AN EVALUATION OF THE PNEUMATIC LIME INJECTION BENEFITS FOR THE PRODUCTION OF C82D2 STEEL BY ELECTRIC ARC FURNACE

D. Mombelli, G. Dall’Osto, G. Villa, C. Mapelli, S. Barella, A. Gruttadauria, L. Angelini, C. Senes, M. Bersani, P. Frittella, R. Moreschi, R. Marras, G. Bruletti
TRADITIONAL PROCEDURE

Lime added in form of lumps

Essential for a Proper bath chemistry

Slag foamability

Bath dephosphorization
Lime injection allows to achieve:

- **Consumptions reduction**
- **Foaming benefits**
- **Operational cost benefits**
- **Environmental benefits**

**Evaluate and validate the benefits of injecting lime compared to the traditional practice for the production of special steels**

**AIM**
### EXPERIMENTAL PROCEDURES

#### Operational Profiles

- **STD**: 100% lime in lumps
- **INJ1**: Injected lime
- **INJ2**: INJ1 + 400 kg lime in lumps

#### Steel Grade and Procedure

<table>
<thead>
<tr>
<th>Steel grade</th>
<th>Procedure</th>
<th>N° of heats</th>
</tr>
</thead>
<tbody>
<tr>
<td>C82D2</td>
<td>STD</td>
<td>231</td>
</tr>
<tr>
<td>C82D2+Cr</td>
<td>INJ1</td>
<td>160</td>
</tr>
<tr>
<td></td>
<td>INJ2</td>
<td>163</td>
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</tbody>
</table>

#### Analyzed Data

- CaO Consumption
- Electrical Consumption
- O₂ and CH₄ Consumption
- Slag Amount

#### Slag Sampling

- At the beginning of refining
- At the end of refining

#### Foamability Analysis

- Isothermal Solubility Diagram (ISD)
- Total Harmonic Distortion (THD)
CaO CONSUMPTION

Interval Plot of CaO Addition [kg]
95% CI for the Mean

The pooled standard deviation is used to calculate the intervals.
Interval Plot of Total Electrical Consumption [kWh/t]

95% CI for the Mean

Theoretical Reduction

The pooled standard deviation is used to calculate the intervals.
**ELECTRICAL CONSUMPTION (REFINING)**

Interval Plot of Electrical Consumption [kWh/t]

95% CI for the Mean

The pooled standard deviation is used to calculate the intervals.
Interval Plot of Power On [min]
95% CI for the Mean

Savings in Power On time [min]

STD INJ1 INJ2

Procedure

The pooled standard deviation is used to calculate the intervals.
ELECTRICAL CO₂ EMISSIONS SAVINGS

Main Savings

- Lime: ~950 kg
- Electrical: ~32.5 kWh/t
- Power-On: ~1.25 min/heat

Assumptions

- Scrap Load: 88 ton
- Production: 4950 heat/year
- Eq. Factor: 0.2763 kgCO₂/kWh

<table>
<thead>
<tr>
<th></th>
<th>INJ1</th>
<th>INJ2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Savings [kWh/t]</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>Annual Savings [MWh/year]</td>
<td>13 068</td>
<td>15 246</td>
</tr>
<tr>
<td>Tons of Oil Equivalent saved</td>
<td>2443</td>
<td>2851</td>
</tr>
<tr>
<td>Tons of not emitted CO₂eq</td>
<td>3610</td>
<td>4212</td>
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</tbody>
</table>

Assumptions
Interval Plot of Oxygen Consumption [m3/t]

95% CI for the Mean

The pooled standard deviation is used to calculate the intervals.

Tukey Simultaneous 95% CIs
Differences of Means for Oxygen Consumption (m3/t)

If an interval does not contain zero, the corresponding means are significantly different.
Interval Plot of Methane Consumption [m3/t]

95% CI for the Mean

The pooled standard deviation is used to calculate the intervals.

Tukey Simultaneous 95% CIs
Differences of Means for Methane Consumption [m3/t]
METHANE CO₂ EMISSIONS SAVINGS

Assumptions

Scrap Load 88 ton
Production 4950 heat/year
Eq. Factor 0.2763 kg CO₂/kWh

<table>
<thead>
<tr>
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<th>INJ2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Savings [m³/t]</td>
<td>0.4</td>
<td>0.55</td>
</tr>
<tr>
<td>Specific Savings [kWh/t]</td>
<td>4.38</td>
<td>6.02</td>
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<tr>
<td>Annual Savings [MWh/year]</td>
<td>1907</td>
<td>2622</td>
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<tr>
<td>Tons of Oil Equivalent saved</td>
<td>357</td>
<td>490</td>
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<tr>
<td>Tons of not emitted CO₂eq</td>
<td>417</td>
<td>574</td>
</tr>
</tbody>
</table>
SLAG FOAMABILITY

Slag a bit "crusty"
No optimum foaming
Erosion of the EAF roof

Near optimum foaming
Refractory lifetime increased

Far from optimal condition
Slag composition in the range of possible slag foaming
TOTAL HARMONIC DISTORTION

Interval Plot of Total Harmonic Distortion
95% CI for the Mean

Individual standard deviations are used to calculate the intervals.
SLAG AMOUNT

Interval Plot of Slag Amount [t]
95% CI for the Mean

Reduction of 1 t of CaO
Variation in scraps properties and quality
SLAG MICROSTRUCTURE

Globular development (avg. size 2÷20 μm)

Development in 75% of samples

High fraction

Coarser morphology (higher lime amount)

Wüstite

3CaO · SiO₂

Brownmillerite

INJ2

INJ1

INJ2
SLAG AMOUNT IMPACT

Contour Plot of Slag Amount vs CaO and Oxygen

Scatterplot of Electrical Consumption and Slag Amount

Gianluca Dall’Osto
4th European Academic Symposium on EAF Steelmaking – 18th June 2021
The main results of the new lime injection technique and the furnace parameters enhancements are summarized as follows:

❖ **Lime** decreased by ~1000 kg
❖ **Electrical** decreased by $30\div35$ kWh/t (65% during refining)
❖ **Power-On** decreased by ~ 1.5 min
❖ **O$_2$ and CH$_4$** decreased by $1.5\div2.5$ m$^3$/t and ~$0.5$ m$^3$/t, respectively
❖ **Slag foamability** best foaming for INJ1 procedure (validated by ISD and THD)

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<th>INJ2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Savings [MWh/year]</td>
<td>14 975</td>
<td>17 868</td>
</tr>
<tr>
<td>Tons of Oil Equivalent saved</td>
<td>2790</td>
<td>3341</td>
</tr>
<tr>
<td>Tons of not emitted CO$_{2eq}$</td>
<td>4027</td>
<td>4786</td>
</tr>
<tr>
<td>$^1$Carbon tax savings [€]</td>
<td>120 810</td>
<td>143 880</td>
</tr>
<tr>
<td>$^2$Social cost savings [€]</td>
<td>744 995</td>
<td>887 260</td>
</tr>
</tbody>
</table>

Considering the **EPA carbon tax**$^1$ (30€/t$_{CO_2}$) and the **social cost savings** according to the **Stanford University**$^2$ (185€/t$_{CO_2}$)

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Thanks for your attention!

For any further information:

gianluca.dallosto@polimi.it