

Problems encountered during the commissioning of the carbon-in-pulp plant at Beisa Mine

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SYNOPSIS

Difficulties with the screening of large volumes of pulp to remove plus 600 μm material before the adsorption circuit and to retain plus 20-mesh carbon in the adsorption contactors have largely been solved, with the result that the plant can now handle its design throughput. The elution and electrowinning processes have been modified to simplify the circuit, but the regeneration of carbon remains unsatisfactory.

The production of fine carbon in the plant can lead to increased gold losses, and this carbon must be collected and treated. Collection methods for fine carbon and some indications of the quantity of the carbon and its gold values are given.

SAMEVATTING

Probleme met die sif van groot volumes pulp om die materiaal groter as 600 μm voor die adsorpsiekring te verwyder en die koolstof groter as 20 maas na die adsorpsiekontaktors terug te voer, is in 'n groot mate opgelos met die gevolg dat die aanleg tans die toevoer waarvoor dit ontwerp is kan hanteer. Die elueer- en elektrowinningsproses is gewysig om die kring te vereenvoudig, maar die regenerasie van koolstof bly onbevredigend.

Die produksie van fyn koolstof in die aanleg kan tot groter goudverliese lei en hierdie koolstof moet versamel en behandel word. Daar word metodes om fyn koolstof te versamel aangegee asook aanduidings van die hoeveelheid koolstof en die goudwaardes daarvan.

Introduction

Beisa Mine, situated 25 km south of Welkom, was developed from its conception as a uranium mine with gold as an important byproduct. The process comprises run-of-mine milling and pulp thickening, followed by batch leaching, belt filtration, solution clarification, and solvent extraction for the recovery of uranium; solids from the belt filters are repulped, neutralized, and leached for gold in batch agitators, followed by the carbon-in-pulp (CIP) process.

The conventional process for the recovery of gold differs from the CIP process in that the pulp filtration, solution clarification, zinc-dust precipitation of gold, and acid treatment of the resultant black slime are replaced by gold adsorption onto activated carbon, screening of carbon from the pulp, elution of loaded carbon, and electrowinning of gold from the eluant; the carbon after elution is regenerated and returned to the adsorption circuit.

CIP was chosen for Beisa because of the potential savings in capital and working costs. In mid 1979, the CIP plant cost approximately 2,3 million rands, whereas the estimate for the plant that CIP would replace was 6,1 million rands. At that time, the saving in working costs was estimated at 14,4 cents per ton treated in favour of CIP; at 100 kt per month, this saving amounts to 14 400 rands per month.

It should be stressed that the CIP plant was not designed to make significant improvements in the recovery of gold over that obtained from conventional circuits; the loss of dissolved gold was guaranteed not to

exceed 0,03 g/t, which would have been the design figure for a filter plant. No account was taken of the possibility of a decrease in the loss of undissolved gold in the adsorption circuit since the magnitude of the effect at Beisa was unknown and was difficult to predict.

The CIP plant was commissioned with waste rock in August 1981. Since start-up, problems have occurred with the movement of the pulp, carbon, and solution owing to the presence of wood-chip particles in the ore. In addition to work aimed at reducing the effects of wood chips in the plant, process changes have simplified the elution and electrowinning sections. Although the modifications have improved the operation of the CIP plant, the design residue values have not been achieved over a significant period of time and testwork is continuing.

Removal of Wood Chips

The activated carbon used in the CIP plant has a size range of 2,38 to 1,19 mm (ASTM mesh 8 to 16), and it is retained in each stage of the adsorption circuit by 0,84 mm (20-mesh) air-cleaned screens that allow the pulp to flow through continuously. Carbon is moved up circuit countercurrent to the pulp flow, and from the first-stage adsorption contactor to the loaded carbon screens by airlifting of a pulp and carbon mixture. Any particles larger than 0,84 mm that enter the adsorption circuit with the pulp are retained in the first adsorption tank and follow the loaded carbon to elution and regeneration. For this reason, most CIP plants¹⁻⁴ have installed 0,6 mm (28-mesh) screens to remove the oversize material prior to the adsorption circuit.

The plus 600 μm particles comprise a small quantity of ore particles that form the top end of the particle-size distribution in the mill-cyclone overflow plus wood chips and small pieces of plastic. Two Derrick screens, each

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1,0 m wide, were used to remove this material from the pulp feed to CIP. They proved to be over 96 per cent efficient, but suffered from a high consumption of screen cloth, leading to high operating costs and low equipment availability. The stainless-steel cloth had an average life of only a few days, and the monthly cost of screen replacements was over R1000. At the design throughputs (200 m³/h of pulp with a relative density of 1,5), the screens could not produce a clean product that could be discarded, and extra screening area was therefore required.

Testwork at Grootvlei⁵ and Kinross⁶ Gold Mines indicated that a Velmet dewatering screen would be suitable for removing wood chips; by use of a polyurethane deck with slots of either 0,3 by 12,0 mm or 0,4 by 12,0 mm, over 97 per cent of the plus 600 μm material could be removed from the pulp. Table I shows results of this testwork compared with those achieved at Beisa by use of the same screen.

TABLE I

REMOVAL OF WOOD CHIPS (PLUS 600 μm) AT GROOTVLEI, KINROSS, AND BEISA BY THE USE OF VELMET SCREENS

Mine	Screen slot size mm	Specific throughput of pulp per m ² of screen per hour (r.d. of pulp 1,5) m ³	Removal efficiency %
Grootvlei	0,4 by 12	42	97
	0,3 by 12	31,5	98
Kinross	0,5 by 12	44	72
	0,4 by 12	28	99
Beisa	0,4 by 12	47	Up to 74
	0,3 by 12	27	84

A visual comparison of the wood chips in the CIP feed pulp at the three mines indicated that those at Beisa are much finer than at the other two mines, which explains the poor efficiencies at Beisa as shown in Table I. Beisa operates a reverse-leach process (cyanidation after uranium extraction), and the warm, acidic, oxidizing conditions of the uranium leach could perhaps 'modify' the wood chips by dissolving cellulose from the chips and reducing them to a fibrous material before they reach the gold plant. A visual comparison of wood chips before and after acid leaching supports this theory.

At that time, the best solution to the problem was thought to be the removal of all the plus 600 μm material from the thickener feed pulp (i.e. before uranium leaching) by the use of a polyurethane screen. The pulp at that point in the circuit is very dilute, containing about 5,5 t of water to every 1,0 t of solids, and the total screening area required for a 0,3 mm by 12 mm slotted polyurethane deck was 50 m². The total cost of the screens alone would have amounted to R180 000.

The Council for Mineral Technology (Mintek), which had also been working on the prescreening of CIP feed pulp, developed a prescreening tank, known on the mine as the Mintek tank. This tank (shown in Fig. 1) is a mechanically agitated vessel fitted with peripheral 28-mesh air-cleaned screens through which the pulp flows to the CIP plant. Coarse material is retained in the

tank and allowed to build up in concentration so that a small flow can be bled from the tank for external screening of the plus 600 μm material. Table II shows typical results⁴ that Mintek investigators obtained at Beisa using this prescreening concept.

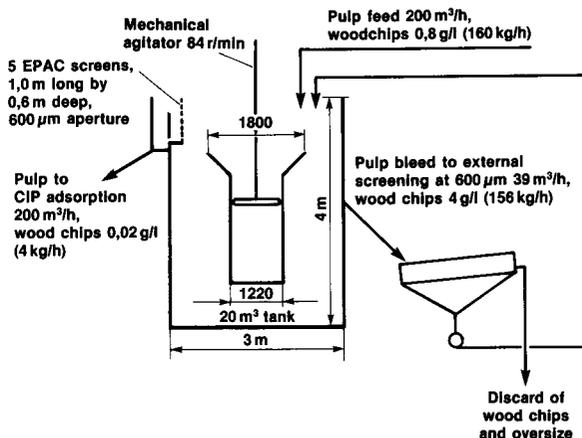


Fig. 1—The Mintek prescreening tank for the removal of wood chips

The development of equalized-pressure air-cleaned screens (EPAC), also by Mintek, improved the potential of the air-cleaned screens by increasing the specific throughput of the screens in terms of cubic metres of pulp per square metre of screen per hour. The original air-cleaned screens were modified by the placing of a weir plate on the external side of the screens (Fig. 2) to equalize the pulp pressures across the screen; an increase in pulp throughput of 300 per cent was achieved.

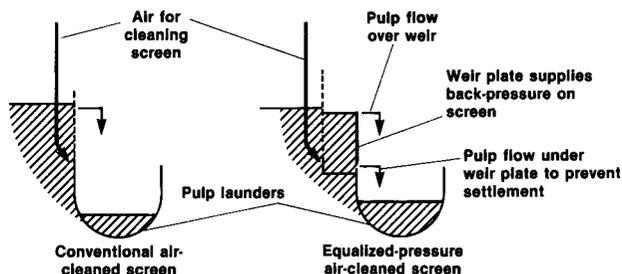


Fig. 2—Air-cleaned screens

Hourly flowrates of pulp through the EPAC screens of 90 m³ per square metre (as calculated from Table II) mean that only 2,5 m² of submerged 28-mesh screen is required to prescreen the design throughput at Beisa, and this screen area is the only limiting factor in the sizing of the Mintek tank.

Until the final installation of the Mintek tank, the CIP plant suffered severe problems with wood chips. The chips built up in the first adsorption contactor and blocked the 20-mesh interstage screens, and they were collected on the loaded-carbon screens and caused

TABLE II
THE SCREENING OF WOODCHIPS FROM BEISA PULP THROUGH SCREENS OF 28 MESH (0,6 mm)

Pulp feed			Screen			Air flow	Circulating pulp			Final pulp
Concn of over-size g/l	Pulp flow m ³ /h	Relative density	Total length of three screens m	Depth of immersion of screens in pulp m	Screen area submerged in pulp m ²	Total to screens l/min	Pulp flow m ³ /h	Amount of over-size from screen kg/h (wet)	Concn of over-size in contactor g/l	Concn of over-size g/l
0,79	84	1,55	2,86	0,33	0,92	3,000	18	440	3,23	0,02

numerous problems.

- (1) Wood chips made up a considerable percentage of the volume of loaded carbon (between 25 and 40 per cent by volume, or 13 per cent by mass) and decreased the amount of loaded carbon eluted and regenerated.
- (2) The transfer of carbon to the elution columns, and from the eluted carbon tanks to the regeneration kilns, was laborious and time-consuming because of frequent blockages in the eductors and pipelines.
- (3) Wood chips fed with eluted carbon to the regeneration kilns caused poor regeneration owing to surges of feed as a result of blocked pipelines.
- (4) Wood chips entered the electrowinning circuit with the catholyte and blocked the cathodes in the electrowinning cells, adversely affecting the production of gold.

The first three points above led to losses of dissolved gold from the plant of about 0,06 g/t.

The elutriation of wood chips from loaded carbon has proved to be successful. Loaded carbon, pulp, and wood chips are lifted from the first adsorption tank onto the loaded-carbon screens, from which the pulp flows back to adsorption, and the carbon and wood chips are washed with sprays and fed into the top of the elutriator, as shown in Fig. 3. Manually controlled water at a flowrate of 1,0 l/s is fed in at the apex of the cone, and overflows a weir at the top of the cylindrical portion of the tank, removing the wood chips as it rises but allowing the carbon to descend into the cone. Carbon is discharged near the apex of the cone by an automatic valve. The upward flowrate of the water is critical; excessively high flowrates wash carbon up with the wood chips, and low flowrates are insufficient to remove the wood chips. A small agitator operating in the wood-chip zone of the elutriator helps to lift the wood chips that would otherwise settle with the carbon.

There is little quantitative information on the efficiencies of wood-chip removal achieved by this unit, but its success can be measured by its effect on the elution and regeneration circuits; the time to fill the elution column with carbon decreased from 5 hours to approximately 1 hour, and the blockages in the carbon-feed lines to the

regeneration kilns ceased.

The combination of the Mintek prescreening tank and the elutriator have not entirely eliminated wood fibre in the CIP plant but have reduced it to manageable proportions, and both units are recommended for CIP circuits operating on slimes.

The Adsorption Circuit

Five air-agitated tanks, each 7 m in diameter by 7 m high, are used for the adsorption of gold. The residence time of the pulp in the circuit is approximately 5 hours (i.e. 1 hour per stage), and the carbon concentration is 25 g/l in all stages. The circuit was designed to give a loss of dissolved gold of 0,03 g/t and a loaded-carbon assay of 10 000 g/t.

Apart from the elimination of wood chips, the most important operating aspects of the adsorption circuit are as follows:

- (i) keeping the carbon in suspension in the tanks,
- (ii) preventing the carbon from moving downstream with the pulp, and
- (iii) moving the correct quantity of carbon up-stream

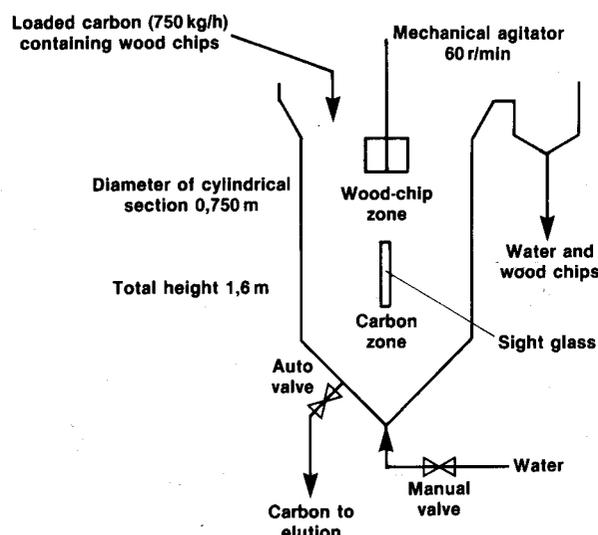


Fig. 3—The wood-chip elutriator

and keeping the circuit in balance with regard to the concentration of carbon in each stage.

Activated carbon has a bulk density when dry of 0,60, and the carbon itself has a density of 2,2. Tests conducted by Montan Chemicals⁷ suggest that granules of wet carbon have a relative density between 1,60 and 1,76, and loaded carbon therefore tends to settle out of pulps with a relative density of less than about 1,50 (with a water-to-solids ratio of 0,9) unless the agitation in the contactor is very good.

The feed pulp to CIP must be controlled at a density of more than the 1,5 required to maintain the carbon in suspension, which will allow for dilution entering the circuit in the form of

- (a) water spray from the loaded-carbon screens,
- (b) solution drained from the elution columns,
- (c) eductor water entering with fresh or regenerated carbon,
- (d) spray water on the wood-chip removal screen, and
- (e) return spillage and hosing.

Air agitation in flat-bottomed agitators has the disadvantage of producing 'dead' spots of stagnant material between the air bells, which causes a build-up of settled material, even if the pulp density is maintained above the critical value of 1,5. Indications are that a depth of settled slime, sands, and carbon of 1500 mm is deposited between the air bells over a period of ten days.

The build-up of material reduces the live volume of the adsorption tanks and causes blockages in the air lifts used for transferring the carbon upstream. The settlement of the carbon increases the lock-up of carbon and gold in the circuit. A regular programme of tank drainage and cleaning has been initiated to overcome these problems, but, during this exercise, one adsorption stage is off-line and the losses of dissolved gold from the circuit are affected.

An open-tank mechanical agitator, which was installed in the fifth-stage contactor at a cost of R25 000, was commissioned in December 1982; plant trials have shown little or no settlement of solids on the base of the tank and, after a 3-hour shut-down of the unit, all the settled material was resuspended within an hour.

The four remaining air-agitated contactors were converted to mechanical agitation in 1983. The justification for these units was based on an expected decrease in residues owing to the increased availability and live volume of the contactors, and a decrease in the lock-up of carbon and gold. It has been suggested³ from pilot-plant tests at Grootvlei Mine that an increase in the extraction of gold can be attained as a result of the improved mixing achieved by mechanical agitation. These results are shown in Table III.

The bypassing of the interstage screens by carbon leads to inefficiencies in the circuit and a flat carbon profile (the concentration of gold on the carbon is the same in all stages). Bypassing can occur as a result of holes in the screens, badly fitted screen plates, or splashing over the screens, and the presence of carbon in the pulp leaving each tank must be checked on a regular basis by the use of a 20-mesh test sieve. Splashing over the screens was

TABLE III
COMPARISON OF AIR AND MECHANICAL AGITATION, GROOTVLEI MINE

	Feed solution	Stages				
		1	2	3	4	5
Air agitation	2,64	1,10	0,370	0,132	0,051	0,022
Au, p.p.m.						
Adsorption per stage, %						
Average adsorption, %			63			
Mechanical agitation	3,15	0,806	0,206	0,052	0,016	0,008
Au, p.p.m.						
Adsorption per stage, %						
Average adsorption, %			74			

the particular problem at Beisa, and this was corrected by the conversion of the original air-cleaned screens to deeper EPAC screens. These screens (Fig. 2) have already been described. Each adsorption tank had a total screening area of 6,3 m² of air-cleaned screens—this has been reduced to 3,2 m² of EPAC screens, which are expected to handle the design tonnage.

The interstage screens are 20-mesh (0,84 mm) static woven-wire screens mounted vertically on the top of two launders running across the top of the adsorption tanks. The system gives good access to the screens and the possibility of bypassing any number of stages in contingency situations, but suffers from the disadvantage of high wear rates on the launder itself (another cause of the downstream flow of carbon), which must be rubber-lined inside and out.

Table IV shows the solution and carbon profiles attained at Beisa during the fourth quarter of 1982. The solution profile is compared with one that would result from a stage efficiency of 70 per cent in each contactor.

TABLE IV
CIP ADSORPTION RESULTS FROM BEISA WITH A FEED SOLUTION VALUE OF 1,71

Parameter	Stage				
	1	2	3	4	5
Carbon profile, g/t	1560	1372	922	633	370
Solution profile at 70% stage efficiency, g/t	0,51	0,15	0,05	0,01	0,004
Actual solution profile, g/t	0,56	0,28	0,13	0,07	0,04
Actual stage efficiency, %	67	50	54	46	43

The actual stage efficiencies shown in Table IV are not indicative of carbon 'poisoning' since the stage efficiency does not gradually increase down the circuit. In fact, the lowest stage efficiency occurs in the fifth stage, which contains fresh and regenerated carbon. That stage also contains the most dilute pulp, and it is therefore suggested that these results indicate silted-up contactors and poor control of the carbon concentrations.

The Elution of Loaded Carbon

Gold loaded onto activated carbon is stripped off into a low volume of concentrated solution during the elution process, and this solution passes through electrowinning cells, where the gold is deposited onto steel-wool cathodes, which are calcined periodically and smelted to form the conventional gold bar.

There are two processes for the stripping of gold from loaded carbon: the ZADRA or Homestake elution, which comprises in the circulation of a 1 per cent sodium hydroxide and 0,2 per cent sodium cyanide solution at 90°C through the column and the electrowinning cells; and the AARL elution, which comprises a carbon soak at 90°C with 5 per cent sodium hydroxide and 2 per cent sodium cyanide, followed by an up-wash with water at 110 to 120°C. The temperature and pressure variations in these two procedures are described in the literature^{8,9}. The original Beisa elution included an acid-washing stage prior to elution; the sequence of operations was therefore as follows:

Carbon transfer to column using water eductor (no wood chips)	1,5 h
Acid wash and soak with 5 per cent hydrochloric acid at 80°	2,5 h
Removal of acid by hot-water wash	5 h
Draining of column	0,25 h
Conditioning with caustic cyanide and soak	2,0 h
Elution with water (120°C)	6 h
Transfer of stripped carbon	0,25 h

This entire elution sequence took 17,5 hours to complete, and was a complex operation that was susceptible to operator errors. The possibility that the hydrochloric acid and sodium cyanide solutions would become mixed at high temperatures as a result of malfunctioning valves, instruments, or operators was ever present.

So that this potential danger would be removed and the elution times would be reduced to two elutions per day, acid treatment of the carbon in the column was discontinued and this step placed after the carbon-regeneration step. The elution efficiencies were not affected, and the removal of the calcium that builds up on the carbon has been good—a 5 per cent solution of hydrochloric acid at ambient temperature reduces the calcium level from about 14 000 p.p.m. to approximately 3000 p.p.m.

In an attempt at further simplification of the circuit, a continuous elution test was carried out in January 1983. The gold on the loaded carbon was reduced from 1374 to 79 g/t during an elution and electrowinning period of 20 hours (i.e. an elution efficiency of 94 per cent). The elution flowrate was limited to 0,66 l/s (0,82 bed volume per hour) as a result of the design of the present equipment. The temperature of the solution feed to the column was 120°C (and that to the electrowinning step was 78°C), and the sequence of events was as follows:

Transfer of carbon to column	1,5 h
Draining of column	0,25 h
Elution-electrowinning	18,00 h
Transfer of eluted carbon	0,25 h
Total time	20,00 h

The continuous elution is thus a far simpler operation. However, the elution times do not compare with those of the AARL elution, although the efficiencies are approximately the same. At this point, a decision as to the final elution circuit has been delayed pending further test-work.

Plate heat-exchangers have been employed in the elution circuit for heating eluate and cooling catholyte, and have proved susceptible to regular blockage owing to a build-up of scale. Sodium tripolyphosphate added to the fresh eluate at a dosage of 3 p.p.m. proved satisfactory in inhibiting the formation of scale in the heat-exchanger, but appeared to slow down the rate of gold elution. A liquid scale inhibitor gave good results in the heat-exchanger and did not affect the elution of gold, but it caused frothing in the electrowinning cell and appeared to hinder the deposition of gold. Because of production pressures, this line of investigation was curtailed. The plate heat-exchangers have been replaced with a shell-tube type of heat-exchanger, which still suffers from the build-up of scale but requires descaling only on a monthly basis.

During the initial stages of plant operation, attempts were made to elute carbon at low temperatures; Table V shows the results obtained in the laboratory. The conditions were a soak for 1 hour with 1 per cent sodium hydroxide and 5 per cent sodium cyanide for carbon that had not been acid treated, and with 2 per cent sodium hydroxide and 5 per cent sodium cyanide for acid-treated carbon. The elution was carried out with 1,5 bed volumes of water per hour.

Electrowinning and Smelting

The original electrowinning circuit at Beisa employed four cells in series, each cell comprising a packed-bed graphite cathode compartment sandwiched between two anode compartments and separated from them by ion-exchange membranes (Fig. 4). An anolyte solution of 10 to 15 per cent sodium hydroxide circulated through the cells while the catholyte deposited gold on the graphite cathode and was then discarded to the gold-leach agitators. Reversal of the polarity of any cell and the passing of a 10 per cent solution of potassium cyanide through the cathode compartment stripped the gold into a very concentrated solution of potassium aurocyanide, from which the gold was electroplated in a separate vessel and then melted in an electric furnace and poured into bars.

Gold was produced from this circuit for two months, but difficulties were experienced in maintaining the flow of catholyte through the cells owing either to physical blockage of the graphite bed by wood fibre or to gas bubbles trapped by interfacial tension between the

TABLE V
LABORATORY ELUTIONS OF LOADED CARBON FROM BEISA AT VARIOUS TEMPERATURES

Elution conditions	Loaded Au, g/t	Stripped elements						
		Au, g/t	Ag, g/t	Ni, g/t	Ca, %	Fe, g/t	Cu, g/t	Si, g/t
Head sample	2258		434	558	1,07	1329	< 30	4820
80°C, not acid-washed	2562	580	37	71	1,02	570	< 20	5000
90°C, not acid-washed	2555	443	< 30	57	1,04	1927	< 30	3866
110°C, not acid-washed	2621	93	< 30	105	1,03	679	< 20	3756
90°C, acid-washed	2130	344	75	43	0,94	554	< 20	4004
110°C, acid-washed	2334	81	< 30	61	0,19	554	< 20	3564

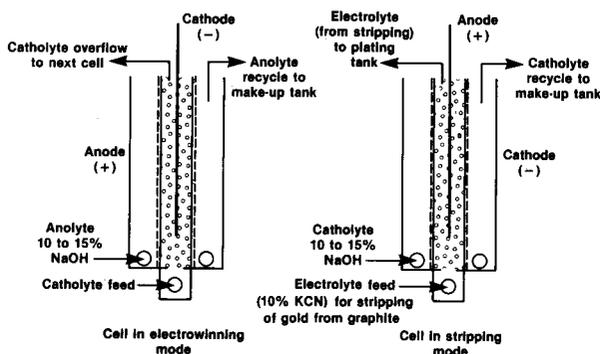


Fig. 4—The initial electrowinning cell at Beisa

graphite particles. It has been reported that the graphite can become passivated³, but during the short time of operation at Beisa no problems were experienced with the chemistry of the system. However, the circuit was not suited to the industrial environment because of its complexity and because of the danger in the make-up and use of strong solutions of potassium cyanide. The ion-exchange membranes had to be imported from the U.S.A., were difficult to energize and fit into the cell, and had a short life owing possibly to wood chips in the catholyte.

A Mintek steel-wool cell (Fig. 5) was obtained in February 1982 for test. Since its installation, very little testwork has been conducted on the cell, and it operated as the main production unit until it was supplanted by an identical cell produced by the mine.

Each batch of solution from elution is circulated through the cell for 12 hours (this amounts to 3 or 4 passes), and catholyte containing approximately 180 g/t gold is stripped to about 9 g/t—an overall efficiency of 95 per cent.

The cell is fabricated from 316 L stainless steel, and is 600 by 600 mm in cross-section by 1000 mm long. It contains six cathodes, each 64 mm thick, 560 mm high, and 560 mm wide, spaced with their centres 146 mm apart. Each cathode holds 500 g of standard-grade 2

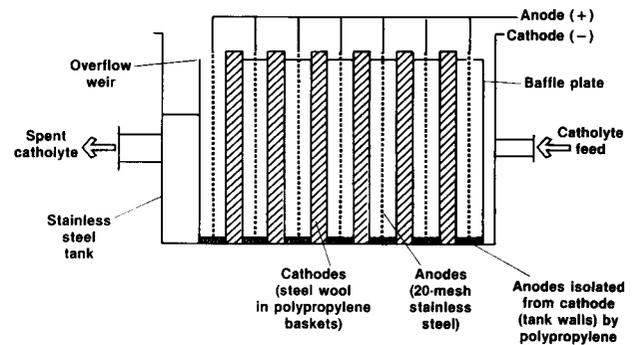


Fig. 5—The Mintek steel-wool cell

steel wool obtainable in 500 g packets costing R2,25 each.

The cell operates at 500 A, 5 V and a throughput of catholyte of 3,5 to 4,0 m³/h. Solution leaving the cell is returned to the catholyte tank and recycled through the cell until it contains less than 10 g/t gold, when it is discarded to the gold leach.

Correct sequencing of the batch elutions and electrowinning is important, particularly when more than one elution is attempted in a day. Situations arose where the catholyte tank was never operated less than 60 per cent full of solution, and high-grade solution from the latest elution was being mixed with low-grade solution from the previous two. So that the number of elutions each day would be maintained, solution of a higher grade than 10 g/t had to be discarded to the gold leach, which led to a high circulation of gold in the circuit. The installation of a second catholyte tank and the future installation of a second electrowinning cell will provide operating flexibility in this circuit.

It is possible for 2 kg of gold to be loaded onto the 0,5 kg of steel wool in each cathode compartment before the cell efficiency drops or the cathode becomes blocked by the gold deposit. The cathodes are removed from the cell when loaded, and are calcined at 700°C for 20 hours. The dry calcine is mixed in the ratios 1 part of calcine to 0,40 part of borax, 0,30 part of sodium carbonate, and

0,25 part of silica, and is then melted at 1300°C.

The gold-melting furnace was designed to melt up to 400 kg of gold per month that was stripped from the titanium cathodes in the electroplating tank. With the change in electrowinning process, the furnace is not large enough. The capacity limits the mass of the bars poured to about 15 kg, and a bar thus produced is returned to the next melt to enable the standard 25 to 30 kg bar to be produced for further refining at the Rand Refinery. The present bar quality is approximately 78 per cent gold and 18 per cent silver.

Regeneration of Carbon

Two regeneration kilns have been installed at Beisa, each capable of handling one batch of eluted carbon per day, regenerating 60 kg of carbon per hour at a temperature of 600 to 700°C.

Eluted carbon is fed at a controlled rate from the eluted-carbon tank through a time-controlled automatic ball-valve into a screw feeder that moves the carbon over a dewatering screen into the electrically heated kiln. Problems were initially encountered with the feed of the carbon owing to pipe blockages caused by wood chips, and with surges of feed to the kiln, and it soon became apparent that the dewatering screen could not handle the amount of free water present and was continually becoming choked with abraded carbon. The installation of the elutriator to remove wood chips from the loaded carbon solved the blockage problem, but the dewatering problem remains.

Four different schemes have been used to dewater the carbon prior to the kiln screw feeder, culminating in a small dewatering vibrating feeder with a wedge-wire deck. This last installation has proved successful in removing free water but suffers blinding of the deck by particles of sand in the loaded carbon. The present feeling is that a dewatering classifier is the best solution^{4,10}.

The measurement of temperature is essential for the control of carbon regeneration. Early installations included temperature measurement of only the heating elements, which proved to be misleading; control of the kiln temperature should be affected by the temperature in the carbon bed. Fig. 6 shows the effect of regeneration temperature on the activity of the regenerated carbon, and the effect of the carbon feed rate on temperatures in the carbon bed, above it, and at the heating elements⁴.

The values for gold in solution reflect the activity of the carbon. In the Mintek test, 1 g of dry carbon is mixed with 400 ml of potassium aurocyanide solution assaying 20 g/t. Gold in solution is measured after a predetermined time—usually every 15 minutes—and the results are compared with those for fresh carbon. The lower the remaining gold in solution, the more active the carbon sample: Beisa requires a gold concentration of 5 g/t in solution after 1 hour, and carbon that produces this result is recorded as having an activity of 5.

For a temperature of 700°C in the carbon bed when the carbon feed to the kiln has not been sufficiently dewatered, the kilns have to be run at their upper limit. This fact, coupled with the drawback that the kilns are designed for continuous operation and are run inter-

Curve	Feed rate of carbon	External gauge °C	In kiln above carbon °C	In carbon feed °C
A	Slow	750	722	681
B	Average	750	640	500
C	Fast	750	472	

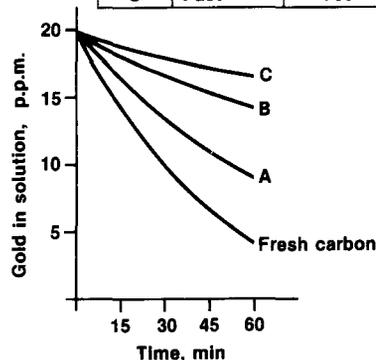


Fig. 6—The regeneration of carbon at various temperatures at Beisa

mittently, has led to mechanical and electrical problems. One set of heating elements has burnt out, one kiln drum has warped, and the other drum has cracked. Beisa will probably order an additional unit that will be specified to run at 900°C on an intermittent basis.

Fine Carbon

Fine carbon is produced in several places in the plant because of the degradation of carbon by attrition in the pulp, in pumps and pipelines, in the elution column, and in the regeneration kilns during carbon conditioning.

Conditioning of the carbon knocks the rough edges off particles of fresh carbon and breaks up weak particles that would otherwise abrade in the adsorption circuit and flow out to the tailings with an associated gold loss. The conditioned carbon is screened at 20 mesh (which is to be changed to 16 mesh); the plus 20-mesh carbon is educted to the fifth adsorption contactor and the fine carbon is pumped to the residue.

Carbon broken down in the adsorption circuit to minus 20 mesh passes through the interstage screens with the pulp and across the 28-mesh safety screens. The oversize material on these screens contains carbon between minus 20 and plus 28 mesh, wood fibre that has passed through the Mintek tank and the adsorption circuit, and occasionally plus 20-mesh carbon, which indicates a hole in the carbon-retention screens of the fifth-stage contactor.

The two Derrick screens used as safety screens suffered disadvantages identical to those of the screens that were used for the removal of wood chips: low screen-cloth life, and thus low screen availability and high maintenance costs, and the failure to produce a clean product for further treatment. A large polyurethane screen with 0,5 by 12,0 mm slots was installed recently on this application, and the results are encouraging: the production of fine carbon, wood chips, and sand is about 100 kg per day assaying 175 g/t of gold. This material can be calcined (which increases the assay to over

2000 g/t of gold) and smelted, but there are indications that the quantity produced cannot be handled in the single calcining furnace installed at Beisa.

Before acid treatment, the regenerated carbon is sized on a 20-mesh screen (soon to be changed to 16 mesh). Originally, a pressure filter was installed to filter the fine carbon produced from this screen, and the filter cake was to be calcined and smelted. During operation, the filter blinded quickly (after approximately 30 minutes) with a 5 mm tar-like deposit of very fine carbon, and had to be stripped and cleaned. The resulting downtime caused delays in the elution of carbon, and the filter was finally removed from the circuit. The fine carbon was estimated to amount to 30 kg per elution, or 60 kg per day, and was estimated to assay the same as eluted carbon, i.e. less than 100 g/t. The gold losses were thus minimal but varied with the elution efficiency, and an attempt was made to settle out the coarser particles of carbon before the remaining carbon and solution were pumped to the residue.

Since the commissioning of the new tailings safety screen, fine carbon from the elution and regeneration steps has been screened with the residue pulp, and the carbon has been treated with that from the adsorption circuit.

Conclusion

In the eighteen months since start-up, the CIP plant at Beisa has suffered diverse problems, most of which have been solved satisfactorily. The removal of wood chips, poor interstage screening, and a complex electro-winning circuit were difficulties that reduced the tonnage throughput or gold output and thus warranted the most attention. Several problems that affect the plant residues or ease of operations have not been finally resolved (e.g. mechanical agitation and the handling of fine carbon), and work is continuing in those directions.

Within the next year it is expected that the Beisa CIP plant will be operating below the design operating cost and residue values.

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References

1. LAXEN, P. A., BECKER, G. S. M., and RUBIN, R. Developments in the application of carbon-in-pulp to the recovery of gold from South African ores. *J. S. Afr. Inst. Min. Metall.*, vol. 79, no. 11. 1979. pp. 315-326.
2. ANON. Western Areas CIP plant—tomorrow's recovery today. *Coal, Gold Base Miner.*, Apr. 1981. pp. 45-59.
3. LAXEN, P. A., FLEMING, C. A., HOLTUM, D. A., and RUBIN, R. A review of pilot-plant testwork conducted on the carbon-in-pulp process for the recovery of gold. *Proceedings 12th CMMI Congress*. Glen, H. W. (Editor). Johannesburg, The South African Institute of Mining and Metallurgy, 1982. pp. 551-561.
4. LAXEN, P. A. Carbon-in-pulp in South Africa. Seminar on CIP Technology for Extraction of Gold. Australasian Institute of Mining and Metallurgy, Kalgoorlie, Jul. 1982.
5. DODS, D., MORRIS, A. N., and KENNEDY, A. P. Gencor. Private communication.
6. VOLK, F., HOLTUM, D. A., and STINTON, C. Gencor. Private communication.
7. HARVEY, B. Montan Chemicals, Wadeville. Private communication.
8. DAVIDSON, R. J., and DUNCANSON, D. The elution of gold from activated carbon using deionized water. *J. S. Afr. Inst. Min. Metall.*, vol. 77, no. 12. 1977. pp. 254-261.
9. MENNE, D. Optimization of full-scale circuits for the carbon-in-pulp recovery of gold. *Proceedings 12th CMMI Congress*. Glen, H. W. (Editor). Johannesburg, The South African Institute of Mining and Metallurgy, 1982. pp. 569-574.
10. BAILEY, P. R. Gencor, Springs. Private communication.

Plastics

An international conference, 'Plastics 2001 — a look at the future', is to be held in Pretoria from 26th to 28th September, 1984. The organizers are the Plastics Institute of Southern Africa (PISA), Transvaal Branch, and the National Building Research Institute (NBRI) of the Council for Scientific and Industrial Research (CSIR) with the assistance of the Symposium Secretariat of the CSIR.

The primary objective of this Conference is to assemble an international forum of scientists, engineers, technologists, and managers to discuss current and future developments in the field of plastics. This gathering of expertise and technology from abroad will be of benefit

to the local industry and the future of the plastics industry in general.

In the light of future needs and difficulties, the following topics have been selected:

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