Dissemination of results of the European projects dealing with reuse and recycling of by-products in the Steel sector

Modelling, simulation and digital tools to improve slag reuse and recycling

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- The role of modelling, simulation and digital tools

- Application of a digital tool for evaluating slag reuse in EAF steelmaking

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Depending on the slag features, they can be:

- Internally Reused
- Externally Recycled

Substitution of fresh raw materials
Substitution of clinker in cement-making
Road construction
Solid improvements
Fertilizer
Etc.

The objective is to decrease as much as possible slag disposal.
Introduction

The objective is to decrease as much as possible slag disposal

Optimization of slag internal or external reuse and recycling

Pretreatments could be required

Economic and environmental impacts need to be considered

Consequences have to be investigated

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The role of modelling, simulation and digital tools

- Conventional Industrial Process Investigation Techniques
- Theoretical studies
- Experimental Campaign
- Industrial Process Simulation through standard and advanced tools
- Assessment of non-conventional scenarios difficult to evaluate or test
- Consideration of multiple aspects jointly
- Detailed Industrial Process Analyses

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The digital tool developed during EIRES RFCS project and continuously improved includes a **digital twin of EAF steelmaking production process**.

It has several functionalities and among others, it allows:

- monitoring the composition of slags
- Evaluating the process behavior and product effects in case of process modifications → e.g. in the case of reuse of slags

The effect of the exploitation of different ratio of LF and EAF slags have been evaluated.

Analysed scenarios:
- Standard process
- Complete reuse of LF slag
- Complete reuse of LF slag + partial reuse of EAF slag

Application of a digital tool for evaluating slag reuse in EAF stelmmaking

<table>
<thead>
<tr>
<th>Case Study</th>
<th>Steel Family</th>
<th>Recovered EAF slag</th>
<th>Recovered LF Slag</th>
<th>Recovered EAF slag/LF slag</th>
<th>Recovered LF slag/lime/dolime</th>
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<td>100%</td>
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</table>

Application of a digital tool for evaluating slag reuse in EAF stelmaking

- **Effects on steel composition:** Negligible for all the scenarios

- **Effects on EAF slag:**
  - the increase of slags reuse resulted in an increase of iron oxides and silica and in a decrease of calcium oxides and alumina

- **Effects on LF slag:**
  - not so significant

- **Best results in terms of sustainability are obtained without the reuse of EAF slag (CS_1)**
Application of a digital tool for evaluating slag reuse in EAF stelmaking

CS_1 – Steel Family A

- KPI₂: required electric energy
- KPI₁₂: specific non-metallic charge material
- KPI₁₄: metallic yield
- KPI₁₅: specific EAF slag
- KPI₁₈: specific LF slag
- KPI₂₁: total amount of slag

CS_1 – Steel Family B

- The continuous reuse of LF slag leads to a first significant change of considered KPIs during the first LF slag reuse but then they tend to stabilize toward asymptotical values without oscillations
- no significant changes in:
  - metallic yield
  - steel composition
- The tool allows virtually monitoring the composition of slags on a cast-by-cast basis → slags reuse can be evaluated case-by-case

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Combination of simulation and optimization tools for maximizing the recovery of valuable fractions of BOF slag

During REFFIPLANT and PSP-BOF project the following tools have been developed:

- A **flowsheet model for analysing the separation of the two main fractions of BOF slags** (i.e. magnetic and no-magnetic ones)

- An **optimization tool for maximizing the internal or external recovery of obtained fractions of BOF slags** (alone or combined with further by-products)

- A **simplified model for computing the chemical composition of pellets having the magnetic fraction of BOF slag as main component**
Combination of simulation and optimization tools for maximizing the recovery of valuable fractions of BOF slag

Two main BOF slag pre-treatment configurations were simulated \( \rightarrow \) the second one appears to be better

Different Magnetic Separations were investigated (e.g. wet high and low intensity, dry) \( \rightarrow \) wet high intensity gives better separation results

Combination of simulation and optimization tools for maximizing the recovery of valuable fractions of BOF slag

- The optimization tool allows multi-objective optimizations for maximizing the internal (e.g. pelletization) or external reuse (e.g. for fertilizer production) of separated fractions of BOF slags alone or combined with further by-products (i.e. BOF sludge, mill scale)

- Different combination of economic, environmental and quality factors were considered in the optimization analyses

- The jointly simulation and optimization tests with real experimentations allowed producing high quality pellets and founding the best solutions for improving the benefits
Combination of simulation and optimization tools for maximizing the recovery of valuable fractions of BOF slag

The optimal combination of internal (i.e., pellet production) and external recovery (e.g., fertilizer raw material) of BOF slag can produce significant revenues, although the management costs for the separation of slag fractions increase.


Slags are valuable by-products.

Optimization of internal and external slag reuse and recycling requires the evaluations of necessary pretreatments or the impacts and effects of their reuse.

Digital tools can help on these evaluation, especially if combined with real experimentations.

Conclusions

Zero slag disposal

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