Classification of bauxite residue

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Main application areas of the Solid/Liquid Separation - research group at LUT:

- **Mining & metallurgy**
  - Dewatering of metal concentrates
  - Tailings treatment processes
  - Deliquoring and washing of Red Mud (bauxite residue) and other leaching suspensions

- **Biorefining**
  - Processing of residues generated by the pulp industry
  - Solid/liquid separation processes in production of biofuels
  - Separation of biochemicals from wood and waste

- **Water**
  - Polishing of process waters
  - Treatment of mining waters by electrocoagation & filtration
  - Pretreatment for membrane separation processes

- **Materials**
  - Development, characterization and testing of new filter materials
  - Regeneration of filter media
Introduction:

1) Treatment and utilization of solid waste from the mining industry

2) New sustainable products from the solid side streams of the chemical pulp mills

3) Deliquoring and washing of Red Mud (bauxite residue)

Classification of bauxite residue
1) TREWA – Treatment and utilization of solid waste streams from the mining industry

- The objective of this project was to generate a technically and economically viable process for the treatment of tailings to recover value added components and decrease the quantity of waste
- Several separation technologies needed to be considered: S/L separation, S/S separation (fractionation), selective leaching, membrane separation, precipitation, …
- TREWA was a 3 year project started in January 2013 (Funding from Tekes Green Mining – programme; LUT-budget about 480 kEur)

Initial process flow diagram for treating tailings from the mining industry.
Conclusions / main results:

- The concentration of valuables in the overflow of the hydrocyclone was 2 – 3 times higher than in the initial primary ore of the mine.
- The amount of valuables in the underflow of hydrocyclone was insignificant.
- Filtration of the underflow was improved significantly when the fines were removed from the feed => improved water recycling
2) New sustainable products from the solid side streams of the chemical pulp mills

- **Duration of the project:** 12/2014 – 12/2017
- **LUT - budget about 420 kEur**
- **Funded by a consortium of 7 companies. The consortium is also supported by Tekes.**
2) New sustainable products from the solid side streams of the chemical pulp mills

- Main conclusions:
  
  o **Successful removal of harmful components (Cd, Pb, Zn) from the Green Liquor Dregs by classification >> the underflow of hydrocyclone (≈ 85 w-% of the initial dregs) is suitable for soil improvement purposes**

  o **The filtration properties of the pre-treated dregs improved significantly >> no need for filter aids, better recovery of process chemicals, smaller filtration equipment**
3) Deliquoring and washing of Red Mud (bauxite residue)

• What is bauxite residue?
  • Bauxite residue is a waste of the Bayer process (invented in 1888) which refines bauxite into alumina.
  • Depending on the quality of the bauxite processed, between 1 and 2.5 tonnes of bauxite residue is generated per tonne of alumina produced (global production ≈ 130 million tonnes per year).
  • The mud primarily contains non-aluminium compounds present in the bauxite ore along with NaOH used to dissolve the aluminium hydroxide.
  • Typical composition:
    - Fe₂O₃: 40 – 45 %
    - Al₂O₃: 10 – 15 %
    - SiO₂: 10 – 15 %
    - CaO: 6 – 10 %
    - TiO₂: 4 – 5 %
    - Na₂O: 5 – 6 %
    - + chromium, arsenic, mercury, various REE’s, etc.
    - pH: 13 - 14
Bayer Process

Historical evolution of disposal methods

Figure 3: Evolution of storage practices at 17 refineries (representing 44% of global alumina production in 2007) for which information is available over the period 1955-2007 (see Table 3).

Where is Red Mud?

Figure 4: World map showing alumina refineries in existence to our knowledge: before 1970 (blue), after 1970 (green), closed (red) and unknown (yellow). GOOGLE

Ajka, Hungary, 4th of October 2010
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- Approximately 700,000 m$^3$ of red mud slurry discharged because of the rupture of a red mud pond.
- The mud was released as a 1 – 2 m wave, flooding several nearby villages/towns.
- 10 people died and at least 300 people were injured.
- About 40 square kilometres of land and > 300 houses were affected.
- Three employees of MAL (Hungarian Aluminium Production and Trade Company) have been charged by professional misconduct of causing deaths and impair of the environment.
- MAL was taken under state control.
- Hungarian government estimated the cleanup would take at least a year and cost tens of millions of dollars.

Lessons to learn from the accident in Ajka


- Use the dry mud stacking as soon as possible
- Bauxite residue washing, de-watering and disposal should be driven rather by environmental considerations than the economy
- Significantly more emphasis is to be paid on
  - development of the red side of the Bayer process
  - dewatering techniques
  - utilization of the bauxite residue, re-assessment of previous results
Bauxite residue – research at LUT

- The primary target has been to optimize the deliquoring and washing of bauxite residue in filter presses.

On the right: Filtrates obtained from the pumping (I), washing (II) and pressing (III) stages.
Target of the study:

1) Treatment and utilization of solid waste from the mining industry

2) New sustainable products from the solid side streams of the chemical pulp mills

3) Deliquoring and washing of Red Mud (bauxite residue)
Research questions:

• Can the filtration characteristics of bauxite residue be improved by classification by hydrocyclones?

• Can the valuables in the bauxite residue be concentrated by classification?

• Can the recovery of important process chemicals (Al, Na) be improved by classification?
HYDROCYCLONE EXPERIMENTS

- Pre-treatment of bauxite residue by hydrocyclone classification

- Variables
  1. Fixed pumping pressure (1.0 bar)
  2. Fixed diameter of overflow opening: 11.1 mm
  3. Underflow diameters: 3, 5 and 6.5 mm

- Measurements
  a) Total mass flow rates
  b) Mass flow rates of solids
  c) Particle size distributions
  d) ICP analysis for various elements
  e) Filtration properties
HYDROCYCLONE EXPERIMENTS

- **Sample:**
  - Several bauxite residue samples from various plants around the world have been tested >> only one sample is introduced in this presentation:
  - Total suspended solids ≈ 15 wt-%
  - Total dissolved solids ≈ 4 wt-%
PRESSURE FILTRATION EXPERIMENTS

- Nutsche pressure filter
  - Laboratory-scale filter unit
  - $\Delta p = 4, 5 \& 6$ bar
  - $A = 20 \text{ cm}^2$
  - $V_{\text{max}} = 0.35 \text{ L}$
  - $m_{\text{batch}} = 140 \text{ g}$
  - Room temperature
Hydrocyclone results

<table>
<thead>
<tr>
<th>Diameter ratio (Do/Du)</th>
<th>Mass flow (kg/h)</th>
<th>TSS content (wt-ratio)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2.11</td>
<td>0.55</td>
</tr>
<tr>
<td>5</td>
<td>4.54</td>
<td>0.42</td>
</tr>
<tr>
<td>6.5</td>
<td>8.24</td>
<td>0.34</td>
</tr>
</tbody>
</table>
Hydrocyclone results

![Graph showing Hydrocyclone results](chart.png)

**Suspended solid mass flow (g/s)**

- **Underflow**
- **Overflow**

**Size of underflow (mm)**
- 3
- 5
- 6.5
Volumetric particle size distributions
Average specific cake resistances

**Filtration pressure = 4 bar**

Cake average specific resistance (m²/kPa)

- **Underflow**: 3.3E+10, 1.4E+11, 2.0E+11
- **Overflow**: 5.6E+11, 5.2E+11, 5.1E+11
- **Slurry**: 3.1E+11, 1.3E+11, 2.0E+11

**Filtration pressure = 5 bar**

Cake average specific resistance (m²/kPa)

- **Underflow**: 3.1E+10, 1.3E+11, 2.0E+11
- **Overflow**: 5.5E+11, 5.3E+11, 5.1E+11
- **Slurry**: 3.0E+11, 1.4E+11, 2.0E+11

**Filtration pressure = 6 bar**

Cake average specific resistance (m²/kPa)

- **Underflow**: 3.0E+10, 1.4E+11, 2.0E+11
- **Overflow**: 5.9E+11, 5.6E+11, 5.3E+11
- **Slurry**: 3.0E+11, 1.4E+11, 2.0E+11
Filtration area required for daily slurry feed of 5000 tons

Filtration pressure = 4 bar

Filtration pressure = 5 bar

Filtration pressure = 6 bar
Classification of REE’s
Classification of other elements
Conclusions / remarks:

• Some valuable elements in bauxite residues could be concentrated to underflow by hydrocyclone >> good enough for further valorization?

• Filtration characteristics of the underflow could be significantly improved >> better washing efficiency >> better recovery of important process chemicals (Al, Na)

• Treatment of the overflow is problematic (dilute, large volume)

• Each (bauxite residue) suspension needs to be tested in laboratory due to differences in compositions

• >> systematic research is needed in order to understand the behaviour of different kinds of suspensions in hydrocyclones

• >> multistage classification, more detailed optimization of classification parameters, dilution of feed, etc. could further improve the classification results