

SPOTLIGHT

on milling

by G.J.C. YOUNG*

Opening

On Tuesday, 9th June, The South African Institute of Mining and Metallurgy held a well-attended Colloquium on Milling at Mintek, Randburg.

The meeting opened with a short address by Dr H. Wagner, Director General of the Chamber of Mines Research Organization. In his address, he highlighted the cost of the milling process to the industry. The fact that the industry at home and overseas had, at considerable expense, sent some 270 delegates to the Colloquium demonstrated the industry's concern at the high cost of this process. Clearly, this cost could be reduced only by a greater understanding and interchange of information, which was the purpose of meetings such as these.

Dr Wagner made the point that electricity charges were escalating at a very high rate and that, as the grinding process consumed by far the highest amount of energy of all the surface processes, it was of paramount importance that the industry as a whole should address the problems associated with grinding in an organized and energetic manner.

Since the release of gold from the shackles that had held it at 35 US dollars an ounce until 1972, the mining industry has seen average mill grades decline from some 13 g/t to around the present average of about 5 g/t. Furthermore, these grades can be expected to drop even further in the near future. To maintain gold production, ore tonnages have increased commensurately, resulting in even greater total costs.

Dr Wagner closed his address by emphasizing the nature and title of the meeting. The word *colloquium*, he said, implied discussion, and this was of great importance if the meeting was to achieve its aims.

Two Sessions

The meeting was split into two sessions: the first during the morning, chaired by Pieter van Aswegen, and the second during the afternoon, chaired by Bill Flook. Both are consultants to Gencor, a mining group that has pioneered much of the innovative work done on the grinding process during the past three decades or so.

Removal of Pebbles

John Freer, also of Gencor, presented a paper on the effects of pebble removal on the performance of run-of-mine (ROM) mills. This is a concept that deserves considerable interest since, not only does it enable waste sorting to be introduced into a grinding plant, but it increases a mill's capacity by withdrawing pebbles of a critical size. These pebbles, which are thought to contribute little to the grinding process, are very difficult to grind and thus tend to reduce the throughput of a mill. By contrast, the

very property that causes them to be refractory to grinding results in a well-rounded pebble, which is ideal for sorting either by hand or by mechanical means. At Bracken Mines, where the testwork was undertaken, it was found that the reef component of the ore was far more friable than the waste, and this meant that a high proportion of the ejected pebbles were of barren quartzite.

Gold Lock-up

Concern for the large amount of gold absorbed by a grinding mill behind its liners is of particular importance today because of the high price of gold. This problem has been squarely addressed by workers at the Doornkop plant, where a mill was taken off line for an exacting assessment of the gold locked in the mill and of its deportment. In his paper, 'Gold lock-up in ROM mills', Alan Phillips of JCI put forward some startling facts, which showed that a grid-lined ROM mill 4,27 m in diameter by 10 m long could lock up as much as 200 kg of gold. At today's prices, this amounts to a staggering R5,6 million per mill, or some R90 000 per month if discounted for ten years at 15 per cent p.a.

This phenomenon was first documented by Dr White close on sixty years ago, but it has not attracted much attention until recently, except on the mines of the Evander field, where it has given rise to the successful collection of concentrates of gold and platinum-group metals. The scale of this absorption as revealed by Alan (and my own work has indicated similar levels) is such that it can no longer be ignored. Either it must be exploited as at Evander, or a means must be found to prevent it.

Behaviour of the Charge

Keith Liddell, of Mintek, spoke on the effects of mill speed and filling on the behaviour of the charge inside a grinding mill. This was a paper of considerable interest despite its highly academic approach. Keith, I fear, went a little too fast for many in his audience, but most of us managed to grasp the importance of the interactive effects of charge level and mill speed on mill performance. This work is of significant fundamental importance since a clearer and better understanding of the grinding mechanisms is vital if we are to attain greater efficiencies in our mills. This is a paper which should be re-read and examined while the presentation is still fresh in the mind.

Mike Moys, of the University of the Witwatersrand, discussed the behaviour of the particles inside a mill, particularly the effects of slurry viscosity. Using electrodes implanted through the mill shell, he had traced the path of a charge in motion and had studied the effects of changes in viscosity.

Mike demonstrated how the peak torque required to

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rotate a mill operating at speeds close to critical is highly sensitive to pulp viscosity. He made a case for the inclusion of instrumentation to measure the density of mill pulp. He showed how a probe inserted through the mill shell could be used to provide this information, and he also mentioned the Anglo American system that employs an array of microphones for this purpose.

The peak-power seeking strategies that are used at present concern themselves only with the load level inside the mill. Instrumentation to provide information about slurry rheology is being developed and can now be incorporated into the mill hardware.

An allied paper, by Mark Giddy of Western Deep Levels, was also of interest. He demonstrated the importance of the effect of charge moisture content on the power draft of an operating ROM mill, confirming much of what the previous speaker had highlighted. Mark showed how the power draft is dependent on both the charge level and the moisture content, and made a plea for account to be taken of both these important parameters in the optimization of software, instead of merely controlling the mill feed and ratioing the mill inlet dilution accordingly.

Control Strategy

A multivariable control strategy for ROM mill control was presented by Dr Dave Hulbert of Mintek. This paper described the work that had culminated in the successful application of multivariable control to a ROM mill at Vaal Reef's (a system known irreverently on the mine as 'dial-a-grind'). The purpose of this strategy is to maintain a steady final grind from the operation, and the mill feed rate is varied as necessary to achieve that aim. The success of the system is such that it tends to obscure the painstaking work in its development. Oddly enough, Dave found that control of the inlet dilution water was not a parameter of significant importance in his strategy, and he demonstrated this with illustrations of the system's response to changes in mill dilution water. This finding seemed to be in conflict with the work of the previous speaker but, as Mark Giddy pointed out during the discussion, the moisture content of the charge is of primary importance in keeping the mill grinding under optimum conditions, but is not a parameter to control the final product from the milling unit.

Discussion

In accordance with Dr Wagner's injunction, the discussion was fairly lively, considerable attention and interest being given to the paper on gold lock-up. An interesting comment questioning the local preference for grate mills as opposed to overflow mills was ably answered by Dr Brian Loveday and Alex Mokken. It was agreed that, although overflow discharge is satisfactory for ball mills, the grate-and-pan lifter is necessary in autogenous and semi-autogenous mills because the lower-density pebbles in these mills were unable to 'punch' their way effectively through a pool of viscous pulp.

Milling Equipment

After lunch three papers were presented under the watchful eye of Bill Flook.

The first, by Jan Skorupa, dealt with his painstaking

research into the best material for liners that are to be used in mills grinding abrasive coal. This paper was interestingly presented, with tables and photomicrographs of polished sections taken from working mill liners.

Mr Patzelt, of Polysius, ably described the application of high-pressure roll mills in ore-preparation circuits. The high-pressure roll mill is an interesting and recent development, and appears to offer several advantages over conventional mills in terms of greater power efficiency and greater liberation of valuable mineral. The latter he showed to be largely due to the propagation of deep cracks in the ore particles, which either allowed the ready penetration of leaching reagents or assisted in a later finer-grinding process in conventional mills.

The concept of a linear screen as a mill classifying tool was introduced by Malcolm Wilkinson of Anglo American Research Laboratories. In certain applications, screening has significant advantages over conventional classification, especially where there is a tendency for an ore to overgrind by producing an excess of fines. The linear screen, it was claimed, is a simple machine that makes screening down to very small sizes practical, without the problems normally associated with conventional vibrating screens.

Closing Discussions

Discussions in the afternoon session centered largely on the role of the linear screen, and Dr Loveday emphasized its important role in gold circuits incorporating flotation.

The proceedings were closed by the chairman for the afternoon. In his remarks, Bill Flook laid some stress on the fact that the problems of overgrinding had not been as significant with Witwatersrand gold ores as they had been elsewhere. He pointed out that, although the use of a linear screen would reduce the chance of gold particles returning to the mill and remaining in the circulating load, there were certain particles containing gold, notably those encased in pyrite, that should be returned for regrinding. It was for the selective regrinding of the gold so encased that the cyclone classifier had been eagerly adopted by the industry almost four decades before.

As author of this Spotlight review, I endorse these remarks and refer those who fear overgrinding of Witwatersrand gold ores to the works of Dick Klimpel, a respected authority on milling, especially on the effects of pulp rheology on the process. I recall a conversation with Dick in which he repeated the words 'Your mills in South Africa are hungry for fines'.

Bill also referred to the papers on roll crushing and mill lock-up. The product from a roll crusher, he suggested, should be ideal for heap-leaching applications because of its ability to induce the formation of multiple cracks with the minimum production of fines.

Bill stressed how the phenomenon of mill lock-up could be turned to advantage. On the mines of the Evander field, up to 25 per cent of the gold production (together with a major proportion of the world's osmiridium) is recovered by the use of a liner system especially designed to exploit this property. The mill, in fact, is a highly efficient and cost-efficient concentrator, and has the advantage of almost-impregnable security. The chairman closed his summary by pointing out that, although the

study of mill lock-up had provided very valuable information, these results should not be misinterpreted as a cause of chronically low mine call factors. 'The solution to that problem will not be found on surface', he said.

Closure

The Colloquium closed with a well-attended cocktail party. The Institute and the delegates are most grateful

to Morganite (SA) Pty Limited for their generous sponsorship of this party.

Undoubtedly, the Colloquium was a great success, and the work described to the wide audience was of considerable value. The organization was excellent, and our thanks and admiration go out to those of the Institute who worked so hard to ensure its success.

Mine water

The Third International Mine Water Congress is to be held in Melbourne from 23rd to 28th October, 1988, the year of Australia's bicentenary.

The Congress objective will be to provide a forum for technical discussion on the management of mine water for the benefit of industry, community, and environment, covering as broad a spectrum of technology and mining environment as possible. Pre- and Post-Congress tours will be arranged to a variety of mining environs in Australia and at the same time to view Australia's flora and fauna. Overseas delegates may take the opportunity of planning their holiday to Australia to visit tourist attractions such as Ayers Rock, the Great Barrier Reef, Sydney, and Perth, and at the same time attend this important international event.

A Pre-Congress tour will also be arranged to New Zealand.

This will be the first Mine Water Congress to be held in the Southern Hemisphere, and the first in the rapidly developing mining environment of Asia and the Pacific. The Congress will follow the standards set by the successful 1978 and 1985 Granada Mine Water Congresses and the 1982 Budapest Mine Water Congress. Not only did these congresses incorporate high-quality technical papers, but they extended the opportunity for technical discussion and contact.

The Third International Mine Water Congress in 1988 is being organized by The Australasian Institute of Mining and Metallurgy (The AusIMM) for the International Mine

Water Association (IMWA). His Excellency the Right Honourable Sir Ninian Stephen, AK GCMG GCVO KBE, Governor-General of the Commonwealth of Australia, has accepted the invitation to be Patron of this Congress, and Sir Russel Madigan OBE has been appointed President of the Congress.

It is expected that delegates will be drawn widely from the countries in the region, as well as from the host country. A major delegation is expected from Eastern and Western Europe, Canada, the USA, People's Republic of China, and the USSR, bringing with them their broad experience in mine-water management. More than four-hundred delegates are expected.

Further information is obtainable from

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