ANIONIC-CATIONIC PROCESS FOR SILICA SAND FLOTATION

RYAN XIONG, JAMES GU AND GUOXIN WANG
Outline of The Presentation

- Introduction
- Objectives
- Case Studies
- Summary
Introduction

Source: U.S. Bureau of Labor Statistics

Industrial Sand Mining: Industrial Glass Sand

Industrial Sand Mining: Industrial Foundry and Molding Sand
Sand and gravel reserves of the world are large. However, because of their geographic distribution, environmental restrictions, and quality requirements for some uses, extraction of these resources is sometimes uneconomic or challenging.

*U.S. Geological Survey, Mineral Commodity Summaries, January 2018*
Froth flotation

Froth Flotation process is a particle hydrophobic surface-based separation technique.
Mathematical models for $P_c$ (Yoon and Luttrell, 1989)

\[
P_c = \left[ \frac{3}{2} + \frac{4 \text{Re}^{0.72}}{15} \right] \left( \frac{D_p}{D_b} \right)^2
\]

$P_a$ can be calculated (Yoon, 2000)

\[
P_a = \sin^2 \left[ 2 \arctan \left( \frac{45 + 8 \text{Re}^{0.72} V_b t_i}{15 D_b \left( \frac{D_b}{D_p} + 1 \right)} \right) \right]
\]

$P_d$ can be calculated (Tao, 2004)

\[
P_d = \left[ 1 + \left( \frac{3(1 - \cos \theta_d) \gamma}{g \left( \rho_b - \rho_w \left( \frac{1}{2} + \frac{3}{4} \cos \frac{\theta_d}{2} \right) \right)} \right) \left( 1 + \frac{D_p}{D_b} \right) \right]^{-1}
\]
Introduction

Illustration of particle-bubble attachment and detachment in a liquid medium (Nguyen, Ralston and Schulze, 1998).

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Effect of coal and mineral particle density on the upper particle size limit and the lower particle size limit of effective flotation (Jowett, 1980)
Introduction

Feed

Reagents With pH modifier

Well sized feed

Concentrate

Good water quality

High condition solids

Tails
Introduction

Oxides of Al, Ti, Fe, Ca and Mg

- The iron is present as free or loosely bound iron oxide which is easily removed by a simple washing procedure.
- The iron is tightly bound to the sand as a mineral impurity which is difficult to remove within the framework of existing environmental and economic considerations.
Introduction
Objective

Develop a process relates to an efficient and economical method for beneficiation of glass and foundry sand, especially for lower grades of sand.

Zeta potential of uncoated sand and sand coated with iron and aluminum oxide (Dinesh Shah and Monica James, 2006)

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The newly developed Anionic-Cationic Process is directed to a new flotation process for beneficiating glass sand and foundry sand deposits. The flotation feed is relatively lower grade flotation feed prepared by conventional washing and sizing method. The methods of the present invention includes steps of:

(a) Conditioning the flotation feed at neutral or acidic pH with an anionic collector at 0.6 to 1.0 lb per ton of feed;

(b) Subjecting conditioned flotation feed to anionic flotation to reject heavy mineral or carbonate impurities as waste.

(c) Mixing the underflow of anionic flotation with cationic collector as 0.24 to 0.34 lb per ton of feed at neutral or acidic pH;

(d) Subjecting the mixed slurry to second stage cationic flotation;
Glass Sand Beneficiation

- Reverse flotation
- Conditioning with anionic collector at acidic pH
- First stage anionic flotation at acidic pH
- Second stage cationic flotation at acidic pH
- Final sand concentrate

No conditioning step
Glass Sand Beneficiation

<table>
<thead>
<tr>
<th>Feed sample</th>
<th>%</th>
<th>%</th>
<th>%</th>
<th>%</th>
<th>Size</th>
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<tbody>
<tr>
<td></td>
<td>Fe2O3</td>
<td>Al2O3</td>
<td>TiO2</td>
<td>SiO2</td>
<td>-40+70 Mesh</td>
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<tr>
<td>Glass sand</td>
<td>0.3397</td>
<td>0.227</td>
<td>0.0326</td>
<td>99.34</td>
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</table>

<table>
<thead>
<tr>
<th>Reagent</th>
<th>Dosage lb/t</th>
<th>Mass Yield, %</th>
<th>Assay, %</th>
<th>Removal rate, %</th>
<th>Flotation process</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fe2O3</td>
<td>Al2O3</td>
<td>TiO2</td>
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<tr>
<td>CF 7028</td>
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<td>98.59</td>
<td>0.066</td>
<td>0.176</td>
<td>0.0204</td>
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<td>CF 7028</td>
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<td>98.56</td>
<td>0.0599</td>
<td>0.15</td>
<td>0.0182</td>
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<td>CF 7028</td>
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<td>98.58</td>
<td>0.0535</td>
<td>0.147</td>
<td>0.0182</td>
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<tr>
<td>CF 7028</td>
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<td>96.32</td>
<td>0.0493</td>
<td>0.139</td>
<td>0.018</td>
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<tr>
<td>CF 7028</td>
<td>0.50</td>
<td>96.82</td>
<td>0.0393</td>
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<tr>
<td>CA E130</td>
<td>0.24</td>
<td>96.82</td>
<td>0.0393</td>
<td>0.129</td>
<td>0.018</td>
</tr>
</tbody>
</table>
Foundary Sand Beneficiation

- Foundry sand Flotation Feed
- Conditioning with anionic collector at neutral pH
- First stage anionic flotation at neutral pH
- Second stage cationic flotation at neutral pH
- Final sand concentrate

No conditioning step

Reverse flotation

Direct flotation

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## Flotation results

### Feed sample

<table>
<thead>
<tr>
<th></th>
<th>%</th>
<th>%</th>
<th>%</th>
<th>%</th>
<th>%</th>
<th>%</th>
<th>ADV</th>
<th>Size</th>
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<tbody>
<tr>
<td>Fe2O3</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Al2O3</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>TiO2</td>
<td></td>
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<td></td>
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<tr>
<td>CaO</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>MgO</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>SiO2</td>
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<td></td>
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<td></td>
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<td></td>
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<td></td>
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<tr>
<td>Foundry sand</td>
<td>0.7668</td>
<td>3.47</td>
<td>0.1216</td>
<td>0.7472</td>
<td>0.3834</td>
<td>93.19</td>
<td>39.94</td>
<td>-10+140 Mesh</td>
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</tbody>
</table>

### Reagent Dosage lb/t | Mass Yield, % | Assay | Flotation process

<table>
<thead>
<tr>
<th>Reagent</th>
<th>Dosage lb/t</th>
<th>Mass Yield, %</th>
<th>ADV</th>
<th>Fe2O3%</th>
<th>Al2O3%</th>
<th>TiO2%</th>
<th>CaO%</th>
<th>MgO%</th>
<th>SiO2%</th>
<th>Flotation process</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF 2211</td>
<td>1.00</td>
<td>77.23</td>
<td>10.53</td>
<td>0.2252</td>
<td>2.75</td>
<td>0.0329</td>
<td>0.3644</td>
<td>0.0704</td>
<td>94.72</td>
<td>Conventional one stage anionic</td>
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<tr>
<td>CF2211</td>
<td>0.6</td>
<td>76.68</td>
<td>1.99</td>
<td>0.158</td>
<td>0.526</td>
<td>0.0299</td>
<td>0.082</td>
<td>0.0679</td>
<td>98.86</td>
<td>Anionic-cationic</td>
</tr>
<tr>
<td>CA 1507</td>
<td>0.34</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>
Benefits of the new reagent scheme

An Anionic-Cationic flotation process with CustoFloat collector and CustAmine collector:

Compared with conventional one-stage flotation or two stage anionic flotation with anionic collector:

- Better product can be produced with similar yield.
- Relatively Easier to adopt into current plant set-up
- More tolerable for ore body changes, like Low grade feed
- Mine life extended
Schematic Flowsheet of Anionic-Cationic Flotation

Application in Glass sand – easily adapted

CustoFloat™ Series anionic collector + pH modifier (sulfuric acid)

CustAmine™ series cationic collector

Heavy minerals tail  Heavy minerals tail  Final sand Concentrate

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Schematic Flowsheet of Anionic-Cationic Flotation

Application in Foundry sand

- CustoFloat™ Series anionic collector
- CustAmine™ series cationic collector

Modification required

Carbonates tail

Final sand Concentrate

Carbonates tail

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High grade sand deposits become depleted and less accessible, it becomes imperative to provide methods for beneficiation of lower grades of sand.

The newly developed Anionic-Cationic flotation process with CustoFloat collector and CustAmine collector are more efficient for processing low grade feed and it can be easily adapted to the plant, especially for glass sand processing plant and no further modification required in the process.
THANK YOU

QUESTIONS?