Oxygen demand test - A diagnostic tool for determining the optimum aeration in the selective flotation of chalcopyrite from pyrite

Clement Owusu, William Skinner, Daniel Fornasiero, Jonas Addai-Mensah, Massimiliano Zanin*

The Wark™, University of South Australia, Australia
Copper flotation plants often experience difficulties in the post-regrind flotation of Cu sulfides from pyrite:

- Low flotation rate of the Cu sulfides
- Poor selectivity between Cu sulfides and pyrite

Correlation exists between the amount of pyrite in the feed and the low flotation performance.
The Effect of Pyrite in Grinding

• Cathodic mineral $\rightarrow$ galvanic interactions, oxidation of chalcopyrite, release of $\text{Cu}^{2+}$ and $\text{Fe}^{3+}$ ions (Huang and Grano, 2005)

• Consumes oxygen $\rightarrow$ xanthate adsorption on Cp is inhibited in an $\text{O}_2$ depleted pulp (Gaudin, 1974; Ahmed, 1978)

• Can become Cu activated and compete with Cp for collector adsorption

Cu activated pyrite becomes flotable even at high pH (Huang & Grano, 2005)

Galvanic interactions in complex sulphide ores (Huang & Grano, 2005)
Metallurgical Implications

In copper ores, the presence of pyrite causes:

1. Reduction of chalcopyrite flotation recovery
2. Activation/flotation of Py and reduction of the concentrate grade
3. Higher reagents consumption (lime, collectors)

Evidence suggests that intense aeration of the pulp can mitigate the negative impact of pyrite on copper flotation.
Objectives (AMIRA P260 Project)

- Investigate the effect of post-regrind pulp aeration on the flotation response of chalcopyrite in Cp/Py mixtures
- Develop a methodology to assist plant operators optimising flotation

- Can we predict the optimum aeration levels for maximum metallurgical performance (Cu recovery and selectivity)?
- Can we efficiently aerate the pulp in the plant?
- Can we respond to changes in feed composition?
Tools: Oxygen Demand Test

- Measures the amount of dissolved $O_2$ in the pulp and the rate of $O_2$ consumption
- It is an indicator of the pulp reactivity
- Measures the amount of air/O$_2$ needed to passivate the reactive mineral surfaces

The pulp is purged with air/O$_2$ in an intermittent regime (5 min ON and 5 min OFF). DO, Eh and pH are monitored (Greet et al., 2004; Spira and Rosenblum, 1974)
Cp/Py blends are prepared at increasing Py content

Rougher concentrate produced and reground in IsaMill

Aeration at increasing time performed before cleaner flotation
Results
Pyrite content and Oxygen Consumption

- Pyrite in the pulp rapidly consumes oxygen
- The reactivity of Cp/Py blends depends on the relative amount of pyrite
Pyrite content and Cu Flotation Response

- Pyrite in the feed reduces the flotation recovery of chalcopyrite
- Aeration restores in part chalcopyrite recovery
- The optimum amount of air is linearly related to the amount of pyrite
Surface Modifications Upon Aeration

XPS surface analysis of Cp and Py particles at different aeration times. 50:50 blend. Surface wt.%.

<table>
<thead>
<tr>
<th>Aeration time</th>
<th>0 min</th>
<th>48 min</th>
<th>80 min</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cp</td>
<td>Py</td>
<td>Cp</td>
</tr>
<tr>
<td>Cu</td>
<td>9</td>
<td>0.7</td>
<td>12</td>
</tr>
<tr>
<td>Fe</td>
<td>10</td>
<td>17</td>
<td>11</td>
</tr>
<tr>
<td>O</td>
<td>18</td>
<td>21</td>
<td>18</td>
</tr>
<tr>
<td>C</td>
<td>43</td>
<td>36</td>
<td>42</td>
</tr>
<tr>
<td>S</td>
<td>19</td>
<td>26</td>
<td>18</td>
</tr>
</tbody>
</table>

- Aeration increases the exposed O and reduces the exposed S
- At the optimum aeration, Py is depressed, while Cp surface is marginally affected
- Prolonged aeration also depresses Cp
Determining Optimum Aeration

- Maximum Cp recovery (and grade) is achieved after aerating the pulp until the Kla reaches a bottom plateau.

![Graph 20 wt% Py](image1)

- The optimum aeration ($V_{AIR}/V_{PULP}$) determined by DO demand test can be used to scale up to plant conditions.
Plant Implementation

Aachen reactor installed on mill discharge

Sponsor Cu/Au operation in WA

Copper Flotation

Cu/Au Con

CIL

Au/Cu prefloat

Pyrite Flotation

Py Regrind

Graph:

- $y = 10.073e^{1.828x}$
- $O_2$ demand = 1.83

- $y = 14.017e^{4.217x}$
- $O_2$ demand = 4.22

Dissolved Oxygen (ppm)

Time (min)
• Post-regrind aeration significantly increased Cu recovery and grade
• Au showed similar trend as Cu
• With no aeration, flotation rates and recoveries of Cu and Au were very low
Increased Au Flotation Rate

Laboratory Metallurgical Data

- The flotation rate of Au (and Cu) increased remarkably upon aeration
- Selectivity versus pyrite also increased
- With no aeration, the flotation rates of Cu and Au were extremely low
Conclusions

• Pyrite in the feed depresses chalcopyrite flotation

• The reduction of DO in the pulp in the presence of pyrite is significant, which inhibits collector adsorption on chalcopyrite. The effect is particularly high after fine regrinding

• Post-regrind aeration of the pulp can in part restore chalcopyrite recovery

• The optimum aeration levels depend on the amount of pyrite in the feed, and can be predicted by means of DO demand test

• Plant trials in a sponsor’s operation showed significant benefits in post-regrind aeration of a high pyrite plant stream before Cu/Au flotation
Acknowledgements

The authors kindly acknowledge AMIRA International and the industry sponsors of the AMIRA P260F project on minerals flotation.