JOGMEC Project on arsenic reduction

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Copper smelters in Japan

Capacity [thousand t]

- Naoshima: 306 thousand t, 17%
- Saganoseki: 450 thousand t, 25%
- Toyo: 450 thousand t, 25%
- Tamano: 348 thousand t, 19%
- Onahama: 260 thousand t, 14%

Total 1,814 thousand t

Ref: JOGMEC

Photo: Web pages
Japan imports all of copper concentrates from overseas while the arsenic content in copper concentrate is increasing. At present, the Japanese smelters fix arsenic in slag, however, the more arsenic in concentrate increases, the more difficult treating arsenic would be at the smelters.

### Regulation in Japan

<table>
<thead>
<tr>
<th>Regulation</th>
<th>As limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>① Air</td>
<td>No limitation</td>
</tr>
<tr>
<td>② Surface water</td>
<td>0.01 mg/L</td>
</tr>
<tr>
<td>③ Underground water</td>
<td>0.01 mg/L</td>
</tr>
<tr>
<td>④ Slag (Elution)</td>
<td>Elution: 0.01 mg/L</td>
</tr>
<tr>
<td></td>
<td>Content: 150mg/kg</td>
</tr>
</tbody>
</table>

2.70 million t/year
Development of a new process for arsenic removal at the mineral processing stage, and safe storage of arsenic product.
Cu mineral and As mineral have similar properties. As mineral is finely disseminated in Cu mineral. Difficult to separate by conventional techniques.

Advanced Mineralogical Analysis

Comminution to promote separation

New separation technique including new flotation reagent

Non binding substance

As binding substance

Custom smelters

Mining countries

Arsenic fixation

Open pit mine

Ore

Mill

Ore with high As

Concentrate
Development of comprehensive analyzer for mineral processing

Enhancement of mineral liberation of impurity mineral in Cu ore by HPGR and separation by flotation

Development of separation and treatment process of ore with high As applicable to actual Cu ore
## Comparison between Cu and As minerals

<table>
<thead>
<tr>
<th></th>
<th>Chalcopyrite</th>
<th>Bornite</th>
<th>Enargite</th>
<th>Tennantite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Composition</td>
<td>CuFeS₂</td>
<td>Cu₅FeS₄</td>
<td>Cu₃AsS₄</td>
<td>(Cu, Fe)₁₂(Sb, As)₄S₁₃</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>4.1-4.3</td>
<td>5.06-5.08</td>
<td>4.45</td>
<td>4.62</td>
</tr>
<tr>
<td>Hardness</td>
<td>3.5-4</td>
<td>3</td>
<td>3</td>
<td>4-4.5</td>
</tr>
<tr>
<td>Magnetic property</td>
<td>Antiferromagnetic</td>
<td>Paramagnetism</td>
<td>Diamagnetism</td>
<td>Paramagnetism</td>
</tr>
<tr>
<td>Cu grade %</td>
<td>34.6</td>
<td>63.3</td>
<td>48.4</td>
<td>51.6</td>
</tr>
</tbody>
</table>

Flotation behavior is similar because all of them are sulfides.
Development of comprehensive analyzer for mineral processing

- Evaluation of
  - Detailed mineral liberation in 3D
  - Shape characteristic of mineral particle in 3D

- Estimation of
  - Result of gravity separation
  - Result of magnetic separation
  - Flotation behavior

- Comprehensive evaluation of separation results with recommended process
High Pressure Grinding Rolls

Features
- Add pressure 5 -10 times higher than conventional mill
- Feed highly packed particle to rolls
- Add sufficient grinding force to highly packed particle layer with hydraulic cylinder
- Achieve effective inter-particle grinding

Nittetsu Mining, Furukawa and Waseda Univ.
Search biosubstance binding to As mineral

Search chemicals based on first-principles calculation and experiments

Tohoku Univ., Miyazaki Univ.
Conditioning for flotation

JX and Akita Univ., Sumitomo and Kyushu Univ.

As mineral

Surface modification

pH Control

ORP Control

etc.

Cu mineral

Similar surface property

As mineral

Cu mineral

Only surface of As mineral modified
Precise magnetic separation of arsenic from copper concentrate with high content of arsenic

This figure indicates that enargite and tenanntite can be separated from chalcopyrite by precisely controlled magnetic separation.

Pretreatment before magnetic separation has also investigated.
As mineral treatment

High pressure leach

- O₂ gas
- Impeller
- Thermometer
- Lixiviant
- Ore
- Heater

High pressure, max. 2MPa
High temperature, max. 200℃

Bioleach

- Fe(II)-oxidizing microbes
- Catalyst (e.g. silver)

Catalyst

Enargite (Cu₃AsS₄)

- Cu(II)
- H₃AsIIIIO₃
- Fe(II)
- Fe(III)
- S⁰-
- SO₄²⁻

JX and Akita Univ.
Sumitomo and Kyushu Univ.
Summary

- Arsenic in copper concentrate is increasing and getting to cause serious problem.
- But, the property of Cu and As sulfide mineral is very similar.
- Some experiences using single mineral species in laboratories indicated the possibility of the separation, however, there are no actual operations.
- Against this background, JOGMEC has been carrying out research to separate Cu and As minerals by physical separation technique.
- The research will help to develop sustainable development of copper mining.
Thank you!