\text{O}_2 + \text{C} \rightarrow \text{CO}_2$

Gaseous state:

- Vapour metallurgy: zinc reduction in blast furnace
- Halide metallurgy: halides preparation and reduction

Hydrometallurgy

3 basic steps:

- Leaching: metal species from solid to solutions
 - Acid, alkaline, bacteria, heap
 - $\text{ZnO} + \text{H}_2\text{SO}_4 \rightarrow \text{ZnSO}_4 + \text{H}_2\text{O}$
- Purification: removal of impurities, species separation
 - Hydrolysis, precipitation, cementation, solvent extraction, ion exchange
 - $\text{Fe}^{3+} + 3\text{H}_2\text{O} \rightarrow \text{Fe}(\text{OH})_3 + 3\text{H}^+$
 - $\text{CuSO}_4 + \text{Zn} = \text{Cu} + \text{ZnSO}_4$
- Metals precipitation
 - Electrowinning, cementation, hydrogen reduction
 - $\text{NiSO}_4 + \text{H}_2 \rightarrow \text{Ni} + \text{H}_2\text{SO}_4$

Electrometallurgy

Electrowinning

- Part of hydrometallurgical operation
- $\text{ZnSO}_4 + \text{H}_2\text{O} \rightarrow \text{Zn} + 0.5\text{O}_2 + \text{H}_2\text{SO}_4$

Electrorefining

- Part of pyrometallurgical operation
- $\text{Cu}(\text{impure anode}) \rightarrow \text{Cu}(\text{pure anode})$ (DC current)

Molten salt electrolysis

- Also as pyrometallurgical operation
- $\text{Al}_2\text{O}_3 \rightarrow 2\text{Al} + 3/2\text{O}_2$

Electroslag refining

- Special steel manufacturing
- Liquid steel drops bypassing molten refining slag