Short Course

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

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

### Heap Leaching Technology General
- Basics
- Alternative Process Flowsheets
- Layout
- Pad Design
- Liner Selection
- Ore Transport and Heap Building Methods
- Solution Management
- Operation and Control
- Cold and Wet Climate Operation
- Reminig of Partially Leached Heaps

### Applications of Heap Leaching
- Application to Copper Ores
  - Role of Bacteria in Treatment of Sulphide Ores
  - Alternative Ferrous Re-Oxidizing Methods
  - Typical Copper Heap Leach Design Criteria
- Application to Gold Ores
- Application to Uranium Ores
- Application to Nickel Ores

### Testwork and Scale-Up

### Industry Trends

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Notes

1. The above flowsheet is for crushed ore. ROM ore leaching would not have a crushing circuit.

2. Agglomeration is used to achieve adequate percolation rates with finely crushed ore in the presence of fines or clays, especially swelling clays such as the smectite group. For copper, uranium and nickel ores in acid conditions, the agglomerant can be water, barren leach solution, strong lixiviant solution and/or polymer in severe cases. Cement, limestone or fly ash are used for heap leaching gold ores with cyanide, and could be considered for alkaline heap leaching of uranium ores or ammonia leaching of copper oxide ores. Agglomeration is generally carried out in a rotating drum.

3. Curing with strong lixiviant solution may be included even when agglomeration is not required. It can be useful for accelerating leach kinetics during the early portion of the leach cycle, which enhances the initial metal production rate. It is commonly used with on-off pad systems to minimize the pad area. In some cases curing may reduce impurity levels, such as silica, in acid copper systems, while in others it may result in higher lixiviant consumption. For crushed ores, rotating drums are commonly used, and a cure time of one or more days may be included before commencement of irrigation. For ROM ore, a similar effect is achieved by an initial soak of the heap during which the ore is irrigated with strong lixiviant solution.

4. Pre-wetting of the ore with water, lixiviant and and/or bacteria is also commonly used for crushed ore in order to minimize the migration of fines in the heaps, to initiate early leaching, to avoid dry areas, to promote bio-activity, and to avoid an adverse lixiviant concentration profile when starting to leach a new lift (e.g. high pH in the lower portion of the lift for acid systems which can lead to precipitation of pay metal or impurities which may plug the heap. Pre-wetting can be carried out in a rotating drum or via conveyor belt sprays.

5. Rest-rinse operation is commonly used during the latter portion of the leach cycle or for scavenging additional metal from leached heaps. It can also be used throughout the leach cycle in order to achieve a higher PLS concentration.

6. Low pressure air is generally sparged into the base of the heaps when bio-leaching of sulphide ores is involved. It may also be applicable to alkaline leaching of primary uranium ores.

7. Various ore transport and stacking systems are used, depending on the ore particle size, the shape of the leach pad area, the site topography, the ore treatment rate, and whether permanent or on-off pads are used.
LEACH PAD DESIGN CONSIDERATIONS

- Site environmental regulations.
- Pad site selection to achieve suitable slopes, minimizing required earthworks, and avoiding underground water resources.
- Selection of impermeable liner system: Plastics - HDPE, LLDPE, VLDPE, PVC, or compacted clay, or a combination.
- Ground and underliner preparation to minimize settlement and avoid liner punctures.
- Underdrains to detect leaks through the liner.
- Overliner layer of permeable crushed rock to protect liner and facilitate solution drainage.
- Drainage pipes in overliner to minimize phreatic head.
- Aeration pipes (when required, e.g. for bioleaching).
- A protection layer for liner may be used when the drainage layer is very coarse. It can be a geotextile, silty sand, or gravelly clay.
- Division into panels with berms to minimize cross flow.
- Provision of collection ditches for PLS and ILS (if included).

Notes

1. Characterization of the pad foundation conditions requires a thorough geotechnical Investigation.
2. Underliner should have low permeability, for example fine-grained soils. In some projects, bentonite may be added to minimize potential seepage.
3. For bio-oxidation systems, aeration pipes are typically placed in the overliner above the maximum anticipated solution level, which may require a deeper overliner layer. In some cases it may be feasible to place them in the bottom of the actual ore layer.
4. Phreatic head is the depth of solution in the base of the heaps during leaching. It needs to be minimized to avoid the risks of submerging the base of the ore and causing hydraulic instability.
5. Interlift liners are sometimes used at intervals up the heap to:
   - Avoid long term contact of the leach solution with lower leached out lifts when there is a risk of excessive on-going acid lixiviant consumption, acid generation or solubilization of unwanted impurities.
   - Reduce the risk of poor percolation in lower lifts due to ore degradation or presence of clays which could reduce irrigation rate and lock up solution containing valuable product.
   - Interlift liners are generally thinner than base liners, typically 0.5 mm thick.
6. Geotechnical tests are required to determine stability of heaps at the ultimate projected height, taking account of particle size, ore characteristics, ore degradation during leaching, extreme weather, possible seismic activity and the effect of any interlift liners.
7. Various polyethylene liner types are: HD=high density, LLD=linear low density, VL=very low density (decreasing in density).
8. Collection pipes instead of open ditches may be used to direct solutions to the ponds for environmental and safety reasons – e.g. in gold and uranium leaching.