Challenges and Opportunities in Modern Smelting

Bergforsk

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Theo Lehner
Boliden Mineral AB
Rönnskär Smelter
SE 932 81 Skelleftehamn
Sweden

Theo.lehner@boliden.com

Cajsa Samuelsson
Div. Process Metallurgy
Luleå Technical University
SE 971 87 Luleå
Sweden

Cajsa.Samuelsson@ltu.se
Challenges and Opportunities in modern Smelting

<table>
<thead>
<tr>
<th>Challenges</th>
<th>Opportunities</th>
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<tbody>
<tr>
<td>• Political</td>
<td>• Political</td>
</tr>
<tr>
<td>• Legal</td>
<td>• Legal</td>
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<td>• Market</td>
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<td>• Structural</td>
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<td>• Economical</td>
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<tr>
<td>• Environmental</td>
<td>• Environmental</td>
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<tr>
<td>• Knowledge gaps</td>
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</tbody>
</table>
Knowledge cannot replace resources. Knowledge is the resources.

T.R. Gerholm

Yet: ... Knowledge is about the past, Wisdom is about the Future.

American Indian Chieftain
Industrial Learning Curves go hand – in - hand

LCV

Productivity (hrs/t)
SO2
Pb blood
High level quality costs?

Decision level

Quality cost
Less metals ....

...more plastics
Values i Anodes

Source: Anode Assays Brook Hunt 2006
What if all the content would be turned into by-products?

<table>
<thead>
<tr>
<th>Element</th>
<th>med % WP</th>
<th>max % WP</th>
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</thead>
<tbody>
<tr>
<td>Se</td>
<td>125%</td>
<td>650%</td>
</tr>
<tr>
<td>Te</td>
<td>245%</td>
<td>5205%</td>
</tr>
<tr>
<td>Bi</td>
<td>9%</td>
<td>200%</td>
</tr>
<tr>
<td>Sb</td>
<td>1%</td>
<td>27%</td>
</tr>
<tr>
<td>As</td>
<td>18%</td>
<td>94%</td>
</tr>
<tr>
<td>Pb</td>
<td>0%</td>
<td>1%</td>
</tr>
<tr>
<td>Sn</td>
<td>0%</td>
<td>1%</td>
</tr>
<tr>
<td>Ni</td>
<td>0%</td>
<td>5%</td>
</tr>
<tr>
<td>Ag</td>
<td>18%</td>
<td>517%</td>
</tr>
<tr>
<td>Au</td>
<td>3%</td>
<td>124%</td>
</tr>
</tbody>
</table>
Metallic Value in lots of electronic scrap and waste

In-situ value as metals

SEK/t scrap

Metallic Value in lots of electronic scrap and waste

Mobile
PWB
PC BAN
Laptopp
Copper, Copper sulphate, Nickel sulphate, Gold, Silver, Palladium, Platinum, Selenium, Tellurium, Lead, Bismuth, Antimony, Sulfuric Acid, Sulfur dioxide, zinc, cadmium, lead alloys, iron sand*).
Integrated Resource and Waste Management

Primary production processes

Health, Safety & Environment

Natural resources

Raw-materials → Semifinished products → Finished products

Use

Fuel → Energy

Fuel recovery

Energy recovery

Co-incineration

Incineration

Discard

Emissions

Compost

Material recovery

Re-use

Landfill process

Inert Material

IRWM
Research vision
Wise processing for varying feedstock

- Fundamental competence in Pyro- and hydro metallurgy
- Process knowledge

Evaluation of process alternatives

- Alternative reduction agents
- Slag chemistry
- Distribution of elements
- Recycling, New mtrls
- Complex ore
- Dust formation
Rönnskärs metallurgy

"influence of impurities on slag properties/quality"
"Distribution of impurities"

Sulphur products

Cu, Fe, S,
Au, Ag, Al,
Ca, Mg, Cr,
Hg….

O₂, SiO₂

Glass as additive and replacement of SiO₂?

Waste, stabilisation

Cu, Au, Ag

Addition of glass

Plastic-mtrl
Reduction agent, energy?
Illustration of research activities

On-going projects

Anita Wedholm, Ltu- responsible for experimental trials
Studentprojects

• Use of CRT och LCD glass in smelt processes
  Use as slag former or as addition to melted slag
• Filler and flame retardants in rubber and plastic
  Replacement of brominated flame retardants
    - Aluminium oxide and its influence on slag properties
• Distribution of chlorine between matte and slag
Illustration of research activities
On-going projects

- Literature survey
- Thermodynamic calculation
- Preliminary bench scale test
Use of CRT and LCD glass

• Decreases solubility of copper in slag
• Decreased leaching of metals from slag
• Below 35% glass addition – no visual phase separation
Distribution of chlorine between matte and slagg

- $L_{sl/sk} \approx 2-3$
- Vaporisation of NaCl and ZnCl$_2$
Influence of Al₂O₃ on slag properties

- Melting point
  - Dependent on gas composition - pO₂
  - Slagg composition etc
- Leaching properties
  - Decreased leaching of several metals
Slag composition

Decreasing

Conductivity
Copper solubility
density

Viscosity

Fayalite

(pO₂ > 10⁻⁹) T_{liq}

(pO₂ < 10⁻¹⁰) T_{liq}

Increasing

SiO₂

"FeO"

Al₂O₃

Literature survey
XRD-analysis after remelting and adding Al$_2$O$_3$ to the fumingslag

F Fayalit Fe$_2$SiO$_4$

P Petedunnite CaZnSi$_2$O$_6$

X Koppar-järn-manganoxid/Kalciumaluminiumsilikat

M Magnetit Fe$_3$O$_4$
XRD-analysis after remelting and adding $\text{Al}_2\text{O}_3$ to the electric furnace slag

Fayalit $\text{Fe}_2\text{SiO}_4$
(Fe, Mn)$\text{Al}_2\text{O}_4$
Koppar-järn-manganoxid/Kalciumaluminiumsilikat
Magnetit $\text{Fe}_3\text{O}_4$

8 % $\text{Al}_2\text{O}_3$
0 % $\text{Al}_2\text{O}_3$
No additional $\text{Al}_2\text{O}_3$ added to the fuming-slag
8 weight% $\text{Al}_2\text{O}_3$ added
To the fuming slag
Resources should be used with wisdom and knowledge to give the future generations worldwide wealth in a healthy environment.