PLATE WATER ABSORPTION METHOD FOR BENTONITE EVALUATION AND ITS RELEVANCE TO IRON PELLETIZING PERFORMANCE

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BENTONITE

A clay mineral with unusual physicochemical / surface properties. These are attributed to the crystalline structure of montmorillonite which is similar to a pack consisting of successive platelets.

Crystal structure of montmorillonite
Montmorillonite characteristics

- Exceptionally small crystal size (Average grain size 0.5μm).
- Negative surface charge.
- High cation exchange capacity
- High surface area.
- High water absorbency.
- Binding properties
- Swelling capacity.
- Thixotropy.
- High plasticity.
Bentonite in iron ore pelletizing

Fired pellets to Blast furnace

Bentonite

Additives silo

Ore beneficiation

Iron ore, conveyor belt 7-10% moisture

Screw mixer

PELLETIZING DRUMS

Pellets (green)

FIRING UNIT (INDURATION FURNACE)
The problem

What are the most appropriate methods for quality assessment of bentonite in pelletizing?

BENTONITE EVALUATION METHODS

- Montmorillonite content (%)
- Cation Exchange Capacity (meq/g)
- Swelling test (ml/2g)
- Plate test (%)
- Enslin test (%)
- Rheological properties
- Thermogravimetric analysis
- Infra Red analysis
Problem constraints

➢ There is a large differentiation in bentonite qualities due to specific genesis conditions of each deposit.

➢ Bentonite cannot be fully characterized by its currently used evaluation methods due to the large interactions between its properties and the pelletizing conditions.

➢ Due to the large number of interfering factors and the complexity of interaction effects, it is often difficult to describe mechanisms that associate bentonite properties with pelletizing performance.
The statistical approach

Statistical design of pelletizing tests allows:

- Determination of significant effects of bentonite properties on agglomeration performance.
- Determination of significant interactions between factors.
- Calculation of experimental errors (quite considerable in pelletizing processes).
The Plate Water Absorption Method

Plate Water absorption test
Plate Water absorption test
## Properties of bentonite samples used for agglomeration

<table>
<thead>
<tr>
<th>Bentonite property</th>
<th>Bentonite A</th>
<th>Bentonite B</th>
<th>Bentonite C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate Water Absorption (4h, 0.5g) (%)</td>
<td>691</td>
<td>835</td>
<td>933</td>
</tr>
<tr>
<td>Swelling (2g/100ml)</td>
<td>31</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>Montmorillonite (%)</td>
<td>73.7</td>
<td>85.0</td>
<td>92.3</td>
</tr>
</tbody>
</table>
### Grain size analysis and specific surface of the iron concentrate samples

<table>
<thead>
<tr>
<th>Vol fraction (%)</th>
<th>Concentrate A</th>
<th>Concentrate B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Undersize (μm)</td>
<td>Undersize (μm)</td>
</tr>
<tr>
<td>10</td>
<td>2.76</td>
<td>1.01</td>
</tr>
<tr>
<td>50</td>
<td>36.24</td>
<td>28.41</td>
</tr>
<tr>
<td>90</td>
<td>138.74</td>
<td>82.70</td>
</tr>
<tr>
<td>Mean diameter (μm)</td>
<td>59.83</td>
<td>36.51</td>
</tr>
<tr>
<td>Specific surface (m²/g)</td>
<td>3.8</td>
<td>4.6</td>
</tr>
</tbody>
</table>
Full factorial experiment 2X3X3. Levels of factors

<table>
<thead>
<tr>
<th>LEVELS OF FACTORS</th>
<th>FACTORS</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Type of iron ore</td>
<td>Bentonite plate Value (%)</td>
<td>Bentonite Addition rate (%)</td>
</tr>
<tr>
<td>0</td>
<td>A</td>
<td>691</td>
<td>0.3</td>
</tr>
<tr>
<td>1</td>
<td>B</td>
<td>835</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>933</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Responses: Green drop No, Green strength (kg/p), Dry strength (Kg/p)

Constant parameters: Moisture level (%)
Results

Prediction profilers for green drop number versus plate and addition rate of bentonite.
Prediction profilers for dry strength versus plate and addition rate of bentonite
Plate Water Absorption had a statistically significant effect on green drop of pellets produced with concentrate A, while had no effect on the pellets of concentrate B.

For dry strength, analysis showed that the effect of plate was statistically significant for both concentrates but higher on the concentrate A.

Significant interaction between plate and type of concentrate indicates that plate should be always assessed in combination with the iron concentrate.
Effect of water hardness on plate water absorption of bentonite
Results

Effect of calcium and magnesium at 100 and 300 ppm concentration levels in the pellet feed water on the plate value of various bentonite qualities.
- Calcium and magnesium in the process water can replace sodium as exchangeable cations and thus seriously deteriorate bentonite performance.

- Not all bentonite qualities have the same ‘resistance’ to water hardness.

- There is no significant difference in water resistance between natural sodium and activated bentonite.
Effect of bentonite thermal stability on its plate water absorption
‘Dry’ versus ‘wet’ milling of bentonite

Effect of initial moisture of bentonite prior to milling on the plate values of various bentonite samples.
Montmorillonite dehydroxylation at 748°C

TG-DTA diagram of bentonite with relatively high thermal stability (sample 1-3).
TG-DTA diagram of bentonite with relatively low thermal stability (samples 4,5)
‘Dry’ grinding of bentonite results in plate decrease that ranges from 80 – 210 units.

Decrease in plate, which may significantly affect pelletizing performance, depends on thermal stability of bentonite, i.e. temperature of dehydroxylation.

Temperature of montmorillonite dehydroxylation depends on the isomophic substitution of Al$^{3+}$ by other cations in montmorillonite lattice and the strength of the Mn$^{n+}$-OH bonds.

It has been found that substitution of Al$^{3+}$ by Mg$^{2+}$ results in bentonites with higher thermal stability than bentonites with isomophic substitution of Al$^{3+}$ by Fe$^{3+}$.
Conclusions

- Plate Water Absorption is a relatively good quality index for bentonite performance in iron pelletizing.

- However, Plate Water Absorption, measured by the conventional method, is not sufficient as it largely depends on pelletizing conditions.

- Due to the large complexity of interfering factors, plate values should be evaluated taking into consideration iron concentrate characteristics, sensitivity to water hardness and thermal stability of bentonite.
THANK YOU FOR YOUR ATTENTION