SHORT COURSE

Treatment of Nickel-Cobalt Laterites



Presented by

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 The data indicates that that small to medium scale operations making a mixed sulphide product (MSP) for off-site refining have been the most successful in achieving a short ramp-up time. This strategy is typified by Sumitomo's Coral Bay and Taganito operations in the Philippines, which have the additional advantage of existing on-site mining and stockpiled ore. Ambatovy is the best performing of the large-scale greenfield projects with on-site refining.



- 1. Pipeline discharge is thickened to 45% solids, and the is feed preheated to 77°C by direct steam injection.
- 2. Pulp is fed by centrifugal pumps to duplex diaphragm high pressure autoclave feed pumps with intermediate oil chamber.
- 3. HPAL is carried out at 245-250°C in a four-stage continuous vertical autoclave system, with draft tube agitation powered by steam injection. The retention time is 90 minutes and acid addition is 0.225 t/t ore. The nickel and cobalt extractions are 95-98%. Initially, four parallel trains were built. A fifth train was added later).
- 4. The leach discharge slurry is cooled by in shell and tube heat exchanger and singe stage flash tank. The steam generated is used for recycle and for process use.
- 5. Includes a six stage CCD system using conventional thickeners, achieving 55% U/F solids.
- 6. Leach solution is pretreated with waste H_2S to reduce chromium (VI) to (III), reduce ferric iron to ferrous, and precipitate copper and zinc as sulphides.
- 7. Leach solution is neutralized with coral mud (water washed to less than 500 PPM chloride) to pH 2.4 in series of four mechanically agitated tanks.
- 8. The precipitated gypsum is thickened and recycled to the CCD circuit.
- 9. The pregnant leach solution is preheated to 118°C by direct steam injection.
- 10. Ni/Co sulphides are precipitated with H₂S injection in continuous, horizontal, three compartment, mechanically agitated autoclaves, with a precipitation efficiency of 98-99%.
- 11. The precipitate slurry is discharged to single stage flash tanks, and excess H₂S is cooled and compressed for recycle.
- 12. The product is thickened to 65% solids then washed in two stages of washing thickeners.
- 13. The product is transported to storage tanks at the port in cement mixer trucks, ready for shipping to the refinery in 1 m³ polypropylene bags.
- 14. Sulphuric acid is produced on site by sulphur burning.
- 15. H₂S is generated on site from sulphur and hydrogen produced by steam reforming of LPG or other hydrocarbon.
- 16. Overall recovery of metals is approximately 90%+.

MHWIRTH TRIPLEX PUMPS AT RAMU HPAL CIRCUIT

(Ref: Highlands Pacific /MHWirth paper, ALTA 2017)



ALTA Treatment of Nickel-Cobalt Laterites

Notes

- 1. Autoclave feed 32% solids, 3 HPAL circuits, residence time 1Hr, acid consumption 260-270 kg/t.
- 2. Autoclave scale said to be acceptable (perhaps below other HPAL operations). Shut down once per year.
- 3. MHP is precipitated with sodium hydroxide and is shipped min one tonne bulker bags.
- 4. MHP 38.5% Ni and 3.5% Co (dry basis), 60-65% moisture (wet basis).
- 5. Acid, activated limestone and milk of lime are produced on site.

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- 1. Ore is dried to facilitate the comminution circuit and reduces energy needed to evaporate excess water.
- 2. Reduced to 100% passing 1mm in the comminution circuit.
- 3. Leaching takes place in closed tanks generally in 3-6 hours at 110°C, just below the boiling point of the slurry. Most of this heat comes from the reaction of the acid with the ore.
- 4. Leaching tanks are covered and with all gases collected and sent to the acid recycling circuit.
- 5. Extraction of +90% of Ni, Co, Mn, Mg and other base metals occurs.
- 6. Leaching of Fe, Al and Cr depends largely on the mineralogy of the samples.
- 7. The PLS is separated from the insoluble residue by a train of CCD thickeners fed at 10-15% solids, followed by pressure filtration.
- 8. Acid in residue is neutralized to pH 7 with MgO, the residue is filtered and dry stacked.
- 9. Solution is then subjected to thermal hydrolysis where +99% of the iron (and chromium) is precipitated into a hematite form which is recovered as a potential by-product by thickening and filtration.
- 10. Aluminium is precipitated with recycled MgO and separated by thickening and filtration. The aluminium by-product at 22-24% Al contains most of the scandium and requires refining, possible to high purity alumina.
- 11. Recycled MgO is used to precipitate Ni/Co hydroxide as a final product containing 35-40% Ni and 1-3% and some nitrogen as nitrate. It can be marketed or refined at a different facility and converted to sulphates for the battery industry.
- 12. The barren solution is evaporated to form a nitrate melt with between one and two moles of water. The melt is fed to a thermal decomposition unit in which the NOx gases are liberated and MgO powder is formed. NOx gases are converted into a 55-60% strength nitric acid in the acid recovery system. Acid and MgO are recycled to the process, and excess MgO is available as a by-product.
- 13. Over 99% of the initial acid used in the leaching process is recycled. The 5% makeup acid is typically 30-80kg of acid per tonne of ore.

Reference:

Altilium website https://www.altiliumgroup.com/the-dni-process-flowsheet/ accessed 23 March 2022.



- 1. Primary (AL) leach testwork indicates up to 98% Ni extraction at 33% solids, 1 ton acid/ton ore, 5 hrs residence time and 95~100°C.
- 2. Secondary (HPAL) leach testwork indicated higher than 93% Ni extraction at 2 hrs retention time, 150°C, and 0.5 MPa . Leaching solution contained only 1.75 g/L Fe.
- 3. A bankable feasibility study for a Philippine laterite indicated that the CAPEX and OPEX were less than 10 USD/lb Ni and 2.6 USD/lb Ni, respectively, ie 40% of the CAPEX for the all HPAL alternative and 65~70% of the OPEX for the all AL alternative.
- 4. The process consumed at least 290 kg acid/t ore lower than AL and the nickel extraction reached more than 91.5%, at least 10% higher than ATL.



