

The Anodic Protection of Steel

A REVIEW OF RECENT PROGRESS

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The use of anodic protection of steels against corrosion in various solutions has been well authenticated by laboratory experiments. However, the method has been little used by the chemical industry. This article summarises the basic principles of the technique and describes the substantial successes obtained in these field trials reported up to the present time.

The well-known method of corrosion protection of metals by cathodic currents has been widely applied. However, the protection of steel by anodic currents, first suggested by Edeleanu (1, 2, 3, 4) has been less used. This is unfortunate, since in certain instances the anodic method can give results which are not possible by any other technique.

This method of protection of steel relies on the formation and maintenance of an oxide film by anodic polarisation. The passivation is achieved when the potential difference between the solution and the steel is maintained at a particular value within a limited range. The determination of this range, and its application to practical problems of corrosion protection have been described by Edeleanu (4) and by Sudbury, Riggs and Shock (5, 6). They have shown that laboratory results can be easily and accurately applied to plant scale protection, and that the passivating film has a very high ohmic resistance, in the region of 10^4 – 10^6 ohm/sq. cm. This high resistance is reported to be responsible for the excellent throwing power of the technique, and it was found practical to protect apparatus of complex geometry by one electrode system, which may even be mounted remote from the protected steel.

Riggs, Hutchison and Conger (7) have reported the results of anodically protecting a sulphonation plant. The vessels included a

stainless steel reaction tank, and a mild steel storage tank for concentrated sulphuric acid. A ten times improvement in the level of iron contamination was recorded, so that, in addition to the reduction of corrosion, an improved product was obtained.

A recent report by Fisher and Brady (8) of the Monsanto Chemical Co, St Louis, gives the results of protecting a mild steel tank against 100 per cent sulphuric acid. Their problem was that the acid during storage was being contaminated by iron, samples taken over a period of three months showing an average increase of 114 p.p.m. iron. Laboratory trials using the same steel indicated that the corrosion could be reduced from 27×10^{-3} inches per year to 0.8×10^{-3} inches per year, corresponding to a reduction of iron pick up of 3–4 p.p.m.

The equipment as installed in the tank consisted of a silver/silver chloride reference electrode and a platinum clad cathode. At the same time a rack holding steel test pieces at various levels in the tank was fitted. Half of these coupons were electrically connected to the tank, whereas the remainder were insulated, thus giving comparative results for the protection obtained.

The DC power supply was capable of 29.5 volts, and when this was connected between the tank and the platinum cathode a current of 12 amperes was passed. It was found that

under these conditions the potential between the tank and the reference electrode rose to 900 mV in 45 minutes. The potential was then controlled by an interesting cycling technique. Instead of maintaining the vessel at a fixed potential within the passive range, using expensive potentiostatic equipment, the current was switched off at the level of 900 mV, and the potential then slowly fell to 800 mV. At this potential the current was switched on again, at a level slightly greater than that required to maintain stable conditions, and the potential climbed slowly back to 900 mV. This cycle was repeated indefinitely, and the vessel remained throughout within the passive range. The control equipment required for this is considerably less complex than for the potentiostatic method.

When the equipment was first started the controller was switching the current on for about sixty per cent of the time, but this percentage fell steadily, and after twelve hours steadied at a level of ten per cent.

No difficulty was experienced with variations of acid level, the polarising current flowing for a greater proportion of the time immediately after the additions, and falling back to 10 per cent after about twelve hours. It was found that the dissolution of the passive film after switching the current off also took about twelve hours, so that protection is maintained for this time. This gave a substantial leeway for any period that the control equipment was out of service. The results obtained by this device were in good agreement with the laboratory trials, the iron pick up into the acid during storage being reduced from the original 114 p.p.m. to an average of 9 p.p.m. Also the protected test coupons showed an average improvement in corrosion to only 10.4 per cent of that shown by the unprotected examples.

It is clear from this report that the technique offers an easy and cheap method of using ferrous materials for construction that would otherwise be unsuitable for the

environment. It is also possible to design plant with a lower safety margin, knowing that anodic passivation will maintain stable conditions. Provided that the preliminary investigations are adequate and the instrumentation complete, the technique has shown that a considerable saving in cost can be achieved with no sacrifice of safety.

References

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Longer Life for Iridium Crucibles

RHODIUM PLATING AND BRAZING

Iridium crucibles are frequently used in growing single crystals of high melting point materials but hitherto their lifetime has tended to be short. R. S. Horwath and C. Whiteley, of Sperry Electronic Tube Division, Sperry Rand Corporation, have now reported (*J. Electrochem. Soc.*, 1963, **110**, (5), 467) that rhodium plating extends the life of new or slightly used crucibles several times and that minor cracks can be repaired by brazing with either platinum or rhodium.

Rhodium plating was chosen because rhodium has a lower vapour pressure than iridium and a higher melting point than platinum. After plating with 0.0002 inch rhodium and heat treatment at 1650°C for 16 hours the cycle is repeated, and the crucible life may well increase from 50 up to about 300 hours.

Cracks may be repaired by spot welding platinum or rhodium wire into the filed-out defects, followed by R.F. heating of the crucible to melt the filler wire which then flows into the crack and seals it as in any other brazing operation.