Hydrometallurgy @ HIF

Jens Gutzmer

EIT Raw Materials & BASF
14 September 2018, Ludwigshafen
Structure of HIF

Exploration

Mining

Modelling & Evaluation
- Economics
- Mathematics
- Stochastics

Analytics
- X-ray methods
- Electron beam methods
- Ion beam methods

Department of Metallurgy and Recycling

Processing
- Flotation and Biotechnology

Metallurgy and Recycling

System Integrated Metal Production

Hydrometallurgy@HIF

Department of Biotechnology

Exploration

Mining
BMBF-r⁴-SE-FLECX-Project

- characterization of different ores (e.g. MLA)
- ore processing, generation of REE concentrates for model solutions

Norra Kärr Ore - Sweden
- REE+Sc+Y=4.5 kg/t ore
- 95% of REE in one mineral: eudialyte gangue minerals: aegirine, microcline, albite
- High-intensity magnetic separation → preparing of two concentrates in two stages

Strange Lake Ore - Canada
- REE+Sc+Y=25 kg/t ore
- REE+Sc+Y in more than 10 minerals (pyrochlore, allanite, monazite, zircon…)

• investigation of acid leaching of silicates
• mechanism of polycondensation, aggregation,…
BMBF-r⁴-SE-FLECX-Project

- development of new selective extraction agents for the extraction of rare earth elements
- two types of proligands:
  - **Type A**: selective separation of uranium and thorium
  - **Type B**: selective separation of rare earth elements
- SX experiments, complexation and solubility studies with REE and actinides

- extraction properties of new calix[4]arenes
- reduction of the number of separation stages
"THEISEN SLUDGE"
230,000 tons deposited between 1978 and 1990

- recycling of elements such as rhenium or molybdenum from copper smelting residues
- main components: Pb, Zn, Cu, Fe, Sn
- components of strategic economic importance: Re, Ge, Mo, Co, Sb
- high organic content of about 10%, environmental pollution (e.g. $^{210}\text{Pb}$)

http://kupferspuren.artwork-agentur.de/index.php?option=com_content&task=view&id=124#nogo
BMBF-r⁴-Theisen Sludge-Project

Processing approach:

- separation and accumulation of the target elements (Ge, Re, Sb, Mo) by the use of precipitation, membrane separation, **classical solvent extraction (HIF)** and bio-solvent extraction

- comparison of bioleaching and chemical leaching
- studies on the leaching mechanism
BMBF-r\textsuperscript{4}-Theisen Sludge-Project

- continuous solvent extraction experiments with a lab-scale mixer-settler unit

- structural characterization of the complexes

- investigations of intra-/intermolecular interactions in the organic phase
- selective solvent extraction from very low concentrated solutions

References:
[3] https://www.chem.pitt.edu/facilities/mass-spectrometry/mass-spectrometry-introduction, 07.09.18
- development of innovative processes for copper (and associated metals (Ag, Co, Ni, Ga, …)) extraction by means of biotechnology
- 17 partners coming from (mining and processing) industries and sciences in France, Germany and Poland
- bacteria, other microorganisms, and biomolecules are used to leach metals from the ore (bioleaching) and selectively separate them (biosorption, biomineralization)
- treatment of **mineral processing wastes** from copper mining industry

**Biotechnological processes as energy efficient, environmentally friendly, and inexpensive way for extracting and recycling important industry metals and strategic high tech raw materials**
production of leachates (from bioleaching) as starting solutions for enrichment and purification steps

- SX process including extraction and stripping using 15 L mixer-settler units
- copper electrolysis (batch or continuous mode)

- mini pilot plant for (bioleaching)-SX-electrolysis process for copper recovery
Metallurgy Pilot Plant

Metallurgy
0.01 - 10 kg

Hydrometallurgy
1 - 500 kg

Pyrometallurgy
1 – 100 kg

Mini Pilot Plant
10 - X00 kg

UVR-FIA GmbH
100 - X000 kg

Lab-scale ➔ Pilot-scale ➔ Industrial-scale

visualization: BBF Baubüro Freiberg GmbH
TOPFLOW: Important link for future hydromet. research!

Today:
- Steam/water experiments up to 7 MPa, 286°C
- $4 \text{ MW}_{\text{el}}$ steam generator
- Test sections up to DN 200
- Intensive instrumentation

Tomorrow:
- Experiments with near-organic NOVEC 642
- Experiments with supercritical CO$_2$
TOPFLOW: chemical reactors from lab to pilot scale

from lab to industry
Ultrafast electron beam tomography

- ≤ 8.000 frames/s
- Dual plane scan
- ~1 mm resolution
- Objects ≤ Ø 180 mm
- Total scan time ≤ 30 s
- Data rate ~1.5 GB/s
Innovative wire-mesh sensors

- Up to 10,000 frames/s
- Up to 128 x 128 wire electrodes
- Resolution ~ 2..3 mm

L. Szalinski et al., Chem. Eng. Sci. 65, 2010
Tomography

EU Innovative Training Network TOMOCON
Example for Flow Control using Tomography, Fast Parallel Data Processing and Massive-Data-Based Model-Predictive Control

Swirl

Gas core, uncontrolled, needs stabilization

Model-predictive control of an inline fluid separator at 1000Hz speed and 0.1s latency basing on tomographic sensor data
Thank you for your attention!