Improvements in copper heap leaching by addition of wetting agents

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Project introduction - improving Cu heap leaching

Background:
- annually rising demand of copper ⇒ increasing prices
- approx. 20 % of primary world Cu production by heap leaching processes + SX/EW
- so far recovery of conventional heap leaching processes range by 75-80 % of the ore’s Cu-content during leaching periods of several months

Target:
- Improve productivity (recovery and leaching kinetic)
  ⇒ by addition of wetting agents
Heap leaching of copper ores

- "reactor" volume: 100,000-500,000 t ore
- retention time of solution: 2-7 days
- leaching duration: several months
Heap leaching of copper ores

- Stacker unit
- Sprinkler system
Principles

Model: shrinking core

- Time
- 30 mm

Image of material with green mineral before and after treatment.
Leaching model (1)

\[ \frac{dn_{Cu}}{dt} = A \cdot D_{eff} \cdot \frac{dc_{Cu}}{dr} \]

- \( C_A \) = acid content
- \( C_{Cu} \) = leached Cu content
- \( r_0 \) = starting radius of particle
- \( r_C \) = radius of unreacted core
- RIM = leached core shell
Leaching model (2)

\[ t(F = 1) = \frac{2 \cdot B \cdot r_0^5 \cdot \tau}{3D \cdot C_{A,0} \cdot n_K \cdot r_K^2} \sqrt{\frac{2 \eta}{r_K \cdot t_p \cdot \gamma_L \cdot \cos \theta}} \]
Requirements of wetting agents

By analysis of the previous attempts to introduce wetting agents to leaching processes the following performance profile was developed:

Requirements for heap leaching process:
- good wetting performance at process temperature
- improved capillary penetration of ores
- no negative impact on further processing steps (SX, EW)
- economically acceptable concentration
- stable in leaching solution
- low foaming
- biodegradable / not eco-toxic
Criteria 1 - surface tension and CMC

Determination of the optimum dosage concentration.

Surfactant in water of 20°C

Critical micelle concentration (CMC)

Surface Tension in mN/m

Concentration in mg/L
Criteria 2 - adsorption rate

Measuring the adsorption rate by miniature column test.

- ore 1
- ore 2

<table>
<thead>
<tr>
<th>Irrigation Time / h</th>
<th>Surfactant Concentration in Outflow / ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>100 ppm</td>
</tr>
<tr>
<td>3</td>
<td>200 ppm</td>
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Surfactant solution
Criteria 3 – capillary penetration

Measuring the ore penetration and the wetting performance.

- solution without surfactant
- solution with surfactant

Load in mN

Time in s

- analytical balance
- ore
- eluent
- tube with sintered glass bottom
Column trials at IME

**Experimental set-up:**
- 8 columns, H = 2150 mm, D = 300 mm
- Perforated stainless steel base
- Filling level: 2000 mm
- Volume: appr. 0.14 m³
- Ore weight: appr. 200 kg / column

**Ore:**
- Origin: Cerro Colorado, Chile
- Particle size: 1 – 30 mm
- Cu-content: 1.05 wt-%
Experimental set up

storage vessel
PE granulate
sprinkler
valve timing pumps
## Experimental procedure

<table>
<thead>
<tr>
<th>column</th>
<th>additive</th>
<th>BASF lab No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 + 2</td>
<td>blank</td>
<td>-</td>
</tr>
<tr>
<td>3 + 4</td>
<td>nonionic surfactant (fatty alcohol alkoxylate)</td>
<td>EVD61549</td>
</tr>
<tr>
<td>5 + 6</td>
<td>nonionic surfactant (fatty alcohol alkoxylate)</td>
<td>RD159491</td>
</tr>
<tr>
<td>7 + 8</td>
<td>anionic surfactant (alkyl ether sulfate)</td>
<td>EVD63635</td>
</tr>
</tbody>
</table>

**conditions:**
- test duration: 4 weeks
- throughput: 0.7 l/h column (10 l/h per m²)

**concentrations:**
- \( \text{H}_2\text{SO}_4 \): 2 %
- surfactant: 0.01 %
Determination of adsorption rate with PE nets

- Total height: 215 cm
- Filling level ore: 200 cm
- Sample A: 135 cm
- Sample B: 75 cm
- Sample C: 15 cm
Spreading of wetting agents

Relatively strong adsorption of all wetting agents
Copper extraction

Nonionc wetting agents improve Cu extraction
Copper recovery

improvement of leaching efficiency up to 6 %
**Summary:**
- proof of concept has been successful:
  - nonionic wetting agents may improve the kinetic of leaching and copper extraction rate
  - still too high adsorption rate for the nonionic wetting agents depending on the ore
  - anionic wetting agents did not achieve a higher extraction rate

**Outlook:**
- optimization in progress with regard to:
  - wetting performance
  - adsorption rate
  - proof of transferability to other acid leaching technologies e.g. Ni
- new trials are planned in Aachen with improved wetting agents
Thank you for your attention.

İlgizine teşekkür ederiz.

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