J. S. Afr. Inst. Min. Metall., vol. 92, no. 3.
Mar. 1992. pp. 65–69

Membrane desalination of service water from gold mines

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SYNOPSIS

The Chamber of Mines Research Organization has been evaluating three membrane-desalination processes for use within the South African mining industry. These processes are electrodialysis reversal (EDR), tubular reverse osmosis (TRO), and slurry precipitation and recycle reverse osmosis (SPARRO). The evaluation of EDR and TRO is complete, and the operating costs (1988) associated with each process are expected to be about 50 cents per kilolitre for a plant of 50 l/s (4 Ml/d) installed capacity. The SPARRO process is still being evaluated. Pilot-plant results, water qualities, and expected capital costs are presented where appropriate.

SAMEVATTING

Die navorsingsorganisasie van die Kamer van Mynwese het drie membraan ontsoutingsprosesse vir gebruik in die Suid-Afrikaanse mynbedryf geëvalueer. Die prosesse is elektrodialise (EDR), buis-tru-osmose (TRO), en flodder, presipitasie en hersirkulasie tru-osmose (SPARRO). Die evaluasie van die EDR en TRO prosesse is afgehandel. Die bedryfskoste (1988) vir die twee prosesse word op ongeveer 50 sent per kiloliter vir 'n 50 l/s (4Ml/d) kapasiteit aanleg, geraam. Die SPARRO proses word nog geëvalueer. Loodsaanlegresultate vir werkverrigting, waterkwaliteit en verwagte kapitaalkostes word waar doenlik gerapporteer.

INTRODUCTION

South Africa's forty major gold mines continuously pump a total of 10 kl/s of spent service water from underground to the surface. About a third of this water is recirculated underground, where it is used as service water for the suppression of dust in watering-down and drilling, water-jetting, and cooling operations. The spent mine water drains out of the workings to the underground settlers and becomes contaminated by explosives residues, salts, and acids leached from the gold-bearing reefs[1], as well as by the chemicals used for neutralization and disinfection. The continual recirculation of water through the workings leads to the concentration of these contaminants. Furthermore, the drought of the past decade and the restrictions placed on the purchase of high-quality water from water boards, which is used as make-up in mine-water circuits, have aggravated the situation.

Currently, the mines do not desalinate their mine service water. The only water treatment undertaken consists of neutralization, disinfection, and solids removal by settling underground, followed on a few mines by filtration on the surface. However, reduction of the salt loads in mine service-water circuits by the use of desalination processes is receiving serious consideration. There are four major reasons for this.

(1) The mines that have an excess of water discharge a portion to the environment, and these effluents have to conform to the restrictions on the discharge standards.

(2) Desalination of the service water could well be an economic alternative to dealing with the internal corrosion of pipe-reticulation systems and machinery underground, particularly when new mining techniques such as hydro-power[2] are being used.

(3) Desalination would promote safety and health.

(4) Within the next five to ten years, it may become economical to reclaim mine service water by desalination as a replacement for purchasing board water.

At present the Chamber of Mines Research Organization (COMRO) is investigating various membrane-desalination techniques that are appropriate to the mining industry. Each process is being evaluated for technical feasibility, suitability of design, and operational requirements, and to establish capital and operating costs. Process development and redesign are undertaken where required. An economic analysis of a proposed application would determine whether such a process is viable or not.

This paper briefly describes research investigations into the membrane desalination of mine service waters carried out between 1986 and 1988. It presents operational results and costs, and indicates the status of the investigation into each process and the potential for its application within the mining industry.

TYPES OF MINE SERVICE WATER

Mine waters can be broadly classified into two distinct groups: those which have a scaling potential with respect to calcium sulphate (Table III), and those which do not (Table I). The latter are essentially sodium chloride waters, forming only about 25 per cent of all mine service waters, and are found predominantly in the Orange Free State goldfields. Since calcium sulphate is a sparingly soluble salt (2,23 g/l at 0°C), high concentrations of calcium sulphate in mine service waters can lead to scaling problems. Data gathered from an extensive survey of mine service waters have revealed that about 75 per cent of them

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 SA ISSN 0038-223X/3.00 + 0.00. Paper received 9th March, 1990. Modified paper received July 1991.

would become scaling when concentrated in a desalination process operating at a water recovery of 80 per cent.

PROCESSES BEING EVALUATED BY COMRO

The present investigation started with a paper study of commercially available desalination processes, which would indicate what processes or combination of processes would be the most suitable for use within the mining industry. Although consideration was also given to energy-intensive processes (e.g. distillation), the study showed that the more recently developed membrane processes appeared to hold the greatest potential for the economical desalination of mine service waters. COMRO decided to investigate, at pilot scale, three membrane processes: electrodialysis reversal (EDR), tubular reverse osmosis (TRO), and slurry precipitation and recycle reverse osmosis (SPARRO). Both the EDR and TRO processes were evaluated on non-scaling mine service water, and the work is complete. The SPARRO process, used for the treatment of scaling mine service waters, is now in the evaluation phase. In addition to the membrane-desalination processes described above, COMRO is investigating various freeze-desalination processes. These processes have been evaluated elsewhere for the desalination of sea water, but COMRO's work on mine service water is novel. There are very significant differences between the freeze desalination of sea and mine water, and these are being addressed by an extensive research programme. Research results on this desalination process have been reported in detail elsewhere[3], and are not repeated here. It is expected that, in time, each of the above processes will find application within the broad spectrum of possible desalination applications on mines.

Electrodialysis Reversal (EDR) Process

EDR is an electrically driven membrane process in which the electrical potential causes ions to move out of the feed stream through cation- or anion-selective membranes. This technology has been applied at a number of brackish-water installations in the USA and other parts of the world, and at present there are two large installations supplied from the USA (design capacities of 70 and 58 l/s) successfully operated in South Africa[4].

A 1,6 l/s (5,8 m^3/h) pilot plant was operated for about 6000 hours on a non-scaling mine service water in the Orange Free State. The aim of the investigation was to establish the technical feasibility of the process, the pretreatment necessary to ensure economically acceptable membrane life, and the operating and capital costs. The Ionics membranes used during this study were 0,46 m wide and 1,02 m long, and were approximately 0,5 mm thick. They were characterized as being resistant to pH in the range 1 to 10, resistant to fouling, impermeable to water under pressure, and having a low electrical resistance and a selectivity of more than 90 per cent for solutions below 0,5 to 0,7 normal[5].

Because EDR is a membrane process, it is important that potential membrane foulants should be removed from the feed stream, and it was shown that a relatively high degree of pretreatment of the feed water was necessary for satisfactory plant performance. Iron and manganese had to be removed to a concentration of less than 0,3 mg/l, and suspended solids to less than 2,5 mg/l (a turbidity of less than 1,0 nephelometric turbidity units (NTU)). This was accomplished by

- oxidation of the iron and manganese in the feed water by the addition of potassium permanganate (as $KMnO_4$ at a dosage of 2 mg/l)
- flocculation by use of polyelectrolyte (at a dosage of 1 mg/l)
- primary filtration through dual-medium (anthracite–sand) filters
- secondary filtration through cartridge filters with a nominal rating of 10 μm.

Owing to the presence of some barium and sulphate ions in mine water, it was necessary to add an anti-scalant (sodium hexametaphosphate at a dosage of 15 mg/l) to the brine stream to prevent the formation of barium sulphate scale.

The plant performed well and achieved an average salt rejection of 80 per cent, and a recovery of product water of up to 84 per cent. Table I shows the average composition of the raw mine service water, EDR pilot-plant feed, product water, and brine obtained during the study. The product water had an average concentration of total dissolved solids (TDS) of 640 mg/l, and a conductivity of 104 mS/m, which satisfies the South African Bureau of Standards (SABS) maximum allowable limit of 300 mS/m (SABS 241-1984) for dissolved solids in drinking water. This water is essentially suitable for human consumption, but would require disinfection and regular checks on micro-determinants, e.g. cyanide, arsenic, and lead.

Table I

Average compositions from a 6000 hour evaluation of a 1,6 l/s EDR pilot-plant operating on brackish mine service water

Item	Raw mine water	EDR feed	EDR product	EDR brine
pH	6,42	6,42	6,14	5,42
Conductivity, mS/m	451	451	104	1 120
Turbidity, NTU	20	0,91	0,36	0,40
TDS, mg/l	3 200	3 200	640	9 150
Cl^-, mg/l	1 750	1 750	375	4 990
Na^+, mg/l	1 400	1 400	200	3 110
Ca^{2+}, mg/l	100	100	25	400
Total iron, mg/l	1,0	0,2	0,15	0,4
Total manganese, mg/l	0,6	0,3	0,16	1,1
Ba^{2+}, mg/l	0,6	0,6	0,3	1,1
SO_4^{2-}, mg/l	74	74	5	340

Tubular Reverse Osmosis (TRO) Process

TRO is a pressure-driven membrane process operating at about 4000 kPa. The membranes available in this configuration at present are made of cellulose acetate thinly coated on the inside of synthetic support tubes of 12 mm diameter. The membrane allows water to pass through it but rejects up to 95 per cent of the salts, which remain inside the tubes as the brine stream. The modules were specified as each having a membrane area of 1,75 m^2, a design flux of between 500 and 600 l/m^2 per day (at 4000 kPa pressure, 20°C, and using a 1000 mg/l NaCl solution), and a salt rejection of 90 to 96 per cent on a 1000 mg/l NaCl solution.

As in the case of EDR, due care has to be taken to protect the membranes against fouling. The TRO membranes are manufactured locally, which makes them cheaper than the imported TRO modules. There are a number of small plants (6 to 10 l/s) in South Africa using these modules, as well as one large installation (about 70 l/s).

A TRO pilot plant of 0,4 l/s (1,4 m^3/h) was operated for about 6000 hours on non-scaling mine service water from the same source as was used in the EDR investigation. The aim of the study was to establish the technical feasibility of the process, the pretreatment necessary to ensure economically acceptable membrane life, and the operating and capital costs. Owing to the robust nature of the membrane tubes, the use of sponge balls for cleaning, and a facility to reverse the flow direction, the membrane suppliers recommended minimal pretreatment of the raw mine water feed, which involved

- cooling of the feed water to reduce the temperature to below 30°C and prevent hydrolysis of the membranes.
- adjustment of the feed water to between pH 5 and 6, also to prevent hydrolysis of the membranes

However, extensive testing demonstrated that additional pretreatment of the feed was necessary in order to prevent deterioration of the membranes. This involved

- oxidation of the iron in the feed water by means of potassium permanganate (at a dosage of 1,5 mg/l)
- in-line flocculation (1 mg of polyelectrolyte per litre), followed by filtration through dual-medium (anthracite–sand) filters to remove the products of oxidation and the bulk of the suspended solids, and to achieve an iron concentration of less than 0,3 mg/l and a turbidity of less than 2 NTU.

The plant operated at an average of 82 per cent salt rejection with a product-water recovery of 75 per cent, and an average daily flux of 657 l/m^2 per day corrected to 4000 kPa and 25°C. Table II presents average figures over the last 1000 hours of the evaluation for the quality of the raw mine-water feed, the TRO-plant feed, the product water, and the brine. As in the case of the EDR product water, the TRO product water would require only disinfection and regular checks on micro-determinants to ensure its suitability for human consumption.

Table II

Average compositions from a 1000 hour evaluation of a 0,4 l/s pilot-plant operating on brackish mine service water

Item	Raw mine water	TRO feed	TRO product	TRO brine
pH	6,40	5,50	5,22	5,42
Conductivity, mS/m	500	500	104	1 561
Turbidity, NTU	20	0,28	0,23	0,90
TDS, mg/l	3 150	3 150	537	10 400
Cl^-, mg/l	1 700	1 700	247	5 000
Na^+, mg/l	1 250	1 250	234	2 500
Ca^{2+}, mg/l	110	110	19	355
Total iron, mg/l	1,0	0,10	0,05	1,5
Ba^{2+}, mg/l	0,5	0,5	0,3	0,7
SO_4^{2-}, mg/l	120	120	7	500

Membrane Desalination of $CaSO_4$ Scaling Mine Service Water

The direct use of EDR and TRO to treat the calcium sulphate scaling waters encountered in the South African gold-mining industry is not economic. The reason for this is that successful operation of these conventional processes requires one or all of the following precautions.

(1) Extensive pretreatment to considerably reduce the scaling potential of the feed water, i.e. by use of a softening process. The disadvantage of this approach is that the overall process becomes very costly owing to the large quantity of chemicals required in the softening step; laboratory tests have shown these softening costs to be in the region of 50 to 75 c/kl (1988) (cents per kilolitre) for a typical scaling type of mine service water.

(2) Operating at significantly reduced recoveries of product water so as not to exceed the $CaSO_4$ saturation limit. In many cases it would be necessary to operate at or substantially below 40 per cent in order to meet this criterion, and this would result in significantly higher costs in terms of the amount of product water.

(3) Use of anti-scalants. The use of anti-scalants in conjunction with these processes is usually applicable only when low masses of scale are expected to form (e.g. in the case of barium sulphate scale). With the calcium sulphate type of waters encountered in the mining industry, the masses of scale expected to form are far too great (more than 200 mg/l) to allow the use of anti-scalants.

In order to overcome this technical and economic problem, COMRO has, since 1983, been evaluating and developing a reverse-osmosis process that utilizes a recirculating slurry of calcium sulphate crystals and allows controlled scaling to take place within the process. Two pilot plants, designed in the USA and utilizing local TRO membrane modules, were tested by COMRO. Both plants, a unit of 0,05 l/s (0,18 m^3/h) and one of 0,5 l/s (1,8 m^3/h), were able to operate at high salt-rejection levels (80 to 90 per cent) while achieving very high recoveries of product water (85 to 95 per cent). Table III shows the main constituents of the product waters obtained from these pilot plants, as well as the quality of the feed water to the units.

Table III

Main constituents of the water from the RO plants operating on scaling mine service water

Item	Raw mine water	Product of 0,05 l/s plant	Product of 0,5 l/s plant
pH	4,20	5,30	5,8
Conductivity, mS/m	230	60	100
TDS, mg/l	2 800	470	800
Cl^-, mg/l	80	50	65
Na^+, mg/l	120	55	50
Ca^{2+}, mg/l	350	20	110
Mg^{2+}, mg/l	30	10	10
SO_4^{2-}, mg/l	1 600	170	480

Notwithstanding the promising performance of both pilot plants, serious design drawbacks and limitations became apparent. These included a high consumption of energy, a high recirculation rate of $CaSO_4$ slurry, and a poor mass-balance control system for $CaSO_4$ seed and brine. However, recognizing the potential of such a desalination process, COMRO, in collaboration with the Water Research Commission, Iscor, and Bintech (a local membrane manufacturer, now Membratech), entered into an agreement to develop a new more efficient seeded RO process designed especially for application in the South African mining industry.

Slurry Precipitation and Recycle Reverse Osmosis (SPARRO) Process

The new process, known as the slurry precipitation and recycle reverse osmosis (SPARRO) process, was based on experiences with conditions and requirements within the South African mining industry and the desalination experience gained during the TRO pilot-plant evaluation. SPARRO has three main advantages over the existing seeded RO processes:

(1) a lower power consumption, which is expected to be between about 3 and 4 kWh per kilolitre—less than half that of the earlier plants

(2) independent control of $CaSO_4$ seed and brine blowdown

(3) utilization of a novel double pumping system to reduce pump wear and scaling potential within the system.

A pilot plant of 0,85 l/s (3,1 m^3/h) was designed and constructed by COMRO, and was commissioned at a test facility at the Hercules Shaft of the ERPM Gold Mine. The process is being evaluated with two main objectives. Firstly, the capabilities of the design are being examined in terms of the quality of the product water and the levels of product-water recovery that can be achieved. It is aimed to produce water that will satisfy the SABS limits for potable water while operating at recoveries in excess of 95 per cent. Secondly, attention is being paid to the power consumption of the process, the chemical costs, and the design features intended to minimize problems associated with the recirculation of slurry containing calcium sulphate, e.g. blockages, optimization of particle size, and slurry concentration. In parallel with this evaluation, there is a smaller plant (0,3 l/s), the Membrane Lifetime Test (MLT) plant, operating at ERPM under conditions similar to those of the SPARRO plant. This plant is being used to determine the long-term life expectancy of TRO-membrane modules exposed to recirculating $CaSO_4$ slurry. Since the costs of membrane replacement can constitute as much as 50 per cent of the operating costs in conventional membrane desalination plants treating brackish water, the evaluation of these costs for the SPARRO process is essential. The plant is also being used to evaluate the optimum operating conditions and maintenance requirements of the locally manufactured slurry plunger pumps. This involves the testing of different plunger materials, packings, and seal arrangements to obtain the most cost-effective configuration.

COSTS

Table IV summarizes both the operating- and the capital-cost estimates as at October 1988 for EDR, TRO, and SPARRO. Direct comparison of these costs should not be made since they are highly specific to design conditions; for example, design flow-rate, feed-water quality, product recovery, and salt rejection.

Table IV

Operating and cost estimates for large-scale installations of EDR and TRO treating brackish mine service water, and SPARRO treating scaling mine service water (1988 prices)

Item	50 l/s EDR plant 80% rejection 80% recovery	50 l/s TRO plant 80% rejection 80% recovery	35 l/s SPARRO plant 85% rejection 95% recovery
Power @ 6,25 c/kWh, c/kl	15,0	14,5	21,9
Membrane replacement, c/kl	20,0	24,0	32,0
Pretreatment, c/kl	11,0	5,0	8,0
Extra costs (e.g. labour, membrane cleaning, maintenance), c/kl	4,0	6,5	10,4
Total c/kl	50,0	50,0	72,3
Budget capital costs, R per l/s of installed capacity	93 500	113 000	130 000

The operating costs for TRO and EDR are based on the pilot-plant costs and have been extended to cover the expected costs of a large installation (50 l/s or 4 Ml/d). They were calculated to be about 50 c/kl of product in both cases for the treatment of brackish mine service water. It can be seen that, for EDR, the cost of membrane replacement is expected to be about 20 c/kl (based on a life of 4 years for anion membranes and 7 years for cation membranes), and electrical costs of about 15 c/kl. The replacement costs of cartridge filters, highlighted as a major portion of the pretreatment costs, totalled 8 c/kl of the overall pretreatment cost of 11 c/kl.

In the case of TRO, the membrane-replacement costs were also the greatest contribution to the total operating costs at 24 c/kl (based on a membrane life of 4 years), while the electrical costs are estimated at 14,5 c/kl. The maintenance costs are expected to be slightly higher in the case of TRO because of the use of high-pressure pumps. The capital costs in both cases were obtained from the suppliers concerned and can be regarded as budget prices.

The SPARRO process produces a high-quality gypsum byproduct, which can be sold to offset part of the overall operating costs. A selling price for this byproduct has not yet been established, and thus the operating costs given in Table IV are the gross costs. These costs are based primarily on pilot-plant experience, and are expected to be about 72 kl for a 3,5 l/s (3 Ml/d) SPARRO plant treating scaling mine service water. The power consumption figure of 2,5 kWh/kl is a calculated value, which will be verified during the plant evaluation. The membrane-replacement cost is based on a membrane lifetime of 3 years. This is considered conservative and will be quantified during the MLT plant study. Based on a lifetime of 3 years, the membrane-replacement cost is of the order of 32 c/kl. Pretreatment, labour, and maintenance are expected to total roughly 18 c/kl for a 35 l/s SPARRO installation. The capital cost is calculated from a knowledge of the construction costs for the 0,85 l/s pilot plant, and has been estimated at R130 000 per litre per second installed capacity.

PLANT OPERATION

All the pilot-plant evaluations are carried out on a continuous operational basis, which has necessitated the use of shift workers. The studies have shown that operators with gold-plant experience are able to adapt to the operation of these desalination plants with the minimum of training. It is envisaged that a large desalination installation would not require dedicated operator supervision for twenty-four hours a day. On the contrary, it is estimated that an operator need spend only about one-third of his time on the desalination plant. Daily checking of the plant-performance parameters would be required by a supervisor.

DISPOSAL OF BRINE

At present there are only two viable brine-disposal techniques available commercially, i.e. the use of evaporation ponds (which is a relatively slow process) and mechanical vapour-recompression evaporation (a rapid and continuous process). The latter process produces a high-quality product water that can be returned to the reticulation system, thereby increasing the overall water recovery. Both these processes are expected to be costly. The approach currently being followed by COMRO is to minimize brine volumes by developing processes with high water recoveries. Alternative and more cost-effective brine-disposal techniques currently under development elsewhere are being considered.

SUMMARY

The status of COMRO's investigations at the end of 1988 into membrane processes for the treatment of mine service water is as follows.

Conventional Membrane Process

Both the electrodialysis reversal (EDR) and tubular reverse osmosis (TRO) processes have been demonstrated to successfully desalinate brackish mine waters when the necessary pretreatment procedures are employed. The evaluation of the EDR and TRO processes on this type of water is complete, and COMRO has gained considerable experience in the operation of these processes on mine water. Both plants are easy to operate. Operators from a gold plant required very little additional training in order to cope with their operation. The application of these processes is limited in the mining industry since only the newer mines in the Orange Free State have truly brackish non-scaling mine waters.

Scaling-water Desalination Process (SPARRO)

Desalination of calcium sulphate scaling waters using a recirculating slurry of calcium sulphate and a TRO membrane configuration has been demonstrated to be technically feasible. The evaluation of novel design features and the cost implications of the SPARRO process are now in progress. Since most mine service waters are of a scaling nature, a process such as SPARRO holds great potential for application within the mining industry.

CONCLUSION

In most water-consuming industries in South Africa at present, there is scepticism about desalination, mainly because of the relatively high costs associated with these processes and the lack of an incentive to desalinate. These industries perceive desalination as a 'last resort clean-up process' forced upon them by legislation. From the point of view of the South African gold-mining industry, COMRO is addressing the problem by developing processes with lower costs that could in time be used cost-effectively in day-to-day mining operations. Furthermore, it should be realized that it will often not be necessary to desalinate total process streams, but that side-stream treatment will be all that is required.

ACKNOWLEDGEMENTS

This work forms part of the research programme of the Chamber of Mines Research Organization. It was carried out with the financial assistance of the Water Research Commission. ERPM and Beatrix Gold Mining Company Limited assisted in the pilot-plant evaluations.

REFERENCES

1. JUBY, G.J.G., HARRIES, R.C., and GREIG, J.D. Improving the quality of mine service water in gold mines in South Africa. Second International Mine Water Association Congress, Granada (Spain), 1985.
2. JOUGHIN, N.C. A system for providing mechanical and cooling power in deep mining. 13th CMMI Conference, Singapore, 1986.
3. SHONE, R.D.C., and SHEER, T.J. An overview into the use of ice for cooling deep mines. Proceedings 4th International Mine Ventilation Congress, Brisbane (Australia), 1988.
4. JONES, R.A. Electrodialysis in South Africa. Technology Forum on Effluent Treatment and Chemical Recovery by Electrically Driven Membrane Processes, National Institute for Water Research, CSIR, Pretoria, 1987.
5. MELLOR, F.H. (ed.). *Electrodialysis (ED) and electrodialysis reversal (EDR) technology*. Ionics Incorporation, USA, 1984.

Engineering co-operation*

A unique co-operative effort in the establishment of shared facilities between the Department of Metallurgy and Materials Engineering at the University of the Witwatersrand and the Department of Metallurgy in the School of Mines at the Witwatersrand Technikon is proving a great success.

The facilities, made possible by funding from the Chamber of Mines, include a well-equipped mineral-processing teaching laboratory at the technikon and a new range of pilot plants in an existing teaching and research laboratory at the university.

EQUIPMENT

According to Dr Laurie Woollacott, senior lecturer in metallurgy at Wits University, there was plenty of space in the new mineral-processing laboratory at the technikon, but the limited equipment available had not yet been commissioned. Bench-scale apparatus from the university has now supplemented the technikon's existing facilities to develop an effective combined mineral-processing teaching laboratory.

The equipment includes bench flotation machines, magnetic and electrostatic separators, a cyclone rig, sampling and sample-preparation bays, wet-screening bays, screening and pressure-filtration facilities, gravity-separation equipment in the form of two shaking tables and a mineral jig, thickening, filtration and settling test equipment, a drying oven, and crushing facilities.

The new facilities will be used by almost 80 undergraduate university students annually. Second-year practicals have also been introduced for technikon students, and some 20 students are introduced to mineral-processing basics each semester. Further exposure of students to practical metallurgy is being planned.

PILOT PLANTS

The second major area of co-operation involves the development of the existing mineral-processing laboratory at Wits University to include pilot-scale and larger operating pilot plants for research, teaching, and commercial use.

Pilot plants now available include coalwashing, column-flotation, and dense-medium plants, milling rig, conventional flotation rig, and CIP pilot plant. Mr Handfield-Jones, head of metallurgy in the technikon's School of Mines, says access to these combined facilities is helping his students to obtain a broader knowledge of the types of treatment plants and processes being used throughout the base-metal, gold, diamond, and coal industries.

Students coming to grips with sampling techniques in the mineral-processing teaching laboratory at the Wits Technikon

Both laboratories are to be further expanded and upgraded to provide exposure for more advanced technikon and university students to pilot-plant continuous operations and advanced unit-process operations.

COMPUTER NETWORK

Also funded by the Chamber of Mines has been a computer network comprising more than 50 terminals and shared by the Department of Chemical Engineering and the Department of Metallurgy and Materials Engineering at Wits University. Sharing of the network will in due course be expanded to include the Witwatersrand Technikon, with a view to rationalizing software teaching in extractive metallurgy between the two institutions.

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