Metals Recovery and recycling in zinc industry

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Boliden Kokkola

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Boliden operates mines and smelters in Nordic countries

- Main metals are zinc and copper
- Produces also gold, silver, lead and nickel

- Number of personnel 5 500
  - of which 1 500 in Finland

- Turnover 4,2 mrd €
- Shares are quoted on the Stockholm Stock Exchange

- The discover of the large gold finding in Boliden, Sweden 1924, laid the foundation of the company

- Sweden, Finland, Norway, Ireland:
  - Six mining areas
  - Five smelters
Boliden – a part of circular economy

Boliden takes responsibility for the entire value chain – from exploration and mining operations to production and recycling of metals.

![Diagram showing the circular economy process from exploration, mining, concentration, feed, metal production, collecting and recycling of metals, and use of metals in society.]

- Exploration
- Mining
- Concentration
- Feed
- Metal Production
- Collecting and Recycling of metals
- Use of metals in society
Boliden smelters

Kokkola - 540 employees
Zinc, 290 000 tn
Second largest zinc plant in Europe

Odda – 290 employees
Zinc, 170 000 tn
Expansion project

Harjavalta - 500 employees
Copper, 129 000 tn, nickel 31 000 tn
Operations in Harjavalta and Pori

Rönnskär - 860 employees
Copper, 207 000 tn
Recycles electronic scrap

Bergsöe - 70 employees
Lead, 46 000 tn
Recycles lead batteries

* Production figures 2016
Boliden smelters material circulation

Copper-bearing by-products are sent from the Odda and Kokkola zinc smelting plants to Rönnskär and Harjavalta for recovery of the copper. Bergsöe sends lead-bearing dust to Rönnskär and matte to Odda for final storage in rock caverns. Rönnskär sends a residual product containing lead and antimony to Bergsöe. Lead and silver slag is sent from Kokkola to Rönnskär for lead and silver production. Zinc-bearing filter dust from the Harjavalta copper smelting plant is sent to Kokkola for zinc recovery.
Boliden Kokkola is the second largest zinc plant in the Europe
Conventional zinc production Roast Leach Electrowinning process and direct leaching

RLE = Roasting Leaching & Electrowinning
Direct leaching of concentrates = Atmospheric or autoclave
Iron mostly as residue to a pond

Ref.: Boliden Kokkola general flowsheet
Ore bodies are more complex including more unwanted impurities

- The demand of metals will increase.
- Recycling will be more important part of the metals circulation but it will not replace the need of primary production.

**Need for**

- Cost effective innovations and technologies.
- Improved energy efficiency.
- Full benefit from the side streams and minimization of the amount of generated wastes.
- Outlet and safe disposal for the unwanted impurities (As, Cd, Hg, Ca, Si, F, Cl...).
By-product metals are obtained within primary production
Technology becomes more complicated with increasing demand

- In 1990 there were circa 30 elements in a mobile phone.
- In 2014 there were over 60 elements in a smartphone.
- The growth of middle class defines the demand for high technology products.
- In my household I have 82 electric and electronic appliances (EU average is circa 70).

Recycling introduces new manmade compounds and minerology into the feed such as Alloys, ceramics, adhesives, thin films, nanomaterials.
Zinc processes produce large quantities of iron precipitates

Direct Leaching in Kokkola makes combined waste that is landfilled.

**Combined waste = Jarosite, [NaFe3(SO4)2(OH)6] + Sulphur**

Precipitation of iron removes harmful impurities from the process and it is necessary step.

Kokkola has invested in double filtration process making the residue mechanically more stable and reduces the volume required.
Landfilled stabilized combined waste
Landfill outlook globally for iron residue

No landfilling allowed at the site

- Some sites in Europe and Asia – Increasing trend. No landfilling in China.
- In many cases iron rich sludges must be transported elsewhere for treatment or processed at the site.

Landfilling allowed with stabilization

- Jarofix stabilization for non sulphur containing iron residue.
- Stabilization by sulphidation.

Pyrometallurgical treatment of zinc residues

- Pyrometallurgical methods used for making clean stable slag that can be used for urban development. Limits given for Pb and Zn in the slag.
- Simultaneous metals recovery from oxide dust (Zn, Pb, Cd, Ag, As, Hg, In, Ga, Ge).
- Different pyrometallurgical concepts in operation in China, South Korea, India, Europe, and Australia.
Zn residue treatment – Sulphur residue

- Boliden Kokkola produces 100 000 t of sulphur residue annually.
- Sulphur is currently mixed with jarosite as combined waste and landfilled.
- The amount of sulphur residue in separate historical pond is currently **827 982 t** (331 193 t dry). Sulphur content over 80 %, rest metals.

- Sulphur residue is roasted in fluidized bed reactor and also making SO2 for sulphuric acid production.
- After roasting valuable metals in calcine can be recovered.
Fluidized bed pilot tests (FBR) carried out successfully.

- **970°C max temp.**
- **Dimensions**
  - Freeboard
    - Diameter 300 mm
    - Height 6000 mm
  - Bed
    - Diameter 200 mm
    - Height 2000 mm

![Diagram of fluidized bed reactor](image)

Three feeders, 10-50 kg/h

- Synthetic air
- Nitrogen
- Argon
- Reducing gases

Temperature up to 1000°C
Blend hot and cold gas

Waste sulphur can be used to produce marketable sulphuric acid and the metal value from the obtained calcine can be recovered.

- Suitable quality SO2 gas obtained from both pilot tests for sulphuric acid production.
- Range for the main process parameters preliminary determined
- Sulphur residue and its mixtures with zinc concentrates can be granulated
- High quality calcine (~50 % Zn) that is suitable for leaching was obtained.

Calcine sample taking from the Cyclone underflows.
Conclusions

- Waste treatment methods in nonferrous industries are increasingly used.
- This trend is both driven by tightening legislation especially in Asia but also zero waste targets and better overall metals recovery (better resource efficiency).
- Applying advanced pyrometallurgical methods for residue treatment enables better recovery on by-product metals, environmentally stable slag, and sulphuric acid.
- Full beneficiation of treating residues from non-ferrous industries, require
  - New hydro/pyro separation processes for recovery of by-product metals.
  - Outlet for As, Cd, Hg, Se, Sb, F, Cl and other elements of concern.
  - End user for the slag.
  - End user for sulphuric acid.
  - Require integrated and flexible processes.
  - Require large investments.
Martin wants to get the job done. He couldn’t without metals.

Means of communication are essential for growing communities. They bring people and jobs closer together and make it possible for people to move forward in life. Trains, buses and tablets all depend on copper and zinc, that are used in everything from electrical wires to steel bodies. Martin is ready to do his best, and so are our metals.