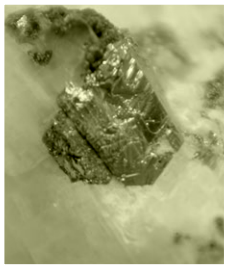
28
Ni
Nickel
58.6934 u
[Ar] $3d^8 4s^2$



WHEN ARE PARTICLE SIZE DISTRIBUTIONS TOXIC FOR LEACHING?

Changes upstream can have subtle effects on downstream performance. In an assignment, consultants were teamed with on-site metallurgists to determine why the autoclave leach was not performing as it normally did. The conversion of nickel had dropped by between 3 to 5%, which had negative implications for both nickel production and downstream processing.

The team was given management support to investigate this as thoroughly as possible.

In-depth data collection and recording

The team operated the autoclave on a shift basis, while other members of the group attended to data collection. The autoclave was sampled - each compartment was sampled during operation several times a shift for a week, and the concentrations, solids densities and other variables were measured. Physical operating parameters, like shaft rotational speed, agitation power draw, oxygen flow rate, cooling coil temperatures and fluid flows were recorded (see Figure 1).

Despite all this data, the problem did not manifest itself.

Figure 1: *A pressure leaching autoclave (Crundwell, et al., 2011, photo courtesy of M. Fox).*

Modelling reactions to understand autoclave performance

Once the shift work was completed, other team members built a model of the pressure autoclave (*Figure 2*). The model accounts for the rate of the reactions using kinetic expressions, including the effect of concentrations and temperature on the rates of reaction. The model accounted for the leaching reaction:

$$NiS\ (s)\ +\ 2\ O_2\ (aq) \rightarrow\ NiSO_4\ (aq)$$

The oxygen is provided from the gas phase (or gas-liquid mass transfer):

$$O_2\ (g) \rightarrow\ O_2\ (aq)$$

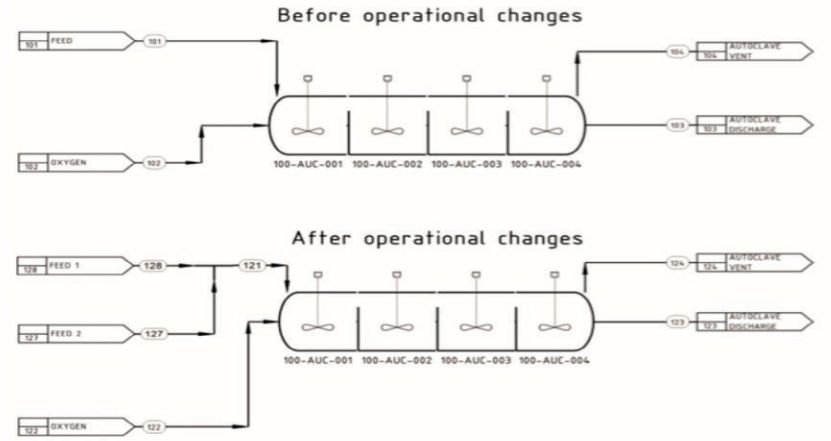


Figure 2: *Representation of the autoclave model in Cycad Process, with reactions modelled for each compartment.*

Particle size distribution under the spotlight

In addition to the effect of the concentration of dissolved oxygen on the rate of leaching, the simulations accounted for the particle size distribution of the feed and described its change through the autoclave compartments. Because there was gangue material with the sulphide mineral that was being leached, the model showed that there was no discernible change in particle size (*Figure 3*). This agreed with the Malvern scree analysis of the plant data before the operational changes on the plant.

Toxic particle size distribution

An engineer decided to investigate the effect of particle size distribution of individual minerals, that is, NiS, on the performance of the leaching using the model. This has a remarkable impact (*Figure 4*). In a flash of inspiration, she asked the mineralogist to look at the particle size distribution of the individual minerals (*Figure 5*). Although it is indiscernible in the overall particle size distribution, there is a clear 'bump' at higher sizes in the distribution for NiS.

The detrimental effect of this 'bump' on the calculated conversion is in shown in *Figure 6*. This type of particle-size distribution was dubbed 'toxic' by the team.

Figure 3: *Model of particle-size distributions before changes.*

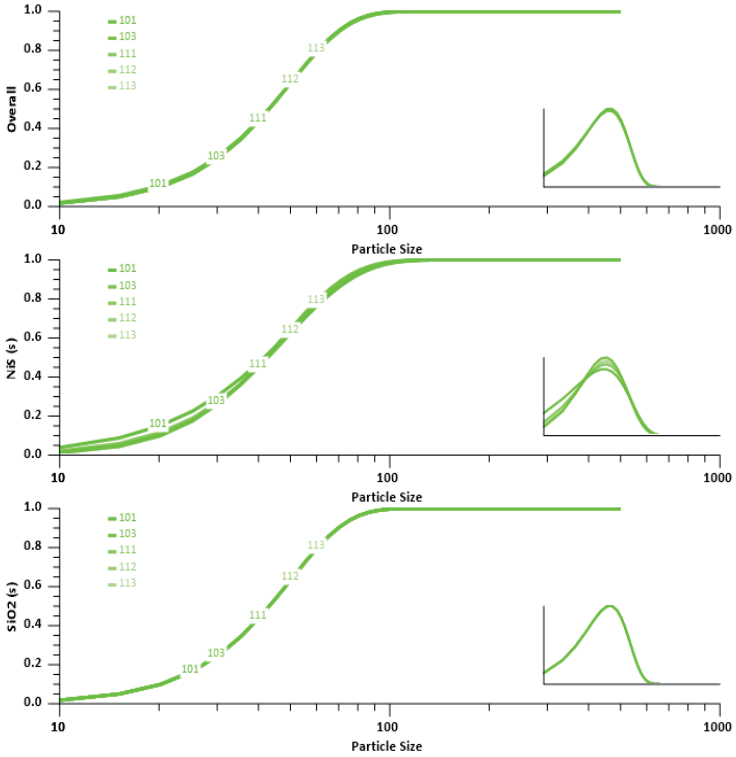
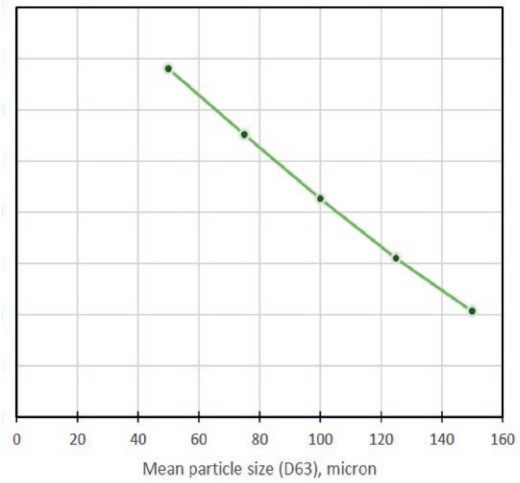


Figure 4: *Effect of mean particle size on leaching performance.*



Upstream changes for downstream benefits

Knowing the cause, the team were able to make adjustments to the cut-point of the cyclone upstream of the autoclave. As a result, the leaching performance improved without any major capital costs.

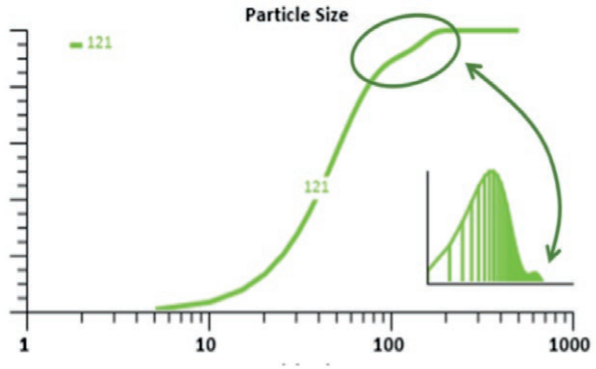


Figure 5: *The particle size distribution of the overall stream, and of the two main mineral components in the feed to the autoclave.*

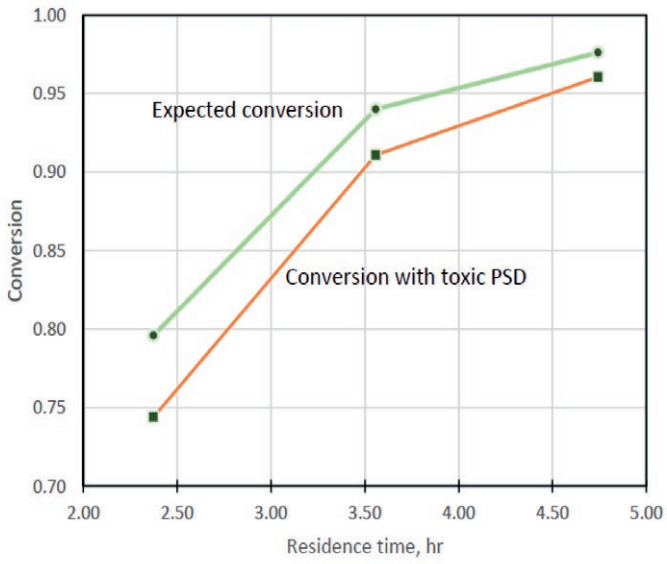


Figure 6: *The expected conversion from the autoclave, and the one with the 'toxic' size distribution.*

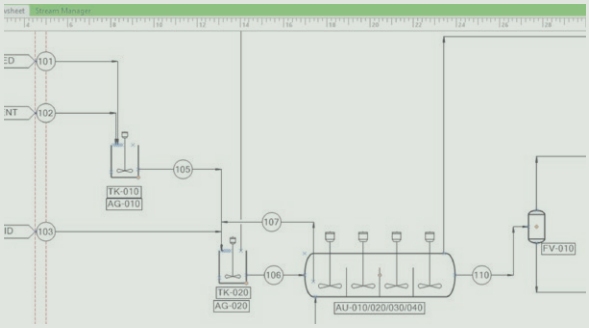
Assessing the causes of poor performance using Cycad Process can yield major benefits. In this case, improving the recovery from 91% to 94% restored significant value to the operation. For this nickel producer, whose annual production exceeded 10 ktpa, this amounted to at least USD 9 million.

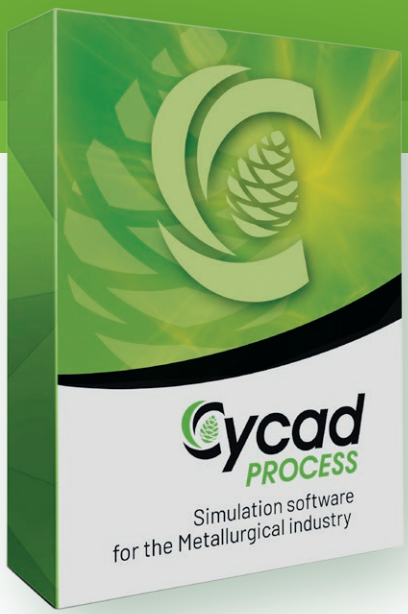
Simulation saves money

Cycad Process Modelling => Performance => Profit

How was Cycad Process® used here?

- Cycad Process has sophisticated modelling systems for reaction kinetics. Gas-liquid mass transfer and other homogeneous reactions can be solved simultaneously with the population balances models of the leaching reactions. The models were calibrated against plant data and literature, and then used in scenario analysis.





What is Cycad Process®?

- Cycad Process® is a **software product for modelling of metallurgical operations** – sophisticated models of unit operations are combined into a model of the process operation, allowing the user to design or optimize their operations.
- The outputs are the mass and energy balances for the plant, presented as **reports and process flow diagrams**.
- Cycad Process® has been used to **design plants and find solutions to metallurgical challenges** for the last 20 years.
- Our clients include leaders in **copper, gold, cobalt, lithium, vanadium, nickel, and the platinum group metals**.

Visit us on www.cycadprocess.com

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