Phosphate in Australia

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Column Flotation of Phosphate Ore

An Engineer’s Perspective

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Something to think about…….

Is the use of column flotation a forgotten or overlooked process option for flotation of fine phosphate ores?
Use of columns first recognised by Klassen and Mokrousov for froth washing in early 1960’s.

Boutin and Wheeler claim to have commercialised column flotation at Opemiska, Canada

Columns have been in use in phosphate beneficiation since the 1980’s

Used for both sedimentary and igneous phosphate

Finer particle sizes better suited to column flotation (<212µm)

Columns are able to treat ultra fine particles (>10µm to <38µm)
Comparison of Technologies – Mechanical Flotation

- **Mechanical**
  - Agitator drive required per cell
  - Bubbles generated by shear at the rotor and stator
  - Larger bubble size
  - Larger foot print
  - Require more stages to achieve grade and recovery
- Mechanical flotation circuit layout
- Structural column centres are 7m
- 120m (L) x 42m (W) = 5040m²
Comparison of Technologies – Column Flotation

- **Columns**
  - No agitator (recirculation pump)
  - Deeper, more stable froth
  - Finer bubble size
  - External bubble generator
  - Requires less stages to achieve grade and recovery
Comparison of Technologies – Column Flotation (Cont.)

- Column flotation circuit layout
- Structural column centres are 7m
- $70\text{m} (L) \times 42\text{m} (W) = 2940\text{m}^2$
Typical Pilot Plant Flow Sheet - Mechanical

Flow: Flotation feed → High Solids Conditioning → Rougher → Cleaner 1 → Cleaner 2 → Cleaner 3 → Scavenger → Tailings

Streams:
- Cl.3 Tails
- Cl.1 Conc.
- Cl.1 Tails
- Cl.2 Conc.
- Cl.2 Tails
- Sc. Conc.
- Ro. Conc.
- Ro Tails
- Reagents
Typical Pilot Plant Flow Sheet - Columns

- Flotation feed
- High Solids Conditioning
- Rougher
  - Ro. Conc.
  - Ro Tails
- Cleaner 1
  - Cl.1 Conc.
  - Cl.1 Tails
- Cleaner 2
  - Cl.2 Tails
- Cleaner Scavenger
  - Cl. Sc. Conc.
  - Cl. Sc. Tails.
- Tailings
- Final Concentrate

Reagents
Typical Phosphate Mechanical Flotation Circuit

Based on Brazilian igneous phosphate plant (0.250mm x 0.030mm)

- 10m$^3$ cells
- 66 float cells
- 17 cleaner cells
- 11 recycle streams

Source: Eriez Flotation Group 2013
Based on a Brazilian igneous phosphate plant (0.250mm x 0.030mm)

- 195m$^3$ columns
- 6 columns
- 5 stages of cleaners
- 0 recycle streams

Source: Eriez Flotation Group 2013
Review of technical benefits

<table>
<thead>
<tr>
<th>Type</th>
<th>Stages in circuit</th>
<th>Trains</th>
<th>Installed Power (kW)</th>
<th>No. of cells</th>
<th>Design Volume (m³)</th>
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<tr>
<td>Mechanical</td>
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<td>6135</td>
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<td>&lt;2066</td>
<td>&lt;56</td>
<td>&gt;1959</td>
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</table>

**Basis:**
- 2400tph flotation feed
- Igneous rock
- Mechanical cells as per vendor recommendations (non-standard sizes for phosphate beneficiation (100m³, 75m³ and 50m³ units))

**Benefits**
- Circuit layout
- Number of flotation cells required
## Review of technical benefits (Cont.)

<table>
<thead>
<tr>
<th>Type</th>
<th>Stages in circuit</th>
<th>Trains</th>
<th>Installed Power (kW)</th>
<th>No. of cells</th>
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<td>&lt;1</td>
<td>&lt;5192</td>
<td>&lt;218</td>
<td>&gt;1959</td>
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</tr>
</tbody>
</table>

**Basis:**
- 2400tph flotation feed
- Igneous rock
- Mechanical cells resized as per industry practice
- Number of cells is based on 20m³ or 600ft³ sized units

**Benefits**
- Circuit layout
- Number of flotation cells required
Review of technical benefits (Cont.)

Metallurgical testwork results

<table>
<thead>
<tr>
<th>Type</th>
<th>Cell type</th>
<th>Mass</th>
<th>P$_2$O$_5$</th>
<th>Conc. Grade P$_2$O$_5$</th>
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</table>
Based on flowsheets as previously discussed

- Capital costs
- Operating costs
Capital costs

- Less flotation columns required to treat same volume throughput
- Less mechanical drives required
- Less electrical drives (no agitators and associated drives in MCC)
- Savings in circuit foot print (Reduced floor space but increase in building height)
- Savings in steelwork and concrete
Operating costs

- Savings in unit power consumption (kWh/t)
- Savings in mechanical equipment maintenance
- Less equipment to supervise / manage
- As phosphate ore deposits require more liberation (finer particle size) to remove deleterious elements so column flotation will become more prominent.
- There are various suppliers of non agitated flotation machines – Eriez, Metso Cisa, MBE (Pnueuflot) and Maelgwyn Mineral Services (Imhoflot).
- Proven metallurgical benefits when particle size range of flotation feed is less than 212µm.
- Process desliming cut point can be reduced as columns can treat finer particle sizes in the deep stable froth beds.
- Process testwork using columns usually starts in pilot scale as the bench scale columns do not produce representative results.
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