Efficient mineral processing and hydrometallurgical recovery of by-product metals from low-grade metal containing secondary raw materials

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VITO NV
Introduction

Current System

<table>
<thead>
<tr>
<th>Metal Production</th>
<th>Production Europe</th>
<th>Metal content</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS, FeCr</td>
<td>1.8 Mt/y</td>
<td>1-2 wt% Cr + 100-500 ppm V, Mo, Nb</td>
</tr>
<tr>
<td>LC + HC ferrochrome slags</td>
<td>~6 Mt/y</td>
<td>2-10 wt% Cr</td>
</tr>
<tr>
<td>Carbon steel slags</td>
<td>~20 Mt/y</td>
<td>1-3 wt% Cr + 100-500 ppm V, Mo, Nb</td>
</tr>
</tbody>
</table>

Metal value currently lost!

Use of steel slags. Source: Euroslag, Statistics 2010
New recovery processes for critical and valuable metals

**Smart combinations** of existing methods and **new technological innovations** to extract valuable and critical metals from slags

**Current System**

- **Primary Ores**
- **Scrap**

**Metal Production**

**By-product: Slag**

- **CS, SS, FeCr**
- **Nb, Cr, Mo, V**

Use as construction materials

**-efficient mineral processing**

- **fine metals to production**

**Selective Leaching**

- **Regenerated Leaching Solution**

- **Dilute Leachate**

**Metal Depleted Stream**

- **Use as construction materials**

**Selective Material Recovery**

- **To Metal Products**

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Efficient mineral processing and Hydrometallurgical Recovery of by-product Metals from low-grade metal containing seCondary raw materials
**Type:** H2020 RIA (Grant Agreement No. 730471)

**Duration:** 1 November 2016 – 31 October 2020

**Budget:** 4.8 M Euro

**Coordination:**

Liesbeth Horckmans, VITO NV, Mol - Belgium
CHROMIC work plan

Value chain assessment

**WP1** A circular economy context and assessment of health, environmental, economic aspects and legal compliance

Technology development

**WP2** Mineral processing

**WP3** Selective/efficient leaching

**WP4** Selective metal recovery

Technology validation

**WP5** Metallurgical system validation

WP7 Project management
Three model streams

Carbon steel EAF slags
- 0-5 mm (photo)
- 20-40 mm
- 40-185 mm

LC ferrochrome slags
Crushed and sieved to 4-9 mm

Stainless steel slags
< 0.5 mm

Potential for replication to other streams
**CHROMIC materials - Mineralogy**

**Challenge:** metals (mainly Cr) present in stable phases

<table>
<thead>
<tr>
<th>Material</th>
<th>Main minerals</th>
<th>Cr-rich phases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Carbon steel EAF slags</strong></td>
<td>Ca-silicates (larnite, gehlenite), Fe-oxides (wuestite), spinel (Fe$_3$O$_4$, MgFe$_2$O$_4$)</td>
<td>Spinel (MgCr$_2$O$_4$)</td>
</tr>
<tr>
<td><strong>Ferrochrome slags</strong></td>
<td>Ca-silicates (merwinite, bredigite, larnite, gehlenite), spinel (MgAl$_2$O$_4$; MgCr$_2$O$_4$)</td>
<td>Ferrochrome particles, spinel MgCr$_2$O$_4$</td>
</tr>
<tr>
<td><strong>Stainless steel slags</strong></td>
<td>Ca-silicates (merwinite, bredigite, gehlenite, cuspidine), calcite</td>
<td>Spinel (MgCr$_2$O$_4$)</td>
</tr>
</tbody>
</table>
Challenge: complex matrix, small particle size

Minerals intertwined at small scale (<100 µm)
Distinct Cr-rich spinels present (10-100 µm)
Challenge: complex matrix, small particle size

Small metallic particles (20-40 µm) present in matrix of Ca-silicates and with intermingled spinels

Ferrochrome slags
FeCr: ferrochrome metal
Ca: Ca-silicates
Sp: spinels containing Cr
Challenge: complex matrix, small particle size

Very small metallic particles (1-10 µm) present in matrix of Ca-silicates and with intermingled spinels

SS slags
S: SS metal
Ca: Ca-silicates
Cr: Cr-rich spinels
P: periclase
A: CaMg-silicates
Cost-efficient, selective comminution and pre-concentration

• Microwave-induced cracking

• Electrodynamically fragmented separation

• Electrostatic, magnetic, enhanced gravimetric separation

• Flotation
Technology development: Selective leaching

Efficient recovery of target metals with minimal matrix dissolution

- Microwave/radiowave assisted leaching
- Traditional/MW roasting
- Ultrasound assisted leaching
- Atmospheric/ozonation leaching

Microwave

Ultrasonic reactor

Roasting oven
Technology development: Selective metal recovery

Efficient recovery of separate target metals from mixed solution

Selective precipitation

Novel sorbents

- Layered double hydroxides

Solvent extraction

Layer: MgAl-, ZnAl-, MgFe- ... LDHs;
Cationic ratio (MeII/MeIII = 2, 3, 4...)

Interlayer exchangeable anions

$\text{Cr}^{3+}$, $\text{Cr(OH)}_4^-$, $\text{CrO}_4^{2-}$, $\text{VO}_4^{3-}$, $\text{MoO}_4^{2-}$, $\text{NbO}_3^-$
CHROMIC work plan

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WP6 Communication, Dissemination, Exploitation, Community Interaction and Clustering

WP7 Project management

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CHROMIC – Metallurgical system validation

Upscaling + valorisation of solid residues

Carbonation

Briquetting

Pelletising
CHROMIC work plan

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CHROMIC – value chain assessment

Circular economy context, integrated LCA-RA-TEA study

Iterative process

Aim: provide feedback to technology development
CHROMIC – community interaction

CHROMIC is an inclusive project

Community involvement in three waves:

- Focus groups: lay people -> be aware of key concerns for LCA-RA-TEA
  - Ongoing (Italy, Belgium completed)
- Stakeholders -> technical/legal concerns
- 3rd wave -> to be defined based on output first two waves

4 locations: Belgium, France, Germany, Italy
Follow our progress on www.chromic.eu

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This project received funding from the European Union’s Horizon 2020 Research and Innovation program under Grant Agreement n° 730471