Life cycle assessment of refractory waste management in a Spanish steel works

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2.-0 LCA consultants

Who we are
• Small consultancy company founded in year 2000 by Bo Weidema
• Entirely dedicated to quantitative sustainability assessment with life-cycle tools
• Currently 10 employees in Denmark, Spain, The Netherlands

What we do
• LCA studies
• LCA tools and methods development
• LCA training

With whom
• Private companies, industry associations and public agencies
• Research in EU-funded projects

“Better decision-making for sustainable development with life cycle assessment (LCA)”
Life cycle assessment

LCA is a compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle (ISO 14040/14044)

Source: P&G
Life cycle assessment

• **Goal and scope:** defines goal, scenarios to assess, functional unit, system boundaries, impact assessment method, data sources...

• **Inventory analysis:** mass and energy balance of the analysed system

• **Impact assessment:** aggregates the information from the inventory analysis in a set of indicators, e.g. carbon footprint

• **Interpretation:** includes contribution analysis, uncertainty analysis, conclusions and recommendations
Refractories

- Materials that withstand high temperatures and maintain their mechanical function, even in contact with corrosive liquids or gases
- Indispensable for all high-temperature processes, such as the production of metals, cement, glass and ceramics
- Come in preformed shapes (bricks) or unformed (monolithic refractories)
- Produced from minerals such as magnesite, considered a critical raw material by the EU

Refractories

- 36.9 million tonnes produced in 2014, around 2/3 in China
- The steel industry uses approx. 75% of all refractories
- Every year almost 20 million tonnes refractory waste are produced

- 36.9 million tonnes
- 49% (18.1 million tonnes) consumed
- 36% (13.3 million tonnes) landfilled
- 15% (5.5 million tonnes) recycled
LIFE 5REFRACT

• Aims at achieving integral valorization of refractory waste in the steel industry, increasing recovery by up to 80% of the generated waste

• Achieved by:
  • Identifying and prioritising how best to use refractory waste in a steel works
  • Facilitating separation of refractories for optimum reuse or recycling
  • Developing refractories incorporating recycled content

• Activities piloted in Basauri Steel Works (800,000 t Steel/y)

• Includes an environmental impact assessment (LCA)
LIFE 5REFRACT

- Coordinated by SIDENOR (Spanish steel manufacturer)
- Consortium counts with industrial, academic and consultancy partners
LIFE 5REFRACT
Life cycle assessment – 5REFRACT

- Goal is to quantify the environmental benefits of 5REFRACT to the steel works
- 2 scenarios
  - Current: situation at start of the project in 2018
  - 5REFRACT: hypothetical implementation in 2018
- Functional unit is the volume of annual refractory waste: 5,798 tonnes

<table>
<thead>
<tr>
<th>Refractory waste</th>
<th>Main components</th>
<th>Production</th>
<th>Current management scenario</th>
<th>5REFRACT management scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Reuse</td>
<td>Landfill</td>
</tr>
<tr>
<td>Bricks</td>
<td>MgO-C</td>
<td>3,194</td>
<td>175</td>
<td>3,019</td>
</tr>
<tr>
<td>High-alumina shapes</td>
<td>Al₂O₃</td>
<td>204</td>
<td></td>
<td>204</td>
</tr>
<tr>
<td>Isostatic</td>
<td>Al₂O₃, MgO, ZrO₂</td>
<td>250</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>Monolithics</td>
<td>MgO</td>
<td>2,150</td>
<td></td>
<td>2,150</td>
</tr>
<tr>
<td>Total waste (tonnes)</td>
<td></td>
<td>5,798</td>
<td>175</td>
<td>2,400</td>
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<tr>
<td>Total waste (%)</td>
<td></td>
<td>100%</td>
<td>3%</td>
<td>41%</td>
</tr>
</tbody>
</table>
Life cycle assessment – 5REFRACT

Current scenario

MgO-C bricks (clean)
MgO-C bricks (bulk)
High-alumina shapes
Isostatics
Monolithics

Collection (forklift)
Collection (truck)
Collection (front loader)

Transport
Recycling
Transport
Landfill

Environmental impacts

Environmental savings

Secondary brick (for reuse)
Brick production
Secondary magnesia
Secondary alumina

Transport

Transport

Transport

Transport

Transport

Transport

Transport

Transport

Bauxite mining
Bauxite calcination
DBM production
FM production
CCM production
Magnesite mining

Bauxite mining
Life cycle assessment – 5REFRACT

5REFRACT scenario

MgO-C bricks (clean) → Collection (forklift) → Secondary bricks (for reuse)

MgO-C bricks (bulk) → Collection (front loader) → Recycling → Secondary magnesia

Isostatics → Collection (truck) → Transport → Secondary isostatics

High-alumina shapes → 5REFRACT scenario

Collection (front loader) → Recycling → Secondary alumina

Monolithics → Collection (truck) → Landfill

Transport → Bauxite calcination → Secondary bricks (for reuse)

Collection (truck) → Recycling → Secondary monolithics

Collection (front loader) → White slag Cone bottom

Transport → Black slag (for reuse)

Secondary monolithics → Black slag recycling

Transport → Black slag (for reuse)

White slag Cone bottom → Black slag recycling

Transport → Secondary aggregate

Black slag → Black slag recycling

Secondary aggregate → Black slag recycling

5REFRACT scenario

Transport → Bauxite mining → FM production

Transport → Chamotte production → FM production

Transport → Zirconia production → FM production

Transport → Zircon mining → FM production

Transport → Graphite mining → FM production

Transport → Magnesite mining

Transport → CCM production

Transport → DBM production

Transport → Bauxite mining

Transport → Clay mining

Transport → Zircon mining

Transport → Graphite mining

Transport → Magnesite mining

Transport → Clay mining

Transport → Gravel mining

Transport → Black slag landfill

Transport → Limestone mining

Transport → Clay mining
Life cycle assessment – 5REFRACT

Data collection

• 5REFRACT data
  • Waste generation, composition
  • Collection and transport
  • Treatment (reuse, recycling)

• (Avoided) refractory production data
  • Peer-reviewed literature, technical reports...

• Background data
  • Ecoinvent database, software SimaPro

Background: data typically from commercial LCA databases or literature

Foreground: data typically from primary sources

SimaPro

LCA consultants
Life cycle assessment – 5REFRACT

Results: Greenhouse-gas emissions per year

5REFRACT implementation saves 3,900 tonnes CO₂-eq/year
Life cycle assessment – 5REFRACT
Results: Greenhouse-gas emissions per year

- **Sensitivity analysis:**
  Shift to natural gas by the Chinese industry

- **Uncertainty analysis (Monte-Carlo):**
  ✓ 95% confidence interval is saving 3,300-4,900 tonne CO$_2$-eq/yr
  ✓ All simulations favourable to 5REFRACT
Life cycle assessment – 5REFRACT

Results: Other indicators

5REFRACT saves:
- 28 TJ/year primary energy from fossil sources
- 1,800 tonnes of waste from going to landfill
Role of regional authorities

- The Vasque government and IHOBE (public company supporting Vasque environmental policies) have expressed interest in 5REFRACT
- Will act as link with other Vasque industries to replicate results and raise awareness
- IHOBE aims at influencing the European BREF document regarding refractory waste management
- LCA is used as a means to reinforce the environmental credentials of 5REFRACT
Thank you!

The project SYSTEMATIC AND INTEGRAL VALORIZATION OF REFRACTORIES UNDER THE "5R" APPROACH (LIFE5REFRACT) is co funded by the LIFE financial instrument of the European Union under contract number LIFE17 ENV/ES/000228.

https://www.life5refract.eu/en/