RECENT DEVELOPMENTS IN THE AUTOMATION OF MINING ANALYTICAL LABORATORIES FOR BASE METAL ANALYSIS

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1.0 INTRODUCTION

Base Metal (Cu, Ni, Mo, Zn, Co etc.) analysis traditionally has been very slow in conventional analytical laboratories which can lead to additional costs being incurred in waiting time of drill rigs or mining excessively off-reef. Recent developments in the automation of analytical laboratories now allow for very rapid turn-around times for base metal analytical data which can help reduce such costs as well as reduce the unit costs of the analyses themselves.

2.0 CONVENTIONAL ANALYTICAL LABORATORY PRACTICE

Conventional analytical laboratories are necessarily are very manual. Sample preparation is slow and laborious, samples are moved from stage to stage manually and, typically, all samples are processed in batches so a sample which is the first to be, say, milled has to wait for the complete milling of the batch before it advances to the next stage eg. mixed with wax prior to pelletising for XRF analysis. Inevitably this results in long sample data turn-around times for laboratories handling large numbers of samples. Manual sample preparation can only be accelerated by increasing staff which increases costs and can lead to additional errors being introduced. Cleaning of sample preparation equipment, eg. crushers and mills, between samples is essential to avoid cross-contamination between samples and this is slow and labour-intensive. In manual sample preparation the correct sample numbers staying with the samples is totally dependent on the efficiency of laboratory operators. It is extremely difficult to detect when errors have occurred due to the switching of sample numbers during the sample preparation stages. Running duplicates and QC samples at best is only partially successful in detecting when sample number switching errors have occurred. Errors of this nature and cross-contamination problems due to incomplete cleaning of sample preparation equipment tend to occur when laboratories are working at pressure due to high sample numbers and when supervisors are not present during 24/7 laboratory operations which is often required on plant process control laboratories. These problems are common to all conventional analytical laboratories and their magnitude is dependent on the level of control and efficiency of QC systems practised by individual laboratories.

The disadvantages of conventional manual analytical laboratories can be summarized as follows:-

1. Labour-intensive which is costly especially when multiple shifts have to be used during 24/7 operations.

2. Manual sample preparation can lead to lower quality of data due to cross-contamination of samples due to poor cleaning and errors due to accidental switching of sample numbers.
3. Slow turn-around times due to sample preparation and analytical procedures being subject to being carried out in batches. Typically for large batches of samples the first results will be available not before 48 hours after submission of the samples to the laboratory and will often be much longer particularly if a back-log of samples has accumulated and new samples have to join the queue for attention.

3.0 AUTOMATION IN THE MINING ANALYTICAL LABORATORY

The introduction of automation into mining analytical laboratories now allows for an incredible improvement in turn-around times from days to minutes.

Automation means the use of air tubes, conveyor belts and robots to move samples through the various stages of sample preparation and analysis. It also means the automated weighing, dosing with dry or wet chemicals and the carrying out of every function normally carried out by a laboratory operator. Samples can now be processed sequentially instead of in batches and 24/7 (continuous laboratory operation) costs no more in staff than operating a single manual shift per day. Even the cleaning of all equipment is, of necessity, automated.

Many aspects of automation have been around for some time. The use of robots in motor vehicle assembly lines is well-known. What is new is their application to the analytical laboratory and the development and invention of the necessary additional components to allow full turn-key automated analytical processes to become a reality. A sample is logged into the sample preparation system at one end, usually by automated reading of a barcode, and a final result comes out at the other less than an hour later and is immediately transmitted to where it is needed.

Automated sample preparation systems for hard rock samples which are now available include :-

1. Bar-code scanning at sample input,
2. Drying
3. One or two-stage crushing,
4. Milling,
5. Splitting,
6. Making up time-based composites
7. Pressed pellets and fusion discs (for XRF).
8. Wet chemical dissolution for wet chemical analysis

For the control of concentrator plants sampling is automated and the process control samples are automatically delivered to a filter press/dryer unit which has been recently developed and patented. In this filter press/dryer unit slurry samples are reduced to a damp cake by vacuum, they are dried by microwave oven at a constant controlled temperature, disaggregated, split, a composite accumulated, if required, and then moved by conveyor belt to the sample preparation robot circle where the appropriate sample preparation procedures are carried out.

The main instrumental analysis methods which have been linked to automated sample preparation are XRFS and OES. Even fire assay has now been fully automated. The most recent development has been the planning of an automated analytical laboratory in the USA to process bore-core and mining samples by wet chemistry for total and acid-soluble Cu.

Other quantitative determinations which have been successfully automated include :_

1. Measurement of particle size distribution,
2. Measurement of relative density by pycnometer,
3. Measurement of moisture content.

Any combination of sample preparation methods and analytical techniques can be automated. Due to cost considerations it is normal practice to automate the sample preparation and analysis of the major analytical throughput of the laboratory and to continue the less frequent analyses on a manual basis. Even a highly automated laboratory must have some staff present at all times to rectify any problems which might occur, re-load magazines etc. and these staff are used for the manual analytical operations.

4.0 SKORPION ZINC – CASE STUDY

The Skorpion Zinc Mine in Namibia makes an interesting case study as it is the first base metal mine which incorporated as part of its planning a fully automated analytical laboratory for the analysis of run-of-mine samples and mining development samples. It was designed for all the sample preparation to be carried out by automation and the analyses to be carried out by XRFS analysis on pressed pellets. A detailed description of this laboratory is a good example of how an automated mining analytical laboratory is designed and functions.

Being situated in a desert environment it was decided that automated drying was not necessary. Conventional manual drying ovens were installed for the rare occasions that they might be needed. Samples are dried manually, if necessary, and then entered into the system by being placed into a stainless steel bucket and a bar-code reader then enters the sample particulars onto the computer system which will then monitor the progress of that sample. Mining (blast-hole) samples are typically 5kg in mass and comprise up to 20cm chips and rocks. The container plus sample is weighed so the sample splitter after crushing can be set with the correct gap to deliver the required mass of crushed sample to the mill. The container is lifted by vertical conveyor and tipped into the mortar crusher where it is crushed and split in two stages. In this case 70gm is delivered to a small steel cup which goes off by conveyor to a disc mill, 500gm goes into a plastic bottle for archiving purposes and is moved to a magazine by robot and the remainder of the crushed sample is discarded. Mining development and exploration samples are typically smaller in mass and particle size and are loaded into plastic bottles in a magazine and are moved to the crusher by robot. Thus in the Skorpion automation application provision is made for two modes of sample input.

The 70gm sample is delivered to the mill and milled typically two minutes after which a wax binder in pellet form is dosed into it and then milled for a further 15 seconds. If the binder is milled for too long it heats up and melts and no longer functions as a binder. After completion of the milling cycle the milled sample is moved by robot and conveyor to a pelletizing press where it is pressed into a pellet in a steel ring. It is then moved by conveyor to the XRFS instrument area where it is analysed. Elements determined are Zn, Fe, Ca and Si. After analysis it is returned to the press where the sample is pressed out of it and discarded. The ring is cleaned and returned to a holding position to await the next sample.

An essential part of the automated circuit are the cleaning functions. Where-ever dust could be created de-dusting units are utilized to remove dust by vacuum extraction before cross-contamination of samples can occur. In addition, provision is made for blank quartz aliquots to be processed between samples, or whenever required, to remove the possibility of contamination.

The Skorpion analytical laboratory is also equipped to carry out many other analyses which are required on a much less frequent basis than the automated analyses. These include ferrous/ferric ratio determination and ICP analysis for a wide variety of occasionally required elements.

The automation section of the Skorpion laboratory is shown in Figure 1. In the sample preparation circuit the robot is surrounded by two mills (2.1), one pelletizing press (2.2), the plastic bottle magazines (2.56 and 2.57) and the crusher/splitter tower (2.3). The robot is in the center of the sample preparation robot circle.

5.0 CONCLUSIONS

These successful advances in automation analytical technology means that virtually any sample preparation method and analytical technique for Base Metals can now be automated. Although the initial capital costs are high the unit cost of analysis is very low so automation lends itself to laboratories which have a high throughput of samples requiring the same or similar analyses on an around-the-clock basis.

FIGURE 1 : Plan lay-out of the automated section of the Skorpion Zinc Mine in Namibia.