Opportunities within the Alumina Refineries to Make Bauxite Residue Easy to Downstream Use

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Why is most BR difficult to use?

Because

• Soda content being between the extremes of 0.7% and 12.3% Na$_2$O, **average is 5.5%** (48 BRs from refineries). The soda content is in the form of
  ➢ chemically combined soda
  ➢ soluble soda

• Physical appearance (consistency) of most residues
Sources of chemically combined soda

Reactions of clay minerals (Al$_2$O$_3$.2SiO$_2$.2H$_2$O) and quartz content (SiO$_2$) of bauxite, such as:

- During the low temperature digestion (140-150°C) kaolinite reacts with NaOH and sodalite type desilication product (DSP) is formed $3$(Na$_2$O.Al$_2$O$_3$.2SiO$_2$.$(1-2)$H$_2$O).Na$_2$X, where X=CO$_3^{2-}$, 2AlO$_2^-$, 2OH$^-$, 2Cl$^-$, SO$_4^{2-}$

- In the course of high temperature digestion (240-280°C) both clay minerals and quartz react with NaOH and dissolved alumina and a mix of sodalite and cancrinite DSP is formed. At higher temperature cancrinite is preferred.
Options to reduce chemically combined soda

- Lime addition to the digestion
- Hydrothermal treatment of BR in presence of lime
- Pyrometallurgical processing of BR
- Improved Low Temperature Digestion (ILTD) and related processes
Lime addition to the digestion
Digestion yield and combined soda content in case of a diasporic bauxite at 250°C

Digestion yield vs. lime addition

Na$_2$O/SiO$_2$ in BR

%CaO for bx.

CaO/SiO$_2$ in bx

Soda content in BR vs lime addition

Conditions d'attaque:
- temperature = 250°C
- concentration = Na$_2$O = 220 g/l
- duree = 50 minutes
Hydrothermal treatment of BR in presence of lime

- **Causticization**: conventionally at about 90-100°C
  - Product: $3\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot k\text{SiO}_2 \cdot (6-2k)\text{H}_2\text{O}$, $k \sim 1.5$

- **Hydrothermal treatment**: at high temperatures, over 260°C, very low A/C ratio < 0.2
  - Soda recovery about 90%
  - $\text{Al}_2\text{O}_3$ recovery possibly up to 70%
  - Hydrogarnet product: $3\text{CaO} \cdot \text{Fe}_2\text{O}_3 \cdot 2\text{SiO}_2$
Soda recovery from BR at 3 mol CaO/mol Na$_2$O (lab tests)
# Pyrometallurgical processing of BR

<table>
<thead>
<tr>
<th>Origin of bauxite</th>
<th>Weipa</th>
<th>Trombetas</th>
<th>South Manchester</th>
<th>Darling Range</th>
<th>Iszka</th>
<th>Parnasse</th>
<th>Arkansas</th>
<th>Pavlodar</th>
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<tbody>
<tr>
<td></td>
<td>Australia</td>
<td>Brazil</td>
<td>Jamaica</td>
<td>Australia</td>
<td>Hungary</td>
<td>Greece</td>
<td>USA</td>
<td>Kazakhstan</td>
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<tr>
<td>Digestion temperature</td>
<td>240°C</td>
<td>143°C</td>
<td>245°C</td>
<td>143°C</td>
<td>240°C</td>
<td>260°C</td>
<td>serial combined</td>
<td>serial combined</td>
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<tr>
<td>Components , %</td>
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<tr>
<td>Al₂O₃</td>
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<td>13.0</td>
<td>10.7</td>
<td>14.9</td>
<td>14.4</td>
<td>13.0</td>
<td>5.5</td>
<td>3.7</td>
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<td>SiO₂</td>
<td>15.0</td>
<td>12.9</td>
<td>3.0</td>
<td>42.6</td>
<td>12.5</td>
<td>12.0</td>
<td>23.1</td>
<td>21.6</td>
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<td>Fe₂O₃</td>
<td>36.0</td>
<td>52.1</td>
<td>61.9</td>
<td>28.0</td>
<td>38.0</td>
<td>41.0</td>
<td>10.1</td>
<td>21.3</td>
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<td>TiO₂</td>
<td>12.0</td>
<td>4.2</td>
<td>8.1</td>
<td>2.0</td>
<td>5.5</td>
<td>6.2</td>
<td>3.6</td>
<td>n.a.</td>
</tr>
<tr>
<td>Na₂O</td>
<td>9.0</td>
<td>9.0</td>
<td>2.3</td>
<td>1.2</td>
<td>7.5</td>
<td>7.5</td>
<td>3.6</td>
<td>1.2</td>
</tr>
<tr>
<td>CaO</td>
<td>-</td>
<td>1.4</td>
<td>2.8</td>
<td>2.4</td>
<td>7.6</td>
<td>10.9</td>
<td>47.2</td>
<td>43.4</td>
</tr>
<tr>
<td>Others</td>
<td>3.5</td>
<td>1.0</td>
<td>2.8</td>
<td>2.4</td>
<td>4.9</td>
<td>2.3</td>
<td>2.5</td>
<td>8.8</td>
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<tr>
<td>LOI</td>
<td>7.3</td>
<td>6.4</td>
<td>8.4</td>
<td>6.5</td>
<td>9.6</td>
<td>7.1</td>
<td>4.4</td>
<td>n.a.</td>
</tr>
</tbody>
</table>
Improved Low Temperature Digestion (ILTD) Process

Principal features:
✓ no predesilication is needed
✓ high A/C ratio, short digestion time
✓ separation of the low soda bauxite residue just after the digestion preferably with Hi-Bar Filtration
✓ seeded pressure crystallization of the Desilication Product (DSP) out of the liquid phase.
✓ Material and energy costs: about 15% savings
ILTD vs. CLTD basics

Modified Sumitomo chart
Extraction yield for gibbsite at 150°C
Dissolved silica at 150°C

Dissolved silica, g/l

BR separation

Reaction time, min
Combined Na$_2$O in BR at 150$^\circ$C
Composition of low soda bauxite residue of ILTD Process

- $\text{Al}_2\text{O}_3$: 9.2%,
- $\text{SiO}_2$: 5.8%
- $\text{Fe}_2\text{O}_3$: 70.4%
- $\text{TiO}_2$: 4.1%
- $\text{Na}_2\text{O}_{\text{combined}}$: 0.6%
- $\text{Na}_2\text{O}/\text{SiO}_2$: 0.1

Average BR composition of two parallel tests at 150°C, 6 min batch reaction time
Washing/dewatering means of BR

• Conventional washer
• Deep cone thickener
• Vacuum drum filter
• Leaf filter press
• Hi-Bar Steam Pressure filtration
Dewatering and Disposal Methods for Red Mud

- **Thickeners**: MC = 48 – 55%
  - Pond (wet) disposal

- **Drum Filters**: MC = 35 – 50%
  - Pond (wet) disposal
  - Dry stacking

- **Filter Press**: MC = 30 – 32%
  - Dry stacking

- **Hi-Bar Steam Pressure Filtration**: MC ≤ 28%
  - Low caustic & thixotropic
  - Industrial re-usage
  - Dry disposal
Moisture contents, soluble soda contents at different means of de-watering

- **Conventional washer**
  - 2,079 kg
  - Liquid per t solids
  - 1,220 kg
  - Liquid per t solids
  - mc = 50 – 55%
  - Thixotropic
  - Na₂O₂: 0.61%

- **Deep cone thickener**
  - 540 kg
  - mc = 35 – 50%
  - Thixotropic
  - Na₂O₂: 0.27%

- **Vacuum drum filter**
  - 470 kg
  - mc = 32%
  - Thixotropic
  - Na₂O₂: 0.24%

- **Filter press**
  - 330 kg
  - mc < 25%
  - Bulky
  - Na₂O₂: 0.17%

- **Steam Pressure Filtration**
  - 2,079 kg
  - Liquid per t solids
  - 1,220 kg
  - Liquid per t solids
  - mc = 50 – 55%
  - Thixotropic
  - Na₂O₂: 0.61%
## Physical appearance, soluble soda content of BR

<table>
<thead>
<tr>
<th></th>
<th>Conventional washer</th>
<th>Deep cone thickener</th>
<th>Vacuum drum filter</th>
<th>Filter press</th>
<th>Steam pressure (HiBar) filter</th>
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</thead>
<tbody>
<tr>
<td>Solids material, t</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>U/F solids, %</td>
<td>30-35</td>
<td>45-50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>moisture content%</td>
<td>65-70</td>
<td>50-55</td>
<td>35-50</td>
<td>32</td>
<td>25</td>
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<tr>
<td>liquid phase</td>
<td>2,079</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>liquid phase remaining with BR at disposal, kg</td>
<td>1,220</td>
<td>1,220</td>
<td>540</td>
<td>470</td>
<td>330</td>
</tr>
<tr>
<td>BR easy to handle</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Na$<em>2$O$</em>{\text{soluble}}$, %</td>
<td>0.61</td>
<td>0.61</td>
<td>0.27</td>
<td>0.24</td>
<td>0.17</td>
</tr>
</tbody>
</table>
Recommended soda content for the further use of BR

- Should be determined on case by case
- In general: < 3% Na₂O
Thank you for your attention!