The design, commissioning, and performance of the NIMCIX section of the Chemwes uranium plant

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SYNOPSIS

The Chemwes uranium plant treats old gold-plant residues from the Stilfontein and Buffelsfontein Gold Mines by acid leaching, belt filtration, countercurrent ion exchange (CIX), and Bufflex solvent extraction (SX). The uranium is recovered by precipitation as ammonium diuranate.

Absorption and elution in the CIX section are achieved in four NIMCIX columns operating as two parallel streams. Each loading column is 4,85 m in diameter and contains 12 absorption stages. The elution columns are 3 m in diameter and contain 8 stages. The eluant used is 10 per cent sulphuric acid at ambient temperature.

During the commissioning and initial operating periods reported here, the plant yielded an average barren solution of 1,6 p.p.m. of U_3O_8 from a feed with a mean U_3O_8 concentration of 132 p.p.m. The U_3O_8 concentrations in the barren solution were better than 2 p.p.m. some 85 per cent of the time, and better than 1 p.p.m. 73 per cent of the time.

Investigations are underway to institute an automatic control system that will result in the U_3O_8 values on the resin and in the barren solution being maintained at or near the target values in spite of changes in the concentration of uranium in the feed solution.

SAMEVATTING

Die Chemwes-uraanaanleg behandel ou goudaanlegresidu's van die Stilfontein- en Buffelsfontein-goudmyn deur suurloging, bandfiltrasie, teenstroomioonruiling (CIX) en Bufflex-oplosmiddelekstraksie (SX). Die uraan word deur presipitasie as ammoniumdiuranaat herwin.

Absorpsie en eluering in die CIX-seksie geskied in vier NIMCIX-kolomme wat as twee parallele strome werk. Elke laaikolom het 'n diameter van 4,85 m en bevat 12 absorpsietrappe. Die elueerkolomme het 'n diameter van 3 m en bevat 8 trappe. Die eluant wat gebruik word, is 10-persent-swawelsuur by omgewingstemperatuur.

Gedurende die inbedryfstelling en beginwerkperiodes waaroor daar hier verslag gedoen word, het die aanleg 'n gemiddelde gestroopte oplossing van 1,6 d.p.m. U_3O_8 gelewer van 'n toevoer met 'n gemiddelde U_3O_8-konsentrasie van 132 d.p.m. Die U_3O_8-konsentrasie in die gestroopte oplossing was ongeveer 85 persent van die tyd beter as 2 d.p.m. en 73 persent van die tyd beter as 1 d.p.m.

Daar is ondersoeke aan die gang om 'n outomatiese beheerstelsel in te voer wat sal meebring dat die U_3O_8-waarde op die hars en in die gestroopte oplossing op of naby die teikenwaardes gehou word ten spyte van veranderinge in die uraankonsentrasie in die toevoeroplossing.

Introduction

Chemwes Limited produces uranium from the accumulated gold residues of Stilfontein and Buffelsfontein Gold Mines, which are operated by General Mining Union Corporation Limited in the Klerksdorp district.

Stilfontein was one of the first mines to be awarded a uranium production quota. Uranium production commenced in October 1953 and was terminated in 1961, when its production quota was sold. The mine's uranium bearing slime was stockpiled from early in 1961.

Buffelsfontein started producing from mid 1956. In the earlier years the capacity of the uranium plant was less than that of the gold plant, and the excess gold residue was stockpiled.

An investigation was initiated in 1974 into the feasibility of producing uranium in a modern extraction plant from these accumulated slimes. Based on initial laboratory and pilot-plant testwork, a pre-feasibility study was completed in April 1976. Further, more-detailed, market and technical evaluations followed, and extensive laboratory testwork and a large number of process optimization studies were conducted. As the preliminary feasibility report (February 1977) and the final feasibility report (January 1978) were both favourable, it was decided to proceed with the construction of the plant.

The flowsheet finally selected consists of bucket-wheel reclamation of Stilfontein slime, water monitoring of Buffelsfontein slime, conventional acid leaching in flat-bottomed pachucas, liquid–solid separation by belt filtration, countercurrent ion exchange (CIX), Bufflex solvent extraction (SX), precipitation of ammonium diuranate, recovery of pyrite by flotation, disposal of tailings, production of sulphuric acid from pyrite concentrate, and recovery of gold from the resulting calcine.

Edward L. Bateman Limited was awarded the contract for project management during January 1978, and engineering started during March 1978.

After a design and construction period of fifteen months, hot commissioning commenced in June 1979. Four months later the plant was operating at the design capacity of 270 000 t per month.

The Chemwes Flowsheet

A general layout of the Chemwes flowsheet is given in Fig. 1. The unit operations shown on the flowsheet are conventional with the exception of belt filtration and CIX. The type of CIX system selected was the NIMCIX system developed by the National Institute for Metal-

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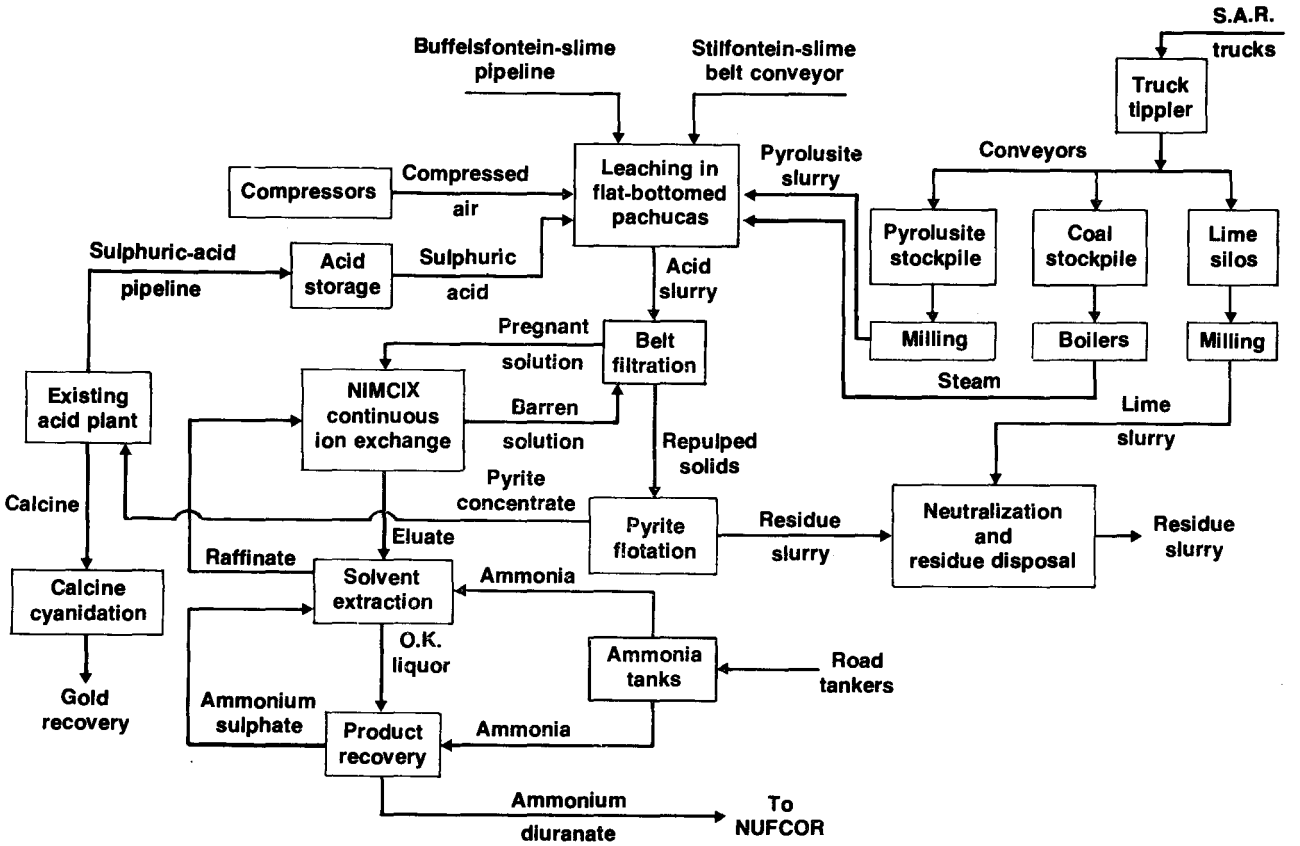


Fig. 1—The flowsheet at Chemwes uranium plant

lurgy, now the Council for Mineral Technology (Mintek).

Slimes are reclaimed from the Stilfontein dams by bucket-wheel excavation and a conveyor system to the plant. High-pressure water monitoring is used to reclaim the Buffelsfontein dam, the slurry being pumped to the plant. The slimes and the slurry are repulped at an approximate relative density of 1,58 before being fed to the leaching pachucas.

Conventional acid leaching at 65°C is employed. Pulp is fed continuously into the number 1 pachuca, where 25 kg/t of sulphuric acid and pyrolusite slurry equivalent to 4 kg/t of 100 per cent manganese dioxide are added and the temperature elevated with steam. From here the acidified pulp flows into one of the remaining pachucas, which are operated individually on a batch basis. This ensures 100 per cent utilization of pachuca volume and an accurately determined leaching period. Provision is made for the addition of further acid, steam, and pyrolusite if necessary.

After a 24 h leach, the slurry, which contains about 5 g/l of residual acid, is pumped to the filter plant. Nine belt filters of Gaudfrin–Elgin design are used for solid–liquid separation, each filter consisting of two separate 45 m^2 belts mounted on the same drive rollers. A single wash is employed, and there are facilities for the utilization of barren solution or acidified fresh water for this purpose. Guar-gum flocculant is added at the rate of 100 g/t.

Pregnant liquor from the filters is pumped into a storage tank of 22 m diameter through Dutch State Mines (DSM) screens. This tank was designed both as a settler for coarse particles and as an 8 hour holding tank for feedstock to the NIMCIX columns. A light rake is employed for dragging sediments to the centre of the tank, and the underflow is pumped back to the filters periodically.

Feed to the twin NIMCIX absorption columns is removed about 2 m from the bottom of the storage tank, each absorption column being able to treat 6500 m^3 of feed per day. Barren solution gravitates through DSM screens, which remove any entrained resin into a storage tank of 22 m diameter, which is also equipped with a rake. Barren solution is neutralized with lime and pumped to an evaporation dam. Once the Buffelsfontein slime has been depleted, the recycling of barren solution to the repulping plant starts.

Loaded resin from the absorption columns is transferred in batches to the twin NIMCIX elution columns, where the resin is eluted with 10 per cent sulphuric acid at ambient temperature. The concentrated eluate proceeds through a DSM screen to a storage tank on the solvent-extraction plant, and eluted resin is returned to the loading column.

The SX plant consists of five extraction, three water-scrubbing, four stripping, and one regeneration stages. The solvent used in Alamine 336 dissolved as a 5 per cent solution is illuminating kerosene with 2 per cent isodecanol added. Raffinate from the extraction section returns to the CIX section, where it is again made up to strength and is re-used as eluant. A bleed facility is

provided for the return of excess raffinate to the leaching plant.

Scrubbed solvent is stripped with ammonium sulphate and ammonia. Uranium is recovered from the OK liquor by its precipitation as ammonium diuranate. The precipitate is thickened before being washed in two stages of rotary-drum filtration, and the final product is despatched to NUFCOR's treatment plant, where it is filtered, dried, and calcined.

Filter cake from the belt filters is repulped with solution from the belt and cloth sprays, and this slurry is pumped to the flotation plant for the recovery of pyrite. Tailings from the flotation plant are neutralized with lime before being routed to the new tailings dam.

Pyrite is burnt in the existing sulphuric acid plant at Stilfontein, which in return supplies Chemwes with acid. Gold is recovered from the calcine at the Stilfontein Gold Mining Company's reduction plant.

Bulk reagents (lime, coal, and pyrolusite) are delivered by rail, the rail cars being unloaded with a tippler. A conveyor system delivers them to their respective stockpiles.

The NIMCIX Section

The development, construction, and operation of NIMCIX columns has been described elsewhere[1-5]. NIMCIX columns were chosen for the recovery of uranium at Chemwes on the recommendation of the Extraction Metallurgy Division of the Atomic Energy Board and taking into consideration the following:

(1) for the Chemwes parameters, a CIX–SX route has economic advantages;
(2) the NIMCIX technology is available locally; and
(3) none of the other CIX systems considered had any large advantage as to capital cost.

Contractual obligations regarding the delivery of uranium made it imperative that the production at Chemwes should proceed without hitches, and a conservative design philosophy was therefore adopted.

It was decided that the pregnant solution would be treated in two separate but identical streams, partly because this would make for flexibility of operation, and partly because difficulties were envisaged in the construction of the column, 6,86 m in diameter, that would be required for the treatment of the feed in a single stream. The construction and operation of such a large column would have been without precedent.

The flexibility afforded by the twin-stream route was invaluable during the commissioning, when, because the supply of feeds was limited, alterations could be made to one set of columns at a time without any adverse effect on productivity. The NIMCIX flowsheet for a single stream is illustrated in Fig. 2.

The parameters of the loading and elution columns are given in Table I. Each stage in each column is 1 m high, and is equipped with a sight glass so that the resin content and fluidization can be observed. Each column is flared at the top into a 90° cone to ensure the disengagement of the resin from the liquid stream. This is particularly important during the resin-transfer periods.

The designed operating cycle of the loading columns gives an on-line period of 91 per cent of the total time.

TABLE I

PARAMETERS OF THE LOADING AND ELUTION COLUMNS

Parameter	Loading column	Elution column
Number of stages	12	8
Column diameter, m	4,85	3
Flare diameter, m	6,86	6
Resin volume per stage, m^3	9,24	4,95
Resin volume transferred per cycle, m^3	6,3	2,1
Total resin inventory, m^3	111	40
Forward-flow period, min	126	34
Settling period, min	2	2
Reverse-flow period, min	5	5
Cone-flush period, min	5	5
Rapid-refill period, min	Not required	4
Total stage volume, m^3	18,47	7,07

In practice, however, this period is adjusted to suit the uranium concentration of the feed. The columns were designed to lower the concentration of U_3O_8 to below 2 p.p.m. in the barren solution, coupled with a U_3O_8 concentration on the loaded resin of 25 g/l.

The nominal operating cycle of the elution columns, as designed, gives an on-line period of 68 per cent of the total time. In practice, so that the balance of the resin inventory can be maintained between the loading and the elution columns, long and short forward-flow periods are used. The short forward-flow period is selected when the elution column is over-full with resin, and the long period when it is depleted. These time periods are altered as required in proportion to the forward-flow period that has been selected for the appropriate loading column.

The elution columns were designed to give a residual U_3O_8 concentration on the eluted resin of less than 1 g/l, coupled with a U_3O_8 concentration in the eluate of between 3,6 g/l and 4,7 g/l. This corresponds to maximum and minimum eluant flowrates of 18,7 m^3/h and 14,3 m^3/h respectively.

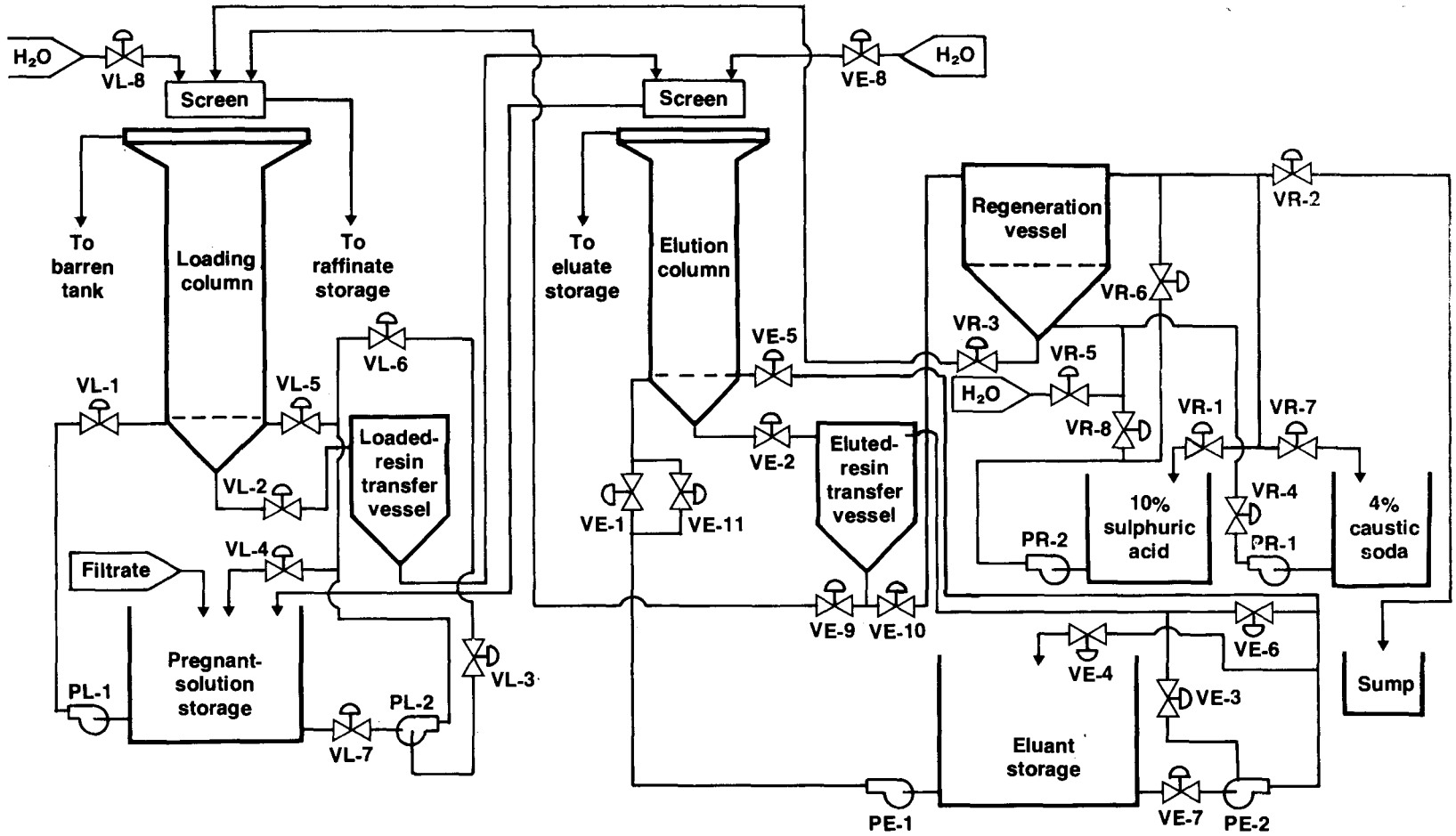
Both columns are constructed of fibre-reinforced plastic (FRP). The PVC trays of the elution column are held in place by PVC bolts on one stream and stainless-steel straps on the other, and those of the loading column by 316L stainless-steel bolts. All the piping is of 316L stainless steel.

The resin used is Duolite A101DU (plus 420 μm minus 840 μm), which is manufactured by Diaprosim, France.

The transfer of resin is effected by means of 316L stainless-steel transfer vessels in the normal way. The transfer resin is screened over 250 μm Sweco screens equipped with wash sprays before it is added, through a still well, into the top of the receiving column. This screening is needed when transfer is made to the elution column to prevent dilution of the eluate and contamination of the eluate with suspended solids.

During transfer to the loading column, the screening and washing

(a) prevent a lowering of the pH value of the barren solution, which could cause an increase in the competitive bisulphate ion concentration, and hence a high concentration of U_3O_8 in the barren solution,
(b) facilitate the recovery of the sulphuric acid from



Valve sequencing

	Loading column				Elution column				
Forward flow	VL-1	PL-1	–	–	VE-1	PE-1	–	–	–
Settle period	–	–	–	–	–	–	–	–	–
Reverse flow	VL-2	VL-3	VL-4	PL-2	VE-2	VE-3	VE-4	PE-2	–
Cone flush	VL-2	VL-3	VL-5	PL-2	VE-2	VE-3	VE-5	PE-2	–
Resin transfer	VL-6	VL-7	VE-8	PL-2	VE-6	VE-7	VL-8	VE-9	PL-2
Rapid refill	–	–	–		VE-11	PE-1	–	–	–

	Regeneration				
Resin transfer to loading	VR-3	VR-6	VL-8	PR-2	–
Resin transfer from elution	VR-1	VE-6	VE-7	VE-10	PE-2
Acid displacement	VR-1	VR-5	–	–	–
Caustic feed	VR-2	VR-4	PR-1	–	–
Caustic circulation	VR-4	VR-7	PR-1	–	–
Caustic displacement	VR-5	VR-7	–	–	–
Resin wash	VR-2	VR-5	–	–	–
Sulphation	VR-2	VR-8	PR-2	–	–

Fig. 2—The NIMCIX flowsheet at Chemwes uranium plant

the carrier eluant for return to the leach,

(c) avoid excessive bleeding of acid into the barren solution, which would result in an increase in the consumption of lime for the neutralization of excess barren solution,

(d) avoid high uranium values in the barren solution if there is a failure in the solvent-extraction section, and so prevent the passing of a high-uranium eluant direct into the NIMCIX barren stream.

All the exit points for the solutions from the NIMCIX columns are provided with 250 μm DSM screens and resin traps to minimize resin losses.

The fouling of anion-exchange resins by silica, a problem experienced with all Witwatersrand acid-leach liquors, necessitated the inclusion of a facility for the regeneration of resin by a 4 per cent caustic soda solution. The fraction of resin reporting to the regeneration vessel is adjusted so that an average silica loading on the resin of less than 2 per cent is maintained. Facilities are also provided for a manual-demand override that allows an additional regeneration cycle to be initiated on demand.

The regeneration vessels, one for each stream, are equipped with a bubble-cap tray that allows the fluidization of the resin on upflow. The resin is washed with water, followed by 4 per cent caustic soda regeneration, a water wash, and resulphation with 4 per cent sulphuric acid. The sulphated resin is available for transfer back to the loading column. Separate storage tanks for the regeneration acid and caustic soda are supplied for each stream. The caustic soda is made up manually, and acid is bled from the eluant storage to the regeneration section as required.

The resin supplied by the manufacturers is in the chloride form. The corrosion of stainless steel in chloride environments necessitates the sulphation of this resin in a separate sulphation vessel, which is a rubber-lined, open-topped, cylindrical tank fitted with a bubble-cap tray for resin fluidization. A 20 m^3 batch of fresh resin is placed in the tank and then fluidized with 10 per cent sulphuric acid until the chloride level in the effluent is less than 500 p.p.m. Sulphated resin is transferred to the regeneration vessel for stream number one, from where it can be transferred to either loading column.

The control equipment can be operated in any one of three modes.

In the automatic mode, process control is fully computerized (the cycle times can be altered by the section foreman). A mimic board displays the status of each column and of all the valves and pumps. Alarms are sounded if an error condition occurs.

The semi-automatic mode enables the operator to order the sequence of events. However, the correct valve and pump operations for each event are still coordinated by computer. Reverse-flow and rapid-refill operations are the only operations still terminated automatically.

An interlock system prevents undesirable operations in both the semi-automatic and the automatic mode.

Manual operation requires the operator to operate all the valves and pumps individually by means of switches on the control panel. There are no safety interlocks in this mode.

The mode of operation of each regeneration section can, subject to certain restrictions, be altered independently of the status of the corresponding NIMCIX columns. This enables, for example, a semi-automatic or manual regeneration to be carried out while the columns themselves are under automatic control.

Metallurgical Design of the NIMCIX Section

The metallurgical design of the Chemwes NIMCIX columns[5] was based on the procedure described by Wright[6]. The design involved laboratory testwork but did not necessitate recourse to pilot-plant studies because of the similarity between the feed to the Blyvooruitzicht demonstration plant[3], on which Wright's model was based, and the Chemwes feed solution.

Three sets of data were required for the design of the loading column.

(i) Physical operating characteristics of the columns, including the durations of various cycles and the fluidization and resin-transfer characteristics. These were all obtained from earlier design work, and from the demonstration plant.

(ii) Characteristics of the resin-loading rate with respect to the expected feed. These were determined in the laboratory by the contacting of used resin with a representative sample of feed. The use of used resin is essential for such tests so that the results are not distorted as they would be by the misleadingly better performance of new resin. The concentration of competing ions in the feed sample used and its pH value must compare with those of the expected plant feed.

(iii) The equilibrium loading characteristics of the resin. These were determined by the contacting of used resin with the feed sample spiked to various concentrations with uranyl sulphate.

The calculations based on these data were carried out in a way analogous to that described by McCabe and Thiele[7]. The McCabe–Thiele method was modified to include stage-efficiency calculations based on laboratory data.

Profiles of the uranium concentrations on resin and in solution, which were predicted from the design calculations for the Chemwes plant, are given in Table II.

TABLE II

CALCULATED PROFILES OF THE LOADING COLUMN

Stage no.	U_3O_8 solution g/l	U_3O_8 resin g/l
Barren	0,0020	1,00
2	0,0023	1,08
3	0,0026	1,13
4	0,0032	1,22
5	0,0040	1,38
6	0,0054	1,69
7	0,0080	2,31
8	0,0136	3,93
9	0,0279	7,66
10	0,0608	17,28
11	0,1458	28,11
Feed	0,2415	

As can be seen from Table II, 4 of the 11 stages are required for the reduction of the uranium concentration in the barren solution from 3 to 2 p.p.m. This number of stages is economically justified by the additional uranium recovered.

The plant incorporates a 12-stage loading column in accordance with the conservative design philosophy, and to cater for possible variations in the feed.

The design of the elution column was based on experience, which showed that a residence time of 15 h would ensure that the residual loading of U_3O_8 on the eluted resin is less than 1 g/l. The column inventory and size were therefore decided on this basis.

For the plant to operate at design capacity, it was essential that the resin selected should perform at least as well as the resin used in the tests. This illustrates the critical importance of resin specification and the need for the development of appropriate test procedures. The invitations for tenders for the supply of resins to Chemwes all included specifications for the resins and descriptions of the tests necessary for ensuring conformity with these specifications. The specifications covered the size distribution and density of the resin beads, their attrition and osmotic-shock performance and equilibrium loading, and the kinetic characteristics of elution and loading. Before any tests were carried out, the resins were preconditioned according to a prescribed procedure[8].

Representative samples of all the batches of resin were tested by the manufacturer and by Chemwes before the resin was sent to the site.

Commissioning

The Extraction Metallurgy Division of the Atomic Energy Board provided consulting services for the commissioning of the NIMCIX plant.

To gain experience in the operation of NIMCIX by Chemwes personnel, it was decided to phase the construction of the plant so that the NIMCIX and SX sections would be completed first. This would make it possible for these sections to be 'cold commissioned' and for the operators to gain experience before the rest of the plant came on-line.

The cold commissioning of the NIMCIX section began during mid April 1979. Initially, the columns were merely tested for leaks and correct operation. Resin sulphation commenced in May, and by 16th June both columns were running automatically on resin and water.

Because of the twin-stream nature of the plant, at no time during the commissioning was production inhibited because of a failure of the NIMCIX section or because it required alterations.

The first task in the commissioning was the trimming of the reverse-flow probes to a length that would ensure the transfer of the correct volumes of resin. At the same time, the rapid-refill probes on the elution columns were trimmed to the correct length.

All the flowrates were checked. When necessary, setpoints were altered to give the correct flowrates. All the flowmeters were later recalibrated.

The cycle times were optimized. Orifices were installed on the reverse-flow lines of both the elution and the loading columns to throttle the reverse flowrate. (Too rapid a reverse flowrate on NIMCIX columns tends to deplete the bottom stage of resin.) The rapid-refill period on the elution columns was adjusted to give the required 70 per cent resin inventory per stage. Settling and cone-flush periods were cut to the minimum, and resin transfers were timed and the timers set accordingly.

Finally, the ultrasonic resin-level probes on the top of each elution column were adjusted to the correct height to allow proper control of the resin inventory balance between the loading and the elution columns.

Various problems that were encountered during the commissioning were corrected as they came to light. The following were the main problems.

(1) The still wells in both the elution columns were too short and allowed the resin to overflow the weirs during the resin transfer. The wells were lengthened and the problem solved.

(2) Because the top stage of the elution column was only 1,5 m high, the control of the resin level had to be done in the conical section of the column. As this was unsatisfactory, the top-stage tray in each elution column was removed. This gave a top-stage height of 2,5 m, and the resin level could now be controlled in the vertical section of the column.

(3) Initially, the elution columns were fitted with 316L stainless-steel U-bolts to retain the PVC trays. Their early failure required their replacement with PVC bolts on one stream and stainless-steel straps on the other. The reason for the failure of these bolts is not clear, and not all the bolts showed signs of corrosion. The bolts conformed to 316L specifications on analysis. It is thought that incorrect annealing after their manufacture may have caused this failure.

(4) Instrumentation was a problem area. A number of instruments including ultrasonic probes and limit switches on valves had to be adjusted or replaced.

(5) The line for concentrated sulphuric acid was lagged to prevent freezing on cold nights.

Performance to Date

The results reported in Fig. 3 cover the period July 1979 to July 1981, and include the commissioning and initial operating periods. All the results obtained were included in the statistical analysis. These results include the following.

(a) The results obtained during the commissioning period, when the performance was subject to teething and operating problems.

(b) The results obtained during the initial operating period. As mentioned previously, the initial performance of any ion-exchange resin is good, and it is therefore not unreasonable to expect a newly commissioned ion-exchange plant to perform better than its design specifications.

(c) High uranium concentrations during the initial period due to the inexperience of the operators in the operation of this new type of plant, which resulted in operational mishaps in the SX and NIMCIX sections that caused short periods of poor performance.

(d) Unexplained high uranium concentrations in the

barren solution and eluted resin. A high proportion of the poor results for eluted resin and barren solution occurred during the first five months of operation. However, poor results have occurred since this period. The results were included, although the validity of these single 'jumps' is highly doubtful because of the long response time of the columns and the normality of all the other conditions. It is thought that these sudden jumps may on occasion be due to sample contamination either on the plant or in the assay laboratory, or even incorrect assays or reporting of results.

(c) High uranium concentrations in the barren solution and eluted resin due to the emptying of an elution column for repairs or inspection. This operation was carried out more frequently than was initially thought necessary. Generally, this did not hinder the plant operation seriously as the loading columns were kept on stream. The main cause of the poor results under these circumstances was that poorly eluted resin was transferred to the loading column. The poor assay results could have been avoided if the resin had been dropped within the bunded area, but this would have created additional problems in the recovery of the resin. An additional vessel to store the resin from the elution column would have been a useful addition to the design.

The histograms shown in Fig. 3 highlight the fact that the plant is well capable of running within its design specifications. The concentration of U_3O_8 in the barren solution was lower than 2 p.p.m. for 85 per cent of the time, and lower than 1 p.p.m. for 73 per cent of the time. The average concentration of U_3O_8 in the barren solution over the period was 1,6 p.p.m.

The performance of the elution column during this period was well within design specification. The concentration of U_3O_8 on the eluted resin was less than the designed 1 g/l for 93 per cent of the time. The amount of U_3O_8 in the eluate was less than 3,5 g/l for 38 per cent of the time, and was greater than 5 g/l for 12 per cent of the time.

Plans and Problem Areas

Some problems are being experienced with the materials of construction.

Serious corrosion problems have been experienced in the regeneration vessels, in that vessel welds have parted and wedge-wire screens have failed catastrophically. An unproven theory is that the high chlorides in the caustic regeneration solution have become loaded on the resin and have been eluted during sulphation with 10 per cent sulphuric acid; the resultant high-chloride acid solution then attacks the stainless steel. The problem is being approached from two angles.

(i) Substantial repairs are being made to the tank, involving rewelding of all the vessel welds, fabrication of a wedge-wire screen in a more corrosion-resistant steel, sandblasting of the inside of the vessel and coating with 3 mm of specially cured rubber, and fabrication of a new 30 mm fibreglass plate for the bubble caps.

(ii) A 4 per cent sulphuric acid solution is now being used for sulphation.

Fairly frequent emptying of the elution columns has been necessitated by the following.

(i) Cracking of the PVC stage plates, requiring repairs, bracing, and in some cases replacement.

(ii) Buckling of bubble caps and the bottom stage as the result of one incident in which hot fresh eluate of over 20 per cent sulphuric acid was made up and passed through a column. Stoppages were made so that bubble caps could be replaced and the condition of the plates could be checked. (Stainless steel support braces made from 316 angle iron, fitted after the mishap, were later found to have entirely corroded away.)

(iii) Poor resin distribution, particularly in the upper stages, owing to the blocking of plate holes by tramp material in the resin (wire, plastic, beetles, cigarette ends). The tramp material is believed to have found its way via the resin spillage sump into the elution column since debris on the floor of the CIX area hosed into the resin spillage sump. A modification is planned to screen tramp material from the resin before it is discharged into the elution column since the present screening system retains all the tramp material in the resin that is larger than the resin beads.

The initial corrosion failure of U-bolts occurred on only one elution column, and these were subsequently replaced with PVC bolts. The U-bolts on the other column also showed some signs of corrosion, and these were replaced with 316L stainless-steel straps. The PVC bolts have now become brittle and are breaking at the threads, but the stainless-steel straps in the other column are in good condition. This is not a just reflection of the relative merits of stainless-steel and PVC because it was the column with the PVC bolts that was subjected to the high acid concentration and temperatures referred to above.

Resin losses have been of the order of 3 m^3 per month. There is no evidence that there has been any breakage of resin in the process, and it is believed that the main losses occur during the emptying of columns or other failures that necessitate the deposition of resin on the floors and in the drains and sumps within the bunded areas. Physical losses and breakage have resulted from personnel walking through the area, but the most significant source of loss is believed to be an overflow of resin over the resin traps, the resin then being pumped to the pregnant-solution tank.

The flowrates of pregnant solution per column have averaged 300 m^3/h, but periods of 380 m^3/h have been handled satisfactorily by the system, Some resin carry-over is experienced at these higher flowrates, but the screening system on the barren solution prevents significant losses of resin.

The overall running time of the ion-exchange circuit has averaged 89,4 per cent. Included in this figure are the shorter running times during the commissioning period when lower tonnages were being treated. This figure reflects the availability of the loading stream

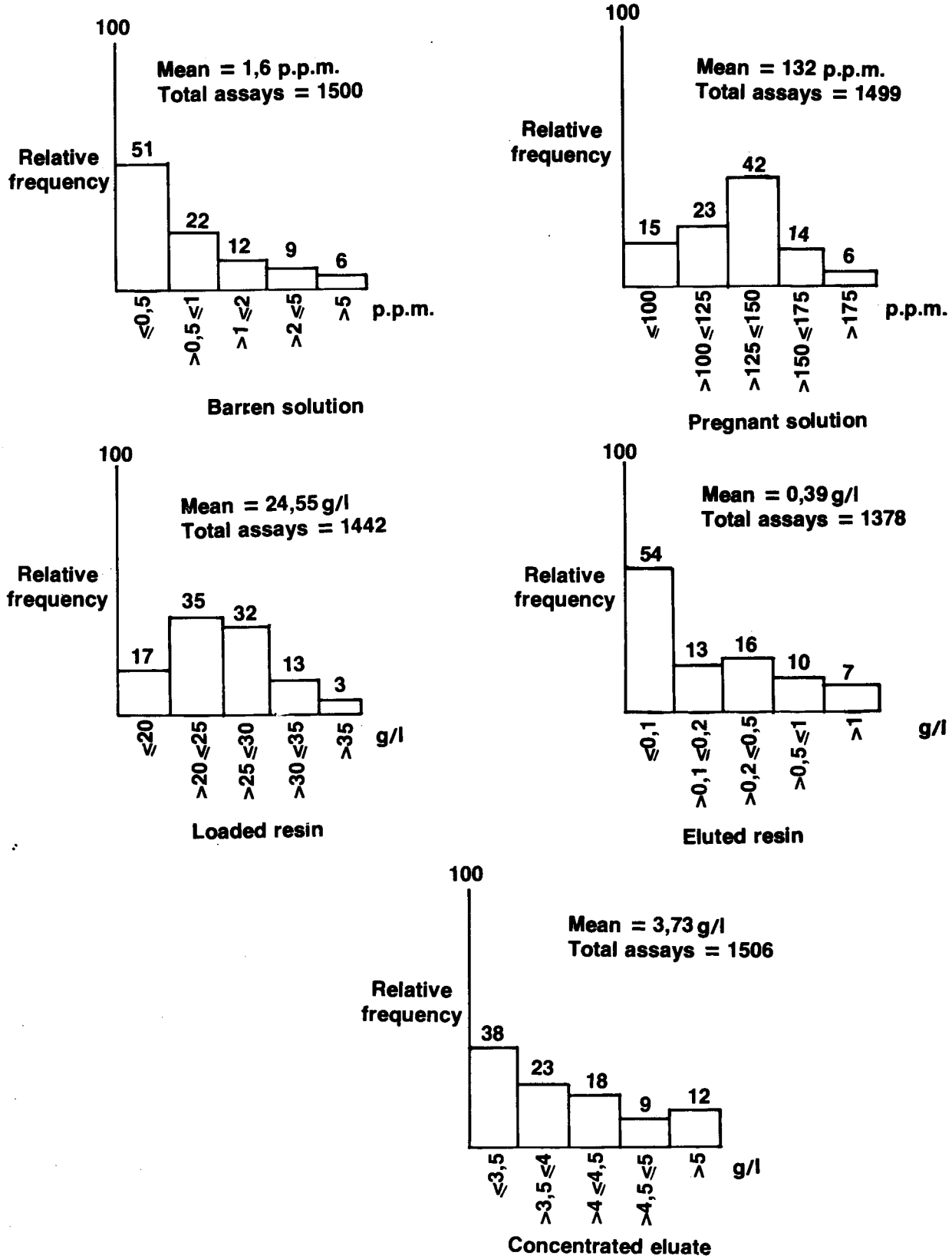


Fig. 3—A summary of the performance of the NIMCIX plant during commissioning and the initial operating period (July 1979 to July 1981)

since, during periods when the elution columns were off-line, loading was maintained, although at lower flow-rates. During 1981 the running time averaged over 99 per cent.

At Chemwes, only very small quantities of anionic cobalt are present in the feed. A close watch is kept on the levels of anionic cobalt to prevent possible 'poisoning' of the resin by cobaltic cyano-complexes. These complexes are present in all the old dumps containing residues from gold-recovery plants in South Africa, the predominant complex having been identified as the hexa-cyano complex[9]. This complex does not polymerize in the resin bead as does the penta-cyano-mono-aquo complex, but it is so strongly held on a strong-base resin that it is not removed at all by normal elution, and only very slightly by caustic regeneration. Thus, over a period of time, the number of sites occupied by the complex increases, and the resin's loading capacity is consequently reduced.

At present, although the NIMCIX columns are automatic in their operation, it is up to the section foreman to alter the forward-flow cycles to correct for varying feed concentrations. The automation of such a process, although not essential, would eliminate delays and operator errors. Two approaches to the problem can be adopted: either the resin phase or the liquid phase can be monitored. Monitoring of the resin phase is the simpler since uranium concentrations in this phase are about 300 to 1000 times higher than in the liquid phase. However, this method has the disadvantage that no direct measure of the concentration of the barren solution is obtained.

Conclusions

The NIMCIX section at Chemwes has proved that it can operate well within its design limits. The operation to date has been satisfactory, and will probably improve as more experience is gained. The automation of the forward-flow periods in the operation of the NIMCIX section is under investigation.

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Applied statistics

The Institute for Industrial Engineering of the University of Stellenbosch, in conjunction with the Department of Statistics of the University, has arranged a two-day course in the application of basic business statistics to be held at Stellenbosch on 27th and 28th September, 1982.

The course is aimed at people with no formal education in statistics who are involved with the processing of data. It is practically oriented and will be presented so that delegates of limited mathematical background will find it easy to follow.

The course will be presented in Afrikaans but bilingual discussion is envisaged.

Further information can be obtained from Miss Helna Maree, Institute for Industrial Engineering, University of Stellenbosch, 7600. Telephone: (02231) 77234.

Toegepaste statistiek

Die Instituut vir Bedryfsingenieurswese van die Universiteit van Stellenbosch bied in samewerking met die Departement Statistiek van die Universiteit 'n tweedaagse kursus in die toepassing van basiese handelstatistiek in Stellenbosch op 27 en 28 September 1982 aan.

Die kursus is gemik op persone wat betrokke is by die verwerking van data, maar wat geen formele onderrig ontvang het in die vakwetenskap Statistiek nie. Dit is baie prakties georiënteerd en word aangebied sodat kursusgangers met beperkte wiskundige agtergrond alles kan volg en verstaan.

Verdere inligting kan verkry word vanaf mej. Helna Maree, Instituut vir Bedryfsingenieurswese, Universiteit, Stellenbosch, 7600. Telefoon: (02231) 77234.