Recycling end-of-life waste streams

Mineral Economy Stakeholder Seminar
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Drivers for recycling of end-of-life electronics

- Critical raw materials (CRMs) are both of high economic importance and vulnerable to supply disruption; in certain cases, their extraction also causes significant environmental impacts. For all these reasons, increasing the recovery of critical raw materials is one of the challenges that must be addressed and overcome with innovative industrial processes.

- CRMs are often present in electronic devices. The current very low rate of recycling of these materials (< 1%) means that significant economic opportunities are lost. It is therefore essential to improve the recyclability of electronic devices by improving the economic viability of the recycling process.

- Waste Electrical and Electronic Equipment (WEEE) is a key source of CRMs.

- Current WEEE recycling processes focus on recovering mainly base and precious metals, which means that significant amount of CRMs and especially Rare Earth Elements (REE) remains unrecovered. It is therefore essential to improve the efficiency of WEEE recycling and thereby the recovery of CRMs by integration of mechanical, thermal and hydrometallurgical unit operations, as well as at the systemic levels of collection, pre-processing, metallurgical recovery and refining.
Aspects taking into account in WEEE Recycling

- Global WEEE generation around 20 - 50 Mt, within EU around 12 Mt

- Heterogeneous mixture of different appliances with complex design

- Contains valuable, precious and critical metals as well as harmful substances

- Fragmented recycling industry, where several players across the value chain are optimizing their own part hampers the recovery of CRM's from WEEE

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Recycling of Waste Electrical and Electronic Equipment (WEEE)

Intelligent collection and sorting

Dismantling and manual separation

Mechanical and thermal treatment

Hydrometallurgical treatment and recovery

Metals, materials, products, energy
Case Study:
Effect of electronic equipment design on WEEE recycling
WEEE and its challenges

- Waste Electrical and Electronic Equipment (WEEE) is a heterogeneous and complex waste stream which is in a constant change i.a. due to the short life time of electronic goods.

- The treatment of WEEE composes of several stages in which metals are strived to be separated from plastics and further on to own metal fractions such as iron and copper. Finally metals are refined to intermediates for manufacturer industry.

- Each treatment stage produces losses (metals) which can become significant in the overall examination. Usually losses are larger in the beginning of the treatment chain. Dusts in mechanical processing is one source for losses.

- Liberation describes how different materials are disengaged from each other and connected to the separation efficiency of the mechanical processes

- Liberation of materials is increased with crushing, however more intense crushing produces also more dusts.

- What do we loose to dusts and how it is connected to crushing and liberation?

Materials and methodology

- Two mobile phone samples from the millennium to recent years:
  - Regular type 5.7 kg
  - Sophisticated type 6.2 kg
- Size reduction was performed with a hammer mill with the output size opening of 100 mm
  - Particle size analysis with shaking sieves (10 pc.); 0.045 – 31.5 mm
- Liberation characterization (>4 mm) by hand dismantling (10 classes); 15 – 95%
- Dust (<1.0 mm) characterization:
  - Half quantified X-ray fluorescence (XRF)
  - Total organic carbon (TOC)

Results (1): Particle size distribution

- Particle size $D_{50}$:
  - Regular 20 mm
  - Sophisticated 23 mm

- Dusts < 1.0 mm were generated around 3.4% for both phone models

Results (2): Liberation distribution of PCA

- The overall PCA grade:
  - Regular 69.7 w-%
  - Sophisticated 70.1 w-%

- Mainly all PCA particles with the liberation below 95% had the particle size above 31.5 mm

Figure 1. Unliberated PCAs from regular phones. Liberation degree from left to right: 80 w-%; 48 w-% and 57 w-%.

Results (3): Dusts and their composition

# Design related aspects and their relation to liberation and dust composition

<table>
<thead>
<tr>
<th></th>
<th>Liberation (PCA/B) (+ = improves liberation)</th>
<th>Dust composition (+ = lower content to be lost through dust)</th>
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</thead>
<tbody>
<tr>
<td>Modularity of main-components/parts</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Platform based PCA-assembly</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Attachment method (adhesive)</td>
<td>-</td>
<td>?</td>
</tr>
<tr>
<td>Less connection/part</td>
<td>+</td>
<td>+</td>
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<tr>
<td>Smaller component size</td>
<td>-</td>
<td>+/-</td>
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<tr>
<td>Tensile supporting structure</td>
<td>+/-</td>
<td>+</td>
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</tbody>
</table>
Conclusions of the case study

- Phone model type did not have a strong effect on the overall PCA grade (~70% for both types)

- However, changes in the liberation distribution was detected i.a. due to the attachment method of the laminated PCA in sophisticated phone type.

- The generation of dusts in the size reduction process was on the same level with both phone types.

- The composition of dusts were rather similar between the phone types with the exception of TOC, Gold and Palladium.

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