Anode Butts & Stubs Inspection

On Line analysis of butts and stubs

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Process Overview

Anode Life Cycle

- Anode rodding
- About 25 days inside the pot
- Removal from the pot ("anode butt")
- Cooling period
- Cleaning
- **Anode butt inspection**
- Removal of residual carbon and cast iron for recycling
- **Stub inspection**
- Anode rodding
Manual Inspection of Anode butts and stubs

- Human visual inspection is qualitative.
- Quantity of measurements are limited.
- Limited number of parameters actually measured.
- Manual measurements are made on sample quantities which provide partial feedback of the information available at the rodding shop.
- Human resources are required.
- Measurements and inspection can be subjective, inaccurate and not consistent.
Inspection of Anode butts

• Characterization of anode butts provides feedback that allows:
  • Optimization of the anode life cycle
  • Optimization of the anode quality – fab. recipe
  • Improvements of performances of electrolysis cells
Automatic Inspection of anode butts and stubs

Technical objectives

• Automate anode stubs inspection.
• Get more information on the conditions of the stubs and butts.
• Get a feedback on 100% of the anode butts.
• Deliver reliable and consistent measurements.
Brief System Description

Anode butts & anode stubs analysis

Plant database

Data analysis

PLC

Network

Weighing Station 1

Anode butt analyser

Carbon & cast iron removal

Weighing Station 2

Stub analyser

HMI

Reuse

Repair area
Anode Butt Inspection System
Anode Butt Inspection System
Anode Stub Inspection System
Anode Stub Inspection System
Example of Stubs for inspection
Example of Stubs for inspection
Stub Analysis
Three different point of view
Stub Analysis Measurements

1 - Min. diameter

2 - Height

3 - L&R spacing - Cowboy Effect

4 - Cast iron

5 - Corrosion Ex.: 25%
# Stubs Analysis Measurements

<table>
<thead>
<tr>
<th>Measure #</th>
<th>Item Description</th>
<th>Measured Dimension</th>
<th>Figure</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Reference line perpendicular to rod</td>
<td>Reference line perpendicular to rod</td>
<td>3.1</td>
</tr>
<tr>
<td>B</td>
<td>Yoke reference line</td>
<td>Angle measured between A and B (deg)</td>
<td>3.1</td>
</tr>
<tr>
<td>1</td>
<td>Left stub absolute length</td>
<td>Length of left stub from to line B (mm)</td>
<td>3.1</td>
</tr>
<tr>
<td>2</td>
<td>Center stub absolute length</td>
<td>Length of center stub from to line B (mm)</td>
<td>3.1</td>
</tr>
<tr>
<td>3</td>
<td>Right stub absolute length</td>
<td>Length of right stub from to line B (mm)</td>
<td>3.1</td>
</tr>
<tr>
<td>4</td>
<td>Left stub minimum diameter</td>
<td>Minimum diameter of left stub (mm)</td>
<td>3.2</td>
</tr>
<tr>
<td>5</td>
<td>Center stub minimum diameter</td>
<td>Minimum diameter of center stub (mm)</td>
<td>3.2</td>
</tr>
<tr>
<td>6</td>
<td>Right stub minimum diameter</td>
<td>Minimum diameter of right stub (mm)</td>
<td>3.2</td>
</tr>
<tr>
<td>7</td>
<td>Inside distance between outer stubs</td>
<td>Minimum inside distance between outer stubs, parallel to line A (mm)</td>
<td>3.3</td>
</tr>
<tr>
<td>8, 9, 10</td>
<td>Left stub erosion from the point of view of cameras 1(Right), 2(Center) and 3(Left).</td>
<td>Projected surface of the lower 180 mm of the stub compared to a new stub (%). For example, 20% erosion means that 20% of the projected surface is eroded. The blue boxes on Figure 3.4 illustrate the surface area corresponding to a new stub. Usually, the worse measurement, coming from the 3 points of view, is used to accept or reject the stub.</td>
<td>3.4</td>
</tr>
<tr>
<td>11, 12, 13</td>
<td>Center stub erosion from the point of view of cameras 1, 2 and 3.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14, 15, 16</td>
<td>Right stub erosion from the point of view of cameras 1, 2 and 3.</td>
<td>Width of cast iron detected on each side of the stub, perpendicular to the stub length, outside of the diameter of the stub (new) (mm). The yellow boxes, drawn on either side of each stub in each of the three views and illustrated on Figure 3.5, are used to detect the cast iron. Usually, the worse measurement coming from the 3 points of view is used to accept or reject the stub.</td>
<td>3.5</td>
</tr>
<tr>
<td>17, 18, 19, 20, 21, 22</td>
<td>Cast iron remaining on the left stub from the point of view of cameras 1(Right), 2(Center) and 3(Left).</td>
<td>Width of cast iron detected on each side of the stub, perpendicular to the stub length, outside of the diameter of the stub (new) (mm). The yellow boxes, drawn on either side of each stub in each of the three views and illustrated on Figure 3.5, are used to detect the cast iron. Usually, the worse measurement coming from the 3 points of view is used to accept or reject the stub.</td>
<td></td>
</tr>
<tr>
<td>23, 24, 25, 26, 27, 28</td>
<td>Cast iron remaining on the center stub from the point of view of cameras 1, 2 and 3.</td>
<td>Width of cast iron detected on each side of the stub, perpendicular to the stub length, outside of the diameter of the stub (new) (mm). The yellow boxes, drawn on either side of each stub in each of the three views and illustrated on Figure 3.5, are used to detect the cast iron. Usually, the worse measurement coming from the 3 points of view is used to accept or reject the stub.</td>
<td></td>
</tr>
<tr>
<td>29, 30, 31, 32, 33, 34</td>
<td>Cast iron remaining on the right stub from the point of view of cameras 1, 2 and 3.</td>
<td>Width of cast iron detected on each side of the stub, perpendicular to the stub length, outside of the diameter of the stub (new) (mm). The yellow boxes, drawn on either side of each stub in each of the three views and illustrated on Figure 3.5, are used to detect the cast iron. Usually, the worse measurement coming from the 3 points of view is used to accept or reject the stub.</td>
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</tbody>
</table>
# Stub Analysis (Tripod) Repetability

Measurements of 50 consecutive inspections (in mm)

<table>
<thead>
<tr>
<th></th>
<th>Left stub</th>
<th>Central stub</th>
<th>Right stub</th>
<th>Space between left and right stubs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Min. value</strong></td>
<td>166.3</td>
<td>141.1</td>
<td>165.4</td>
<td>164.3</td>
</tr>
<tr>
<td><strong>Max. value</strong></td>
<td>168.3</td>
<td>142.2</td>
<td>169.3</td>
<td>177.4</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>167.4</td>
<td>141.8</td>
<td>168.5</td>
<td>781.7</td>
</tr>
<tr>
<td><strong>Std deviation</strong></td>
<td>0.3</td>
<td>0.5</td>
<td>0.8</td>
<td>0.6</td>
</tr>
<tr>
<td><strong>Height</strong></td>
<td>451.2</td>
<td>477.0</td>
<td>449.0</td>
<td>782.7</td>
</tr>
</tbody>
</table>
Stub Analysis (Tripod)
Example of Reports – Min Stub Diameter
Stub Analysis (Tripod)  
Example of Reports – % Erosion
Anode Butt Analysis
Anode Butt Analysis

• The anode butt inspection system performs more than 20 different measurements.

• The following measurements are presented:
  • Classification by defects.
  • Bath remaining on carbon
  • Carbon thickness remaining underneath the cast iron thimbles.
Anode Butt Analysis
Classification by Defects

Some examples of abnormal shapes
Anode Butt Analysis
Classification by Defects

<table>
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<tr>
<th>MEASURE #</th>
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<td>A</td>
<td>Reference line perpendicular to rod</td>
<td>3.1</td>
</tr>
<tr>
<td>B</td>
<td>Angle measured between A and B</td>
<td>3.1</td>
</tr>
<tr>
<td>C</td>
<td>Angle measured between A and C</td>
<td>3.1</td>
</tr>
<tr>
<td>D</td>
<td>Angle measured between A and D</td>
<td>3.1</td>
</tr>
<tr>
<td>E,F,G,H</td>
<td>Search for surface within the window</td>
<td>3.1</td>
</tr>
<tr>
<td>I,J,K,L,M,N,O</td>
<td>Measures the surface area within each window (1 to 7) (mm$^2$)</td>
<td>3.2</td>
</tr>
<tr>
<td>P1,P2,P3</td>
<td>Surface area of the defects, height, width and location within zones 1-7 (mm$^2$, mm, mm, 1 to 7) The figure 3.6 presents an example of automated deformation classification based on the measurements P</td>
<td>3.2 &amp; 3.7</td>
</tr>
<tr>
<td>Q</td>
<td>Measures lost carbon surface (ratio)</td>
<td>3.3</td>
</tr>
<tr>
<td>R</td>
<td>Projected butt surface (sum of measurements I to O)*(mm$^2$)</td>
<td>3.4</td>
</tr>
<tr>
<td>S,T,U</td>
<td>Carbon heights left under each stub (mm)</td>
<td>3.5</td>
</tr>
<tr>
<td>V</td>
<td>Ratio of; the surface areas with white bath remaining, on the total surface area of the anode butt (R).</td>
<td>3.6</td>
</tr>
</tbody>
</table>
Anode Butt Analysis Classification by Defects

- Database reporting software uses the threshold values to automatically classify families of defects.

Raw Measurements From Anode Butt Inspection System  →  Plant Database  →  Reporting Software to Automate the Classification
<table>
<thead>
<tr>
<th>Characterizations of defects</th>
<th>Zones (Z)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width (W)</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>Height (H)</td>
<td></td>
</tr>
<tr>
<td>Zone (Z)</td>
<td></td>
</tr>
<tr>
<td>Surface (S)</td>
<td></td>
</tr>
</tbody>
</table>

**Family 1 (Mushroom)**
- Ratio $W/H$ low
- Zones 2 to 6

**Family 2 (Belly)**
- Ratio $W/H$ high
- Zones 2 to 6

**Family 3 (Heel)**
- Zones 1 and 7
Anode Butt Analysis
Classification by Defects

Family 4 (Uneven)
- Difference between A1 & A2 angles

Family 5 (Incomplete)
- Carbon surface remaining into zones 1, 3, 5 & 7

Family 6 (Oxidized (top))
- Surface of carbon remaining into a predefined area (new anode shape)
Anode Butt Analysis
Remaining bath on carbon
Anode Butt Analysis
Carbon Thickness

Carbon thickness remaining underneath the cast iron thimbles is determined when combining measurements from both equipment.

- Anode butt inspection system
- Anode stub inspection system
Conclusion

• Both systems are in operation at Alcoa Deschambault since May 2006.
• 100% of the anode butts and anode stubs processed in the rodding shop are automatically measured and analysed.
• These systems are fully automated.
• Statistic distributions of families of defects and stub statistics are continuously monitored.
• Both systems have proven to be reliable and easy to maintain.
Questions?