CIP AND CIL CIRCUIT MODELLING

The SGS carbon-in-pulp (CIP) / carbon-in-leach (CIL) modelling package is used to estimate the performance of a full-scale CIP or CIL plant and to derive the optimum design criteria based on the results of small scale experiments. It is a powerful design tool that uses the results from standard leach and adsorption tests (bottle roll tests) to generate kinetic data that are fitted to leaching and carbon adsorbtion rate equations (Figure 2). The rate data and mass balance equations are then applied to the SGS model to calculate the concentrations of gold in solution, on the carbon and in the ore for each stage of a multi-stage leach-adsorbtion circuit. The model allows for the generation of multiple operating scenarios, where

- the number of leach and adsorption stages can be varied,
- the carbon concentration per tank can be adjusted,
- the carbon loading and final barren solutions can be manipulated,
- and carbon advance and elution rates adjusted.

PHILOSOPHY

The SGS CIP/CIL model is based on a model developed by Fleming and Nicol (1984). The philosophy then was to strive for simplicity and user-friendliness, rather than precision through complexity. This is still true today in SGS' CIP and CIL modelling package.

This semi-empirical model combined academic perfection and pragmatic simplicity, and SGS has over 20 years of experience proving its suitability for full scale operations. This is a result both of the validity of the model's many assumptions under most CIP/CIL operating conditions, as well as the inherent robustness of the CIP and CIL processes. SGS' current data modelling tool-set is proven to allow for:

- Robust predictions of steady state as well as transient carbon adsorption behaviour from simple laboratory batch tests,
- Economic sensitivity analyses of the plant performance changes that arise when parameters such as the number of stages, the carbon concentration in each stage, and the relative flow rates of pulp and carbon are varied,
- An evaluation of CIP versus CIL for a new project,
- An assessment of the consequences of plant upset conditions such as poor elution/regeneration, carbon poisoning, carbon loss through breakage or screen rupturing.

APPLICATIONS

The SGS CIP/CIL model can be used for feasibility or production stage projects. It is a cost effective way to determine the optimum design criteria and it allows clients the opportunity to test changes to the circuit without actually making the changes.

CIP and CIL plants are often still designed using "rules of thumb" design criteria

with minimal theoretical basis. The SGS CIP/CIL modelling package allows for optimization and creates better plant designs.

FEASIBILITY

In greenfields operations, the testwork data can be used to lower capital costs in new plants. SGS can help examine the key parameters associated with CIP/CIL circuits and adjust these parameters, using the modelling package, until an optimum design is identified.

PRODUCTION

The SGS CIP/CIL model allows existing mines to lower operating costs by changing their design targets and analyzing the effect of these changes without actually making the changes.

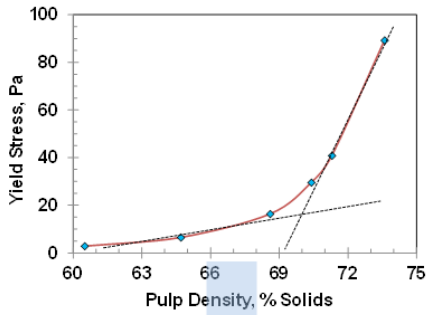
The processes in which gold cyanide is adsorbed on activated carbon are very robust mechnically and very efficient metallurgically. CIP and CIL circuits are tolerant of plant upsets, changes in feed composition and "less-than-optimal" plant designs. As a result, owners and operators may not realize that their plant design could be "less-than-optimal". The gold extraction is usually "good enough" and the economic payback is very good, even though capital and operating costs may be higher than necessary. The SGS CIP/CIL modelling package is a very cost effective way to optimize this.

TECHNICAL FEATURES

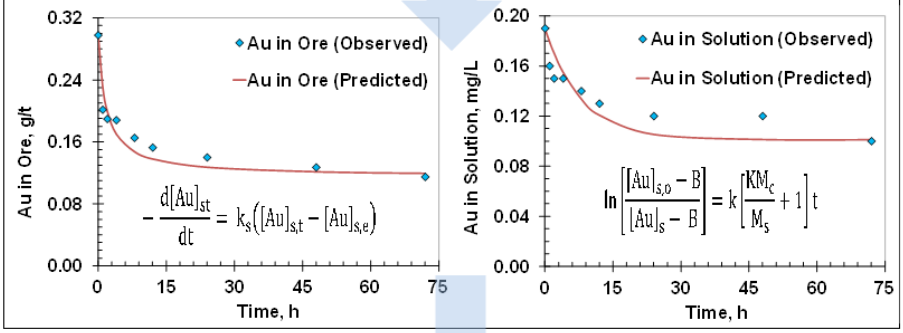
RHEOLOGY

A key factor influencing pulp-phase mass transfer (film diffusion) kinetics is pulp rheology. The pulp density will greatly influence the efficiency of the mass transfer in the leaching and adsorption processes. Therefore, before carbon modelling testwork is undertaken, SGS must establish the rheological properties of the pulp sample to determine the optimum leach and adsorption pulp density.

1. Rheology - Optimised Pulp Density (65% solids or less was ok for this ore)



2. Leach and Adsorption Tests (Bottle Roll) - Generate Leach and Adsorption Constants, k and K



3. Modelling

Inputs:

Solids Feed Rate	=	335	t/h
Number of Stages	=	3	(2800 m^3 per tank)
Gold in Barren Solution (Plant Data)	=	0.044	mg/L
Pulp Density	=	50	%
Gold on Plant Carbon	=	49	g/t
Efficiency Factor, kK	=	161	(>90 is very good)

Variables Examined: Increased carbon concentration, number of stages, and increased carbon flowrate

Outputs: Ten Operating Scenarios

CIL Parameters	Scenarios									
	1	2	3	4	5	6	7	8	9	**10**
Number of stages	3	3	3	4	5	5	5	6	6	5
Au in loaded carbon (g/t)	254	255	251	271	282	281	279	285	275	209
Carbon flowrate (kg/h)	208	208	208	208	208	208	208	208	208	313
Daily carbon transfer (kg/d)	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	7,500
Carbon inventory per stage (kg)	50,000	100,000	25,000	50,000	50,000	50,000	varied	varied	varied	varied
Au lock-up on carbon (kg)	26.8	53.7	13.3	35.0	42.4	41.8	35.0	37.5	34.3	24.1
Overall Au leaching efficiency (%)	57.4	57.4	57.4	58.1	58.7	57.4	57.4	57.4	57.4	57.4
Overall Au adsorption efficiency (%)	69.5	70.0	68.5	75.5	79.3	81.3	80.5	83.0	89.1	85.1
Overall Au recovery (%)	39.9	40.2	39.3	43.9	46.5	46.6	46.2	47.6	51.1	48.8
Au on loaded carbon / Au in feed	852	856	844	910	948	943	937	956	922	703
Upgrading ratio	1,777	1,785	1,760	1,899	1,977	1,966	1,954	1,995	1,924	1,466
Au on stripped carbon	49	49	49	49	49	49	49	49	25	49
Au grade in residue (g/t)	0.127	0.127	0.127	0.125	0.123	0.127	0.127	0.127	0.127	0.127
Au in final barren solution (mg/L)	0.044	0.043	0.045	0.035	0.030	0.027	0.028	0.024	0.016	**0.021**

Results: Decreased gold in final barren solution from 0.044 mg/L to 0.021 mg/L by:
- Increasing the number of stages to 5 from 3, and
- Increasing the daily carbon transfer to 7.5 tonnes/day from 5 tonnes/day

Example: CIL plant in Northern Ontario, Canada that treats low grade gold ore flotation tailing.

TESTING (LEACH AND ADSORPTION KINETIC TESTS)

The SGS approach to CIP and CIL modelling involves conducting batch gold leaching and carbon adsorption tests with representative samples of ore or concentrate contacting commercially available activated carbon or plant carbon. The rate of leaching is determined in a traditional bottle roll experiment. Timed samples of slurry are taken from the bottle and the solution phase analyzed for gold. The rate of adsorption of the leached gold onto activated carbon is then determined by adding carbon to the same leach slurry, and taking further timed samples of slurry, and analyzing the solution phase for gold. Gold on the carbon is determined by mass balancing the solution phase, while gold in the leach residue is determined by analysis at the end of the test, to produce an overall gold balance for the test. As a check, the final test carbon is also assayed for gold.

MODELLING AND RESULTS

The leaching and carbon adsorption kinetic data are then fitted to the rate and mass balance equations. The model then generates profiles of gold in solution, on the carbon and in the leach residue across a series of leaching and adsorption tanks in which carbon is advanced counter-current to the flow of slurry.

SGS metallurgists can then optimize the plant design based on the predicted metallurgical performance for various design and operating scenarios.

Model Inputs

- Plant throughput (tonnage, pulp density, gold head grade)
- Leach and adsorption constants (ks, k, K)
- Number and size of leach and adsorption tanks
- Target concentrations of gold on the loaded and eluted carbon, and in the barrens

Model Outputs

- Concentration profiles:
  - Gold in solution, in the ore and on the carbon in each stage of the multi-stage adsorption circuit.
- Amount of carbon needed in each stage to achieve target metallurgical performance
- Loaded carbon advance rate to elution and regeneration required to achieve target metallurgical performance
- Gold lock-up in the plant

OPTIMIZATION AND DESIGN

The SGS CIP/CIL modelling package maximizes gold extraction efficiency by reducing soluble gold losses from a CIP or CIL plant. We can help you accomplish this by:

- Increasing the number of adsorption stages.
- Increasing the amount of carbon in each stage.
- Reducing gold loading by moving carbon to elution and regeneration more rapidly.
- Improving the quality of the recycled carbon by improving acid washing, elution and regeneration efficiency.

All of these changes result in increased capital and/or operating costs, so modelling a number of scenarios allows an economic optimum design to be established.

BENEFITS

CIP and CIL circuits represent the primary gold process, and as such, their efficiencies have significant impact on your overall plant efficiency. A comprehensive CIP and CIL modelling program from SGS can help you develop a robust and efficient process design. Our services will allow you to:

- Mimic the performance of an existing plant to evaluate the consequences of making changes, without actually making the changes to the operating conditions in the commercial plant, avoiding any distruption in operations.
- Generate data for trade-off studies for a new plant, from which an economic optimum design can be derived.
- Predict how a pilot plant will perform, and then use this information to determine the pilot plant operating conditions. Allows for rapid attainment of steady state, thereby shortening the duration and cost of the pilot plant.

REFERENCES

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