Ductile Iron Slag Management in Coreless Furnaces

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Ductile Iron Society Annual Meeting May 11-13, 2010 Surrey BC
Ductile Iron Slag Management in Coreless Furnaces

- Slag Generation and Handling Options
- Discussion of Analytical Testing and Results
- Tips on Minimizing Slag Generation
Slag Generation

Influential Factors

• Charge materials
• Alloy addition
• Preheat
• Fines removal
Charge Materials

Steel / Plate / Shred

- Sizing and flowability
- Surface area to weight ratio
- Coated or galvanized steel
- Be aware of micro contaminants

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Charge Materials

Remelt / Shop Scrap

- Blasted vs unblasted
- Flowability
- Filters

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Charge Materials

Pig Iron
- Great surface area : weight
- Use magnetic handling

Alloy Addition
- Use high quality
- Proper sizing
- Early but not first

Pre Heat / Fines
- Ensure fines removal
- Avoid excessive preheat

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Slag Removal

- Raking
- Twirl
- Scoop
- Clam Shell
Slag Removal

- Paddles
- Rakes
- Spoons
- Refractory coatings
- Clam shells
- Slag coagulant

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Slag Testing and Sampling

- Analysis with XRD/XRF
- Small Sample Size for Analysis
- Gathering Sample Critical
  - Gather 10-20 lbs
  - Crush large chunks
  - Pull out contaminants
  - Submit 3-5 lbs
Slag Testing and Sampling

- Don’t use slag coagulant
- Use proper tools
- Collect sample at the same time during melt cycle
- Collect sample at the same temperatures

- Establish baseline
- Sample frequency
Slag Testing and Sampling

- Ideas to Consider
  - Establish melt slag baseline
  - Take samples from holders
  - Take samples from ladles
  - Consider primary vs secondary slags

- Track charge condition
  - Track charge changes
  - Monitor alloy changes
  - Note any defect trends
# Slag Analysis

## Typical Analysis

<table>
<thead>
<tr>
<th>Element</th>
<th>Gray</th>
<th>Ductile</th>
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</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>65%</td>
<td>55%</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>10%</td>
<td>15%</td>
</tr>
<tr>
<td>MgO</td>
<td>2%</td>
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<tr>
<td>CaO</td>
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<tr>
<td>MnO</td>
<td>5%</td>
<td>5%</td>
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<tr>
<td>FeO</td>
<td>10%</td>
<td>10%</td>
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</tbody>
</table>

## Tramp Elements

<table>
<thead>
<tr>
<th>Element</th>
<th>Gray/Ductile</th>
</tr>
</thead>
<tbody>
<tr>
<td>P₂O₅</td>
<td>&lt;0.5%</td>
</tr>
<tr>
<td>K₂O</td>
<td>&lt;0.5%</td>
</tr>
<tr>
<td>TiO₂</td>
<td>&lt;1.0%</td>
</tr>
<tr>
<td>V₂O₅</td>
<td>&lt;0.2%</td>
</tr>
<tr>
<td>Na₂O</td>
<td>&lt;0.2%</td>
</tr>
<tr>
<td>Cr₂O₃</td>
<td>&lt;0.2%</td>
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</table>
## Slag Analysis

<table>
<thead>
<tr>
<th>Component</th>
<th>P₂O₅</th>
<th>B₂O₃</th>
<th>SiO₂</th>
<th>TiO₂</th>
<th>Al₂O₃</th>
<th>ZrO₂</th>
<th>FeO</th>
<th>PbO</th>
<th>CuO</th>
<th>Na₂O</th>
<th>MgO</th>
<th>MnO</th>
<th>CaO</th>
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<tbody>
<tr>
<td>Acidic</td>
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<tr>
<td>Basic</td>
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</tr>
</tbody>
</table>

V Ratio is

\[
\frac{\text{Sum of Basic Components}}{\text{Sum of Acid & Neutral Components}}
\]

- V Ratio > 1, Slag is Basic
- V Ratio = 1, Slag is Neutral
- V Ratio < 1, Slag is Acidic
Monitoring Slag Chemistry

Slag Chemistry Control

- Most coreless operations have SiO\textsubscript{2} refractory systems
- SiO\textsubscript{2} refractories require acidic slag
- Importance of SiO\textsubscript{2} in charge

Sources of SiO\textsubscript{2}
- Sand on remelt
- SiC addition
- Dirt
- Alloy loss
- Refractory wear
Monitoring Slag Chemistry

Sources of SiO₂

- Example Foundry “A”
  - Weigh remelt: 292.96 lbs
  - Blast remelt
  - Re weigh remelt: 291.92 lbs
  - Weight of sand on remelt: 1.04 lbs
  - % of sand on remelt: 0.355%

- They found that there will be 7.1 lbs of SiO₂ per ton of remelt

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Monitoring Slag Chemistry

Sources of SiO₂

- Example Foundry “A”
  - Adds 6000lbs remelt in a 12000lb charge
  - 6000lbs × 0.355% = 21 lbs sand/charge
  - Slag weight is 79.74 lbs/12000lb charge
  - SiO₂ addition from remelt will be 26.7% of slag weight
Monitoring Slag Chemistry

Sources of SiO₂

- SiO₂ from SiC
  - 50 lbs SiC addition
  - 7% SiO₂ in SiC
  - 3.5 lbs SiO₂ from SiC
  - SiO₂ addition from SiC will be 4.4% of slag weight

- SiO₂ from Remelt (21 lbs)  26.7%
- SiO₂ from SiC (3.5 lbs)    4.4%
- Total SiO₂ intentionally added (24.5 lbs)  31.1%

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Monitoring Slag Chemistry

- Analyzed SiO₂: 53.8%
- Added SiO₂: 31.1%
- Difference: 22.7%

- Slag weight: 79.74 lbs
- Missing 18 lbs of SiO₂

- Alloy Loss
- Refractory
- Dirt

<table>
<thead>
<tr>
<th>Slag Analysis</th>
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<tbody>
<tr>
<td>MgO</td>
<td>9.81</td>
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<tr>
<td>Al₂O₃</td>
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<td>SiO₂</td>
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<td>S</td>
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<tr>
<td>TiO₂</td>
<td>0.34</td>
</tr>
<tr>
<td>V₂O₅</td>
<td>0.06</td>
</tr>
<tr>
<td>Cr₂O₃</td>
<td>0.22</td>
</tr>
<tr>
<td>MnO</td>
<td>5.57</td>
</tr>
<tr>
<td>FeO</td>
<td>5.05</td>
</tr>
</tbody>
</table>
Minimizing Slag Generation

- Evaluate charge materials thoroughly
- Proper selection & addition of alloys
- Use of SiC
- Avoid excessive preheat

- Fines removal system
- Iron level in the furnace
- Lid use & condition
- Slag coagulant
- Right tools for the job