Relining of Pohang No.3 Blast Furnace

I. Outline
II. Relining Criterion
III. Relining Strategy
IV. Conclusion

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POSCO, Ho-soon JANG
1. Outline

- Pohang No.3BF (blow-in May, ’06) have been relined from ‘17.2 to ‘17.6
- Inner volume is enlarged from 4,350 to 5,600m³

**Major schedule**

<table>
<thead>
<tr>
<th>’15.3</th>
<th>’15.6</th>
<th>’15.8</th>
<th>’17.1</th>
<th>’17.2.23</th>
<th>’17.2.24</th>
<th>’17.5</th>
<th>’17.6.13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approval</td>
<td>Contract</td>
<td>Pre-construction</td>
<td>Delivered Facility</td>
<td>Blow-off</td>
<td>Construction</td>
<td>Test Operation</td>
<td>Blow-in</td>
</tr>
</tbody>
</table>

**Compare to P3R2**

<table>
<thead>
<tr>
<th></th>
<th>P3R2</th>
<th>P3R3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production (t/d)</strong></td>
<td><strong>P₀</strong> 9,610 (2.21)</td>
<td><strong>14,000 (2.50)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>P_max</strong> 10,100 (2.32)</td>
<td><strong>14,280 (2.55)</strong></td>
</tr>
<tr>
<td><strong>Inner Volume (m³)</strong></td>
<td>4,350</td>
<td>5,600</td>
</tr>
<tr>
<td><strong>Belly Dia. (m)</strong></td>
<td>14.0</td>
<td>15.6</td>
</tr>
<tr>
<td><strong>Throat Dia. (m)</strong></td>
<td>10.1</td>
<td>11.1</td>
</tr>
<tr>
<td><strong>Tuyere (Ea)</strong></td>
<td>38</td>
<td>42</td>
</tr>
<tr>
<td><strong>Top Pressure (kg/cm²)</strong></td>
<td>2.8</td>
<td>2.8</td>
</tr>
<tr>
<td><strong>Gas cleaning</strong></td>
<td>D/C+Bischoff</td>
<td>Cyclone+Bischoff</td>
</tr>
<tr>
<td><strong>Hot stove</strong></td>
<td>One Dome Type (Heating Area 76,000m²)</td>
<td>One Dome Type (Heating Area 80,000m²)</td>
</tr>
<tr>
<td><strong>Slag granulation</strong></td>
<td>6.0 t/min</td>
<td>9.5 t/min</td>
</tr>
</tbody>
</table>
2. Relining Criterion

- **Relining Criterion**
  - The most critical factor to decide relining is hearth remaining, generally considered the minimum remaining point is about 600mm.

- **Hearth Remaining (Calculation)**
  - It is calculated by factors material heat conductivity, thermocouple temperature, thermocouple insertion length, heat transfer coefficient, shell thickness and so on.

![Graph showing hearth remaining over time]

- **Design**
- **Y+0**
- **Y+1**
- **Y+2**
- **Y+3**
- **Y+4**
- **Y+5**
- **Y+6**
- **Y+7**
- **Y+8**
- **Y+9**
- **Y+10**

- **P3R2 ('06.5/4)**
2. Relining Criterion

**P3R2 Hearth Remaining (Actual)**

Remaining below No.3 TH (132°)

Confirmation of salamander (71°)

850mm

Salamander
## Extending campaign life

### Replacement of whole belly shell

<table>
<thead>
<tr>
<th>Date</th>
<th>Shutdown Time</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1\textsuperscript{st} '14.3.11</td>
<td>93Hr</td>
<td>17.6m (8EA), 35%</td>
</tr>
<tr>
<td>2\textsuperscript{nd} '14.5.13</td>
<td>86Hr</td>
<td>15.6m (7EA), 31%</td>
</tr>
<tr>
<td>3\textsuperscript{rd} '14.7.1</td>
<td>81Hr</td>
<td>17.6m (8EA), 35%</td>
</tr>
<tr>
<td>Total</td>
<td>260Hr</td>
<td>50.8m (23EA), 100%</td>
</tr>
</tbody>
</table>

√ Shell installed cooling plate need to be replaced since it happened many cracks and deformation

### Process of shell replacement

- Cutting deformation shell
- Setting the new shell
- Welding the new shell
- Spray the Belly part
3. Relining strategy for a long campaign

- **Design concept**

  ○ Smooth furnace profile is beneficial to extend a long campaign of BF (POSCO design guideline)

  ![Diagram of BF relining areas]

  **Strategy of a long campaign**

<table>
<thead>
<tr>
<th>Area</th>
<th>Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upper Shaft</strong></td>
<td>- Installed CI Stave for wear resistance and proper cooling ability</td>
</tr>
<tr>
<td><strong>Shaft Belly Bosh</strong></td>
<td>- Adopted dense Cooling plate with Graphite and SiC refractory for sufficient cooling ability ※ Expect a long campaign life (15→30 years)</td>
</tr>
<tr>
<td><strong>Hearth</strong></td>
<td>- Adopted additional one layer with BC-12SR for extending hearth campaign life</td>
</tr>
<tr>
<td></td>
<td>- <strong>Adopted larger block</strong> compared to the past</td>
</tr>
<tr>
<td></td>
<td>- To minimize refractory wear by sufficient pool depth</td>
</tr>
</tbody>
</table>
3. Relining strategy for a long campaign

**Furnace Profile**

- Decide throat, belly and hearth diameter in line with POSCO design guideline

**Graphs:**

- [Belly Dia. Vs Throat Dia]
- [Belly Dia. Vs Hearth Dia]
3. Relining strategy for a long campaign

- Keep going to find optimal bosh & shaft angle range according to productivity and efficiency.
Furnace Profile

- **[Pool Depth Vs Heath Dia.]**

- **[Tuyere~Taphole Vs Heath Dia.]**

- Tuyere~T.H Vol/I.V designed about 18% in the latest BF's relining for high productivity.
3. Relining strategy for a long campaign

**Refractory Design**

<table>
<thead>
<tr>
<th></th>
<th>Wear Factor</th>
<th>Bricks Design</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upper Shaft</strong></td>
<td>Mechanical $\gg$ Heat</td>
<td>Graphite+SiC 2 layers&lt;br&gt;Graphite 1 layer</td>
</tr>
<tr>
<td><strong>Lower Shaft</strong></td>
<td>Mechanical $\approx$ Heat</td>
<td>Graphite+SiC 1 layers&lt;br&gt;Graphite 2 layer</td>
</tr>
<tr>
<td><strong>Belly</strong></td>
<td>Mechanical $\approx$ Heat</td>
<td>All Graphite</td>
</tr>
<tr>
<td><strong>Bosh</strong></td>
<td>Mechanical $\ll$ Heat</td>
<td></td>
</tr>
</tbody>
</table>

- Designed refractory based on region wear factor
- Install SiC Bricks in the un-softened solid burden area to prevent wear of refractory
3. Relining strategy for a long campaign

**Design of Bosh & Tuyere**

- Reinforced cooling efficiency with graphite adoption in bosh part for skull formation
- Minimize the distance between tuyere cooler and first low of plate coolers to against abrasion
- Anti-abrasion with High-Alumina brick right above tuyere refractory
- Installed large tuyere Block for protecting tuyere cooler and tuyere
3. Relining strategy for a long campaign

**Design of Hearth**

- Reinforced cooling efficiency with the highest conductivity carbon (BC-12SR) in hearth wall
  - additional one layer with BC-12SR

- **Installed larger carbon in hearth corner area to avoid “elephant foot wear”**

- Upper refractories of bottom with ceramic cup

- Hearth shell with horizontal CI stave cooling

- Bottom cooled by water
### Design of Taphole

<table>
<thead>
<tr>
<th>Division</th>
<th>P4R2</th>
<th>P3R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity of Block</td>
<td>3Piece</td>
<td>2Piece</td>
</tr>
<tr>
<td>Design</td>
<td>![Diagram P4R2]</td>
<td>![Diagram P3R3]</td>
</tr>
</tbody>
</table>

- Designed 2 piece taphole refractory to minimize contact surface of refractory
4. Summary & Conclusion

■ Summary
○ We are trying to optimally designed large-sized Blast furnace for furnace life extension through lots of POSCO’s reline experience.

○ We expected to keep going high productivity & efficiency operation for a long time, as we adopted dense cooling plate at recently relining BFs.

○ We expected that BF Campaign life can be extended at least 10~15 years through replacement technology of Shell during ordinary shutdown period.

■ Future Plan
○ We are planning to find suitable furnace profile & cooling system when we will do partial relining with the lowest cost.

○ How long hearth campaign life without intermediate reline? And we need to develop intermediate hearth repair.
Thank you for listening!