SPOTLIGHT

on on-stream analysis

by D.A. HOLTUM*

On Tuesday, 10th November, 1987, The South African Institute of Mining and Metallurgy held a colloquium attended by some 120 delegates on 'On-Stream Analysis' at Mintek, Randburg. Mr John Moore, Consulting Metallurgist of Anglo American Corporation of South Africa Ltd, introduced Mr Gene Fivaz, the President-Elect of the SAIMM, who read an address by Mr B.C. Alberts, the current President. Mr Alberts was unable to attend the Colloquium owing to urgent business overseas.

Opening

The opening address emphasized the important role of minerals in the South African economy. In particular, it was noted that 20 per cent of the work force were employed in the minerals industry or associated industries. In recent years, production costs had risen as a result of inflation, and sanctions had had some effect on the exportation of minerals. Thus, there was continuing pressure on the industry to improve recoveries and increase efficiency. Quality control had long been recognized as an important factor in increasing efficiency. In the past, mineral streams had typically been sampled only every two hours, and it could take days for the results to be fed back to the plant. With the advent of on-stream analysis, the feedback time had been reduced so that analyses were available almost immediately. This allowed much closer control of the process, and had led to increased metal recoveries and improved efficiencies. In view of the difficulties faced by the mineral industry in South Africa, it was opportune that a colloquium concerned with on-stream analysis should be held at this time.

The Colloquium was split into two sessions. The morning session was chaired by John Moore, and the afternoon session by Neville Randolph, Consulting Chemist of Johannesburg Consolidated Investments Ltd. Eleven papers were presented, four dealing with on-line analysis by X-ray-fluorescence methods, five concerned with the chemical analysis of gold pulps, and two dealing with novel instrumentation. The programme was well organized both with regards to the sequencing of papers and the timing of breaks. Discussions on the papers were held immediately after the presentation of each paper.

XRF Analysis

The first paper of the day was presented by Ken Blake of Texas Nuclear Instruments, USA. The paper was a useful introduction to the principles of X-ray-fluorescence (XRF) analysis and the benefits to be derived from its use in on-stream analysis. The choice of sample-presentation systems, excitation sources, and spectrometer–operator interfaces was considered, and the point was made that the ideal combination depends on what the XRF analyser is being used for. In the discussion held after the paper, the question arose as to the use of XRF in the gold industry. The author replied that the XRF technique was unfortunately not yet sensitive enough for the analysis of gold, but that work was being carried out on this problem.

Peter Jerman of Batemans Process Instrumentation presented a paper on the use of on-stream XRF analysis in Southern Africa. There are currently ten on-stream XRF installations in Southern Africa, which determine copper, lead, zinc, silver, tin, and platinum-group metals (PGM). The PGM analysis is a special application requiring a high-energy 3 kW X-ray tube. Specific benefits deriving from the use of on-line XRF analysis were often not well documented because of the time required to develop control strategies. However, savings in reagents and increases in metal extraction had been recorded, and savings of R3000 to R10 000 per day could be estimated for the Prieska copper-flotation operation. Most of the difficulties in the operation of XRF analysis occur in the start-up phase, and are associated with problems in the computer hardware, water quality, and electricity supply. It is important that planned maintenance should be carried out on the analysis systems, particularly on samplers, slurry lines, and screens for tramp material. The calibration of analysers is an on-going exercise owing to changes in the ore with time and other factors. During the discussions, the question was asked as to how an XRF installation can be justified economically in terms of the savings it would produce. Mr Jerman replied that the analysis of benefits from existing installations or the hiring of an on-line XRF system for a year would indicate whether benefits could be derived or not.

The other two papers on on-stream XRF analysis dealt with two specific applications in South Africa. The use of the Courier 300 system at Black Mountain was evaluated by Jasper Esterhuyse (the paper was co-authored by Messrs G.I. Cunningham and R.S. Fickling) and the Amdel on-line analysers at Rooiberg Tin Mine by Tom Owen. Both installations have been in operation for some years, and both can demonstrate economic benefits from the use of on-line X-ray analysis. One of the difficulties experienced at Rooiberg was the gaining of operator acceptance for the on-line analysers. This, however, had been overcome as the operators became familiar with the system.

A point that arose in discussion was the use of on-line XRF analysers for automatic process control and metallurgical accounting. The analysers tended to be used in the optimizing of control schemes rather than for direct process control. Metallurgical accounting was usually carried out using laboratory samples. With regard to metallurgical accounting, it should be noted that Prieska Copper Mine uses results from the on-line XRF analyser to

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perform this function, although the stated accuracies of 5 per cent for on-line XRF analysis would not generally be accepted as adequate for this. To sum up, it appears that on-stream analysis by XRF has been accepted in South Africa as a useful and cost-efficient system. The benefits of XRF will probably become more apparent in the future as plant operation improves owing to optimization exercises.

Analysis of Gold Pulps

One of the major areas for on-line analysis in the gold-mining industry is the measurement and control of cyanide in the gold-leaching circuit. Several instruments have been developed for this purpose based on photometric methods, automatic titration, or ion-selective electrodes. Three papers were presented at the Colloquium on the analysis and control of cyanide.

The first was presented by Hans Zehnder of Polymetron AG, Switzerland. He described the Cyanostat analyser system developed in conjunction with Gold Fields of South Africa Ltd. The operation of the Cyanostat is based on a two-stage photometric method in which the optical density of a chemically formed coloured complex is measured. Cyanostat systems have been installed in South Africa, Australia, and New Guinea; in South Africa, systems are operating on West Driefontein, Buffelsfontein, and Doornkop Gold Mines. No direct automatic process control is yet undertaken on these mines, but there are plans to carry this out in the near future.

The other two papers concerned with cyanide measurement and control described the development and practical application of a silver electrode for the measurement of gold-leaching efficiency. The term *gold-leaching efficiency* is used for this electrode because the output is affected by other components in the leach pulp, i.e. any component that will affect the dissolution of silver by cyanide solutions affects the electrode, e.g. lime, air, and sulphides.

The paper by Wally Ormrod and B. Fitzgerald of Mintek described the development of the re-designed Kegold probe and its testing against a Polymetron cyanide analyser at the Doornkop Gold Mine. The results of the test showed that the Kegold and Polymetron give similar results for cyanide concentration, but that the Kegold's response is faster. This is one of the main advantages of the Kegold, and derives mainly from the fact that the Kegold is placed directly into the pulp and requires no ancillary sampling system to give a clear solution for analysis. Other advantages seen for the Kegold are its low cost and ease of maintenance.

Deon van Rensburg of BRCS Instrumentation described some practical experience with the Kegold electrode at the Crown Plant of Rand Mines Milling & Mining (RM 3). The electrode had originally been installed in the primary leaching tank, in which oxygen caused an excessive noise signal that resulted in an uncertainty in the cyanide value of 20 p.p.m. Subsequently, the probe was installed in the second leaching tank and the noise signal was reduced considerably. Because of the long lag times between the addition of cyanide and the reaction of the electrode in the second leaching tank, the electrode has not been used for control purposes but has been accepted as a monitoring device by the plant staff. An interesting observation made on the plant concerns the effect of the lime concentration on the electrode response. When the lime concentration was above 360 p.p.m., a reduced current was measured by the electrode, indicating a decrease in the leaching efficiency.

In the discussion after the two papers on the Kegold probe, it was clear that there are reservations about the use of the Kegold electrode for the measurement and control of cyanide. However, is thought that there is a place for it as an alarm device to indicate anything abnormal with the gold leach. It does not seem unreasonable to suggest that the electrode may be used in the future in conjunction with the measurement of pH and dissolved oxygen to control conditions in a gold-leaching plant more closely

The other two papers concerned with the analysis of gold pulps described the mobile laboratory set up by Mintek to measure various process variables in gold-leaching plants. The first paper, by Rob Robért and Mrs C. Pohlandt-Watson, described the adaptation of standard laboratory equipment for the mobile laboratory. Two analysers, one for gold and the other for cyanide, were dealt with in the presentation. The gold analyser is based on atomic-absorption spectrophotometry (AAS) with electrothermal atomization. The instrument used for the AAS is capable of covering several analytical ranges and, with the use of nitrogen gas and a novel water-dilution system, it can measure gold concentrations between 0,002 and 12 p.p.m. The automatic sampler for the analyser had been modified by Mintek to allow for the calibration of an instrument with up to six calibration solutions.

Cyanide analysis was carried out by a flow-injection method in which the sample is transported in a carrier stream past a cyanide-specific electrode. Mintek have had a great deal of experience with on-line analyses, and it has become clear that, to obtain satisfactory results, the analytical instrumentation needs to be accommodated in a dust-free, temperature-controlled environment. In addition, an independent cooling system for the AAS instrument and an independent electricity supply were considered necessary. To provide these requirements, Mintek converted a caravan to a mobile laboratory. The development of the mobile laboratory was described by Hennie du Plessis of Mintek. In addition to the gold and cyanide analyses described previously, analyses for dissolved oxygen and lime can also be carried out. The operation of the instruments in the mobile laboratory is controlled by programmable logic controllers linked to a personal computer. Clear solutions for the various analysers are supplied by a Millipore filter system. Transportation of the filtrate is effected by pressurization with nitrogen gas. Nitrogen is used to avoid side reactions such as the precipitation of calcium, which would block the sample lines. The mobile laboratory was tested on a Mintek pilot plant. Samples were anlysed both by the mobile laboratory and by conventional methods at Mintek. The analytical results were in good agreement, showing that the mobile laboratory can successfully provide rapid indications of plant conditions. It can be concluded that the mobile laboratory is a very useful facility for plant trouble-shooting and process control. The author emphasized the point that trained personnel should be

responsible for the laboratory to ensure correct use and regular maintenance of the instruments.

Novel Instrumentation

The first paper in this category concerned the development of an instrument for the measurement of carbon concentration in pulp. The paper was presented by Jackie McEwan of Mintek; two co-authors, A. Holton and M. Tao, had also been involved in the development of the instrument. The instrument consists of a submersible probe coupled to an external electronic circuit. The probe uses ultrasonic attenuation to measure the concentration of carbon, and impedance mismatch to compensate for the effects of pulp density on the attenuated ultrasound. Temperature also affects the ultrasonic attenuation, and this is also compensated for. The probe was tested in the laboratory and on the Doornkop Gold Mine, and was shown to give measurements of carbon concentration that agree with hand sampling to within 2 ml of carbon per litre of pulp.

Further work is being carried out to improve the accuracy of the pulp-density measurement since the compensation for this is vital to the satisfactory operation of the probe. During the discussion on the paper, the effect that woodchips in the pulp may have on the performance of the probe was raised. Mr McEwan replied that this was a factor that would be tested in future but that the effect was unknown at present.

The last presentation of the Colloquium was entitled 'The Measurement of Rheological Properties inside Grinding Mills' authored by Mike Moys and A. Montini, both of the University of the Witwatersrand. The viscosity of the slurry inside a grinding mill is an important variable governing milling efficiency. Dr Moys described an instrument capable of measuring the slurry viscosity by measuring the rate of slurry drainage from a conductivity probe mounted in a mill-liner bolt. The probe had been tested on a pilot-plant mill at the University of the Witwatersrand, and was able to distinguish the percentage solids in the mill (which is closely related to the slurry viscosity) to within 3 per cent. In the discussions after the presentation, the effect of particle size on the probe reading was raised. Dr Moys pointed out that it was the finer particles that most affected the viscosity of the mill slurry, and changes in particle sizes above about 150 μm would have little effect on the measurement of viscosity.

Both the novel instruments presented at the Colloquium offer plant metallurgists new possibilities for the control of their processes and, it is hoped, will be used in the future.

Closing Address

Neville Randolph, in his closing address, gave an informative summary of the development of on-line instrumentation from the 1950s to the present. He said that nearly all the techniques developed in the past 30 years for use originally in analytical laboratories were now used in on-line analysis. For example, atomic-absorption spectrophotometry, X-ray fluorescence, ion-selective electrodes, and inductively coupled plasma analysis were all in use in an on-line capacity somewhere in the world. In fact, the only large-scale widely used chemical analysis that had not been automated was the fire assay for gold analysis, and there was a possibility that this, too, could be replaced in the future by an on-line analysis. Many new analytical devices were under development such as the Chamber of Mines gold analyser, which was designed to measure gold contents in the reef underground, and he was sure that many other developments would be made in the future.

Acknowledgements

Mr Moore closed the Colloquium by thanking all who had been concerned with its organization, in particular the SAIMM Technical Programme Committee—Extractive Metallurgy, chaired by Mr Richard Beck, and the SAIMM secretaries Celeste Mackintosh and Pam Binstead. He also expressed his appreciation to the SAIMM President-Elect, Mr Gene Fivaz, who had spent a full day participating actively in discussions, to Mintek and their staff, and to the suppliers of instrumentation who had put on an exhibition during the Colloquium, particularly Scitec and Peritech, who had jointly sponsored the cocktail party. Finally, he thanked the authors for their excellent presentations and the delegates who had attended the Colloquium, without whose support the day would not have been possible.