120 YEARS OF COMBINED PAL OPERATION FOR NICKEL LATERITES - MORE THAN ENOUGH FOR A REALISTIC ASSESSMENT

April 2017

Ten PAL plants for low grade nickel laterites have been built since the PAL revival started in the 1990s in Western Australia. Eight are operating today. Remarkably, so is their distant ancestor from 1960, Moa Bay in Cuba. This amounts to 120 years of combined PAL operating experience, including 56 years at Moa alone – more than enough to make a realistic assessment. Here are some of the key points which have emerged:

- PAL is applicable to limonite and mixed limonite/saprolite ores with a magnesium content of up to about 6% Mg. Above this level there is a risk of increasingly heavy scaling in the PAL autoclaves and excessive acid consumption.
- The proportion of saprolite ore can be extended in the EPAL process, which combines PAL for limonite ore with atmospheric tank leaching for saprolite. EPAL is commercially applied at one operation, First Quantum at Ravensthorpe, Western Australia.
- The ore grade in existing commercial operations is in the range of 1-1.5% Ni. Ore upgrading can be applied to some orebodies.
- Nickel extraction is high, typically 90-95%. Cobalt recovery is also high and is a potentially valuable by-product, though the market price tends to be volatile. Other possible by-products include scandium, hematite and chromite.
- Small to medium scale operations making an intermediate mixed sulphide product (MSP) for off-site refining can now be reliably designed, constructed and ramped up to design capacity within a two-year period as typified by Sumitomo's Coral Bay and Taganito operations in the Philippines[1].
- Large scale PAL operations, particularly those with on-site refining, have experienced engineering and operating problems, cost overruns and slow ramp up. The most recent, Sherritt's Ambatovy complex in Madagascar, which uses their well proven mixed sulphide precipitation and refining technology, is the best performing, reaching 80% of design in four years, including a three-month period at over 90%[2].
- Large scale PAL production of mixed hydroxide intermediate product (MHP) for off-site refining has been demonstrated at MMC's Ramu operation in PNG. Ramp-up time is similar to Ambatovy with 83% of design reached in four years[3]. MHP is also produced on a large scale at First Quantum's Ravensthorpe EPAL operation.
- Downstream refining by SX technology has been used at two operations, Bulong in the 1990s and Vale's

more recent Goro operation in New Caledonia using a different system. Bulong ran into significant operating problems which were eventually overcome, but closed due to termination of its acid supply; while Goro is still ramping up to design capacity.

- All operations except Goro have adopted PAL temperature in the range of 245-255°C. Goro operates at a higher temperature, around 270°C.
- Multi-compartment horizontal leach autoclaves with mechanical agitation and several stages of flash tanks and direct contact pre-heaters are used for all PAL plants other than Moa Bay, and is now standard industry practice. (Moa uses individual vertical autoclaves with steam driven draft tube circulators.)
- Titanium clad steel is used for autoclaves at all PAL plants except Moa Bay. (Moa uses lead and brick lining.)
- Early materials of construction problems in the PAL have been largely overcome, although improvements are still being developed – e.g. severe service valve coatings.

So what strategy offers the best chance of success for projects reluctant to switch to as yet commercially unproven alternative processes?

For processing predominantly limonitic ore:

- Small to medium scale producing 10,000-30,000 tpa nickel
- One or two PAL autoclaves operating at 245-255°C
- MSP or MHP intermediate product
- No on-site refining initially
- Include ore upgrading if feasible
- Possible future addition of refinery either on-site or at a more favourable site
- Possible future development of value adding by-product recovery (e.g. scandium, hematite, chromite)

For processing limonitic and saprolitic ores:

- EPAL type operation
- 20,000-30,000 tpa nickel
- One PAL autoclave plus atmospheric tank leach system
- Other items as above

Alternative processes under development include sulphuric acid heap or atmospheric tank leaching which are most suitable for predominantly saprolitic ores, and hydrochloric or nitric acid atmospheric tank leaching which are potentially applicable to both limonite and saprolite.

Pressure Acid Leaching is the featured the topic for the ALTA 2017 Nickel-Cobalt-Copper Forum and Panel, which will be held 22-24 May in Perth, Australia.

For more information on PAL, attend the *Treatment of Nickel-Cobalt Laterites Short Course* scheduled for 20 May in Perth, as part of the conference. The short course manual is available from ALTA Publications

Alan Taylor
Metallurgical Consultant/Managing Director
ALTA Metallurgical Services
www.altamet.com.au/MetBytes

References

1. Tsuchida, N, HPAL in Past, Present and Future, ALTA 2015 Conference, May 2015, Perth, Australia.
2. Valle, L et al, Completing the Ambatovy Ramp-Up: The Road to Successful Financial Completion, ALTA 2016 Conference, May 2016, Perth, Australia.
3. Jolly, P, Ramu Nickel Mining Project in Papua New Guinea, ALTA 2015 Conference, May 2015, Perth, Australia.

MetBytes are metallurgical commentary and insights written by Alan Taylor who has 40+ years' experience in the metallurgical, mineral and chemical processing industries. He has worked in metallurgical consulting, project development, engineering/construction, plant operations, plant start-up and technology development. Projects and studies have involved copper, gold/silver, nickel/cobalt, uranium, base metals, phosphates and alumina.