Zhang Baiyong, SAMI

The Challenging and Solutions for The Decreasing of Bauxite Grade in China
Content

1 Overview of Chinese bauxite resource
2 The economical process for different grade diasporic bauxite
3 The fly ash resource and its extracting process in china
4 Nephelelite resource and its extracting process in china
5 Conclusions
1 Overview of Chinese bauxite resource

1.1 Overview of Chinese bauxite reserves
1.2 The present status of bauxite using for alumina refining in china
1.1 Overview of Chinese bauxite reserves

**Chinese bauxite reserves** \((10^9 t)\)

<table>
<thead>
<tr>
<th>Province</th>
<th>Shanxi</th>
<th>Henan</th>
<th>Guangxi</th>
<th>Guizhou</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>0.99</td>
<td>0.75</td>
<td>0.61</td>
<td>0.51</td>
<td>0.33</td>
<td>3.20</td>
</tr>
</tbody>
</table>
1.2 The present status of bauxite using for alumina refining in China

![Chart showing the diasporic bauxite A/S ratio over years]

- A/S = 7.5
- A/S = 5.77
- 23%
## Chinese bauxite A/S for refining

<table>
<thead>
<tr>
<th>Branch</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
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<tbody>
<tr>
<td>Shandong branch of Chalco</td>
<td>7.30</td>
<td>5.58</td>
<td>4.32</td>
<td>6.30</td>
<td>6.31</td>
</tr>
<tr>
<td>Henan branch of Chalco</td>
<td>7.29</td>
<td>6.52</td>
<td>5.42</td>
<td>5.56</td>
<td>5.04</td>
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<td>Guizhou branch of Chalco</td>
<td>9.27</td>
<td>7.71</td>
<td>8.11</td>
<td>7.52</td>
<td>6.44</td>
</tr>
<tr>
<td>Shanxi branch of Chalco</td>
<td>8.17</td>
<td>8.68</td>
<td>7.33</td>
<td>6.60</td>
<td>5.77</td>
</tr>
<tr>
<td>Guangxi branch of Chalco</td>
<td>13.87</td>
<td>12.38</td>
<td>12.06</td>
<td>13.38</td>
<td>12.15</td>
</tr>
<tr>
<td>Zhongzhou branch of Chalco</td>
<td>6.65</td>
<td>5.94</td>
<td>4.93</td>
<td>5.58</td>
<td>4.84</td>
</tr>
<tr>
<td>Zhengzhou pilot plant of Chalco</td>
<td>8.67</td>
<td>7.94</td>
<td>7.76</td>
<td>-</td>
<td>7.20</td>
</tr>
<tr>
<td>Henan minal company of Chalco</td>
<td>7.16</td>
<td>6.41</td>
<td>5.40</td>
<td>5.46</td>
<td>4.96</td>
</tr>
<tr>
<td>Zunyi branch of Chalco</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7.26</td>
</tr>
</tbody>
</table>
Summary

• The bauxite grade is decreasing with the increasing of chinese alumina capacity.
• High grade bauxite were excessively used to refine alumina in last years.
• The surveyed bauxite resource is about 3.2 billion tonnes in China, more than 60% of which is medium and low grade bauxite (A/S=4~6).
2 The economical process for different grade diasporic bauxite

2.1 Overview of Bayer and combination process in china
2.2 The compositions of raw materials & fuel cost for different process
2.3 The influence for raw materials & fuel cost with the decreasing of bauxite grade
The capacity and product of Chinese refineries

2.1 Overview of Bayer and combination process in China

The graph shows the production capacity and output of Chinese refineries from 2007 to 2010.

- Production Capacity:
  - 2007: 25.08
  - 2008: 28.95
  - 2009: 41.65

- Output:
  - 2007: 19.44
  - 2008: 25.08
  - 2009: 28.95
  - 2010: 41.65

The capacity utilization rate is indicated as 66% and 49% for 2007 and 2008, respectively.
Total for 2011: 92,108 thousand metric tonnes of alumina (total)
Total for 2012: 47,773 thousand metric tonnes of alumina (till to 31/Aug)
Mixed Combination

Bayer Dressing Bayer

Serial Combination

Low Grade Bauxite

High Grade Bauxite

Digestion

Seed Precipitation

$\text{Al(OH)}_3$

$\text{Al}_2\text{O}_3$

Low Grade Bauxite

Sintering

Bauxite Residual

Carbonation Precipitation

$\text{Al(OH)}_3$

$\text{Al}_2\text{O}_3$
The Capacity of Different process (2010)

- Gibbsite Bayer: 25%
- Diaspore Bayer: 25%
- Diaspore Combination process: 50%
### 2.2 The compositions of raw materials & fuel cost for different process

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Process</th>
<th>A/S</th>
<th>12</th>
<th>10</th>
<th>8</th>
<th>6.5</th>
<th>5</th>
<th>4.5</th>
<th>4</th>
<th>3.5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bauxite charge (BAR)</strong></td>
<td>t/t-(\text{Al}_2\text{O}_3)</td>
<td>Bayer</td>
<td>1.734</td>
<td>1.818</td>
<td>1.934</td>
<td>2.092</td>
<td>2.315</td>
<td>2.473</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dressing Bayer</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2.474</td>
<td>2.614</td>
<td>2.804</td>
<td>3.171</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sintering</td>
<td>-</td>
<td>-</td>
<td>1.633</td>
<td>1.683</td>
<td>1.766</td>
<td>1.832</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Serial combination</td>
<td>-</td>
<td>1.556</td>
<td>1.602</td>
<td>1.665</td>
<td>1.725</td>
<td>1.779</td>
<td>1.917</td>
<td>2.004</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mixed combination</td>
<td>-</td>
<td>1.607</td>
<td>1.65</td>
<td>1.702</td>
<td>1.749</td>
<td>1.781</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Soda usage</strong></td>
<td>kg (\text{Na}_2\text{CO}_3)/t-(\text{Al}_2\text{O}_3)</td>
<td>Bayer</td>
<td>91.49</td>
<td>109.23</td>
<td>137.06</td>
<td>172.28</td>
<td>235.78</td>
<td>271.11</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Dressing Bayer</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>137.3</td>
<td>137.3</td>
<td>137.3</td>
<td>137.3</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Sintering</td>
<td>-</td>
<td>-</td>
<td>57.76</td>
<td>59.44</td>
<td>82.57</td>
<td>97.92</td>
<td>-</td>
<td>-</td>
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<tr>
<td></td>
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<td>-</td>
<td>33.53</td>
<td>37.63</td>
<td>45.52</td>
<td>56.32</td>
<td>61.03</td>
<td>70.29</td>
<td>78.87</td>
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<td>Mixed combination</td>
<td>-</td>
<td>44.09</td>
<td>51.26</td>
<td>58.58</td>
<td>68.42</td>
<td>72.49</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Process energy</strong></td>
<td>GJ(/\text{t-}\text{Al}_2\text{O}_3)**</td>
<td>Bayer</td>
<td>12.31</td>
<td>12.38</td>
<td>12.52</td>
<td>12.66</td>
<td>13.43</td>
<td>13.47</td>
<td>-</td>
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<tr>
<td></td>
<td></td>
<td>Dressing Bayer</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>12.78</td>
<td>12.8</td>
<td>12.81</td>
<td>12.85</td>
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<tr>
<td></td>
<td></td>
<td>Sintering</td>
<td>-</td>
<td>-</td>
<td>32.07</td>
<td>32.86</td>
<td>34</td>
<td>34.78</td>
<td>-</td>
<td>-</td>
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<td></td>
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<td>Serial combination</td>
<td>19.71</td>
<td>20.87</td>
<td>22.69</td>
<td>25.05</td>
<td>26.38</td>
<td>28.44</td>
<td>30.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mixed combination</td>
<td>-</td>
<td>23.42</td>
<td>25.36</td>
<td>27.37</td>
<td>29.93</td>
<td>30.96</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Raw materials &amp; fuel</strong></td>
<td>Cost Ratio*</td>
<td>Bayer</td>
<td>0.871</td>
<td>0.881</td>
<td>0.907</td>
<td>0.949</td>
<td>1.042</td>
<td>1.091</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dressing Bayer</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.083</td>
<td>1.109</td>
<td>1.145</td>
<td>1.218</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sintering</td>
<td>-</td>
<td>-</td>
<td>1.142</td>
<td>1.154</td>
<td>1.195</td>
<td>1.228</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Serial combination</td>
<td>-</td>
<td>0.929</td>
<td>0.945</td>
<td>0.988</td>
<td>1.044</td>
<td>1.080</td>
<td>1.146</td>
<td>1.205</td>
<td></td>
</tr>
<tr>
<td></td>
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<td>Mixed combination</td>
<td>-</td>
<td>1.014</td>
<td>1.052</td>
<td>1.096</td>
<td>1.153</td>
<td>1.179</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
2.3 The influence for raw materials & fuel cost with the decreasing of bauxite grade.

Cost is based on the price of 2010. Which win? Winner is different for different bauxite A/S.
Summary

• For raw materials & fuel cost at the same A/S (4.9), the raw materials & fuel cost of Bayer, serial combination and dressing Bayer process are obviously cheaper than sintering and mixed combination process.

• For middle and low grade bauxite (4~6), combination process is realistic for technical reconstructing and production organization of alumina refineries with both sintering system and Bayer system.
3 The fly ash resource and its extracting process in China

3.1 Overview of fly ash resource
3.2 Lime stone sintering process
3.3 Soda lime sintering process
3.4 Sulphuric acid process
3.5 Alkali and acid combination process
3.1 Overview of fly ash resource

• Until the end of 2008, the quantity of fly ash is 5.6 billion tonnes.
• The consumption of coal for Coal fired power plant is 1.4 billion tonnes in 2008, and the quantity of fly ash is more than 0.3 billion tonnes. At same time the quantity of fly ash is 0.4 billion tonnes in 2009. base on the data of 2009, alumina in discharged fly ash is 0.1 billion tonnes, it is three times of alumina product which is refinied from bauxite in China in 2009.
### Typical content of fly ash in China

<table>
<thead>
<tr>
<th>Content</th>
<th>( \text{SiO}_2 )</th>
<th>( \text{Al}_2\text{O}_3 )</th>
<th>( \text{Fe}_2\text{O}_3 )</th>
<th>CaO</th>
<th>MgO</th>
<th>( \text{SO}_3 )</th>
<th>( \text{Na}_2\text{O} )</th>
<th>( \text{K}_2\text{O} )</th>
<th>L.O.I</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>34.30~65.76</td>
<td>14.59~40.12</td>
<td>1.50~16.22</td>
<td>0.44~16.8</td>
<td>0.20~3.72</td>
<td>0.00~6.00</td>
<td>0.10~4.23</td>
<td>0.02~2.14</td>
<td>0.63~29.97</td>
</tr>
</tbody>
</table>

Some alumina content is higher than some gibbsite.
Four processes

3.2 Lime stone sintering process

There are much more residue
3.3 Soda lime sintering process

SAMI design the feasibility of Mengxi 400kt/a alumina refinery
3.4 Sulphuric acid process

SAMI design the detail design of pilot plant in inner Mongolia
3.5 Alkali and acid combination process

SAMI design the pilot plant detail design in Shanmenxia of Henan
Summary

- Basing on above processes, the alumina pilot plants have been built in order to guide the constructing of refinery which extracting alumina from fly ash.
- There is a alumina refinery using fly ash in Inner Mongolia.
- Fly ash is the biggest industry pollution in china, at same time there is a great mount of alumina in fly ash. Extracting alumina from fly ash should be a strategic way for Chinese alumina industry in the future.
4 Nephelite resource and its extracting process in china

4.1 Overview of nephelite resource
4.2 Lime stone sintering process
1 Overview of nephelite resource

There are 2.4 billion tonnes nephelite in China,

Typical content of nephelite in China

<table>
<thead>
<tr>
<th>Content</th>
<th>SiO$_2$</th>
<th>Al$_2$O$_3$</th>
<th>Fe$_2$O$_3$</th>
<th>Na$_2$O</th>
<th>K$_2$O</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>48.00~ 58.69</td>
<td>17.33~ 23.21</td>
<td>2.03~ 4.93</td>
<td>3.84~ 10.42</td>
<td>3.14~ 11.18</td>
</tr>
</tbody>
</table>
2 Lime stone sintering process

- Grinding
- Sintering
- Leaching
- Settling and Washing
- Desilication
- Separation
- Green Liquor
- Carbonation
- Precipitation
- Filtration
- Evaporation

- Lime Stone
- Nephelite
- DSP
- CO$_2$
- Al(OH)$_3$
- Na$_2$CO$_3$, K$_2$CO$_3$
- Al$_2$O$_3$
Summary

• Nephelite is another important issue for Chinese alumina industry with the decreasing of bauxite grade.
• Limestone sintering process is the typical process for dealing with nephelite, nephelite was used to refine alumina for a long time in Russia, but there is not nephelite refinery in China. Extracting alumina from nephelite will be a realistic way for Chinese alumina industry in recent future.
5 Conclusions

• Last ten years, there was a quickly increasing for Chinese alumina capacity which results in the depleting of bauxite resource.

• Low grade bauxite and non-bauxitic resource will be more and more important for Chinese alumina industry with the decreasing of bauxite quality.

• The combination process is a realistic way for low grade bauxite for the refinery with sintering and Bayer system, and the extracting process from fly ash and nephelite is another realistic way for Chinese alumina industry.
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30-31 October 2012
Marina Mandarin, Singapore
Welcome to SAMI