



The effect of corrosion on the wear rate of steel pipelines conveying backfill slurry

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Synopsis

The wear of steel pipelines used for the transportation of backfill slurries is frequently regarded as an erosion problem only.

An investigation was undertaken of the likely contribution to the total 'wear rate' made by corrosion. Use was made of a pipe flowloop with cathodically protected specimens and corrosion inhibitors. Laboratory electrochemical tests utilizing a rotating-cylinder electrode were also conducted. The slurries used were classified tailings from two mines at a relative density of 1,7. The velocities were between 2 and 4,9 m/s.

Substantial decreases in the wear rate of up to 80 per cent for one slurry and up to 67 per cent for the other were obtained with the use of corrosion control, showing that corrosion and, more importantly, interaction between erosion and corrosion, contribute a significant portion of the overall wear in steel pipelines.

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Introduction

The wear of pipelines transporting backfill slurries is often seen to be only an erosion problem. The role played by corrosion is frequently not understood and often ignored. Several authors have examined the corrosion contribution to wear rates in pipes transporting slurries, finding that corrosion constitutes a significant part of the total wear rate.

Economic methods for controlling the mass loss from piping in backfill systems depend on a determination of the relative effects of the different components of total wear. In slurry pipelines, there are three possible modes of material loss from the pipe wall: erosion, corrosion, and a synergy between wear and corrosion (erosion-corrosion).

Corrosion alone can be measured fairly easily by the use of electrochemical methods, or of mass-loss methods using coupons or even test pipes inserted in water pipelines. The question arises as to what portion of the total 'wear rate' in a slurry pipe is due to corrosion, either as corrosion alone or as some synergy between wear and corrosion. Madsen¹ defines this synergy as existing when the wear rate is greater than the sum of the erosion and the corrosion components acting individually. This may be due to the removal of corrosion products from the surface of the corroding metal, thus providing a clean, unprotected surface that allows the maximum rate of corrosion, or to turbulence in a slurry, increasing the mass transport of oxygen to the corroding surface. Corrosion products on steel piping (rust) may be easier to remove through abrasive action than the steel itself.

Lui and Hoey² state that, when the wear rate depends only on erosion, the rate of surface removal is governed by the conditions of fluid flow, the properties of the solid particles and the material surface, and the mechanism of material removal. The addition of corrosion, however, adds further variables that affect the rate of material loss, these being the nature and property of the corrosion products formed and the rate at which they are formed. This rate depends very much on the corrosivity of the liquid medium of the slurry.

Postlethwaite *et al.*³ found that, in slurries made up of silica sand (20 per cent by volume), corrosion is the dominant mode of metal loss. They concluded that erosion prevents the formation of a complete film of rust that stifles or, at least, slows down the corrosion reaction. Postlethwaite and Hawrylak⁴ found that, even when the solid particles in a slurry were softer than steel, they were able to accelerate the corrosion process.

Experimental Method

In an examination of the contribution to the total wear rate made by corrosion, use was made of a pipe flowloop, cathodic protection, corrosion inhibitors, and electrochemical corrosion testing. Two slurries were used in the tests, both at a solids concentration of 42 per cent by volume, details of which are given in Table 1 and Figures 1 and 2.

Table 1

Parameters of the test slurries

Parameter	Vaal Reefs (VR) slurry	Western Deep Levels (WDL) slurry
pH	9,4	11,0
Conductivity	407	268
Alkalinity	85	180
Alkalinity as CaCO ₃ , ppm	120	335
Hardness as Ca, ppm	1545	1005
Hardness as CaCO ₃ , ppm	70	<5
Total hardness, ppm	1615	1005
Total dissolved solids, ppm	3615	2310
Total suspended solids, ppm	<10	<10
Chlorides, ppm	195	245
Sulphates, ppm	2200	950
Sodium	365	215

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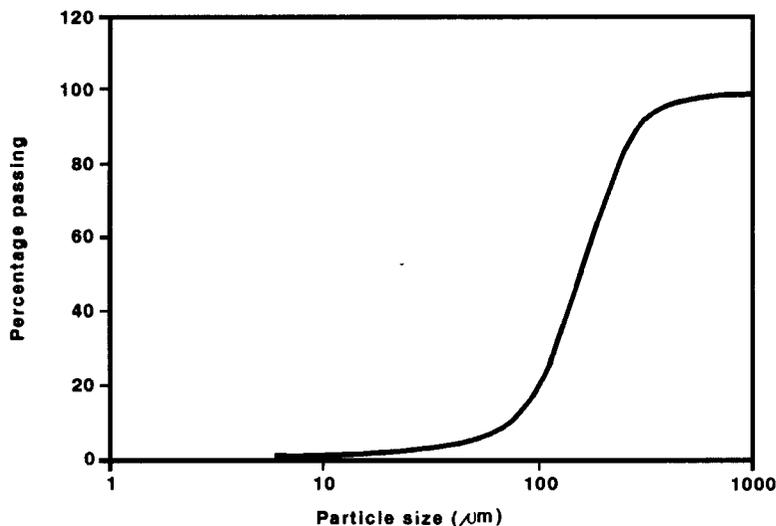


Figure 1—Particle-size distribution of the slurry from Western Deep Levels

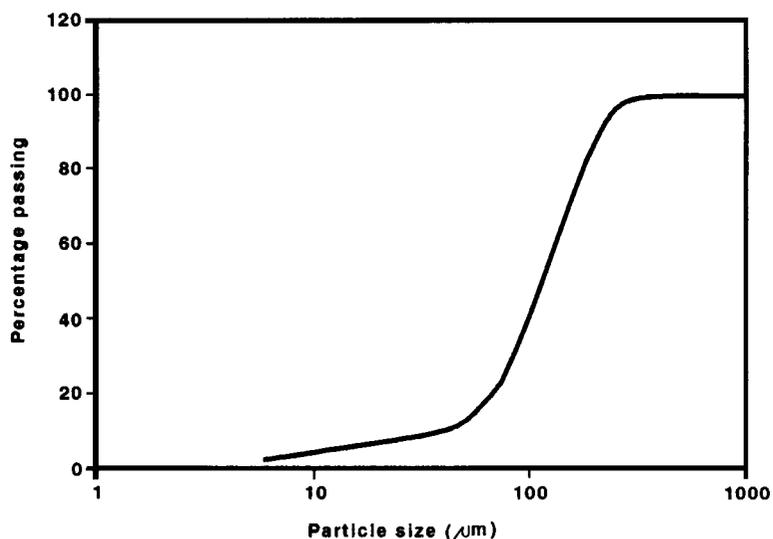


Figure 2—Particle-size distribution of the slurry from Vaal Reefs South

Acknowledgements

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Flowloop Tests

A pipe loop complete with a variable-speed pump, magnetic flowmeter, and mechanically agitated storage tank was used in the tests (Figure 3), as described previously by Steward and Spearing⁵.

The wear specimens were made from Schedule 40 (ID 52,5 mm) ASTM A106 Grade B seamless tube of 50 mm nominal bore, with a nominal composition of 0,30 per cent C, 0,29 to 1,06 per cent Mn, 0,10 per cent (min.) Si, 0,048 per cent (max.) P, and 0,058 per cent (max.) S. The hardness as measured was 152 Vickers hardness value (Hv). Lead-in and lead-out lengths of 500 mm were provided to straighten the flow. The arrangement of the test sections is shown in Figure 4.

The plain-wear specimens were 200 mm lengths of tube, while the cathodically protected specimens consisted of a 200 mm long tube sectioned longitudinally in half. The two halves were insulated from each other, with one half forming a cathode and the other an anode. The cathode was drilled to receive a 3 mm porous tapping for a connection to a reference electrode. The anode-cathode assembly is illustrated in Figure 5. In preparation for the test, the specimens were abraded with a 200-grit 'flexi-hone' and then cleaned in inhibited 10 per cent sulphuric acid as specified⁶ in ASTM G1-1981. This ensured that all the specimens had the same surface finish, as well as removing any scale or corrosion products. The specimens were stored in an airtight container with desiccant before being weighed and installed in the flowloop. After being exposed, the specimens were again cleaned with inhibited acid if any corrosion product was visible on their surfaces; if not, they were rinsed, wiped clean, and dried with warm air.

A variable-voltage d.c. power supply was applied across the two anode-cathode pairs. The potential on the cathode surface at the point most distant from the anode was measured with reference to a saturated calomel electrode (SCE).

Trials were conducted with a range of different potentials at the cathode. At a potential of -1,2 V (SCE), no mass loss at all occurred at the cathode. This was due to a build-up of scale, which appeared to consist mainly of carbonates with slurry particles embedded in the scale.

After further trials, a potential of -0,70 to -0,71 V (SCE) was used in the tests. This potential, although being slightly above that recommended for use in cathodic protection^{7,8} (minimum of -0,77 V (SCE) by NACE), was used for the following reasons. Firstly, more negative potentials resulted in the deposition of copper and scale on the surfaces of the cathodically protected specimens. Secondly, this voltage would have been the least negative potential on the specimen surface owing to its curvature; the voltage on other parts of the specimen nearer the anode would be more negative. The calculated current densities on the cathode surfaces were in the range 0,75 to 3 mA/cm².

The test conditions are summarized in Table II.

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- 1 Slurry reservoir
- 2 Centrifugal pump
- 3 Magnetic flowmeter
- 4 Test pipeline
- 5 Heat-exchangers
- 6a Ball-valve switch-over
- 6b Bypass pipeline
- 6c Weigh tank
- 6d Jet impact nozzle

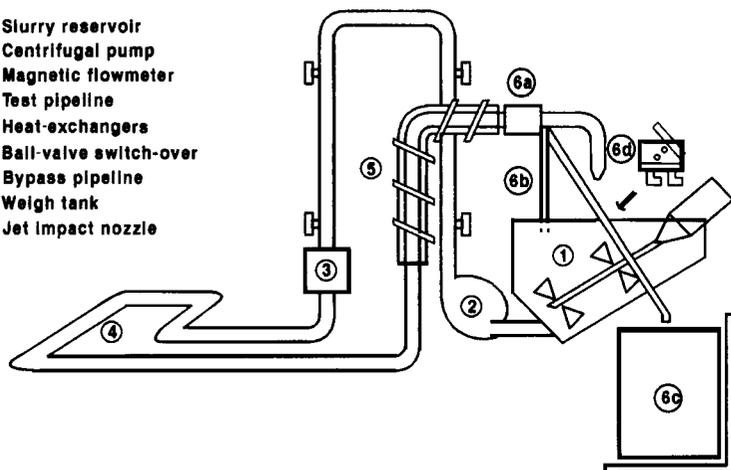


Figure 3—Layout of the slurry flowloop (after Steward and Spearing⁵)

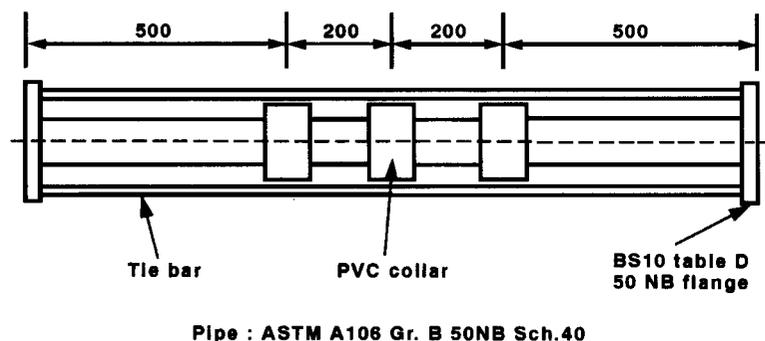


Figure 4—Schematic diagram of the pipe test sections (dimensions in millimetres)

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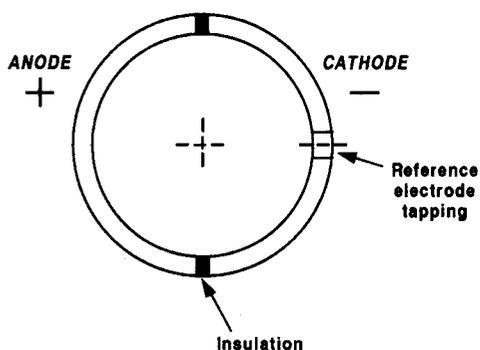


Figure 5—Schematic diagram of the anode-cathode assembly

More limited testing was also performed in which the same two slurries were used with the addition of a corrosion inhibitor. The inhibitor used was NaNO_2 with an initial dosage of 2 g/l of water, followed by 0,17 g/l of water after 1, 2, and 3 hours of pumping the slurry. Work conducted by White⁹ formed the basis for the selection and use of this inhibitor.

Table II

Flowloop test conditions

Variable	Value / Description
Velocity, m/s	2,75 3,77 4,88
Slurry used	Vaal Reefs South Plant (VR) Western Deep Levels West Plant (WDL)
Relative density of slurry	1,7
Test duration, h	4
Temperature range, °C	22 to 27

Table III

Conditions for the electrochemical tests

Variable	Value / Description
Rotational speed, r/min	1433 2168 2913 equivalent to 2, 3, and 4 m/s with slurry in a pipe of ID 52 mm and 2279 (equivalent to 3 m/s with water in the same pipe)
Slurry	VR and WDL
Relative density of slurry	1,7
Approximate temperature, °C	22
Method of corrosion-rate measurement	Linear polarization resistance (LPR) and Tafel extrapolation over the range $E_{\text{corr}} \pm 200 \text{ mV}$
De-aerator (when used)	Nitrogen
Inhibitor (when used)	2 g/l NaNO_2

Electrochemical Tests

Electrochemical tests were conducted with a rotating-cylinder electrode (RCE) machined from ASTM A106 Gr. B pipe. The cylinder was 20 mm in diameter and 10 mm in height.

The composition of the pipe was 0,13 per cent C, 0,23 per cent Si, 0,96 per cent Mn, 0,017 per cent S, and 0,012 per cent P. Tests were conducted both in the slurries and in the water used for the make-up of the slurries. The speed of the electrode was calculated by use of a correlation determined at Mintek, which is based on the achievement of equal shear stresses at the surface of a pipe and the RCE. This included such factors as viscosity and pipe diameter to provide an equivalent set of speeds used in the electrochemical tests to three pipeflow velocities.

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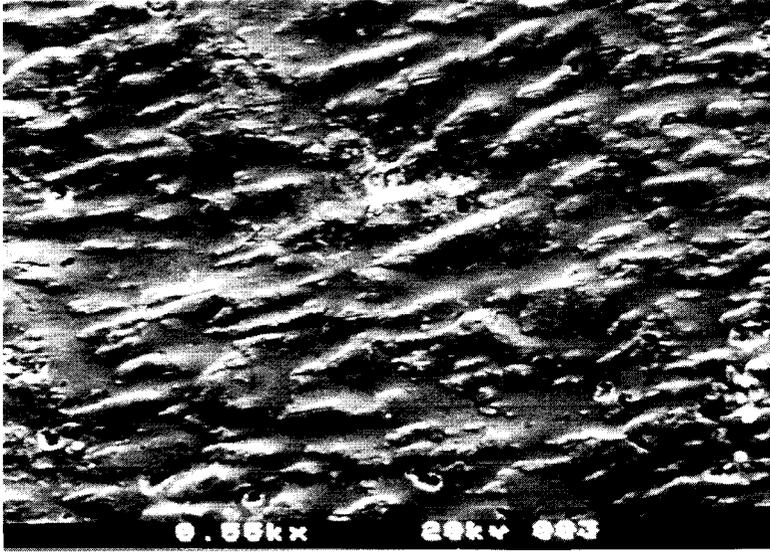


Figure 6—Cathode surface after exposure (VR slurry 4,88 m/s)



Figure 7—Corrosion pits in a plain specimen (VR slurry 2,75 m/s)

7. NACE Standard RP-01-69. Recommended practice, control of external corrosion on underground or submerged metallic piping systems. 1983 Revision, NACE, Houston, 1983.
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The test conditions are given in Table III. The tests were conducted with an electrochemical cell consisting of the RCE, three carbon counter-electrodes, and an SCE connected via a Luggin probe. Mechanical agitation was used to maintain the slurry in suspension.

Tests of mass loss were conducted over 140 hours on the same RCE in agitated containers of slurry.

Results

Pipe Tests

After the specimens had been exposed to the slurry, a visible difference was apparent between the cathodes, the anodes, and the plain specimens.

The cathodes were clear of corrosion products and, at the higher velocities, had a polished appearance. The surface still showed many of the original markings. Their surfaces (Figure 6) were essentially the same in appearance as those observed by Postlethwaite *et al.*³ in their work, viz a smooth rippled appearance.

The plain specimens tended to have a rougher surface with numerous pits. These pits contained corrosion products. Figure 7 shows corrosion pits on the surface of an unprotected specimen (VR slurry 2,8 m/s). Some polishing marks were still visible in the direction perpendicular to the direction of flow. At the lower speeds and on specimens used only once, the polishing marks were still visible while, at the higher flow velocities, the polishing marks had all been removed, even on the cathodically protected specimens. Figure 8 shows the interior of a typical pit on the plain specimens. Further exposure of the plain specimens at higher velocities resulted in a surface as shown in Figure 9, again with large numbers of pits and a polished surface (exposed three times, the last time being WDL slurry at 4,88 m/s). No difference in mass loss was found between newly prepared specimens and those that had been re-used, i.e. no effect of surface finish was observed over the period of the tests.

The anodes were covered with orange to brown corrosion products, and there was evidence of pitting, although general dissolution of the surface was perhaps more usual, along with the formation of longitudinal grooves in the direction of flow. The grooves appeared to be mainly due to the linking-up of pits that had extended in the direction of flow. What is particularly interesting is that these grooves had the same general appearance as that seen in vertical backfill shaft piping, albeit on a smaller scale.

The impressed current at the anode has the effect of accelerating corrosion. The observations of the anodes were only of a qualitative nature because of the unrealistic situation arising from the applied current. However, the fact that accelerated corrosion produces a similar surface to that observed in vertical piping that has been exposed to backfill slurries over an extended period may be an indication of the effect that corrosion plays in the typical grooving seen in shaft piping.

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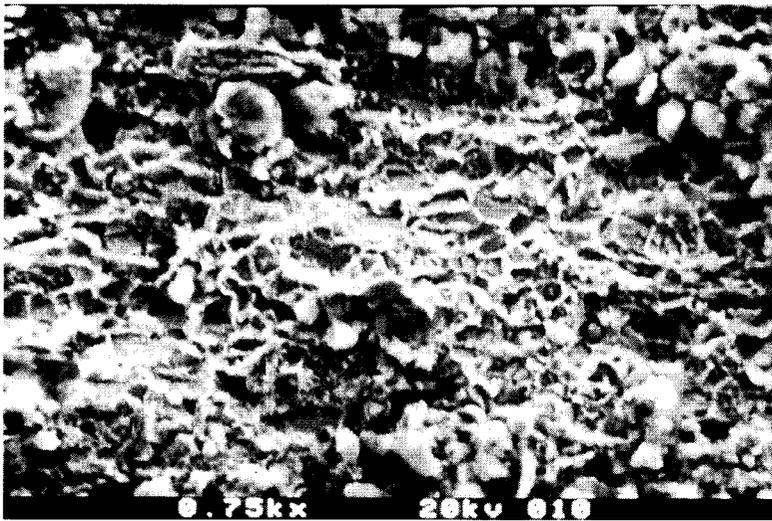


Figure 8—Interior of a corrosion pit in a plain specimen (VR slurry 2,75 m/s)

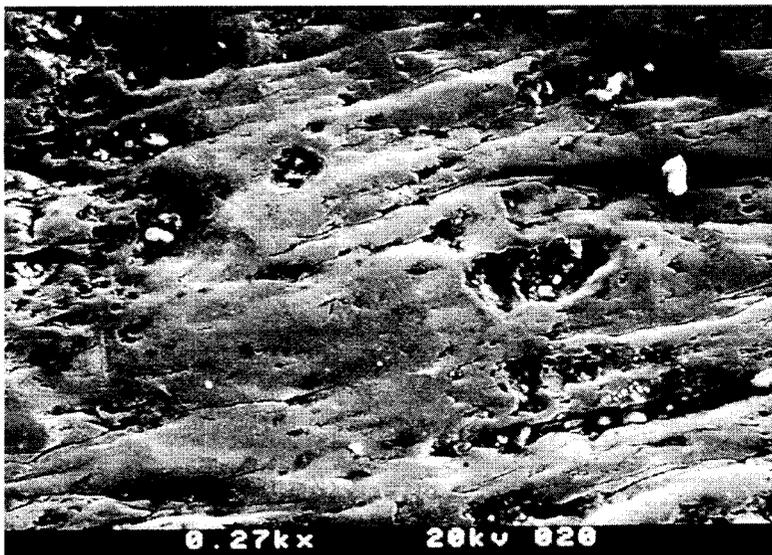


Figure 9—Pits and worn surface in a plain specimen (VR slurry 3,77 m/s and WDL slurry 2,77 m/s and 4,88 m/s)

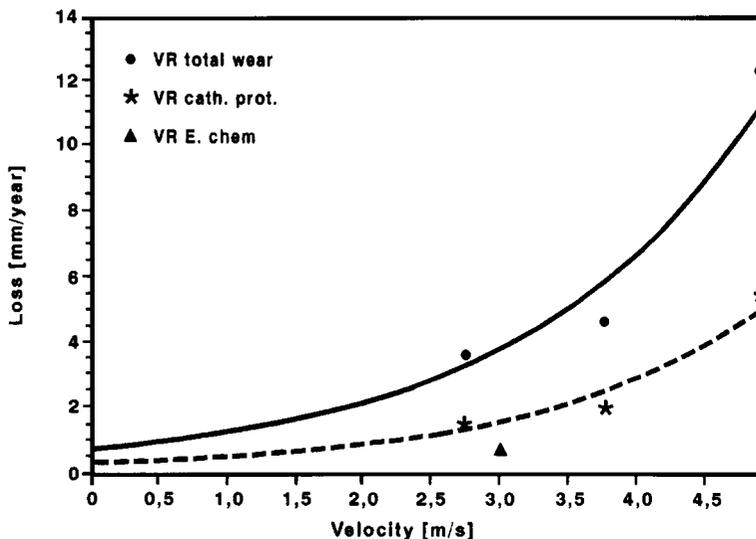


Figure 10—Wear rates in Vaal Reefs slurry

Figure 10 shows the loss in thickness for the plain and the cathodically protected specimens in the VR slurry extrapolated back to no flow. Thickness loss due to corrosion was obtained by Tafel extrapolation using an RCE (denoted VR. E. chem on the figure) for a speed of 3,0 m/s in clear slurry make-up water. As can be seen, the cathodically protected specimens (VR. cath. prot. in the figure), have a substantially lower mass loss. The value obtained for 3,77 m/s cathodically protected specimens appears to be low since it does not follow the pattern of the other VR or WDL results. Excluding this result, the effect of cathodic protection was to lower the wear rate to between 40 and 45 per cent of the wear rate without protection. This implies that corrosion or corrosion-erosion was responsible for at least 55 to 60 per cent of the total mass loss in this situation. When the data were converted to a wear rate per kilotonne of dry solids transported, a linear relationship emerged (Figure 11). The dotted lines indicate the effect of ignoring the questionable result obtained at 3,77 m/s (denoted VR CP mod. and VR total mod. in the figure).

The results obtained with WDL slurry are shown in Figure 12. In this case, the use of cathodic protection caused the total wear rate to decrease to a value of between 67 and 86 per cent of the total loss in mass. This effect is not as marked as with the VR results. There is concern, however, that the cathodic protection was not as effective at the potential used as it was in the VR tests, since the WDL water was found to be approximately 40 per cent more corrosive in the electrochemical tests using an RCE in clear water filtered from the slurry. (The electrochemical corrosion tests in slurry are indicated as 'WDL E. chem. in slurry' and are discussed later.) Areas of corrosion pitting were also found on the specimens when under examination with a scanning electron microscope (SEM). When the data were converted into millimetres of wear per kilotonne of dry solids, a straight line was produced (Figure 13). Corrosion data obtained from the electrochemical tests in slurry were also converted and were then superimposed on these results (denoted E. chem corr.).

The lead-in and lead-out pieces were weighed before the beginning of the tests, and were exposed in all the tests. In between tests, they were left partially wet, as would happen with backfill piping between cycles of slurry pumping. As expected, a loosely adherent layer of orange-brown corrosion product formed during this period. This layer was removed during each period of slurry pumping. A comparison of the total mass losses from the individual tests and the mass loss from the lead-in and lead-out lengths is given in Table IV. This shows that there was an apparent increase of 45 per cent in the total mass loss. This was probably due to the corrosion occurring during the 20 hours between cycles of slurry pumping.

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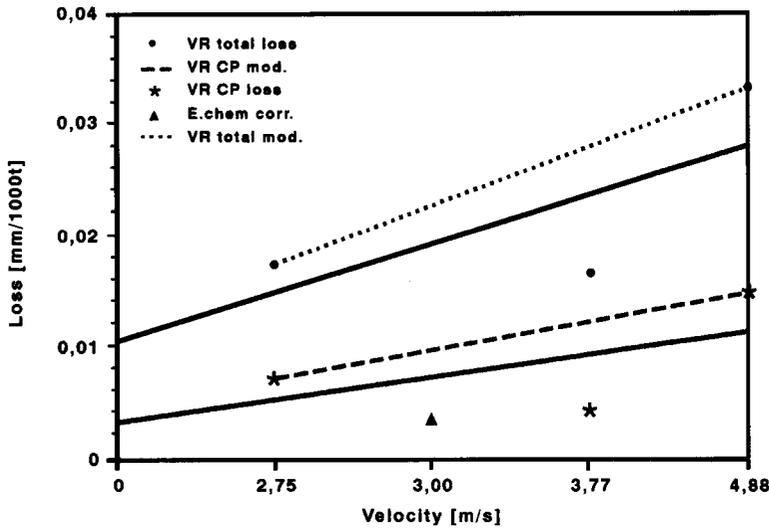


Figure 11—Wear rates in Vaal Reefs slurry expressed in terms of tonnes of dry solids

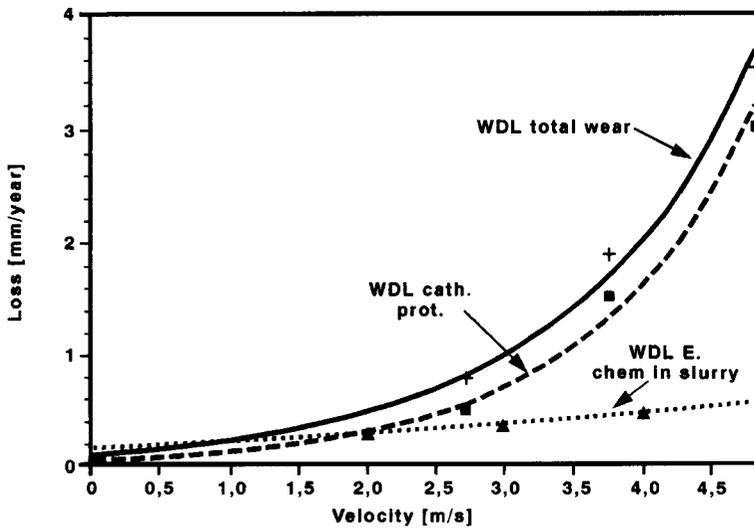


Figure 12—Data for WDL slurry

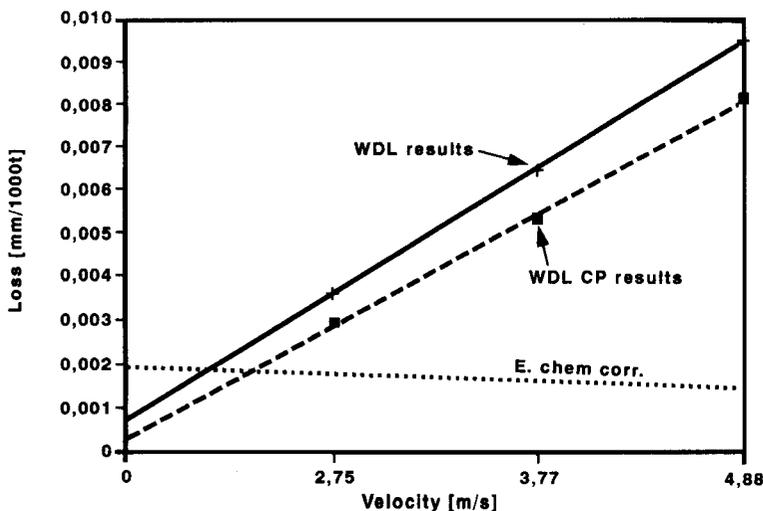


Figure 13—WDL data expressed as a function of the mass of solids pumped

RCE Tests

In these tests, the effect on the corrosion rate of solids added to the water was determined. The expected result was an increase in corrosion rate as measured electrochemically when solid particles were added. However, as Table V illustrates, there was, in fact, a substantial decrease in electrochemical corrosion rates after solid particles had been added to the water. This result was completely unexpected. The RCE test had been found by Mintek¹⁰ to correlate well with corrosion rates in actual pipes. However, this correlation had been developed for clear water only. As the unexpected result here may be the subject of further investigation, no attempt is made to explain it in this paper.

The effect of de-aeration and the addition of a corrosion inhibitor (NaNO_2) on the corrosion rate with both clear water and slurry was examined. Very substantial decreases in corrosion rate were obtained. The inhibited corrosion rate was approximately the same for slurry and clear water in both the VR and the WDL slurries.

The RCE was then used for the measurement of mass losses in slurry, both with and without the addition of inhibitor. Substantial decreases (approximately 96 per cent) in the mass loss were achieved through the use of inhibitor, as shown in Table VI. This implies that the mass loss is due almost solely to a corrosion mechanism, and that erosion plays little part in the process. The conclusion drawn from this is that, while the RCE may be suitable for rapid corrosion testing in clear water, the wear mechanisms associated with it are not equivalent to those in a pipe transporting slurries. It was also found that the mass loss was linear with time, even though the slurry was not replenished over a period of 140 hours. A pure corrosion situation is more likely to have given a decreasing rate over time, as found by Higginson¹¹ in his work on mine waters.

Degradation of the slurry over time would also be expected to provide a decrease in wear rate with time. Thus, it appears that the level of mechanical wear was sufficient only to maintain a 'clean' surface so that the corrosion rate remained constant rather than decreasing with time due to the formation of corrosion products on the surface.

In an examination of the variation of corrosion rate with velocity in WDL slurry, a linear relationship was found between 2 and 4 m/s, which again did not follow the relationship seen with pipe wear.

That there was some component of wear was apparent in that the specimens in the tests conducted in slurry were bright and 'polished' at the end of the tests, whereas in clear water the specimens had a visible corrosion layer on the surface.

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Table IV

The mass loss in lead-in and lead-out pieces, and the total mass loss in plain specimens over all the tests

Specimen	Mass loss, g/m	Difference
Lead-in and lead-out pieces	Mean = 27,10 $\sigma = 1,16$	45 % increase
All plain specimens	18,65	

Table V

Results of the RCE electrochemical tests

Test	VR		WDL	
	Corrosion potential mV	Corrosion rate mm/year	Corrosion potential mV	Corrosion rate mm/year
Water, 3 m/s	-537	2,51	-550	3,52
Water (3 m/s) de-aerated + inhibitor	-402	0,03	-473	0,06
Slurry (2 m/s)	-	-	-506	0,29
Slurry (3 m/s)	-525	0,80	-546	0,35
Slurry (4 m/s)	-	-	-542	0,47
Slurry (3 m/s) de-aerated + inhibitor	-491	0,06	-549	0,08

Table VI

Results of mass-loss tests with the RCE

Test	Thickness loss, mm/year	
	VR	WDL
Slurry (3 m/s)	5,11	5,34
Slurry (3 m/s) de-aerated + inhibitor	0,21	0,18

Table VII

Inhibitor results in the flowloop

Slurry	Velocity m/s	Decrease in wear rate, %
VR	3,77	80
WDL	3,77	47

Substantial differences were seen on the surfaces of the specimens exposed to the different conditions. Those exposed to WDL slurry in the mass-loss tests had numerous elongated pits on the surface that tended to link up to form semi-continuous grooves running around the circumference of the cylinder (Figure 14). The VR specimens had discrete pits with limited elongation in the flow direction (Figure 15). The specimens exposed to the inhibited slurries were very shiny with no macroscopic evidence of pitting. Under the SEM, some small areas where breakdown of the surface had occurred were visible (Figure 16), although this may have been due more to turbulence at rough points on the surface than to corrosion alone.

Flowloop Tests in Inhibited Slurry

The processed results from this work are given in Table VII. The greater decrease in wear rate when a corrosion inhibitor was used than was obtained with cathodic protection was expected since, as previously discussed, it is believed that full cathodic protection was not achieved. The cathodic protection thus appears to have been only 70 to 75 per cent effective at the potentials used.

The decrease in mass loss resulting from protecting the pipes against corrosion gives an indication of the effect of corrosion on the total wear. Previous work done for Anglo American Research Laboratories¹² indicated that, in Vaal Reefs slurry, the corrosion rate in clear water was approximately 33 per cent of the total wear rate in slurry (tests done in an ASTM A106 tube of ID 22,5 mm). Those results took into account only pure corrosion and did not allow for the synergy between erosion and corrosion. Also, the corrosion rate given was the average corrosion rate, which would have decreased over time since the build-up of corrosion products on the surface would have probably slowed down the corrosion reaction over time. Thus, it would be expected that the total corrosion-related component in the wear rate would be substantially greater than 33 per cent. This was borne out in the present tests since, in the VR slurry, corrosion and its related effects were seen to account for a total of 55 to 60 per cent of the wear rate when cathodic protection was used, and 80 per cent when a corrosion inhibitor was used. Postlethwaite³ found that, in a slurry consisting of 20 per cent (by volume) silica sand (30 to 50 mesh) and water containing 3130 ppm of chlorides, corrosion was the dominant mode of metal loss. His final conclusion was that measures to control 'wear' in straight runs of slurry pipeline should focus on corrosion control, rather than on the use of erosion-resistant piping.

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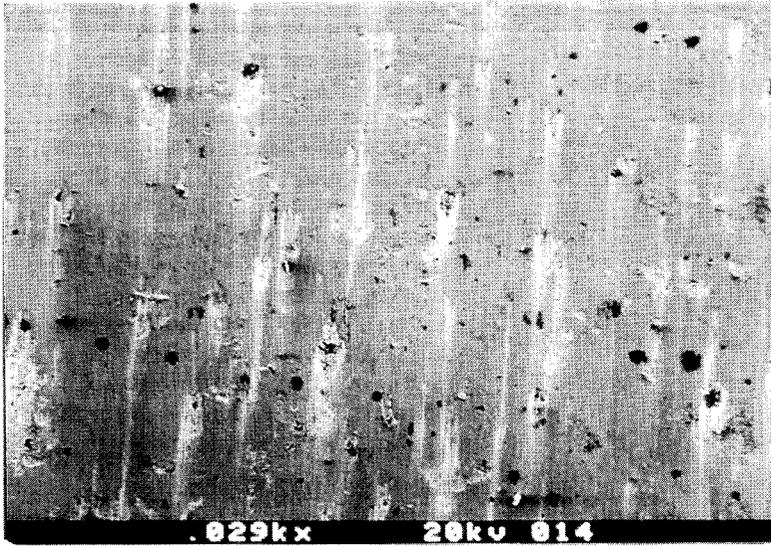


Figure 14—Photomicrograph of the surface of an RCE specimen after exposure for 140 hours at 2168 r/min in WDL slurry, showing elongated pits

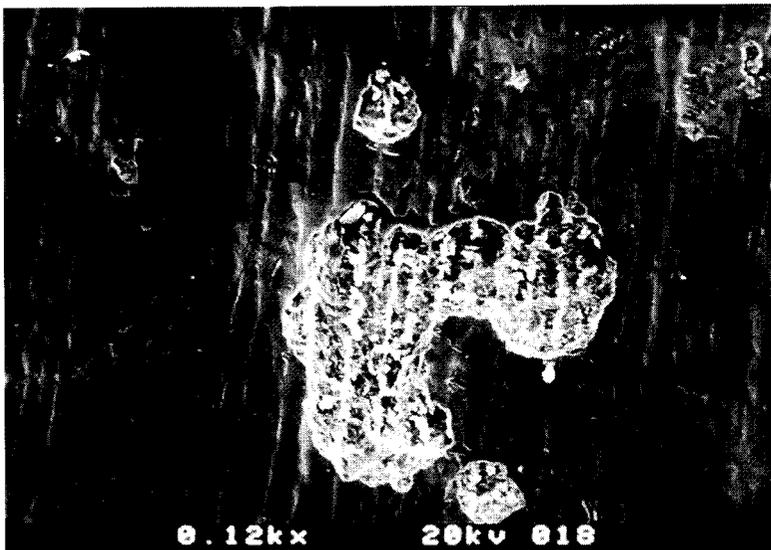


Figure 15—Photomicrograph of the surface of an RCE specimen after exposure for 140 hours at 2168 r/min in VR slurry, showing pitting

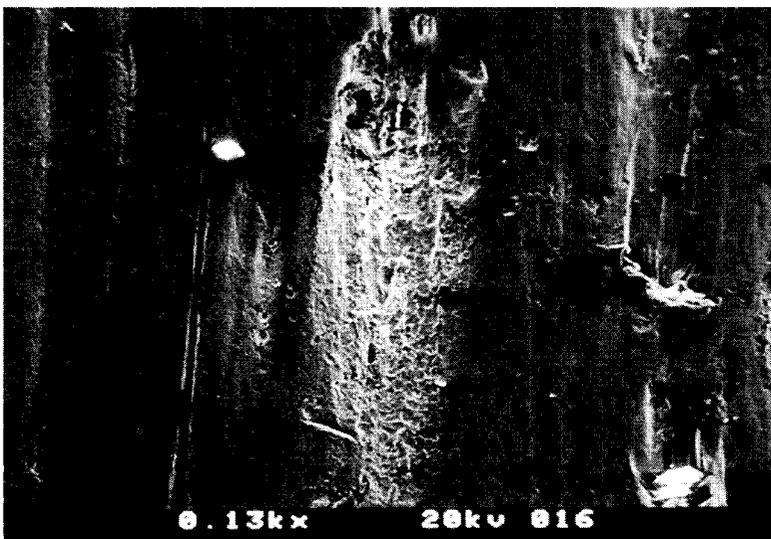


Figure 16—Surface of an RCE specimen after exposure for 140 hours in inhibited slurry, showing very small pits

In a slurry consisting of 31 per cent (by mass) aluminium oxide (200 to 250 mesh) and water containing 1000 ppm of Na_2SO_4 at a pH of 9, inhibition and cathodic protection reduced the mass loss by 43 per cent and 48 per cent respectively². In that work, the authors used these corrosion-control techniques so that a direct comparison could be made of the erosion resistance of various materials. This is, of course, relevant to the backfill situation, where materials are frequently compared on the basis of their erosion resistance, whereas they are really being compared in terms of their resistance to the combined effects of erosion and corrosion. Thus, in a backfill slurry, any polymeric material would gain an advantage over mild steel, even if its erosion resistance was only the same as that of mild steel. A survey on wear and corrosion in the mining industry¹³ indicated that, because of the difficulty in recognizing corrosion as a separate entity in slurry-transportation systems, most personnel identified failures as being due to erosion. De Jongh and Morris¹⁴, in reporting Brabyn's results, point out that corrosion had been found to account for 70 per cent of the wear caused by rod-milled waste, and 95 per cent of the wear caused by classified tailings.

Cost Implications

If corrosion accounts for up to 80 per cent of the mass lost by steel piping for the slurries considered in the velocity range up to 4.9 m/s, there is a strong indication that corrosion control must be investigated when carbon-steel piping is to be used. If corrosion accounts for approximately 60 to 80 per cent of the mass loss in the transportation of VR slurry and 33 to 47 per cent in the transportation of WDL slurry, the costs associated with pipewall wear due to corrosion can be calculated.

The beneficial effects of backfilling in deep-level gold mines have been established, and depend on three main operational parameters:

- the fill-to-face distances (6 m or less)
- good fill contact with the hangingwall
- a high percentage of filled area (60 per cent of the mined area as a minimum).

In addition, the distribution system must be designed so that slurry velocities are minimized (and therefore so that full-flow conditions exist). This will reduce the effect of wear to a minimum (although it could still contribute significantly to the total cost of backfilling).

The actual recorded cost per tonne of backfill associated with wear is difficult to estimate reliably in the short term. This is because the wear-associated cost is not very significant until the pipe ranges actually start failing. The costs are also strongly and adversely influenced if there are free-fall conditions in the pipe range.

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At Vaal Reefs, where free-fall conditions existed in schedule 80 pipes (with a nominal bore of 50 mm), the replacement cost due to pipe wear exceeded R3,00 per tonne of fill placed. At other Vaal Reefs sites, the costs were less than R0,10 per tonne placed, but the overall tonnage per range was still relatively low.

At Western Deep Levels, where schedule XXS pipes (with a nominal bore of 80 mm) are used, the current replacement cost associated with the wear of backfill pipes is around R0,05 per tonne, but this figure will rise as the tonnage increases and more failures occur.

It should be noted that all these costs are associated with mild-steel (grade A106) pipes, and that figures are not yet available for the other pipes used owing to the low tonnage placed via each range to date.

Conclusions

The research has shown that corrosion and, more importantly, the corrosion-erosion interaction contribute a significant portion of the overall wear (loss in pipe mass) in backfill pipelines (up to 80 per cent). This conclusion is drawn for two typical backfill materials under various flow conditions.

Where steel piping is used, attempts to reduce the overall wear rate should include measures to reduce the corrosion effect. A viable and cost-effective alternative is the use of a corrosion-resistant lining (such as polyurethane).

Cathodic protection of the test samples of steel pipe was found to be problematic in the transportation of backfill slurries owing to the plating-out of metallic ions and the formation of scale.

With any backfill pipeline, it is essential that the flow velocities are reduced to a minimum (i.e. full-flow conditions must prevail). This will assist in reducing the wear rate significantly since

Wear \propto Velocity²

Cold comfort for CFCs*

World refrigeration expert Professor Günter Heinrich, at the invitation of the School of Mechanical Engineering at the University of the Witwatersrand (Wits), recently addressed industry representatives in Johannesburg on alternative refrigerants.

Professor Heinrich is managing director of the Institut für Luft- und Kältetechnik (ILK), Germany's largest privately funded institute for research into refrigeration and air-conditioning. According to John Sheer, John Orr Professor of Mechanical Engineering at Wits, the visit was significant in terms of both the Montreal Protocol and research activities within the School of Mechanical Engineering.

The seminar attracted some 45 people from industry, indicating current interest in the Montreal Protocol, in terms of which signatory countries have agreed to cease production of CFCs by the end of 1995. The items discussed included new refrigerants, paths of changeover, and further utilization of existing plants.

'Although some local industries already have short-term solutions, the School of Mechanical Engineering has recently embarked on a long-term research programme on alternative refrigeration processes', says Professor Sheer.

'Professor Heinrich's interest in our work has resulted in valuable co-operation, one example being the joint supervision by the Professor and myself of a local M.Sc. student's thesis on the use of mixtures of refrigerants.'

One of the refrigeration techniques that Professor Heinrich believes would be particularly attractive in Southern Africa is evaporative cooling using the Desiccative and Evaporative Cooling (DEC) process.

'While cooling by adiabatic humidification has been in use successfully for decades, particularly in the textile and mining industries', says Professor Heinrich, 'new applications have recently been established in all fields of air-conditioning in which the cooling effect is increased by drying the air before it is humidified. Through sorptive drying followed by heat recovery, combined with the evaporative cooling of water into the unsaturated air, the cooling effect becomes technically more useful. The DEC-process is realized with a DEC plant, which incorporates a sorption-regenerator wheel packed with desiccant-treated paper or fabric material.'

An agreement has been reached between the ILK and a local company on the marketing of this technology.

* Lynne Hancock Communications, Honeydew 2040.