Recovery of Bentonite in Sand

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Some History

• Acoustic Advanced Oxidation has been used since 1992 to recycle clay from pollution control systems.

• We started recycling clay directly from green sand using a significantly updated method in 2006.

• Research publications are available from multiple sources, including the AFS.
Recycled Clay Research Findings

• Reduces clay consumption and emissions by:
  – Cleaning activated carbon formed in the green sand casting process, if coal is used
  – Cleaning clay surfaces of condensed organic material
  – De-laminating/de-agglomerating clay
Clay Used 3 Ways, Same Casting

Simultaneous Bond & Sand Reclamation Comparison

#Bond/Ton Fe

No Clay Recycle  BMD W/Conventional Blackwater  After BMD Super Clay & Sand Reclamation

AFS Sand Casting Conference
October 20-22, 2014 – Indianapolis, IN USA
## Advanced Oxidation Processing - Size

<table>
<thead>
<tr>
<th>Stirring Time (hr.)</th>
<th>Ultrasonication Time (min.)</th>
<th>Average Particle Size</th>
<th>Specific Surface Area</th>
<th>% change</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$d_{50}$ (mm)</td>
<td>$d_{50}$ (mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>0</td>
<td>4.57</td>
<td>0.83</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>0</td>
<td>4.66</td>
<td>+2.0%</td>
<td>0.92</td>
<td>+10.8%</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>3.88</td>
<td>-15.1%</td>
<td>1.06</td>
<td>+27.7%</td>
</tr>
<tr>
<td>12</td>
<td>10</td>
<td>3.34</td>
<td>-26.9%</td>
<td>1.25</td>
<td>+50.6%</td>
</tr>
<tr>
<td>12</td>
<td>20</td>
<td>3.00</td>
<td>-34.4%</td>
<td>1.27</td>
<td>+53.0%</td>
</tr>
</tbody>
</table>

### Effects of ultra-sonication on bentonite’s physical properties - Submitted to USEPA
# Green Sand Pore Structure

<table>
<thead>
<tr>
<th>Distance from metal</th>
<th>Micropores (d&lt;10Å)</th>
<th>Volume (mL/g)</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>AO as-received</td>
<td></td>
<td>0.04</td>
<td>-</td>
</tr>
<tr>
<td>AO 6-8 cm</td>
<td></td>
<td>0</td>
<td>-100%</td>
</tr>
<tr>
<td>AO 4-6 cm</td>
<td></td>
<td>0</td>
<td>-100%</td>
</tr>
<tr>
<td>AO 2-4 cm</td>
<td></td>
<td>0</td>
<td>-100%</td>
</tr>
<tr>
<td>AO 1-2 cm</td>
<td></td>
<td>0.33</td>
<td>+786%</td>
</tr>
<tr>
<td>AO 0-1 cm</td>
<td></td>
<td>0.73</td>
<td>+1890%</td>
</tr>
<tr>
<td>TAP as-received</td>
<td></td>
<td>0.12</td>
<td>-</td>
</tr>
<tr>
<td>TAP 6-8 cm</td>
<td></td>
<td>0.08</td>
<td>-38%</td>
</tr>
<tr>
<td>TAP 4-6 cm</td>
<td></td>
<td>0</td>
<td>-100%</td>
</tr>
<tr>
<td>TAP 2-4 cm</td>
<td></td>
<td>0</td>
<td>-100%</td>
</tr>
<tr>
<td>TAP 1-2 cm</td>
<td></td>
<td>0</td>
<td>-100%</td>
</tr>
<tr>
<td>TAP 0-1 cm</td>
<td></td>
<td>0.43</td>
<td>+249%</td>
</tr>
</tbody>
</table>
Clay Recycle Process

Advanced Oxidation Treated Clay Slurry to mullers, mixers, coolers, etc.

Reacton Tank and Pumping System

Sand Classification

Back to green sand while damp or additional processing

Waste green sand

$\text{H}_2\text{O}_2 + \text{O}_3$

1 – induced particle collision
2 – induced cavitation
3 – ultrasonic irradiation
Acoustic Advanced Oxidation Reclamation

Clay Recycled

Dried Sand

Waste Green Sand

AFS Transactions 08-140
The good things first

• The production sand & clay reclamation units reduce the reclaimed green sand’s Mb clay by approximately 90%-98%. >90% of all this material (clay, sand & carbon) is recycled.

• Clay recycled from the waste green sand performs significantly better than the clay recycled from sand system dust.

• The sand going back into the green sand system performs as well as new sand.
Different than recycled dust collector clay?

- Twice the new bond reduction per unit of MB clay recycled
- Mulling is significantly improved
- Mull to energy feedback technique is improved in both batch mullers/mixers & continuous mullers
- Energy of sand preparation is reduced, energy incentives are available
It has taken years to optimize this process

- Clay from sand is stronger than expected, more predictable and provides better process feedback than virgin material.

- Both material handling AND machine control systems needed to be redesigned to handle/optimize the increase in casting performance over virgin material.
Case History, Post Reclamation, BEFORE a Mull to Energy Conversion

- Sand related defects are reduced.
- Some sand defects were eliminated altogether.
- Clay moisture levels dropped at previous compactability targets. (36% down to 26%)
- Clay moisture levels then adjusted to a normalized target level of 31% to 33% via a compactability practice change.
- Sand strength develops significantly faster.
- Reclamation allowed reducing fixed mulling time below the pre-reclamation time of 65 second cycle time.
Time held constant at 65 seconds
(Applied energy varied 5,800 kWs with ~14,000 avg.)

These results are not atypical. Excellent casting results & up to 18% energy reductions are achieved by using an energy dose set point slightly above average. Note: The original timers remain functional in the systems as backup.
Conventional Fixed Time!
A single 65 second cycle plot after reclamation

This “clay strength development rate” angle increases
Changing a “fixed” cycle

- We realized several years ago that with recycled clay, the sand was developing strength much faster than with virgin clay.
- New sensors allow us to very easily sense “stable” vs “unstable” regions in the mulling cycle, especially with recycled clay.
Stability, Dose, Time

• With recycled clay, we can easily prepare green sand in batch mullers using three methods:
  • When the sand strength becomes stable (most productive)
  • When the energy dose reaches a set point (most stable)
  • Conventional Timer (How we’ve always done it)
Future Work

• Everything going into a green sand system affects the complex science of reclamation.

• Core resin choice, clay additives, water chemistry, reclamation method and energy awareness are the primary driving forces in our work.
Sources, Partial List


5. www.mii.org/Minerals/photocoal.html


THANK YOU
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