On-Load Boiler Cleaning with Steam

March 16, 2017
FPK II – Combustion Chemistry II
Åbo Akademi University, Åbo
The Cleaning Systems at a Glance

1 Furnace
- Wall blower
- Water cannon

2 Superheater/Re-Heater
- Retractable sootblower
- Oscillating sootblower
- Axial sootblower
- Jetblower
- Part retractable sootblower
- SMART Helix

3 ECO
- Part retractable sootblower
- Rotating element sootblower

4 DeNOx
- Rake sootblower

5 Air heater/Gas heater
- Rake sootblower
- Jetblower

6 DeSOx
- Part retractable sootblower

Optimisation
- SMART Clean

Automation
- SMART Control
- Remote Control
Sootblower
Sootblower in operation
### Sootblower Solutions - Types

<table>
<thead>
<tr>
<th>Sootblower Description</th>
<th>Principle</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wall Blower</strong></td>
<td><img src="image1.png" alt="Wall Blower Principle" /></td>
</tr>
<tr>
<td>➡ Cleaning of wall heating surfaces with heavy slagging</td>
<td></td>
</tr>
<tr>
<td>➡ As steam or water blowers</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Retractable Sootblower</strong></th>
<th><img src="image2.png" alt="Retractable Sootblower Principle" /></th>
</tr>
</thead>
<tbody>
<tr>
<td>➡ cleaning of heating surface banks with heavy fouling and high flue gas temperatures</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Part Retractable Sootblower</strong></th>
<th><img src="image3.png" alt="Part Retractable Sootblower Principle" /></th>
</tr>
</thead>
<tbody>
<tr>
<td>➡ Cleaning of heating surface banks with heavy fouling</td>
<td></td>
</tr>
<tr>
<td>➡ Blowing tube remains in the flue gas pass</td>
<td></td>
</tr>
</tbody>
</table>
Content

- Sootblower solutions
- Sootblower technology for the furnace
  - Wall blower VS-H
- Sootblower technology for convective heat exchangers
  - Retractable sootblowers
    - PS-H, RSG-H, RXC-H
  - Part Retractable sootblowers
    - PS-HB, RSG-HB
- Important design features
Wall blower VS-H

- Nozzle head is axially moved into the boiler.
- Blowing process begins as soon as the nozzle head has passed through the tube wall.
- During the process, the tube wall is cleaned in circular form.
- On reaching the front end position, the direction of movement changes and the nozzle head returns to its starting position.
Wall blower VS-H

- Blowing arc: 30° to 360°
- Blowing medium: Steam, air
- Blower valve: Cast steel with adjustable throttle disc for varied blowing pressure
- Screw spindle:
  - Threaded tube with stuffing box casing
- Feed tube:
  - Stainless steel; Ø60 mm
- Nozzle head:
  - Heat resistant steel
VS-H – Functional aspects

- Gear Motor
- Sealing & Scavenging
- Air Fan
- Valve Actuating Mechanism
- Valve
- Electrical Equipment (not shown in fig. above)
- Wall Box
- Nozzle Head
- Construction Kit
- Screw Spindle
- Feed Tube
VS-H – Cleaning pattern

Cleaning pattern of VS-H wall blower

Spiral cleaning pattern due to wall blower type that advances into the boiler as it cleans
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  - Part retractable sootblowers
    - PS-HB, RSG-HB
- Important design features
Operating principle – Retractable sootblower

- Blowing medium – Steam, air
- The lance with two opposite, high-performance nozzles helically moves into the flue gas pass.
- The blowing process may begin as soon as the two nozzles have passed through the boiler wall.
- During the blowing process the lance tube continues to move helically into the flue gas pass.
- On reaching the front-side end position the direction of movement changes and the lance tube returns to its starting position.
Cleaning mechanism – Retractable sootblower
Retractable sootblowers

PS-H

RSM-H
Retractable sootblower

- **Travel:** 0,3m - 20m over single or double rack (heavy-duty)
- **Blower valve:** Cast steel with adjustable throttle disc for varied blowing pressure
- **Feed tube:**
  - Stainless steel; Ø60 mm or Ø70 mm
- **Lance tube:**
  - Creep resistant or high alloy steels
  - O.D. Ø88,9 mm, Ø101,6 mm and Ø114,3 mm
Retractable sootblowers (PS series)
Cleaning mechanism - Part Retractable sootblower
Part Retractable sootblower

- Travel: 0,3m - 8m over single or double rack (heavy-duty)
- Blower valve: Cast steel with adjustable throttle disc for varied blowing pressure
- Blowing tube:
  - Of material creep resistant steel or of higher alloyed steel
  - O.D. Ø60,3 / Ø 76,1 / Ø88,9 mm
  - With welded-in nozzles and element bearings
- Feed tube:
  - Stainless steel; Ø60 mm (or Ø70 mm in special cases)
- Lance tube:
  - Creep resistant or alloy steel
  - O.D. Ø88,9 mm (or Ø101,6 mm in special cases)
Failure due to axial crack formation
Failure due to surface pitting/axial crack formation
Failure due to spalling

Deposit Spalling

Jet Streamlines

Surface Pitting Area

Compressive Stress

Shear Stress

Mussmann, UoToronto 2009
Deposit break-up by steam jet

Thin deposit
Distance = 9 cm
Soft deposit

Break-up duration: 3 ms
Deposit break-up by steam jet

Thick deposit
Distance = 9 cm
Soft deposit

Break-up duration: 9.50 ms
Deposit asymmetry – Actual deposits in boilers

Boiler tubes → Deposit → Carry-over → Flue gas

Mussmann, UoToronto 2009
Deposit asymmetry

Symmetric

Asymmetric

Deposit

Steel tube

Mussmann, UoToronto 2009
Deposit asymmetry

90°

JET
Deposit asymmetry (0° vs. 90°)

Mussmann, UoToronto 2009
Sootblower solutions

Sootblower technology for the furnace
  → Wall blower VS-H

Sootblower technology for convective heat exchangers
  → Retractable sootblowers
    - PS-H, RSG-H, RXC-H
  → Part Retractable sootblowers
    - PS-HB, RSG-HB

Important design features
Sootblower Design Toolbox

System design

**Known Operating Conditions**

- 2. $P_a$ known

**Nozzle Selection**

- CPE III - 7/8" (12)
- CPE III - 1" (12)
- CPE III - 1.125" (4)
- CPE III - 1.25" (4)
- V - 4.6.6.1 mm (4)
- V - 5.6.6.7 mm (4)
- V - 6.5.1 mm (4)
- V - 7.9.10.1 mm (4)
- V - 11.5.13.6 mm (4)
- V - 12.5.16.2 mm (4)
- V - 16.19.9 mm (4)
- V - 19.19.5 mm (4)
- V - 22.5.26.3 mm (4)
- V - 27.9.30.8 mm (4)
- V - 30.9.36.2 mm (4)
- VM - 11.5.13.7 mm (4)
- VM - 15.5.15.8 mm (4)
- VM - 16.19.6 mm (4)
- VM - 19.21.9 mm (4)
- VM - 22.5.26.4 mm (4)
- VM - 27.9.30.8 mm (4)
- VM - 32.9.36.8 mm (4)
- None of the above, I'll specify my own nozzle design below

**Jet Profile & Nozzle Dimension**

- Jet profile will be calculated up to X_PIPE with an increment of DX_Jet

**Jet Profile**

- Distance from the nozzle exit (X_PIPE): 49.3
- Increment (DX_Jet): 25.4

**CAUTION:**

The program assumes that there is no flow separation inside the nozzle (Dex = the actual jet exit diameter). Note that too large of a divergence angle (i.e., greater than 10 deg) may result in flow separation where the actual jet exit diameter is less than the physical nozzle exit diameter.
Sootblower Design Toolbox

- Project specific input parameters
- Calculation of fluid flow and mechanical stability including heat transfer
- Calculation of droop correction, steam consumption and jet profile

Full Calc With Heat Transfer

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<table>
<thead>
<tr>
<th>Plant</th>
<th>EXAMPLE</th>
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<tbody>
<tr>
<td>Contract #</td>
<td>XXX</td>
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```
<table>
<thead>
<tr>
<th>ΔP Feed - Minor losses</th>
<th>ΔP Lance</th>
</tr>
</thead>
<tbody>
<tr>
<td>P, psi</td>
<td>P, psi</td>
</tr>
<tr>
<td>7.40</td>
<td>2.75</td>
</tr>
<tr>
<td>0.51</td>
<td>3.19</td>
</tr>
</tbody>
</table>
```

```
P p nozzle
76.07 psig 3.17 psig
5.30 bar (g) 3.31 bar (a)

T nozzle
668.81 F 0.00 psi
345.34 C 0.00 bar
```

P nozzle
8.25 psi 23.35 psia
0.50 bar (g) 161 bar (a)

```
Pכנסוי Pアー
0.259019
```

```
<table>
<thead>
<tr>
<th>AMBIENT CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>T Ambient</td>
</tr>
<tr>
<td>2.000 F</td>
</tr>
<tr>
<td>1083.3333 C</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Date Stamp</th>
<th>Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last Calculation : 15-Jun-09 5:19:31 PM</td>
<td>Steam P&amp; known</td>
</tr>
<tr>
<td>Last Reset  : 15-Jun-09 2:58:17 AM</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>P Ambient</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00 psig</td>
</tr>
<tr>
<td>0.00 bar (g)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flow Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.203 lb/hr</td>
</tr>
<tr>
<td>0.31 Kg/s</td>
</tr>
<tr>
<td>N/A SCFM</td>
</tr>
</tbody>
</table>
```
Quality of steam

**Dry- or Wet Steam?**

1: feeding Pressure  
   Temperature  
   30 bar  
   300 °C

2: Blowing Pressure  
   12 bar

3: Expansion at Nozzle  
   (1 bar)

Wet => Possible Erosion
Quality of steam

Dry- or Wet Steam?

1: feeding Pressure
   Temperature 30 bar 400°C

2: Blowing Pressure 12 bar

3: Expansion at Nozzle (1 bar)

Dry => Good Cleaning Performance
Recommended design principals for steam feeding systems

- Piping arrangement:
  - Inclination for proper draining.
  - Avoid “Christmas Tree” piping layout.

- Pre-heating control:
  - Draining temperature controlled, not time controlled.

- Cleaning sequence:
  - Start with sootblower nearest to the drain station.

- Short connecting pipe:
  - Secure complete pre-heating; avoid “cold” pipe parts.