IMPACT OF CALCIUM HYDROXIDE ON THE EQUIPMENT AND PROCESS OF OIL SANDS TAILINGS TREATMENT
Agenda

- Coagulation vs Flocculation
- Mixing
- Thickening simulation settling tube
- Particle size
- Pressure filtration
- Filtrate water chemistry
- \( \text{Ca(OH)}_2 \) impact on dewatering equipment
Coagulation vs Flocculation

**Coagulation**
- Destabilize the electrostatic repulsion of suspended solids by cation exchange and/or chemical reactions
- Coagulants that are multivalent, such as calcium (Ca\(^{+2}\)), link individual particles together which increases the average particle size.
- High shear mixing can be used to ensure that inorganic coagulants are well dispersed

![Diagram: Inorganic Coagulant](image)

**Flocculation**
- Aggregation of clay particles onto a flocculant surface
- Particles adsorb onto large molecular weight flocculants, such as polymers
- Results in large and fragile flocs held together by weaker intermolecular forces
- Mixing procedure is important

![Diagram: Polymer Flocculant](image)
Coagulation Simplifies Mixing

- Amount of mixing required is minimal
- As long as sufficient homogenization is achieved further mixing is unnecessary
- The capability of a coagulant to withstand high shear makes rigorous mixing not only possible but preferential

Filtration Rate Vs Mixing Time

- mL Filtered
- Minutes Mixed

- 1min
- 2 min
- 5 min
- 10 min
Thickener Clarity is Dependent on Dosage
Settling Velocity Increases when Pretreated

- When paired with polymer, settling velocity is improved
  - Dosage of Ca(OH)$_2$ is variable and is dependent mostly on carbonate concentration among other factors
  - Clarity of the water interface is determined by Ca(OH)$_2$ addition

<table>
<thead>
<tr>
<th>Lime Dose (ppm)</th>
<th>Time to settle to 700 mL (s)</th>
<th>Mud Line at 30 min (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Not Observed*</td>
<td>155</td>
</tr>
<tr>
<td>750</td>
<td>8</td>
<td>190</td>
</tr>
<tr>
<td>900</td>
<td>5</td>
<td>245</td>
</tr>
<tr>
<td>1000</td>
<td>3</td>
<td>245</td>
</tr>
<tr>
<td>1250</td>
<td>4</td>
<td>275</td>
</tr>
</tbody>
</table>

*A clear mud line was not noticed until the flocculated particles had settled well below 700 mL*
### Water Chemistry Improves

<table>
<thead>
<tr>
<th>ppm of Ca(OH)$_2$</th>
<th>Ca (mg/L)</th>
<th>Na (mg/L)</th>
<th>K (mg/L)</th>
<th>S (mg/L)</th>
<th>Mg (mg/L)</th>
<th>Al (mg/L)</th>
<th>Cl (mg/L)</th>
<th>(H)CO3 (mg/L)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>31</td>
<td>263</td>
<td>7</td>
<td>28</td>
<td>12</td>
<td>1</td>
<td>90</td>
<td>529</td>
<td>9.09</td>
</tr>
<tr>
<td>750</td>
<td>11</td>
<td>232</td>
<td>4</td>
<td>29</td>
<td>1</td>
<td>1</td>
<td>90</td>
<td>71</td>
<td>11.35</td>
</tr>
<tr>
<td>900</td>
<td>16</td>
<td>261</td>
<td>8</td>
<td>26</td>
<td>1</td>
<td>2</td>
<td>89</td>
<td>23</td>
<td>11.60</td>
</tr>
<tr>
<td>1000</td>
<td>31</td>
<td>246</td>
<td>7</td>
<td>29</td>
<td>1</td>
<td>0</td>
<td>90</td>
<td>18</td>
<td>11.70</td>
</tr>
<tr>
<td>1250</td>
<td>93</td>
<td>279</td>
<td>8</td>
<td>37</td>
<td>1</td>
<td>1</td>
<td>90</td>
<td>17</td>
<td>11.80</td>
</tr>
</tbody>
</table>
Particle Size Determines Turbidity

- Larger particles derived from coagulation with Ca(OH)$_2$ provide less turbid supernatant.
  - Low turbidity coming off the thickener would reduce demand of clarification processes

![Graph showing absorbance at 750 nm vs Ca(OH)$_2$ dose (ppm) for supernatent and underflow samples before and after polymer addition.](image-url)
Pressure Filtration Rates Improve

Pressure filtration of Ca(OH)$_2$ treated tailings

- Dosage of Ca(OH)$_2$ is dependent on a number of variables but is consistently between 3000 and 4000 ppm based on the wet weight of tailings.

- Ca(OH)$_2$ shows a significant upgrade in filtration rate over flocculant alone.

- Faster filtration requires fewer pressure filters

- Cake solids consistently greater than 70%

<table>
<thead>
<tr>
<th>Feed Mixture</th>
<th>Filtration Rate (kg/m$^2$/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flocculant only</td>
<td>1.727</td>
</tr>
<tr>
<td>4000 ppm calcium hydroxide</td>
<td>3.811</td>
</tr>
<tr>
<td>Flocculant and 4000 ppm calcium hydroxide</td>
<td>4.094</td>
</tr>
</tbody>
</table>
Ca(OH)$_2$ Dose is Important

Filtration Rate vs Ca(OH)$_2$ Dose

- 0 ppm
- 2000 ppm
- 3000 ppm
- 4000 ppm
- 5000 ppm
## Filter Cake Properties are Improved

<table>
<thead>
<tr>
<th></th>
<th>Final Cake Solids (wt%)</th>
<th>Dry Cake Density (lb/ft$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unthickened with 4000 ppm Ca(OH)$_2$</td>
<td>71.2</td>
<td>75.7</td>
</tr>
<tr>
<td>Thickened with Ca(OH)$_2$</td>
<td>72.6</td>
<td>77.8</td>
</tr>
<tr>
<td>Thickened with Floc</td>
<td>65.8</td>
<td>65.9</td>
</tr>
<tr>
<td>Thickened with Both</td>
<td>74.3</td>
<td>81.7</td>
</tr>
</tbody>
</table>

- Pressure filtration after thickening shows that Ca(OH)$_2$ can have a dramatic influence on filtration equipment performance.
- Cycle time, cake solids, and density all improve when Ca(OH)$_2$ coagulated tailings are flocculated and thickened before filtration.
- Thickening and filtration equipment benefit from Ca(OH)$_2$ coagulation.
Filtrate Quickly Equilibrates

Water equilibrates to desirable conditions in a short time

- Dissolved Ca$^{2+}$ precipitates when exposed to the CO$_2$ in the air
- pH neutralizes when exposed to the atmosphere
Conclusions

- Ease of mixing Ca(OH)$_2$ removes the necessity of expensive mixing equipment and costly processes for mixing.

- Ca(OH)$_2$ when used as a coagulant in pretreatment to flocculation in settling tube tests radically improved release water clarity and settling.

- Adding Ca(OH)$_2$ to a pressure filtration operation can double filtration rate when compared to polymer alone reducing the amount of required pressure filters.

- The water extracted provides a basic environment without adding more sodium which can be quickly prepared to return to the extraction process.
Questions?