TURNING PROCESS DATA INTO PERFORMANCE INFORMATION

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ABSTRACT

A modern concentrator produces a substantial quantity of technical data such as flow rates, assays, tonnes of product at a particular moisture and so on.

The same concentrator consumes resources that must be paid for such as labour, reagents, grinding media and power. At most operations these costs are assigned to areas, analysed in detail and used as a basis for future cost comparison and –(if possible) cost reduction.

At most operations, it is also fair to say that the performance of each section of the plant is not well recorded or analysed. Nor is any regular correlation carried out to assesss how performance benefits (or losses) might interact with expenditure.

The JKMRC has built a number of prototype data acquisition systems to address sections of this task. Several of these prototypes have been developed into JKTech products. When the raw data is converted into performance information, it can be used to:

- *improve planning*
- *monitor performance in a meaningful way and*
- *identify opportunities for optimisation.*
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This paper makes a case for much more detailed analysis of mine and plant data and reports on progress at the JKMRC towards a configurable metallurgical accounting system which aims to improve both the detail and quality of performance information.

This paper was presented at "Challenges in Metallurgical Accounting and Information Management"
South African Institute of Mining and Metallurgy,
Western Cape Branch. August 1st 2001

Introduction

A modern mine produces a very large flow of data – as well as of ore. With ever increasing regulation, the data production stream may even challenge the ore stream. A great deal of effort goes into maximising ore recovery and concentration of the valuable components. The focussing question(s) for this talk are “How do we maximise the recovery of information from the data stream?” or “How can we mine the data to maximise information recovery?” The underlying question is more basic. “How do we achieve maximum value from each block of ore?”

Its fair to say that cost data is usually readily available and often associated with cost centres in fine detail. This is usually not true for technical performance information.

In short we often don’t know very precisely what we have achieved BUT we do know exactly what it cost. This disparity inevitably leads to cost biased decision making. It should be reasonably obvious that if the project was worth investing in to begin with, then its profitability will be very strongly driven by its technical performance.

Armed with better technical information, management should be able to better balance technical/performance issues versus cost data.

Further, if the performance of each

- section of the ore body and each
- section of the process can be well characterised, then we can
    a) plan better
    b) monitor performance of both mine and concentrator in a meaningful way and
    c) identify opportunities for optimisation.

Over the last few years, the JKMRC has been working with industry to evaluate technical performance across the entire mine to product sequence. With ever more powerful and lower cost computing, there are substantial opportunities to integrate these data analysis methods across the complete process. This approach often identifies opportunities that are quite contrary to decisions based solely on cost. This paper considers some metallurgical accounting projects via pilot studies - then discusses a more general approach to metallurgical accounting. This approach can also be extended to mine accounting.

Data versus. Information

The title of this paper emphasises the difference between data and information. However, there is considerable potential for confusion between the two as both data and information are often expressed as numbers. For the purpose of this paper, data and information are distinguished by their **uses.**

A data point (or datum) is a measurement. To be a useful measurement, it also needs to be associated with an estimate of its quality or accuracy. Any data not supported by reproducable measurements deserve to be treated with caution.

Information by contrast provides a basis for decision making. Information may be simply numeric but it may also be a conclusion drawn from the analysis of many data points. Information therefore will often be expressed in words rather than numbers. An alternative definition of information is that it consists of refined, processed or concentrated data. We can assess the "quality" of information in an analogous way to data. Better quality information improves both the precision and ease of decision making – that is the part played by intuition and gut feel in the process is reduced.

Pilot Systems/Case Studies

Because of its outstanding reputation in the mineral industry the JKMRC is well placed to explore opportunities for optimisation at many levels. The commercial division of the JKMRC – JKTech – develops these prototypes into fully supported products where there is a strong perception of a viable market.

Metallurgical accounting projects at the JK Centre go back more than ten years and have been supported by a wide range of funding methods. Several of them are built around the MBal algorithm developed by Whiten and Morrison, (Richardson, 1991) to provide configurable metallurgical accounting. The MBal algorithm provides a general solution to mass balancing of physical separation flowsheets and is implemented in several commercial products.

The first formal metallurgical accounting customer for JKTech was Renison Goldfields which at that stage operated a complex tin beneficiation plant at Renison Bell and a number of mineral sands concentrators. In 1990 RGC set up an INGRESS based management information system. However, integrating variable flowsheet capability would have been costly to develop and maintain. Hence JKTech was contracted to develop a batch oriented version of JKMBal which could be run as a file-to-file DOS task, or in its user friendly GUI which included an editable, live flowsheet with data access. Each process unit (or sub section), is represented by an icon on the flowsheet. The icons can then be connected in different configurations to represent different flowsheets. This method of flowsheet definition by drawing automates a quite complex programming task. However, it requires a powerful, general purpose "engine" to execute the flowsheet. The MBal engine is well suited to processing redundant measurements and accuracy estimates. This allows process information to be checked against itself for consistency.

The automated MBal engine has been used for flexible metallurgical accounting at many sites. It has also evolved into a stand-alone product called JKMetAccount - which is described later.

Coal Losses

Perhaps the next significant "information" project was the ACARP coal loss project (Wedmaier and Scott 1995; Scott, 1998). This project examined every detail of coal handling from pit to train. Substantial losses of saleable coal were identified. Many of the losses occurred because they were "transparent" to the measurement and accounting process. In addition to a written report, a "Coal Loss" workbook was produced on CD. This workbook contains a hyperlinked version of the report. More importantly, it details measurement techniques and contains some simple spreadsheet-like models to allow operators to reduce the "transparent" losses.

The old saying “If it ain’t broke, don’t fix it” has a corollary. “If product losses are transparent to your measurement process, you don’t need to fix them either”. Overall, a powerful technique for identification of losses was developed. But it was not an ongoing tool – unlike the outcome of the next project.

An excellent (non JK) example of what can be achieved by converting data into information was reported by Pease et al (1998) with a major improvement in profitability at the MIM lead-zinc operation by rejection of unprofitable stopes and a reduction of plant throughput. This achievement is absolutely contrary to the conventional wisdom that “more tonnes” is always better!

MetAccount for Finucane Island Beneficiation Plant

The next study evolved into a custom product for ongoing management use. In 1997, JKTech was contracted to review the BHP Iron Ore Finucane Island Beneficiation Plant, with a view to application of the MBal engine. The Beneficiation Plant used a sophisticated algorithm implemented in C, combined with an INGRESS data base running on a 386 based XENIX server, with three VT 100 terminals. The system had initially been developed to analyse pilot plant data.

While very sophisticated for its time, the system was becoming expensive to maintain. The hardware was obsolete - probably not repairable after a major failure. The MBal algorithm required additional sampling and flow rate measurements. Hence JKTech were contracted to produce an updated version of the original balancer in Visual Basic (VB4) over an Access data base. This program was well received at the Finucane Island Plant. It provided for automated entry of assay data from the LIMS (Laboratory Information Management System) as well as a user friendly interface. This interface provided graphical tools to allow the process engineer to quickly assess the data as well as provide the essential accounting and KPI generation. The time required to carry out a daily balance was cut from several hours to 20-30 minutes. The interface also received very favourable comment. Because of this favourable response, JKTech has developed a general purpose, configurable metallurgical accounting system for physical separation processes. This system is called JKMetAccount. Prototypes are installed at five mine sites.

Conventional Metallurgical Accounting

In the conventional sense, metallurgical accounting monitors what comes from the mine and what is sold as concentrate. That is, we consider the plant as a “black box”, assume two of our measurements are precise and assign all of the errors to an unmeasured third stream.

At many precious metal mines bullion production is added to new feed flow rate multiplied by tailings assay to estimate feed grade. This type of balance may be unambiguous, having only a single value for recovery, but this doesn’t mean it is correct. There is also the potential for the usual arguments with the mine over tonnes and grade received. These may be entertaining, but as we have no useful accuracy estimate for our calculated feed grade, such arguments are difficult to resolve.

More importantly, our metallurgical results offer little guidance towards opportunities to improve plant performance.

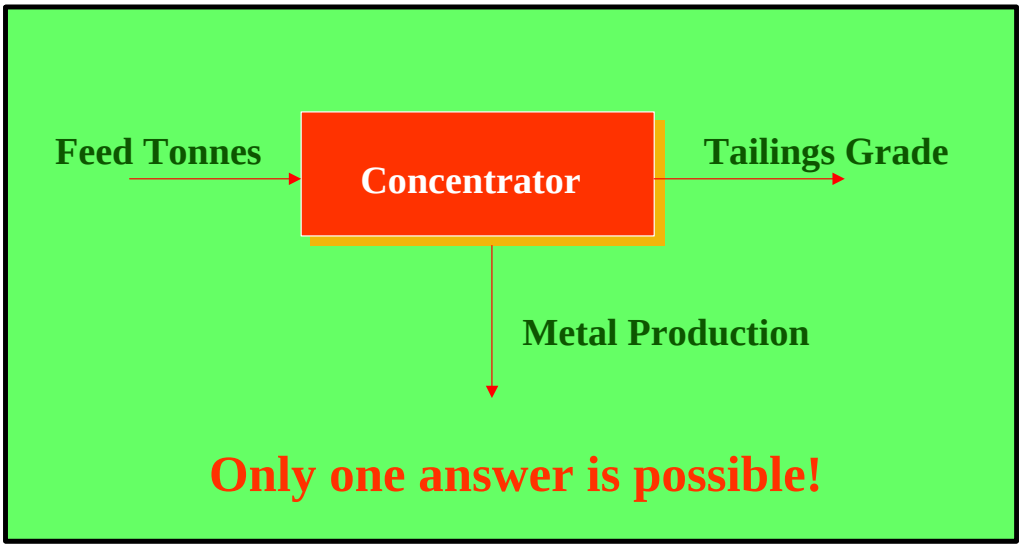


Figure 1 – The "Black Box" approach

Flowsheet Based Metallurgical Accounting

A typical process plant has several (sometimes quite a few) sections. Each section contributes to the cost of running the plant and to the separation performance. Some plants have sections in series (eg. copper flotation), some have sections in parallel treating different size fractions (eg. iron ore beneficiation) and some have sequential process plants (eg. Selective lead and zinc flotation). While it is still possible to consider the complete plant as a "black box" it is obvious that it will be more useful to monitor the performance of each section of the plant.

The big problems are

1. We may now have much more data than we need to generate a balance

2. The answer we get depends on how we do the calculation, and

3. Each time the flowsheet is modified we need to redevelop our accounting balance.

Item 3 is the most serious as it may make performance comparison with other flowsheets difficult or even impossible.

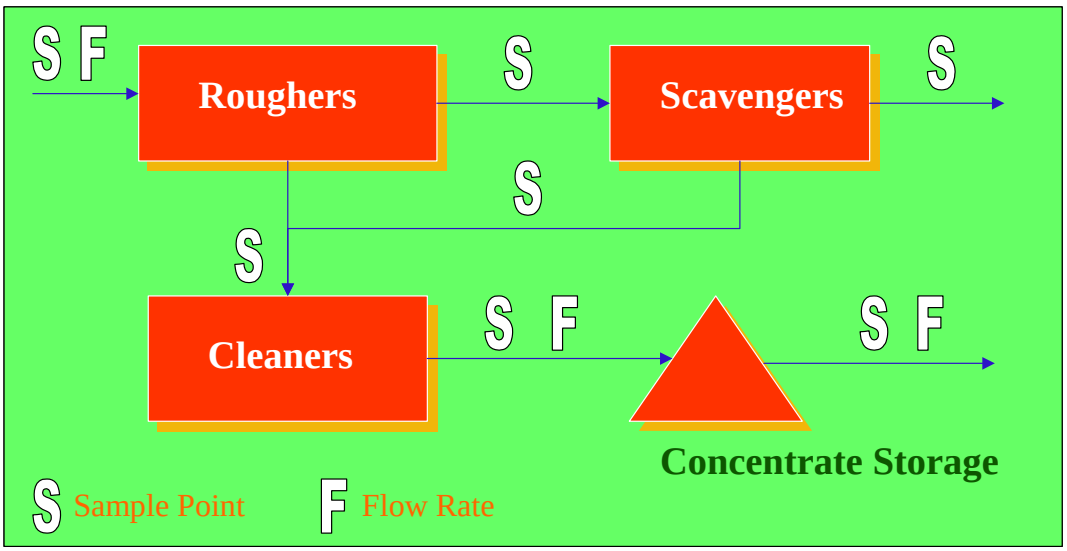


Figure 2 - A typical flowsheet based approach

A More General Approach to Flowsheet Balancing

We can take advantage of factors 1 and 2 if we can use a general solution to the problem.

This means considering the accuracy with which we can make measurements at each point, ie. How accurate is the weightometer or flowmeter? How good is the sampling and assaying process?

The latter can be quantified using repeated samples or estimated from plant experience.

We then apply a solution (a mathematical routine) which is aware of the constraints provided by each flowsheet, in other words the solution must add up. The usual criterion is to minimise the sum of squares of each measured value minus the balanced value divided by our estimate of its accuracy.

Setting up the problem this way makes it relatively straightforward to identify questionable measurements.

If we have to adjust a measurement by more than twice our estimate of its accuracy, either the accuracy (standard deviation) is much worse (larger sd) than we estimated or the measurement deserves careful examination.

It is worth noting that changes in stockpile contents can be included in the balance if enough redundant information is available. As a bonus, we get a calculated estimate of accuracy of each balance flowrate. This makes reconciliation with the mine a more useful exercise as we now have a range of reasonable values – not a single point.

Item 3 can be handled by always storing the circuit feed and products (and key intermediate streams where possible) under the same names. If we make major changes within a circuit, stream by stream comparisons are rarely useful.

The serious shortcoming of this approach is that the balancing process is somewhat complex. However, the JKMBal balancer has been used at the JKMRC for more than 20 years. It is well proven and robust.

JKMetAccount

As noted earlier, JKTech have assisted numerous sites with measurement and accounting systems. The development of JKSimMet V5 for MS Windows 95, 98 and NT provided an opportunity to develop a user-friendly, configurable accounting system built around the JKSimMet flowsheet interface. As the JKMBal algorithm is also a key component of JKSimMet, many of the program objects are common to both programs.

There are many other key aspects associated with a met accounting system.

- Data management
- Data transfer from laboratory management and process control systems
- User feedback regarding data quality (ie. many data views)
- Reporting (formal and informal)
- Interactions with corporate data systems
- Training, documentation and support (which are often not associated with in-house systems).

JKMetAccount Structure

The design goal was to build a system where most (ideally all) attributes would be configurable instead of programmable. The underlying reason for this design goal is to enable JKMetAccount experience at one site to be transferable to another. All of the system set up is done via the MetAccount configuration module. This module defines key aspects such as working areas, process equipment and flows, shift and schedule considerations. The process equipment and process flows can then be joined together to define process flowsheets.

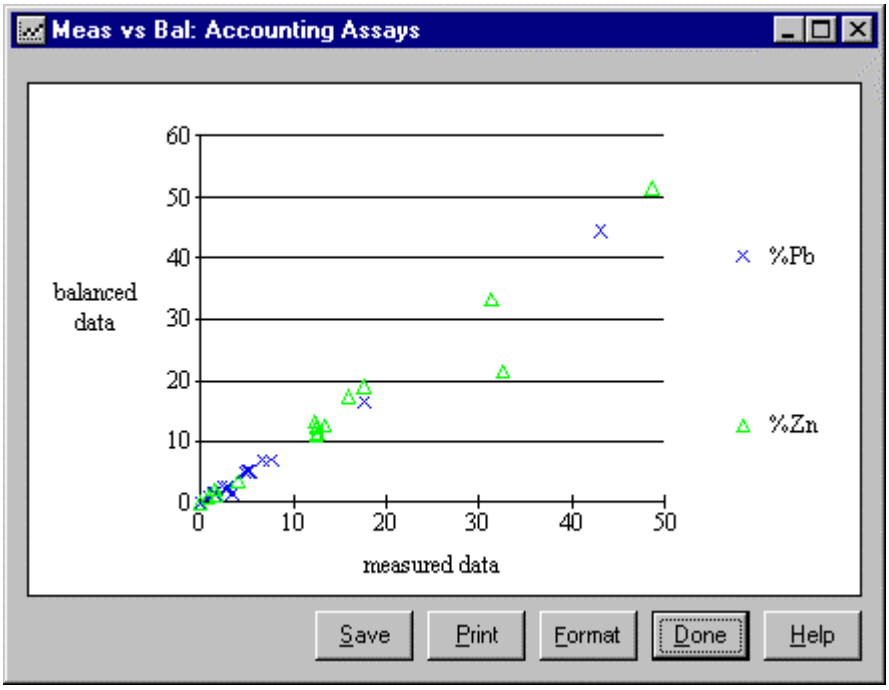
Working “Areas” provide a convenient way of dividing up the data and might refer to

- Separate processing plants
- Different measurements for the same plant, and/or
- On-line and off-line accounting.

A Report Configuration module provides a straightforward way to set up several reports styles with a wide range of filters. Filters are used to define each reporting period such as shift, daily, week to date, month to date and so on. This allows each report format to be used for many reports.

The User module provides for data entry or data import, data analysis and examination. The user selects the Area to work in, the appropriate flowsheet and time period, imports and checks the data and then runs the balance.

A graph of measured versus balanced helps to either accept good data or reject poor data.



Questionable data can be omitted, if there are only a few points or the estimate of its accuracy adjusted to give it less weight.

There may also be a problem with sampling or assays. A common problem is transposition of assays.

If the balance exhibits serious problems, it can be balanced section by section to help to identify the problem data.

The Balance module generates simple reports that can be exported to many formats, such as text, MS Excel files, HTML files etc.

Once the data has been accepted it can be reviewed graphically for any stream over any specified time period or exported to file or spreadsheet.

Accepted data can also be exported to the corporate data base and reporting system or reported via the configured JKMetAccount reports.

As several of our beta test clients wished to generate further analysis via complex reports, an MS Excel add-in has also been developed. This add-in can read the JKMetAccount configuration and database files.

Spreadsheet functions can then be used to generate complex reports or to do “data mining”.

Integration with In-stream Analysis.

Another beta tester wished to carry out a real time metallurgical balance as well as the off-line version.

Assays for the ISA system and flowrates from the control system are transferred to a batch version of JKMetAccount via MS Excel files.

Thermo GammaMetrics Minerals and JKTech are building an interface to facilitate data transfer from the TGMM ISA system and other process control devices to JKMetAccount via ModBus.

The same link can be used to transfer balanced data back to the process control system where on-line recoveries or economic criteria such as “net smelter return” can become part of the control scheme via operator actions to optimise the separation.

If the ISA and accounting samples share the same sampling system, there are further opportunities to enhance long term ISA calibration.

Where do we go from here? (or what do we do with all of these numbers?).

A full process database of section by section performance provides a powerful way of characterising ore type behaviour.

There are several possibilities for calibrating simple circuit models for each ore type. These will be offered in the near future as an optional Planning Module for JKMetAccount.

The same approach can be applied to a mine with multiple sources of ore. Particularly for precious metal mines, this provides an alternative way of balancing/reconciling values drawn from each stope or pit, with ore movements in each section, mill production and tailings.

Justifying Investment in Metallurgical Accounting

For a new operation, or a significantly altered flowsheet, the justification is straight forward, ie. An off the shelf solution which can be configured to suit many physical separation processes and flowsheets.

For an existing concentrator – “if it ain’t broke don’t fix it” - is always a tempting option. However, if your present system cannot identify (and quantify) how well each section of the plant is performing, some sections will almost certainly be under performing or not performing at all.

If your present system doesn’t help to identify which sections overload on different ore types, then it is certainly costing production and recovery.

Using a more precise accounting system also provides opportunities for better planning and even on-line optimisation of net smelter value or an index related to it.

A clearer focus on which instruments and samples are actually reliable may well provide an adequate justification in itself.

In short, reliable detailed performance data is just as important for effective management as reliable cost data.

We really want to avoid the common situation where we don't know what has been achieved (with any accuracy) but we do know exactly what it costs.

Conclusions

JKMetAccount offers the mineral industry a standardised approach to a long standing and difficult industry problem – converting large quantities of data into information that can then be used to make decisions about the best course of action in the concentrator. – The accumulated information can indicate, where to focus attention for maximum improvement potential. Priorities can then be placed on the problems and opportunities thus identified.

JKMetAccount provides flowsheet based, configurable metallurgical accounting in a user friendly and well-supported format.

Used to the full, it provides considerable economic opportunities in terms of

- Ore type characterisation
- Product Optimisation on-line and better performance through better planning.
- Cost savings. If a plant section is not performing, reliable metallurgical data simplifies the decision to either turn it off or to rectify its problems.

This approach is equally applicable to mines with multiple ore sources.

JKMetAccount is the detailed application of a very simple model (what goes in = what comes out) to a wide range of operational data.

While this simple model offers a way to turn process data into information, it is also clear that there would be substantial benefit in developing still broader operational models for optimisation and control from deposit to product.

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