Valorisation of refractory waste: latest developments & progress

Aintzane Soto
10/03/2020
Introduction. Sidenor

Current management of refractory waste in Sidenor

On-going projects & Latest developments

Conclusion
Introduction to the Company
“Sidenor is a market leader in the European special steel long product industry as well as an important supplier of cold finished products in the European market”

INTRODUCTION TO THE COMPANY

Production Centres, Commercial Offices & Manpower

Annual Sales (Tonnes) 666,000
Revenues (mil€) 694
Employees 1,712

www.sidenor.com
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Process Researcher

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INTRODUCTION TO THE COMPANY

Products

APPLICATIONS AUTOMOTIVE

• Crankshafts
• Gears
• Common rails
• Leaf springs
• Coil Springs
• Bearings
• Shafts
• CVJ’s
• Steering racks
• Steering pinions
• Shock absorbers
• Fasteners
• …

APPLICATIONS NON-AUTOMOTIVE

OIL & GAS

WIND POWER

RAILWAY

OFF HIGHWAY EQUIPMENT
Current management of refractory waste in Sidenor
Refractory consumption in Sidenor

Refractory consumption (2019)

11000 t/y

- **EAF**: 41% MgO-C bricks, 26% MgO masses, 8% Alumina and High Alumina bricks, 5% Alumina refractory concrete
- **Ladle**: 24% MgO-C bricks, 26% MgO masses, 8% Alumina bricks, 5% Alumina refractory concretes and masses
- **CC**: 35% MgO-C bricks, 5% MgO masses, 5% Isostatics, 8% Alumina bricks, 5% High Alumina refractory concretes and masses

**CURRENT MANAGEMENT OF REFRACTORY WASTE IN SIDENOR**

**Valorisation of refractory waste: latest developments & progress**

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### CURRENT MANAGEMENT OF REFRACOTORY WASTE IN SIDENOR

**Refractory waste generation in Sidenor**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>MAIN COMPONENT</th>
<th>PICTURE</th>
<th>DESTINATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>MgO-C in bulk</td>
<td>96.5% MgO</td>
<td></td>
<td>VALORISATION</td>
</tr>
<tr>
<td>MgO-C spent bricks</td>
<td>96.5% MgO</td>
<td></td>
<td>VALORISATION</td>
</tr>
<tr>
<td>High Alumina</td>
<td>&gt; 80% Al₂O₃</td>
<td></td>
<td>VALORISATION</td>
</tr>
<tr>
<td>Isostatics</td>
<td>50 - 60% Al₂O₃ (+80% ZrO₂) (+70%MgO)</td>
<td></td>
<td>LANDFILL</td>
</tr>
<tr>
<td>Continuous Casting tundish masses</td>
<td>&gt; 80% MgO</td>
<td></td>
<td>LANDFILL Work in progress</td>
</tr>
</tbody>
</table>

**Systematic and INTEGRAL valorisation of refractory waste**

- **MgO-C in bulk**: 96.5% MgO - VALORISATION
- **MgO-C spent bricks**: 96.5% MgO - VALORISATION
- **High Alumina**: > 80% Al₂O₃ - VALORISATION
- **Isostatics**: 50 - 60% Al₂O₃ (+80% ZrO₂) (+70%MgO) - LANDFILL
  Work in progress
- **Continuous Casting tundish masses**: > 80% MgO - LANDFILL
  Work in progress
CURRENT MANAGEMENT OF REFRACTORY WASTE IN SIDENOR

Adoption of the 4R Model

1R REDUCE
Minimize the refractory consumption through process optimization

2R REUSE
Direct reuse in a different application

3R REMANUFACTURE
Reuse in a different application after simple transformations

4R RECYCLE
Convert waste materials into new materials

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Adoption of the 4R Model: First steps

Refractory waste sorting

Violet containers are located in the steelworks, in the refractory waste main generation points.

1. EAF MgO-C bricks
2. Ladle High Alumina
3. CC Isostatics
Adoption of the 4R Model: First steps

Refractory waste sorting

Conditioned area divided by walls to separate MgO-C in bulk from High Alumina waste and MgO-C spent bricks.
Adoption of the 4R Model: First steps

Refractory waste sorting

Systematic palletisation of MgO-C spent bricks and disposal in an specific area.
CURRENT MANAGEMENT OF REFRACTORY WASTE IN SIDENOR

Implementation of the 4R Model: Ind. Applications

1. **Reuse** of MgO-C bricks from the EAF and LF wear lining to build an EAF Pre-wall.

2. **Reuse** of MgO-C bricks from the LF wear lining to build an Emergency Ladle.

3. **Reuse** of MgO-C or Alumina bricks to fill the Ladle Tapping Spout.
Implementation of the 4R Model: Ind. Applications

1. Replace the usual mixture material composed of dolomite lime and magnesia masses in the EAF Breast.

2. Channels in the ground to prevent water or other fluids from going to the pits.

3. Lining of the refining and bloom cooling pits

4. Support of the tundish lids in the Continuous Casting pavements
On-going projects & Latest developments
Latest European Projects

Systematic and integral valorization of refractories under the “5R” approach

Ecological and Economical waste management of the ladle refractory bricks by implementing circular economy criteria
ON-GOING PROJECTS
LIFE 5 REFRACT

Main figures:
- Started in July 2018
- Coordinator: Sidenor
- Total Project Budget: **1,675,395 €**
- Duration: “2 years” (27 months)

![Pie chart]

- MgO-C (bricks and bulk) **39%**
- MgO (masses) **46%**
- High Alumina **9%**
- Isostatics **6%**

CHALLENGING GOAL
Increase the potentially recoverable fraction including the MgO masses
ON-GOING PROJECTS

LIFE 5 REFRACT - Valorisation scope

Searching for high value added refractory products incorporating a significant amount of recycled refractory

Magnesia base
MgO-C bricks + Tundish masses (MgO)

Alumina base

Isostatics

Refractory masses for gunning

Refractory concretes
Groups of refractory waste

MgO-C in bulk
Groups of refractory waste

Tundish masses valorisation – Tilting area
<table>
<thead>
<tr>
<th>Waste group</th>
<th>Product</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1 MgO-C</td>
<td>New Product 1</td>
<td>EAF Gunning</td>
</tr>
<tr>
<td>Bulk</td>
<td>New Product 2</td>
<td>Ladle top ring gunning</td>
</tr>
<tr>
<td></td>
<td>New Product 7</td>
<td>EAF Steepbank</td>
</tr>
<tr>
<td></td>
<td>New Product 3</td>
<td>EAF Breast</td>
</tr>
<tr>
<td></td>
<td>New Product 8</td>
<td>EAF Gunning</td>
</tr>
<tr>
<td>P1 + P2</td>
<td>New Product 4</td>
<td>EAF Gunning</td>
</tr>
<tr>
<td></td>
<td>New Product 5</td>
<td>Ladle top ring gunning</td>
</tr>
<tr>
<td></td>
<td>New Product 6</td>
<td></td>
</tr>
</tbody>
</table>

% Recycled material in New Products *UP TO 70%*
ON-GOING PROJECTS
LIFE 5 REFRACT – Magnesia Base

Industrial Trials
Ladle gunning trials - Videos

**P1 based - New Product 1**

**P2 based - New Product 6**
ON-GOING PROJECTS
LIFE 5 REFRACT – Magnesia Base

Industrial Trials

**Example:** EAF Steepbank

**Example:** EAF gunning

**P1** New Product 7

**P1P2** New Product 8
ON-GOING PROJECTS

LIFE 5 REFRACT – Alumina Base

Groups of refractory waste

High Alumina

High Alumina + Isostatics

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### Industrial Trials

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<tr>
<td></td>
<td>New Product 3</td>
<td>Maintenance of the CC cooling chamber</td>
</tr>
<tr>
<td>High Alumina + Isostatics</td>
<td>New Product 4</td>
<td>Ladle top ring segments</td>
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<td></td>
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<td>Ladle top ring segments</td>
</tr>
<tr>
<td>Isostatics</td>
<td>Pending</td>
<td>Pending</td>
</tr>
</tbody>
</table>

% Recycled material in New Products **UP TO 65 %**
ON-GOING PROJECTS

LIFE 5 REFRACT – Alumina Base

Industrial Trials

High Alumina

New Product 1: Ladle top ring

New Product 3: Maintenance of the CC cooling chamber
ON-GOING PROJECTS
LIFE 5 REFRACT – Alumina Base

Industrial Trials

High Alumina + Isostatics

New Product 4: Ladle top ring segments
ON-GOING PROJECTS

LIFE 5 REFRACT – Alumina Base

Industrial Trials

New Product 5: Tundish lids

High Alumina + Isostatics

Tundish 1: cold area

Tundish 11: complete

Tundish 5: product 5

Tundish 1: cold area

Tundish 11: complete

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ON-GOING PROJECTS

LIFE 5 REFRACT: LIBS Technology

First Stage: Samples selection for LIBS calibration

Zr peak?
Final stage: Blind samples for LIBS validation

All grades covered
LCA / Life Cycle Analysis

Closed loop recycling:

Mining → Refractories production → SIDENOR Process 1 → Landfill

T Valorisation → T

Open loop recycling:

Mining → Refractories production → SIDENOR Process 1 → Landfill

T Raw materials → Other industries → Valorisation

Environmental Impact / Benefit CALCULATED

ON-GOING PROJECTS
LIFE 5 REFRACT

Valorisation of refractory waste: latest developments & progress
ON-GOING PROJECTS

RFCS E-CO-LADLEBRICK

**Main figures:**
- Started in June 2019
- Coordinator: Sidenor
- Total Project Budget: **1,280,225 €**
- Duration: 3 years (36 months)

**CHALLENGING GOAL**
Promote the “Reduce” stage in the 4R Model
**ON-GOING PROJECTS**

**RFCS E-CO-LADLEBRICK**

- *Reduction* of the volume of Magnesia-Carbon waste by means of monitoring the ladle refractory consumption in order to **optimise the ladle life**.
  - Low cost laser equipment to measure, even in hot conditions, the remaining refractory thickness (accuracy ±10 mm).
  - Novel model to predict the number of heats that the ladle may still be operational.

- Optimized application for the ladle spent bricks (new processes for Reusing, Remanufacturing and Recycling) based on an **expert decision tree**.
Ladle refractory thickness measurement
ON-GOING PROJECTS

RFCS E-CO-LADLEBRICK

Ladle refractory thickness measurement

Beginning of the cycle

End of the cycle
ON-GOING PROJECTS
RFCS E-CO-LADLEBRICK

Decision Tree

- Optical assessment of condition

- Technical properties

- Ecological and Economical Impact

Re-Use  Re-Manufacture  Re-Cycling
### Reducing Refractory Consumption

**Reduce** the refractory consumption by optimizing the **ladle life** (remaining brick thickness).

#### New Remanufacture/Recycle Applications Identified

- **MgO-C:** EAF Gunning, Ladle top ring gunning, EAF Steepbank, EAF Breast.
- **MgO masses:** EAF Gunning, Ladle top ring gunning.
- **High Alumina:** Ladle top ring, tundish lids, taddle tapping spout, Maintenance of the CC cooling chamber, Ladle top ring segments.
- **Isostatics:** Ladle top ring, tundish lids, tadle tapping spout, Maintenance of the CC cooling chamber, Ladle top ring segments.
Nowadays, the management of Magnesia-Carbon and Alumina reclaimed refractories in Sidenor is **totally consolidated**.

The work developed during the last 8 years has allowed the increase of the refractory waste recoverable fraction, and thus, the **global % valorisation**.

**New remanufacture applications** has been identified for the different kind of refractory waste, providing alternatives with **significant profit** (value added).

A **high innovative and important milestone** has been achieved: the **valorization of the MgO masses** from tundish.

Research must be focused on **minimizing** the % of refractory waste and the fraction dumped into landfill.
Thank you very much

aintzane.soto@sidenor.com
david.maza@sidenor.com