Low Temperature Corrosion in a Waste Fired Boiler

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Introduction

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Varmland
Sweden

First fire 12/02/2010

27.4 MWth
10 t/h waste throughput

Keppel Seghers
Solutions for a Cleaner Future
Introduction

Solid Waste
- Waste pre-treatment
  - DANO® drum
- Waste-to-Energy
  - Air Pollution Control
  - Waste-to-energy plant

Water treatment
- Wastewater treatment
  - CAS, UNITANK®
  - Process- & Drinking water treatment
  - Desalination
  - NEWATER / MEMSTILL®

Sludge treatment
- Sludge drying/pelletising/incineration
  - ZEROFUELM™
- Sludge digestion
  - For energy recuperation
NextGenBioWaste-project

SP 2 - Boiler Optimisation

WP 2.6 : Ecoprobe

Life test of Acid Dewpoint in a WtE plant
Basics: Acid Dewpoint

ADT = Acid Dewpoint Temperature

\[
\begin{align*}
SO_2 (g) + \frac{1}{2} O_2 (g) & \rightarrow SO_3 (g) \\
SO_3 (g) + H_2 O (g) & \rightarrow H_2 SO_4 (g) \\
H_2SO_4 (g) & \xrightarrow{T < ADT} H_2SO_4 (l)
\end{align*}
\]

- Presence of catalyst
- Fly ash as absorber
- Soot as condensation site
- Excess air conditions
- Water content
- Temperature

Objectives

Goals
- Collection of plant-scale data on acid dewpoint corrosion at the exit of a WtE-boiler
- Experimental assessment of risk on acid dewpoint corrosion

Ultimate aim
Optimisation of WtE-boiler design by reducing excessive safety margins on:

- BFW-temperature
- Flue Gas temperature

Increase efficiency - increase operational revenue
Objectives

Simulation - potential electrical efficiency gain
Approach

How?

• Insert water-cooled probe of economiser material (ST45.8) in end boiler near economizer section

• Observe corrosion phenomena (s.a. type, depth, intensity, …) at various temperatures for 60 days
Ecoprobe

and many other ...
Experimental set-up

Set-up

- 3-way valve
- Expansion vessel
- Pump
- Heater
- Boiler wall
- PROBE
Antwerpen-Wilrijk (Flanders)

Client: ISVAG

Capacity: 2 x 288 tonnes/day

Calorific value: 8 MJ/kg

Thermal power: 2 x 28 MW<sub>th</sub>

Electrical power: 12 MW<sub>e</sub>

Flue gas treatment: SNCR + ESP + semi dry + AC injection + fabric filter + wet

Capacity: 2 x 65,000 Nm³/h

Start-up: 1999
Range of Measurement

Estimation of expected ADT

Plant data ISVAG:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flue gas flow</td>
<td>56 000</td>
<td>Nm³/h</td>
</tr>
<tr>
<td>O₂</td>
<td>6 - 8</td>
<td>Vol. %</td>
</tr>
<tr>
<td>H₂O</td>
<td>12 - 15</td>
<td>Vol. %</td>
</tr>
<tr>
<td>HCl</td>
<td>600 – 1500</td>
<td>mg/Nm³ 11%O₂ dry</td>
</tr>
<tr>
<td>SOₓ</td>
<td>50 - 350</td>
<td>mg/Nm³ 11%O₂ dry</td>
</tr>
<tr>
<td>T</td>
<td>250</td>
<td>°C</td>
</tr>
</tbody>
</table>

Dewpoint expected between 105 and 120 °C

Experiments

T = 60 days

<table>
<thead>
<tr>
<th>Test</th>
<th>Temperature [°C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>blanc</td>
<td>125</td>
</tr>
<tr>
<td>test 1</td>
<td>105</td>
</tr>
<tr>
<td>test 2</td>
<td>100</td>
</tr>
<tr>
<td>test 3</td>
<td>90</td>
</tr>
<tr>
<td>test 4</td>
<td>80</td>
</tr>
</tbody>
</table>
Results

T = 0 days
Results

T = 30 days
Results

SEM-pictures
Magnitude 200 x
Nital surface treatment
(a) Blanc
(b) 90°C
(c) 80°C
Results

Corrosion depth [% of section]

<table>
<thead>
<tr>
<th>Temperature [°C]</th>
<th>Corrosion Depth [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>90</td>
<td>10</td>
</tr>
<tr>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td>105</td>
<td>10</td>
</tr>
<tr>
<td>125</td>
<td>20</td>
</tr>
<tr>
<td>new</td>
<td>0</td>
</tr>
</tbody>
</table>
Cl

125°C

105°C

100°C

90°C

80°C

Analyse

%O  30,35
%Al  0,2
%Si  0,27
%Cl  11,37
%Ca  0,63
%Fe  57,18
# Results overview

<table>
<thead>
<tr>
<th>Depth (mm)</th>
<th>0.4 to 0.6</th>
<th>0.15</th>
<th>0.1 to 0.15</th>
<th>0.2 to 0.35</th>
<th>2.0 to 2.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>decrease thickness tube wall</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Cl</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td>S</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Summary

• Superficial corrosion at 125, 105, 100 and 90 °C

• No significant difference between 125, 105, 100 and 90°C

• Very intense corrosion at 80°C

• Cl appears to contribute (HCl ?)
Conclusions

• The onset of low temperature corrosion in a waste fired boiler is situated between 80 and 90°C (FGT 240°C)

• BFW at 105°C represents no corrosion risk

• Room for Energetic/Revenue optimisation
Thank you for your attention