SHORT COURSE

Heap Leaching and its Application to Copper, Gold, Uranium and Nickel Ores

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Notes

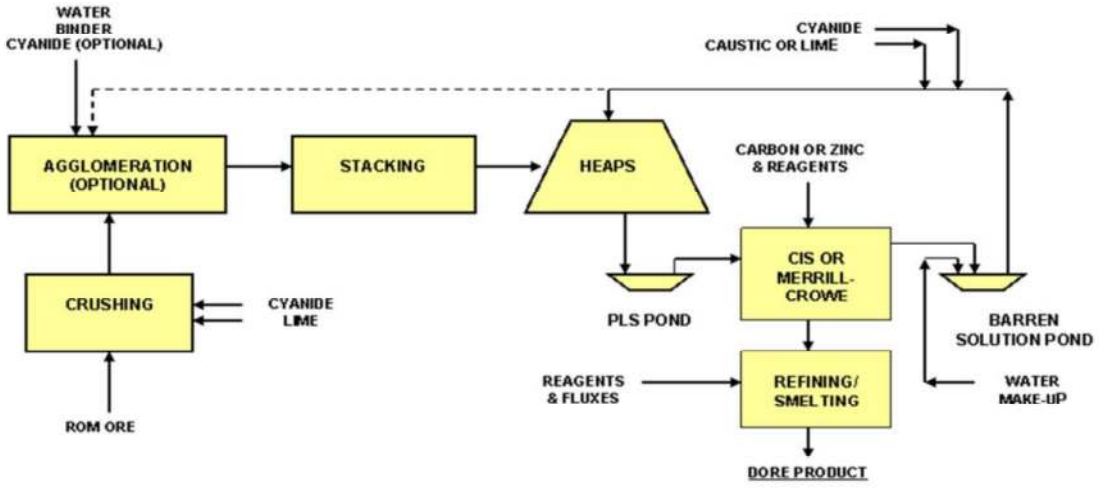
TYPICAL COPPER HEAP LEACH ENGINEERING DESIGN CRITERIA

- PLS Flowrate: determined from required copper production rate, PLS copper content and SX extraction efficiency.
- Pad arrangement: Permanent or On-Off
- Number of Leach Stages: 1 –3
- Angle of Repose: 35 – 40°
- Number of Lifts: 1 or Multiple
- Ultimate Heap Height: 3 – 100 m
- Pad Liner Material: Compacted Clay
  HDPE 0.75 – 1.5 mm
  VLDPE 0.75 – 1.5 mm
  PVC 0.5 – 1 mm
- Number of Pad Liners: 1 – 2
- Underdrains: HDPE 100 – 200 mm diam

Notes

1. Permanent pads are the most common arrangement, except in Chile where on-off pads are also common. The permanent pad arrangement can be used for oxide, sulphide or mixed ores, ROM or crushed. It can have single or multiple lifts, depending on the type of ore, the available site area, and the size of the operation. High recovery is assisted by the ability of the permanent pad system to accommodate prolonged leaching times, and releaching after periods of repose. This is particularly important for sulphide ores which typically require much longer leach cycle times than oxide ores. The provision of intermediate pond and pumping systems allows control of the copper level in the pregnant leach solution (PLS), together with maximization of copper recovery. This is typically achieved by employing a countercurrent leach system. The ability to prolong the leach cycle and provision of countercurrent leaching also provides a margin of safety to cover uncertainties in scale-up.
2. The on/off pad arrangement coupled with strong acid cure enjoys rapid initial leach kinetics which allows a relatively short leach cycle to be used. In addition, it yields a high copper level in the pregnant leach solution (PLS), which reduces the size, and therefore cost, of the associated SX plant. However, the leaching area itself involves a higher initial capital cost that permanent pads, and secondary permanent pads may be needed to achieve a leach recovery comparable with a total permanent pad system. Rehandling of residue adds to operating cost. The finite pad area represents a significant risk in scale-up, and it is prudent to allow a safety margin in the specification of the area.
3. Two or three leach stages can be used to build up the PLS copper content. They are commonly arranged in a countercurrent system with individual surge ponds, but may be arranged in a closed loop with the heap.
4. Angle of repose is determined from ore characteristics and safe industry practice with similar operations.
5. Single lift operation is commonly used for on-off pads, or for ores subject to severe slumping compaction or poor percolation. The number of multiple lifts is determined by the scale of operation, available site area and the geotechnical stability of the heaps.
6. Number and type of pad liners is determined by ground conditions, ground slope, presence of underground water aquifers, and environmental regulations.

TYPICAL GOLD PERMANENT PAD HEAP LEACH FLOWSHEET



Notes

1. Crushing would be eliminated for treating ROM ore.
2. Agglomeration with a binder such as cement or lime is shown as an option.
3. Recovery is via carbon-in-solution (CIS) or zinc precipitation (Merrill-Crowe).
4. Solution bleed with detox is not considered.

SOMAIR, NIGER

(Ref: Areva presentation, ALTA 2009)

Notes

PIAUI

(Ref: Brazilian Nickel paper, Heap Leach Solutions Conference, 2015)

- Under development in Brazil by Brazilian Nickel based in the UK. Aimed at supplying Ni and Co into the EV battery industry. Resource: 1.03% Ni, 0.048% Co, 10.08% MgO, 17.95% Fe_2O_3, 4.81% Al_2O_3, 51.51% SO_2, 0.29% MnO, 0.73% Cr.
- Proposed flowsheet comprises two-stage crushing, agglomeration, conveying, stacking, counter-current dynamic pad (on-off) leaching.
- Downstream processing includes iron removal and nickel production as mixed hydroxide product (MHP) suitable for the battery industry.
- Studies and testwork completed include small and large-scale column tests, pilot heaps, a demonstration plant, and PFS. BFS in progress.
- Demonstration heaps commenced in 2016 as part of a bankable feasibility study
- Column and heap tests demonstrate an extraction rate of greater than 80% Ni, with low acid consumption and short leach cycles.
- Target production is 25,000 t/a nickel and 900 t/a cobalt.

Notes

1. BRN plans to capitalise on increasing nickel prices by expanding the existing demonstration plant by a factor of 10 (approx.). This will expand the production at the demo plant to 1,400 t of nickel and 35 t of cobalt a year. This expansion can be implemented without the need for a BFS and using existing environmental permissions and thus jump-start BRN's project to immediate producer status.
2. The downstream impurity removal precipitation circuit was continuously operated for 9 months. Nickel and cobalt hydroxide products were produced exported and sold.
3. In parallel with the BFS, BRN is expanding the existing demonstration plant to continuously produce 1,400t/y nickel and 35 t /y cobalt.
4. Production targeted end of 2024.
5. Operating costs after refining charges and cobalt credits are expected to be less than US$ 2.8/ lb of nickel.
6. Reference: Brazilian Nickel Website https://www.braziliannickel.com/piaui-nickel-project/ accessed 13 Feb 2022.

TALVIVAARA HEAP BIOLEACHING OPERATION

(ALTA 2007 Presentation)
Photo Credit Wikipedia)

Notes

1. Ref: Talvavaara Mining Co. Paper, ALTA 2007, Perth, Australia
2. The heap was first covered with a clear plastic non-permeable membrane to minimize heat loss, and later with a foam cell carpet. The ponds were also covered. The covers also prevented rain and snow from being in direct contact with the heaps. Covers
3. The temperature of the PLS has varied between 40 and 50°C and the irrigation solution from 20 to 40°C.
4. The products are precipitated as sulphides using hydrogen sulphide.
5. Uranium recovery circuit using SX was added (Ref: Outotec-Cameco presentation, ALTA 2012).
6. Ref: Terrafame Paper presentation, Heap Leach Mining Solutions, 2016, Lima, Peru
7. New owners Terrafame are testing buried drippers instead of covers which suffered problems due to wind. Presence of pyrrhotite provides useful heat generation for winter operation, but changing heap structure is an issue.
8. Operation has two-stages with single lift on-off type first stage and multi-lift permanent pad type second stage. Retention times are 450 and 1100 days respectively.
9. Water balance is difficult due to rainfall and melting snow. Provision for removal and treatment of solution is included.
10. Irrigation system suffers from gypsum precipitation due to temperature drop in winter, and drip lines have to be changed number of times during the primary leach cycle.
11. Ref: Terrafame Paper, ALTA 2017, Perth, Australia
12. Oxidation of pyrrhotite precipitated iron which caused fusing and hardening of the ore bed making bucket wheel reclaiming impossible. Switching to excavators was successful but large lumps needed crushing prior to secondary leaching. Surface mining was then adopted and achieved breakage to an adequate particle size without crushing, though it needed an increased heap area to operate.
13. A hard layer was left after primary leaching and new drainage layer was laid containing new drainage pipes, while new aeration pipes were laid on top to minimize oxidation in the drainage layer.
14. Ref: Terrafame Paper, ALTA 2018, Perth, Australia
15. Outlet temp. has increased by more than 30% due to Improved leaching over 2016-2017 which has increased soluble calcium resulting in gypsum precipitation in irrigation pipelines. Control measures are being investigated including heating and precipitation onto gypsum seeds.
16. Lab Testwork is being carried out to optimize extraction of uranium and REE. Granted permit in Feb. 2020 to operate uranium recovery facility. (Refs: Reuters Feb 5, 2020 and ALTA 2018)
17. Terrafame plan to invest in battery chemicals plant to produce nickel and cobalt sulphates for growing Ev market.