APPLICATION OF THE PULP CHEMISTRY MONITOR AT A COPPER MINE IN AUSTRALIA

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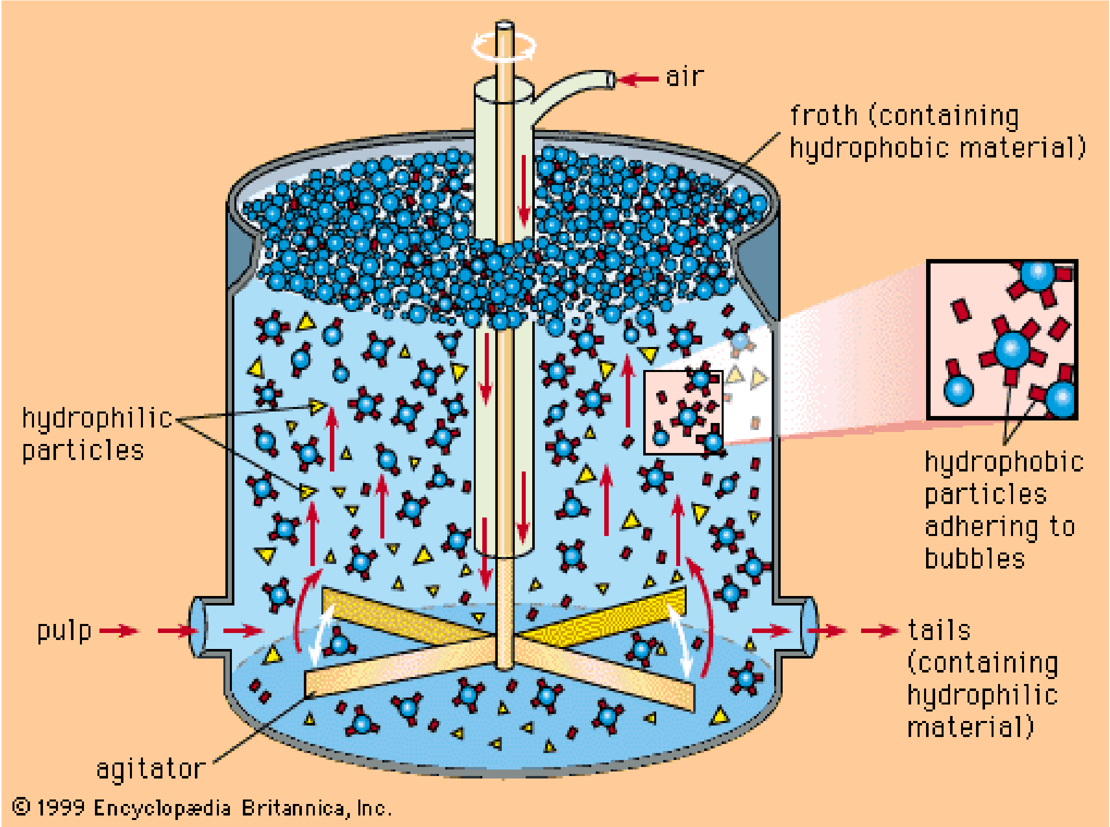
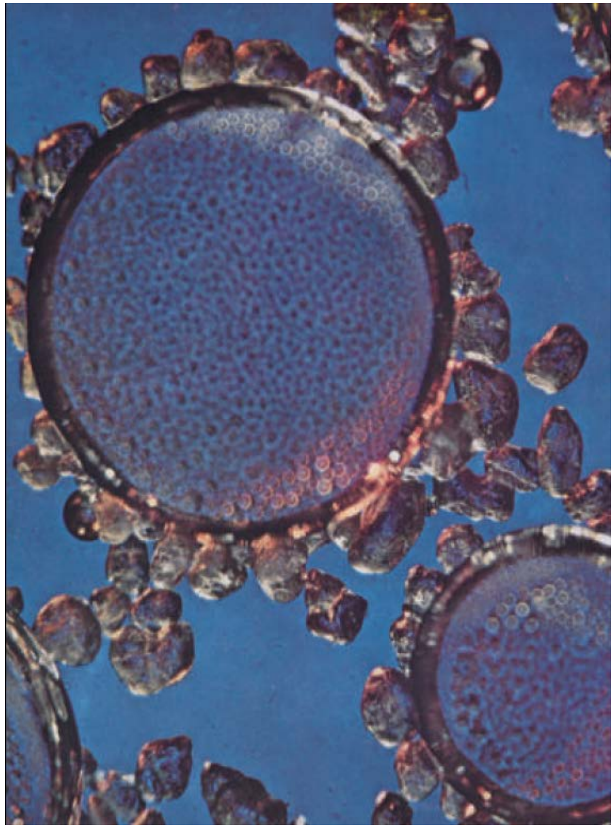
MINERALS

Most non ferrous base metals are found in nature as sulphide minerals, which are usually associated with gangue minerals. About 80 percent of these minerals are processed using flotation.

FLOTATION

Flotation is a separation (concentration and/or purification) process based on the differences in physicochemical surface properties of mineral particles.





- Reagents are added to the pulp
- Pulp is agitated and air is added
- The **hydrophobic** particles adhere to air bubbles when they collide and are taken to the surface
- A **froth** containing the valuable hydrophobic material is recovered at the top of the cell
- The **tailing** constituting the hydrophilic waste material is evacuated

WHEN THINGS GO PEAR SHAPED . . .

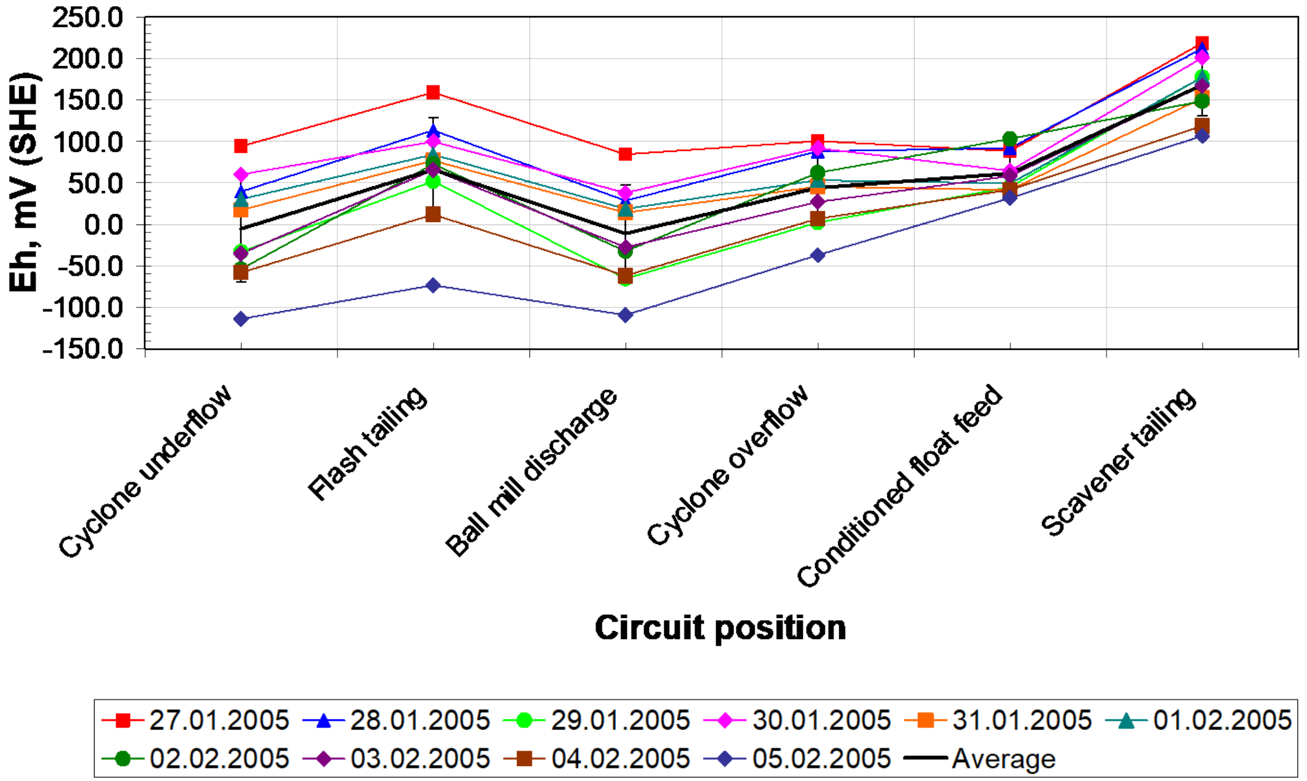
What does the operator check:

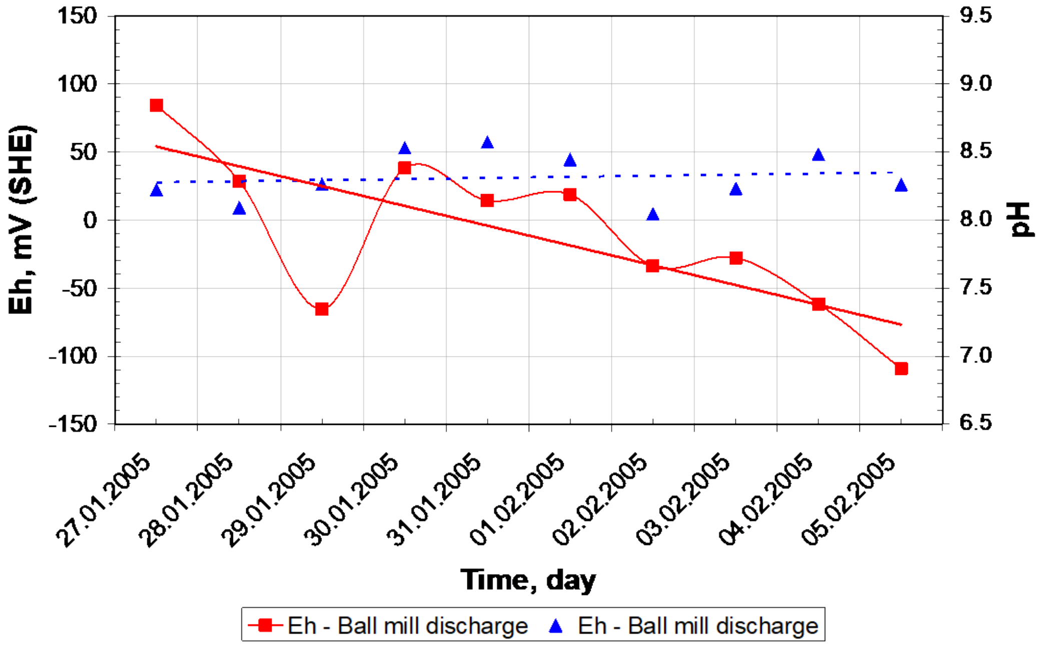
- The feed grades;
- The particle size distribution;
- The throughput;
- The pulp density;
- The reagent additions;
- The pH;
- The air flow rate into the flotation cell;
- The froth depth; and
- Occasionally they will leave the control room and just have a look at the froth!

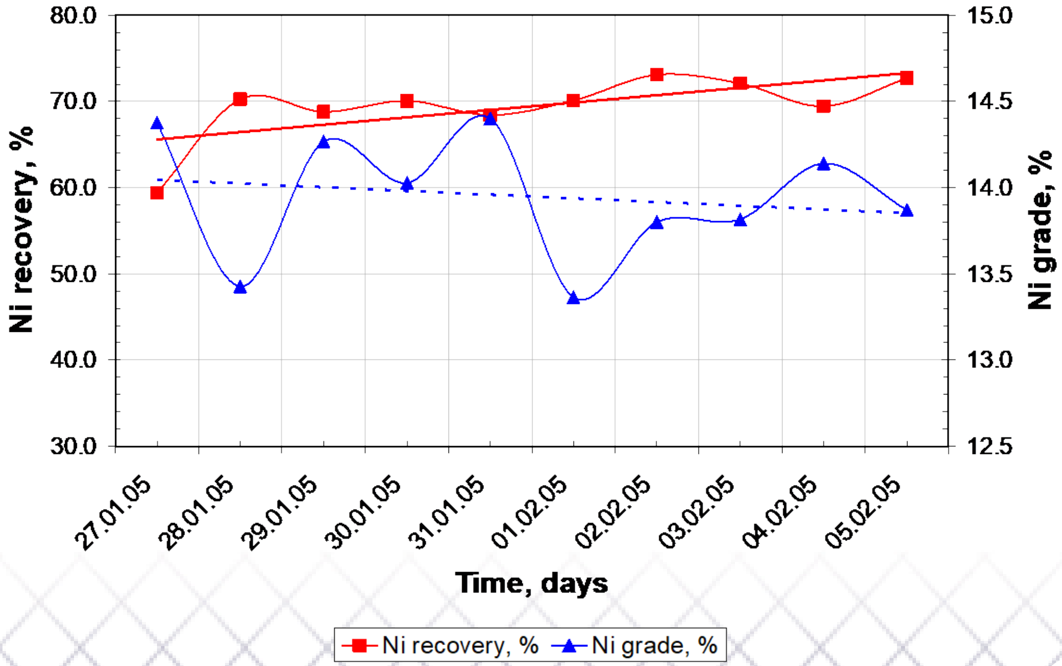
Assuming the particle size distribution is set to yield adequate liberation, the issues are probably related to changes in the surface/pulp chemistry . . . but, this is not measured routinely in a concentrator!

IS THE PULP CHEMISTRY CONSTANT?

AND, WHAT DOES THIS MEAN FOR THE METALLURGY?







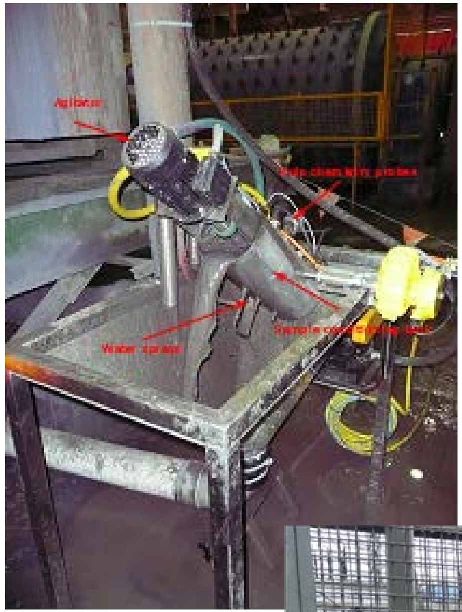
MEASURING THE PULP CHEMISTRY – THE OLD WAY

Generally, pulp chemistry measurements are made you a metallurgical technician using laboratory meters and probes.

This data gives the metallurgist a point in time, which can be used to diagnose problems in the plant or recognise changes.

But, it is not normally completed on a routine or continuous basis.

MEASURING THE PULP CHEMISTRY – THE NEW WAY



Manual measurements do not provide continuous reading of the pulp chemistry, so the pulp chemistry monitor (PCM®) was developed in 2008. This instrument has been refined with time to make it more robust, but it is able to measure the pulp chemistry continuously, on-line and in real time.

BUT, IS MEASURING ENOUGH?

A day's worth of data generates a spreadsheet with 217 columns and 86,400 rows!

Timestamp	Stream 1 Oxygen Demand	Stream 1 Dissolved Oxygen	Stream 1 Dissolved Oxygen Array	Stream 1 pH	Stream 1 Eh	Stream 1 Temperature	Spare	Stream 2 Oxygen Demand	Stream 2 Dissolved Oxygen	Stream 2 Dissolved Oxygen Array	Stream 2 pH	Stream 2 Eh	Stream 2 Temperature
	PCM-OX-DEM-1.PV	PCM-OX-DIS-1.PV	PCM-OX-ARR-1.PV	PCM-PH-1.PV	PCM-EH-1.PV	PCM-TEMP-1.PV	Spare	PCM-OX-DEM-2.PV	PCM-OX-DIS-2.PV	PCM-OX-ARR-2.PV	PCM-PH-2.PV	PCM-EH-2.PV	PCM-TEMP-2.PV
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OBSERVATIONS

If we look beyond grinding chemistry typically we observe that as the pyrite in the ore increases:

- The Eh becomes more reducing;
- The dissolved oxygen decreases; and
- The oxygen demand increases.

These changes generally lead to lower concentrate grades and lower recoveries.

GENERATING DATA DOES NOT AUTOMATICALLY LEAD TO ANSWERS

Initially, we cleansed the data and using Excel we started modelling using multiple linear regression models . . . without significant success!

We questioned the logical of whether many of the parameters are linear and moved to multivariate, second order polynomial model or the form:

$$Y = a_0 + \sum_{i=1}^{n} a_i \times X_i + \sum_{i=1}^{n} b_i \times X_i^2 + \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} c_i \times X_i \times X_j$$

Again, Excel let us down . . .

IN-HOUSE MODELLING

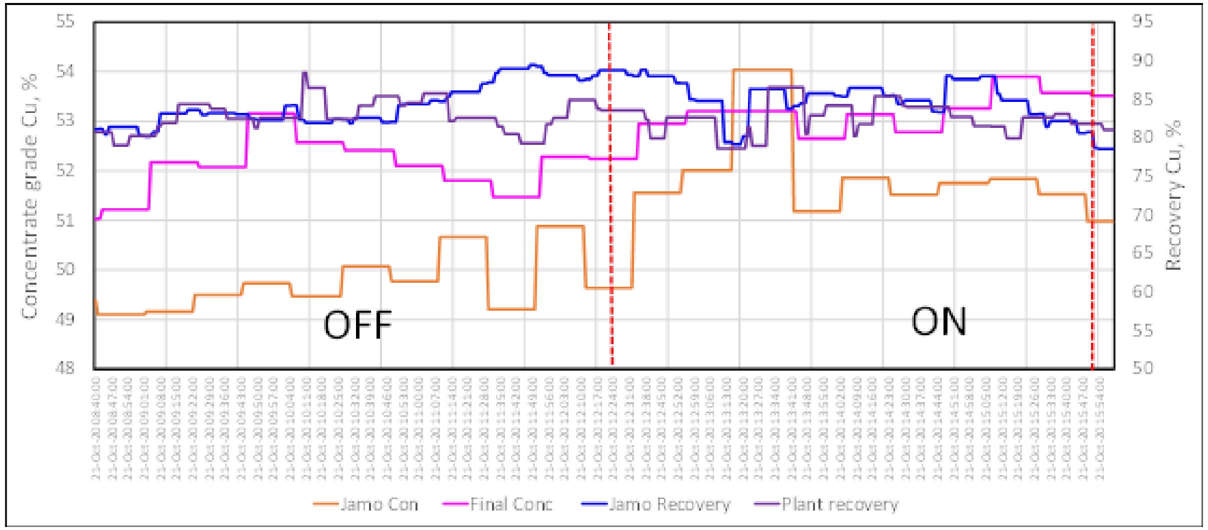
It became apparent that this was not trivial so we have moved to using MATLAB® by MathWorks®, which provides greater flexibility in the models available and significantly reduced the analysis time.

By examining the process and think about what parameters influence the behaviour of valuable and gangue minerals typical variables using in our algorithms are:

- Throughput
- Particle size
- Feed grade
- Collector addition
- Air
- Level
- Pulp chemistry

BUILDING AN APPLICATION

- Based on a knowledge of the process and what the parameters measured mean an application was developed that describes concentrate grade and recovery.
- Using this application it is possible to input either as target concentrate grade or recovery, and for the pulp chemistry readings for a given time adjust the collector, air and level in the flotation cell to maximise the recovery or concentrate grade.
- A short ON/OFF trial at OZ Minerals' Prominent Hill Mine demonstrated that the App was able to increase the final copper concentrate grade by 0.85 percent with no loss in copper recovery compared with the operators running the plant.



	Change due to PCM® App	90 % confidence interval
Final Cu concentrate grade, %	0.85	±0.41
Final Cu recovery, %	No statistical difference	No statistical difference

APPLICATIONS

In the first instance the pulp chemistry can be measured continuously on-line and in real time, and PCM® demonstrates this. But, measuring is not enough!

The pulp chemistry data does reflect changes in the mineralogy and can be used in conjunction with other plant parameters to describe the concentrate grade and recovery of the process. Using various pieces of software from MathWorks® has made building these algorithms easier and more adaptive as the inputs constantly changing.

Applying the algorithms in real time to predict the collector, air and level required to achieve maximum recovery at a specified concentrate grade as the mineralogy (pulp chemistry) changes has been achieved using an executable standalone application developed using MathWorks® software.

The results achieved to date have shown that the use of the App can achieve better results than the operators because it is manipulating the parameters simultaneously to achieve the best result.

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