Project Planning and Verification Using METSIM® Simulation Software at Brazilian Nickel's Piauí Nickel Project

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Abstract

Heap leach projects require extensive planning and data verification, from the preliminary scoping study through commissioning, including information management and proper testwork campaigns. This paper follows the progression of the Piauí Nickel Project (PNP) *(Piauí Níquel Metais)* located in Brazil, a nickel laterite heap leach that utilized METSIM® for these purposes. When Brazilian Nickel acquired the project, initial bottle roll tests for Ni, Co, Mg, Fe, Mn, and several other metals had been completed and showed high recoveries of both Ni and Co. The project then refurbished an existing pilot plant to create a large-scale demonstration plant. Demo plant-scale testwork was concluded on full-height heaps where 8,000 metric tonnes of ore was leached and the pregnant leach solutions were processed in a downstream plant and nickel and cobalt products were produced and sold.

To assist in designing a complex, counter-current leach cycle, the proposed heap geometry and available leach kinetics, along with the as-built demonstration plant, were used to build a dynamic METSIM® model aimed at consolidating and verifying all information. The model was built before the heaps and maintained throughout the test campaign, calibrated as the heap performances were measured over the life of the tests. Specific areas of interest included algorithms to simulate metal extractions for Ni, Co, Fe, Mg, and Mn and for overall acid consumption. Moreover, given the capabilities within METSIM® to model full operations in closed loop, from mine to product, the downstream processing plant was also included in the model, which proved crucial for investigating water and reagent balances. Impurity concentrations in solution streams were tracked and used to design critical processing facilities, such as the magnesium bleed and precipitation. Immediately following, the METSIM® model was then scaled to commercial production, including an annual mine plan and corresponding heap and downstream equipment sizing.

Introduction

Heap leach projects require extensive planning and data verification, from the preliminary scoping study through commissioning, including information management and proper testwork campaigns. The Piauí Nickel Project (PNP) located in Brazil, a nickel laterite heap leach, utilized METSIM® for these purposes, as well as to scale demonstration heap performance to commercial production.

Project planning and development

When Brazilian Nickel acquired the project in 2012/2013, initial modelling efforts were focused on the conceptual flowsheet (see Figure 1) from ROM ore receiving through nickel production, including heap and downstream precipitation plant operations and dynamic mass balances of solid and aqueous phases.

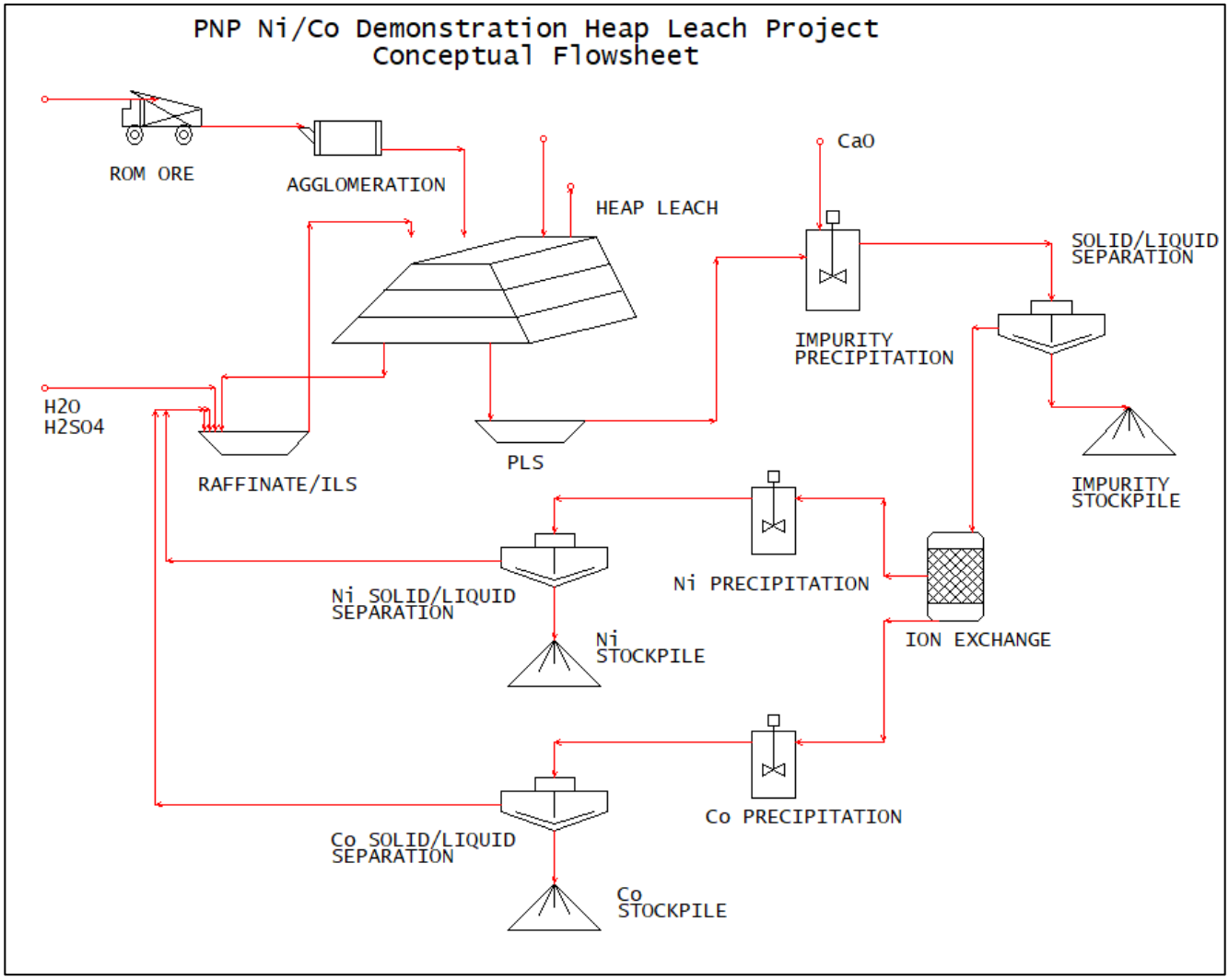

Figure 1: PNP demonstration heap project conceptual flowsheet

In parallel, initial bottle tests were conducted to measure extraction rates of Ni, Co, Mg, Fe, Mn, and several other metals. Tests showed high recoveries of both Ni and Co; these reaction kinetic coefficients would then serve as the basis for metal extraction rates in the heap. To assist in designing a complex, counter-current leach cycle, the proposed heap geometry and available leach kinetics, along with the as-built demonstration plant, were used to build a dynamic METSIM® model aimed at consolidating and verifying all information. This model would serve as the engineering plan for further project testwork.

The PNP team then refurbished an existing pilot plant to create the large-scale demonstration plant, including an 8,000 metric ton heap leach and all downstream processing facilities shown in Figure 1. Not depicted in the flowsheet is the solution neutralization process for the precipitation and removal of Mg from the raffinate and process water streams.

The demo plant was operated for approximately one year (365 days), during which time the METSIM® model was updated and calibrated with the measured results. Specific areas of interest included algorithms to simulate metal extractions for Ni, Co, Fe, Mg, and Mn and for overall acid consumption. Moreover, given the capabilities within METSIM® to model full operations in closed loop, from mine to product, the downstream processing plant was also included in the model, which proved crucial for investigating water and reagent balances. Impurity concentrations in solution streams were tracked and used to design critical processing facilities, such as the magnesium bleed and precipitation.

The demo heap was built and leached as three separate cells or modules, named Heap 0 (H0), Heap 1 (H1), and Heap 2 (H2). H0 was built and leached before H2 and H3 and was designated the "calibration heap" by the modelling team; i.e., all algorithms for metal extractions were calibrated against the measured ILS/PLS solution tenors from H0. Relationships between the metal head grades in the ROM ore and free acid available within the raffinate and heap inventory were developed and applied to the leach kinetics within the heap. The model iteration was one day, and each iteration evaluated these relationships and applied factors to each chemical reaction kinetic coefficient to adjust for the simulated conditions. Figure 2 shows the simulated PLS Ni tenor versus the actual PLS Ni tenor from H0 over the operating period of approximately 300 days.

Following this calibration stage for H0, the same algorithms were applied to H1 and H2 and the simulated PLS Ni tenors were compared to the measured results (Figures 3a and 3b). As demonstrated in these figures, the simulation results aligned extremely well, proving the validity of the developed algorithms and their ability to be used to calculate the metal leach kinetics.

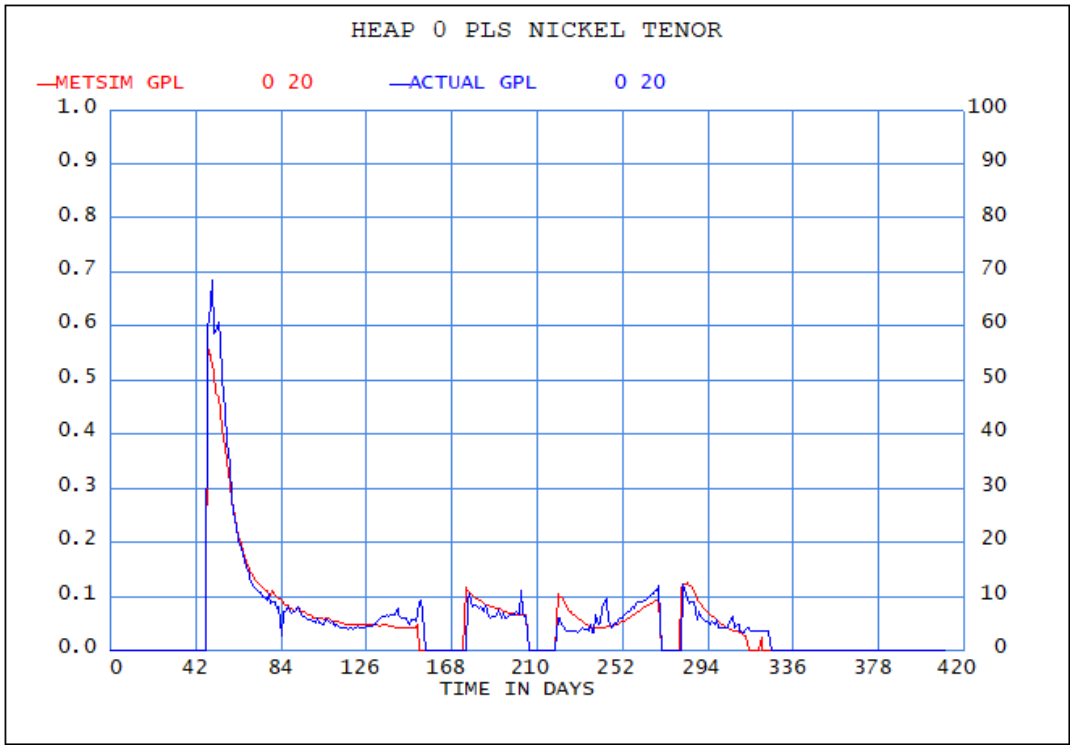

Figure 2: Simulated (red) vs. actual (blue) H0 Ni PLS solution tenor

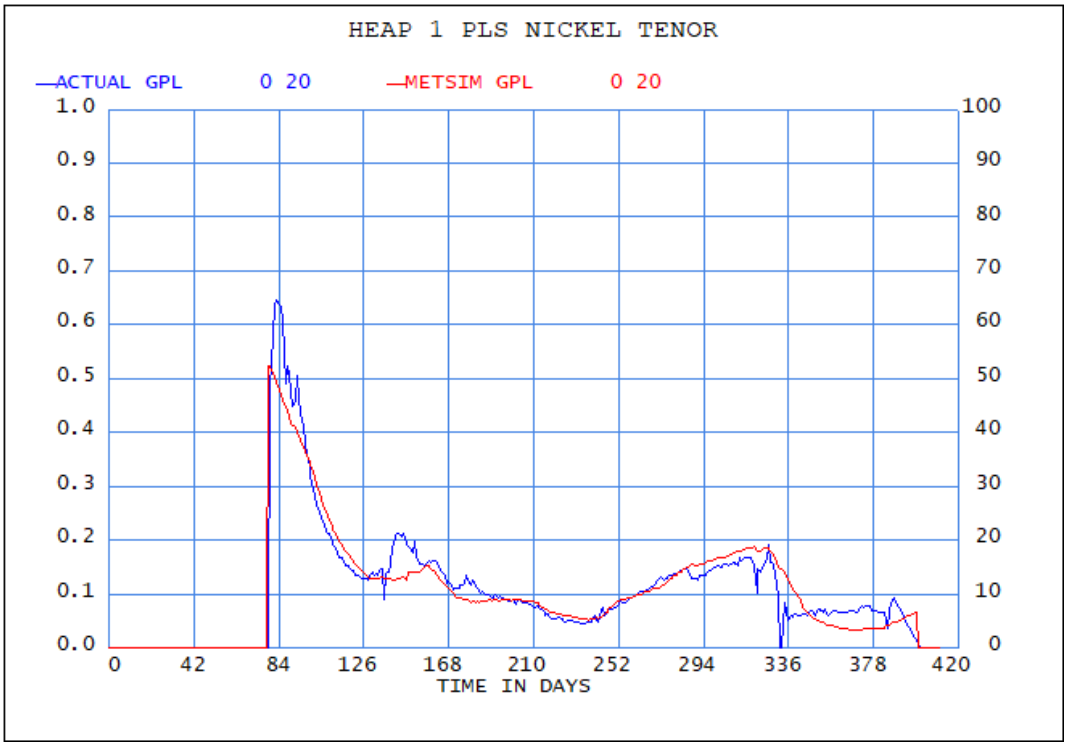

Figure 3a: Simulated (red) vs. actual (blue) H1 Ni PLS solution tenor

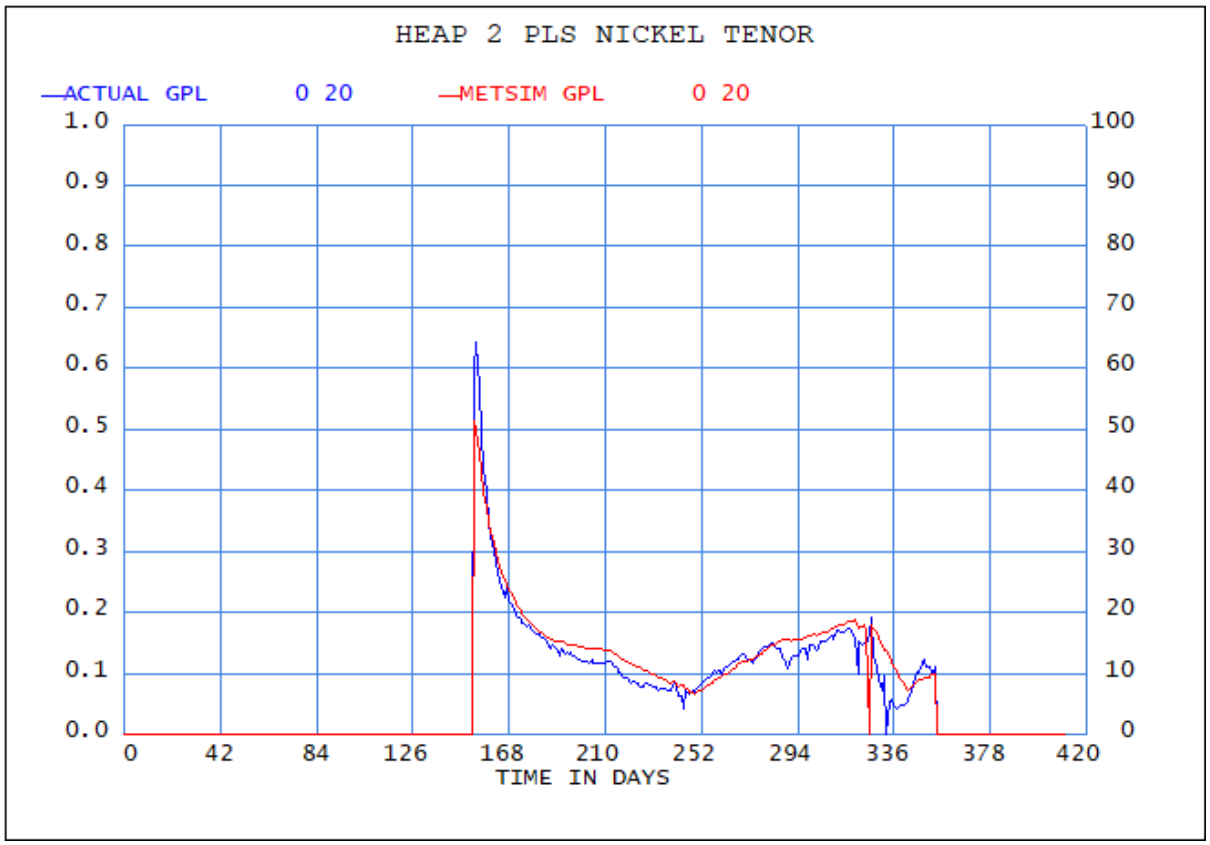

Figure 3b: Simulated (red) vs. actual (blue) H2 Ni PLS solution tenor

Immediately following, the METSIM® model was then scaled to commercial production, including an annual mine plan and corresponding heap and downstream equipment sizing. Static and dynamic mass balances for the commercial operation were developed and presented to local engineering companies, saving significant time and cost for the detailed engineering and design stages.

Moreover, with reliable production forecasts resulting from the scaled model, ore tonnes and grade plan variations could be run through the model to optimize not only the heap leach but also the mine operations.

Simulation verification

Since this abstract was originally submitted, the PNM heap leach project has begun commercial production of Ni and is closely tracking extraction rates within the heap's first leach module. Figure 4 compares the model-predicted Ni extraction rate versus the first 45 days of operation of the first leach module on the commercial heap leach.

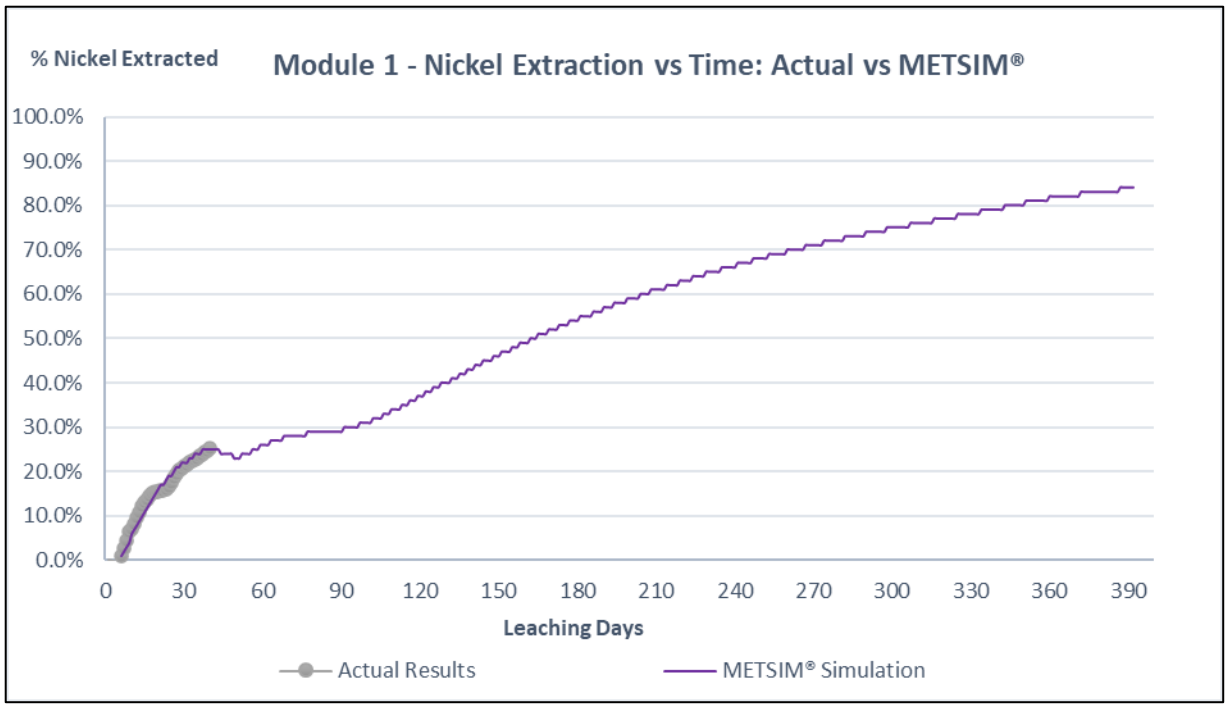

Figure 4: Simulated (purple) vs. actual (grey) module 1 Ni extraction rate

Conclusion

Though still in the early days of commercial production, initial operational results provide validation for the team's modeling efforts and the power of a well-calibrated simulation. In the future, additional heap leach project evaluations on similar ore bodies will become simpler, faster, and cheaper with the use of these METSIM® simulations.

Acknowledgements

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