The developing of red mud utilization in China

Dr. Wanchao Liu
Zhengzhou Research Institute of CHALCO
for BR2015, KU Leuven
1 Alumin production and red mud in China
2 Utilization of red mud ——Commercially
3 Utilization of red mud ——In research
4 Our focuses
5 Conclusions
1 Alumina production and Red mud

Alumina production growth in China and the world in the past 15 years
1 Alumina production and Red mud

Red mud in China and in the world

<table>
<thead>
<tr>
<th></th>
<th>Total amount</th>
<th>Annual product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
<td>&gt;3 billion tons</td>
<td>&gt;120 million tons</td>
</tr>
<tr>
<td>China</td>
<td>0.4 billion tons</td>
<td>≈60 million tons</td>
</tr>
</tbody>
</table>
1 Alumina production and Red mud

Red mud from sintering/combined process

Category of red mud

- Red mud
- Bayer red mud
  - Low iron red mud
  - High iron red mud

Larnite

- Low temperature Bayer red mud
  - Sodalite hematite
  - Cancrinite hematite
### Chemical composition of representative red mud samples (%)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gibbsite</td>
<td>high iron</td>
<td>low iron</td>
<td></td>
</tr>
<tr>
<td><strong>Na₂O</strong></td>
<td>11.34</td>
<td>11.60</td>
<td>5.55</td>
<td>2.80</td>
</tr>
<tr>
<td><strong>MgO</strong></td>
<td>0.48</td>
<td>1.20</td>
<td>1.09</td>
<td>1.70</td>
</tr>
<tr>
<td><strong>Al₂O₃</strong></td>
<td>19.95</td>
<td>16.82</td>
<td>23.97</td>
<td>6.40</td>
</tr>
<tr>
<td><strong>SiO₂</strong></td>
<td>23.71</td>
<td>16.66</td>
<td>17.21</td>
<td>22.00</td>
</tr>
<tr>
<td><strong>K₂O</strong></td>
<td>0.21</td>
<td>---</td>
<td>0.39</td>
<td>0.30</td>
</tr>
<tr>
<td><strong>CaO</strong></td>
<td>2.73</td>
<td>8.86</td>
<td>20.83</td>
<td>41.90</td>
</tr>
<tr>
<td><strong>TiO₂</strong></td>
<td>1.51</td>
<td>4.17</td>
<td>5.96</td>
<td>3.20</td>
</tr>
<tr>
<td><strong>Fe₂O₃</strong></td>
<td>32.04</td>
<td>37.48</td>
<td>10.39</td>
<td>9.02</td>
</tr>
<tr>
<td><strong>LOI</strong></td>
<td>11.40</td>
<td>9.05</td>
<td>7.12</td>
<td>11.70</td>
</tr>
</tbody>
</table>
## 2 Utilization of red mud---Commercially

<table>
<thead>
<tr>
<th>No.</th>
<th>Red mud</th>
<th>Utilization means</th>
<th>Volume</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sintering /combined process</td>
<td>Building and construction materials</td>
<td>200-250 kt/a</td>
<td>Use red mud directly</td>
</tr>
<tr>
<td>2</td>
<td>High iron red mud from gibbsite and diasporé</td>
<td>Building materials (bricks)</td>
<td>1000-1300 kt/a</td>
<td>use the sand separated from red mud</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cement</td>
<td>800-1000 kt/a</td>
<td>iron ore separated from red mud</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Cement</td>
<td>800-1000 kt/a</td>
<td>iron ore separated from red mud</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Iron &amp; Steel Production</td>
<td>800-1000 kt/a</td>
<td>iron ore separated from red mud</td>
</tr>
<tr>
<td>5</td>
<td>Bayer red mud from China local diasporé</td>
<td>Glass ceramics, glass fibre…</td>
<td>100 kt/a</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Rare Earth Elements recovery (REE)</td>
<td>/</td>
<td>In planning</td>
</tr>
<tr>
<td>7</td>
<td>All red mud</td>
<td>Polymer filler</td>
<td>10 kt/a</td>
<td>In planning</td>
</tr>
<tr>
<td>8</td>
<td>All red mud</td>
<td>Environmental protection (exhaust gas and waste water adsorbent)</td>
<td>10kt</td>
<td>In planning</td>
</tr>
<tr>
<td></td>
<td>totally</td>
<td></td>
<td>3000 -3600 kt/a</td>
<td>&lt;10%</td>
</tr>
</tbody>
</table>
2 Utilization of red mud---Commercially

Building Materials from red mud from sintering or combined process

- Larnite is the domestic phase in the red mud, which is common contributor to construction.
- Major products: bricks, insulating materials for furnace, dam construction
- The efflorescence of product is its weakness.

heat insulating material  Non-fired bricks
2 Utilization of red mud---Commercially

- Construction Materials
  - Road base material
  - Dam Construction

The road built with red mud base

The red mud dam constructed with red mud, use for storing Bayer red mud
2 Utilization of red mud---Commercially

- Separating iron and degritting from high iron red mud from gibbsite and diaspore

Almost all of high iron red mud (20-25 million tons) are treated in this process in China.
 Separating iron and degritting from high iron red mud from gibbsite and diaspore
## 2 Utilization of red mud---Commericially

- Separating iron and degritting from high iron red mud from gibbsite and diaspore

<table>
<thead>
<tr>
<th>Bayer red mud</th>
<th>Iron ore</th>
<th>Sand</th>
<th>Fine red mud</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yield, kg/t red mud</td>
<td>Fe$_2$O$_3$,wt%</td>
<td>Yield, kg/t red mud</td>
</tr>
<tr>
<td>Diaspor high temperature Bayer process</td>
<td>60-80</td>
<td>52-57</td>
<td>30-50</td>
</tr>
<tr>
<td>Gibbsite, low temperature Bayer process</td>
<td>80-130</td>
<td>52-57</td>
<td>100-120</td>
</tr>
</tbody>
</table>
Mineral fillers (from red mud or separated red mud)

Application in: plastics, rubber, wood plastic products (substitute of Precipitated Calcium Carbonate (PCC), and white carbon black).

Developing direction: superfine filler, low iron filler

Expected profit: 100-200 RMB/t red mud
Glass-ceramic from low iron red mud from local diaspore

Application: wall and floor tile, wear-resisting lining

Status: In commissioning

Advantage: low melting points, large market

Sample of glass-ceramic

The glass ceramic sintering kiln
3 Utilization of red mud ---In research

- Rare Earth Elements (REE) Extraction

The feasibility of the process depends on the contents of REE in red mud.

<table>
<thead>
<tr>
<th>Contents</th>
<th>TiO₂</th>
<th>Fe₂O₃</th>
<th>CeO₂</th>
<th>Sc₂O₃</th>
<th>La₂O₃</th>
<th>Nb₂O₅</th>
<th>ZrO₂</th>
<th>Y₂O₃</th>
<th>Nd₂O₃</th>
<th>Yb₂O₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample A</td>
<td>4.17</td>
<td>37.48</td>
<td>0.045</td>
<td>0.053</td>
<td>0.026</td>
<td>0.035</td>
<td>0.473</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Sample B</td>
<td>5.96</td>
<td>10.39</td>
<td>0.067</td>
<td>0.026</td>
<td>0.032</td>
<td>0.059</td>
<td>/</td>
<td>0.014</td>
<td>0.028</td>
<td>0.037</td>
</tr>
</tbody>
</table>
3 Utilization of red mud ---In research

- Rare Earth Elements (REE) Extraction
  - Present acid leaching - extraction process is defective.
  - The environmental and economical extraction process is significant and challengeable.
3 Utilization of red mud --- In research

Gas desulfurization

- The pilot test was completed.
- Its de-sulfuring efficiency is satisfying.
  100-120 kg SO\(_2\) could be absorbed by per ton red mud.
- However, the treatment of waste water with Na\(_2\)SO\(_4\) is a problem in practice.
- The application in waste water treatment is in research both in China and oversea.
Geopolymer

✓ The sodium is a common problem in building materials because of its potential on alkali aggregate effect.

✓ Geopolymer is an inorganic polymer with Na or K as well as silicate and aluminate.

✓ The effect of Na⁺ or K⁺ will be overcomed by the 3D net structures from silicon-oxygen tetrahedron and aluminium-oxygen octahedron.
3 Utilization of red mud ---In research

- Improve recovery ratio of iron from red mud
  Magnetic separation technology should be improved for fine weak-magnetic material separation from mud slurry;
  High efficient iron extracting and iron separation technology after magnetization roasting;
  Utilization of the red mud after iron separation.
Neutralization of red mud

✓ It is not possible to realize the completely use all of red mud currently.

✓ The neutralization is necessary to reduce the environmental affect of alkali.

✓ Possible neutralization agents include:

  sea water (about 1/3 alumina capacity is located in coastal area in Shandong);

  coal burning flue gas;

  waste acid.
4 Our focuses

- Reclamation of red mud storage area
  - Few of red mud storage area is reclamed in China, that is not friendly to the surrounding.
  - The key point is to find or to acclimatize plants which are salt-tolerant and alkali-tolerant, but not alien species. (Most alumina refineries are local is the north of China, where is aried and semi-aried climate)
  - Long term monitoring on the ecologicalization of the land;
  - The utilization of harvested plants and the area.
  - The cost of the reclamation also is problem for refineries which are being or will lose money.
5 Conclusions

- China do a lot of work on utilization of red mud. Some advanced technologies are commercially applied with acceptable economic benefit.
- There are still 90% of red mud waiting for exploring as a resource.
- More work should be done by global researchers and refineries for the sustainable development of alumina refining.
Thank you!

Wanchao Liu
Zyy_lwc@chalco.cn

2015.10