Red mud pressure filtration for the alumina refinery’s bauxite residue tailings disposal

Red Mud Pressure Filtration

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Key Points:

- 2.5 tons of red mud residue per ton of Al₂O₃ produced
- Red mud pond dam failure at the Ajka refinery in Hungary in 2010 raised awareness
- Actions are underway at many producers to implement new strategies
- Thickened underflows can be efficiently dewatered into high solids filter press cakes that can be safely stacked in dry storage areas
Red Mud Disposal Strategies

Evolution of disposal strategies from low to high density disposal techniques

River/Sea Dumping
- Slurries at low densities (25–30wt%)
- Dyke height has to be above slurry level
- Largely abandoned practice

Mud Lakes
- Slurries at low densities (25–30wt%)
- Dyke height has to be above slurry level

Dry Storage
- Strategy for filter cake disposal (e.g. filter press) (70–80wt%)
- Transfer to disposal area by truck or conveyor belt & mobile stacker
- Farming techniques for cake compaction
- Dyke height typically below mud level

Dry Stacking
- Disposal strategy for high density slurries (45–65wt%)
- Transfer to disposal area by pumping
- On site farming techniques to increase solids concentration & stability
- Dyke height typically below mud level

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Red Mud Disposal

Alumina Refinery
Red Mud Flow Sheet

- Red mud slurry is thickened and washed
- Dewatering of red mud from final thickener in circuit:
  - Typical red mud drum filters
  - Alternative pressure filters and
    - Transport of cake with conveyor
    - Placement in storage area
    - Utilizing Mobile Stacking Conveyor
Red Mud is Produced from Thickeners

Modern high density sloped bottom thickeners are specially designed to meet the demands of extremely large red mud tonnages, producing high solids in the underflows.

Early Design Flat-Bottom Thickener

Modern HiRate High Density Thickeners
Solids of greater than 50% can be reached
Counter current decantation circuits provide maximum soda recovery

• The high density thickeners are used as washers when specifically arranged to control the amount of residual caustic in the mud discharged in the final underflow.

• These settler-washer units are set up in series to facilitate a counter current decantation (CCD) system to provide maximum soda recovery for the plant at the highest achievable efficiency.
Traditionally, for more than 40 years, rotary drum vacuum filters (RDVF) have been used for red mud filtration and additional washing after the final settler-washer.

Red mud can be transported by truck to the dry stacking disposal area.

The mud can also be re-slurried and pumped to disposal.
Red mud pumped to disposal area

The red mud is thixotropic and filter cake discharged from the RDVF can be shear thinned for pumping to the disposal site.
Automatic filter presses producing high solids filter cake

- Cake is washed for increased caustic recovery
- Automatic discharge of cake to conveyor below the filter press
- High-solids cake may be transported to disposal area by conveyors
- Red mud cake may be distributed into the storage area with automated mobile stackers
Automated pressure filters

Automated Filter Presses

- Pressure filters operate at 15 bar and produce higher solid content filter cakes
- Cake is no longer thixotropic and can be conveyed and stacked for dry storage
- Efficient cake washing is possible for additional soda recovery
- High pressure cloth washing is automatic in operation

2x2 Meter Filter Press – 1,000 sq M
Batch Pressure Filters
Filter Press Process Steps
Batch Sequence of Operation

- Filling to Fully Vent the Filter
- Filtration and Cake Formation

- Air Blow to Remove Residual Liquid
- Core Blow to Clear Feed Eye
- Cake Removal – Automatic Discharge
Filter Press Process Steps
Batch Sequence of Operation

- Filling to Fully Vent the Filter
- Filtration and Initial Cake Formation
- Cake Washing *(If Required)*
- Membrane Squeeze *(If Required to Produce High Solids)*
- Air Blow to Remove Residual Liquid
- Core Blow to Clear Feed Eye
- Cake Removal – Automatic Discharge
  - Cloth Washing
Pressure filters can be fully automatic for unattended operation

Automatic Filter Press
Fast Cycling for Maximum Throughput

- Mechanical time for open/close/cake discharge & cloth washing can be less than 3 minutes
- Ideal for fast filtering materials like tailings & residue
- The quick-cycling filter press allows for smaller filter, or fewer units installed, as more online time is achieved

2x2 Meter AFP IV™ Filter Press – 1,000 sq M
Automatic Cake Discharge:
High TPH Throughput
Automatic filter presses for the largest tonnage

2M X 4M AFP IV™

- Ideally suited for the largest tonnage tailings/residue applications
- Less filters required
- Reduced installation area
- Potential for significant CAPEX & OPEX cost saving over smaller filter presses

2x4 Meter AFP IV™ Filter Press – 1,825 sq M
Automatic Cake Discharge: Highest TPH Throughput
For video clips of the AFP IV™ Automatic Filter Press used in this PPT presentation, visit FLSmidth.com website, News & Press / Videos & Animation pages:

Red mud pressure filtration testing

Bench-Scale & Pilot

Studies are conducted to understand the difference in materials and process parameters including:

- Various bauxite ore red mud materials
- Feed pressure/feed rate
- Plate type: recessed versus membrane squeeze chambers
- Slurry feed concentration
- Air blowing of the filter cake
- Cake washing for caustic recovery
- Cake thickness

Materials may have considerably different filtration characteristics and each case must be studied carefully.
Bench-Scale & Pilot Filter Presses

Test Program
- Laboratory Bench-Scale
- Manual Pilot
- Automatic Pilot

Pilot Filter Press on Site

Fully Automatic Trailer Mounted Pilot Filter Press
### Test Data – Case 1 Example

Filtration cycle time variations include the filtration temperature (related to the liquor viscosity) and the feed solids concentration.

<table>
<thead>
<tr>
<th>Feed temperature</th>
<th>°C</th>
<th>+35</th>
<th>20–30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filtration time</td>
<td>min</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>Discharge time (AFP IV™)</td>
<td>min</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Total cycle time</td>
<td>min</td>
<td>10</td>
<td>15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Feed concentration</th>
<th>wt%</th>
<th>41</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cake solids concentration</td>
<td>wt%</td>
<td>69</td>
<td>69</td>
</tr>
<tr>
<td>Liquid volume removed</td>
<td>kg/kg solids</td>
<td>0.99</td>
<td>1.41</td>
</tr>
<tr>
<td>Filtration time</td>
<td>min</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Discharge time (AFP IV™)</td>
<td>min</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Total cycle time</td>
<td>min</td>
<td>10</td>
<td>13</td>
</tr>
</tbody>
</table>
Filtration pressures between 7 to 15 bar were evaluated.

- **15 Bar Feeding Reduced Cycle Time**

**Case 1 Study**

- Filtration pressures between 7 to 15 bar were evaluated in the case 1 tests.
- The result of increasing the feed pressure, and the associated feed rate, is to increase the cake solids and reduce the filtration time.
Evaluations of recessed and membrane type chamber plates

Membrane Plates

Cake Compression

Cake consolidated with high-pressure squeeze
Filtration pressure comparative results – Slurry pump feed pressure *plus* ... membrane squeezing pressure

Case 1 Study –
- Impact on cake solids with squeezing is an increase of approximately 1 to 2 wt% in the final cake solids content
- Use of membrane plates, and associated added costs, may not be warranted
# Design summary – Case 1

<table>
<thead>
<tr>
<th></th>
<th>Recessed plate filter</th>
<th>Membrane plate filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filtration time</td>
<td>min 7</td>
<td>min 6</td>
</tr>
<tr>
<td>Membrane time</td>
<td>min 5</td>
<td></td>
</tr>
<tr>
<td>Discharge time</td>
<td>min 3</td>
<td>min 3</td>
</tr>
<tr>
<td>Cycle time</td>
<td>min 10</td>
<td>min 14</td>
</tr>
<tr>
<td>Cake solids concentration</td>
<td>wt% 69</td>
<td>wt% 69.5</td>
</tr>
<tr>
<td>Wet cake density</td>
<td>t/m³ 1.8–2.0</td>
<td>t/m³ 1.8–2.0</td>
</tr>
<tr>
<td>Dry cake density</td>
<td>t/m³ 1.29</td>
<td>t/m³ 1.29</td>
</tr>
<tr>
<td>Cake density (filter volume)</td>
<td>t/m³ 1.29</td>
<td>t/m³ 1.25</td>
</tr>
</tbody>
</table>

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## Conclusions – Case 1

<table>
<thead>
<tr>
<th></th>
<th>Best case</th>
<th>Worst case</th>
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</thead>
<tbody>
<tr>
<td>Feed concentration (wt%)</td>
<td>40–44</td>
<td>35</td>
</tr>
<tr>
<td>Feed temperature (°C)</td>
<td>30–40</td>
<td>20–30</td>
</tr>
<tr>
<td>Filtration time (min)</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Discharge time (AFP IV™ only)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Cycle time (min)</td>
<td>10</td>
<td>17</td>
</tr>
<tr>
<td>Dry cake density (t/m³)</td>
<td>1.29</td>
<td>1.29</td>
</tr>
<tr>
<td>Wet cake density (t/m³)</td>
<td>1.84–1.92</td>
<td>1.84–1.92</td>
</tr>
<tr>
<td>Cake solids (wt %)</td>
<td>67–70</td>
<td>67–70</td>
</tr>
<tr>
<td>Filter volume required for a feed of 1,000 t/day dry solids (m³)</td>
<td>5.37</td>
<td>9.12</td>
</tr>
</tbody>
</table>
Cake Moisture & Cycle Time – Case 2

12 minute cycle:

- Initial slurry feed at 35% solids
- Pressure filtration brings moisture to <30%
- Cake air blow reduces moisture to 24%
- Final membrane squeeze reduces moisture in cake to <20%
Cake Washing – Case 2
Filtration and cake washing study using a filter press pilot unit was performed. Filter presses can be specifically designed for applications requiring high efficiency cake washing.

- 80% of the residual causticity in the unwashed cake was removed with 2.5 to 3.0 displacements of wash water.
- Only 10% more was removed by increasing the wash ratio to 4.0.
- 2.8 displacement volumes of the liquor could achieve the goal for caustic recovery, meeting the target ratio for wash water/kg dry solids in the cake.
Conclusions

• Red mud disposal management, and possible re-use of residues, continues to be studied by alumina refineries worldwide.

• The main drivers are safety and environmental concerns, water and caustic recovery, and disposal area rehabilitation costs.

• Options available will vary by geographic region, ore type, environmental regulations, community acceptance, and other factors.

• Capital equipment cost and operational cost must be studied in detail for each case to determine the best path for the refinery to choose.

• Key to the future success of the industry is finding safe and affordable long-term solutions for red mud management.
Conclusions

The information FLSmidth has developed on red mud filtration suggests that filter press technology is a viable and economical substitute for other technology such as mud impoundments and vacuum filtration.

Filter cakes produced from filter presses may be easier to transport and stack, have less entrained caustic values, and require less attention after final disposal.

FLSmidth recommends laboratory and/or pilot testing to study the specifics of each case:

• Filtration steps and cycles times may vary considerably.
• Depending on material, >80% cake solids may be achievable.
• Cake washing efficiency for caustic recovery may be studied.
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Thank You!

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