The Use of Cathodic Protection in Sewage Treatment Plants

V. T. Purohit

Electro Corr-Damp, Bombay

It has been explained and generally accepted that the corrosion of metals immersed in water or buried in ground is due to electrolysis, that is, due to the flow of direct current from one part of the metal to the other. It has also been explained that the corrosion takes place in the areas conventionally called negative, and the areas conventionally called positive are protected. The feasibility of providing cathodic protection to prevent corrosion of immersed and buried structures and its economics is now universally accepted. The basic principles and theory of cathodic protection is explained in a separate paper, and this paper will discuss how cathodic protection can be applied to sewage treatment plants.

Continued immersion of steel in sewage treatment plants causes serious corrosion because of low resistivity of water which is proportional to total dissolved salts. This corrosion is further aggravated as some parts of the structures are partially immersed and the variation of sludge levels causes waterline corrosion.

Surface conditions

While considering possibility of applying cathodic protection to sewage treatment plants, the plants have to be considered in two groups:

(i) Proposed new plants,
(ii) existing plants.

This division is necessary because the capital cost of cathodic protection is primarily determined by the condition of the paint on the surface of such structures. The maintenance and running charges are also largely proportional to the paint systems, a paint system with proper specifications goes a long way in minimising these costs.

Proposed new structures

It would be good practice if all the sections are painted before assembly with coal tar epoxy. In order that the paints have a good bond with the metal surface, the surface should be very clean before the paints are applied. Any dirt, grease or oil film, mill scale which is cathodic to mild steel, have to be thoroughly removed, and unless the metal surfaces are sand blasted, it is likely that these costly paints would not justify their application. Any paint film damaged during construction should also be repaired. This initial expense would be more than compensated by the reduced current requirement for cathodic protection. Besides, when painted with such good paint, designing of the cathodic protection system is not very difficult.

Old structures

It is not possible to paint the existing structures unless a long shut down is taken and this is usually not practicable. If good quality painting system is not possible to apply, the structure would require 4 to 6 times more current than when a coal tar epoxy paint is used. Also, the installation of the cathodic protection system may make it necessary that a few days shut down is taken.

Cathodic protection

The two methods available to the corrosion engineer have to be compared for their cost and performance;

	Sacrificial Anode System	Impressed Current System
(1)	Requires replacement every 2-3 years.	Replacement required every 7-8 years.
(2)	Current output of anodes cannot oe controlled once the installation is designed and commissioned.	The current outpıt can be monitored and re-adjusted because of fine voltage control.
(3)	Too many number of anodes, and heavier weight to be supported.	Compact and less number of anodes.
(4)	No A.C. power is ıequired.	A.C. power is necessary.
(5)	To make it technically efficient, magnesium anodes may have to be used on old or on poorly painted structures and this would require an import licence.	Even large current capacity rectifiers are available from local markets to meet the demands of such old structures.
(6)	If capital cost Rs. X thousand the same amount will be required every 3 years or so, but there is no running cost.	The capital cost will be about Rs. 1.33X for 7 to 8 years-life; replacement cost after that period will be about 0.50X every 8 years, nominal running cost.
(7)	Requires no supervision and maintenance.	This would require daily inspection, and occasional maintenance brush gears etc.
(8)	Very little possibility of hydrogen gas formation and hence no explosion hazards.	Tends to liberate hydrogen gas, and may become a cause of explosion if the ventilation is restricted.

Sacrificial anodes system

This system uses blocks or cylinders of metals which are baser to iron in the electrogalvanic series. The most commonly used metals for this purpose are magnesium, zinc and aluminium alloys. The magnesium alloy can discharge large amount of current and thus for a given surface area only a few anodes would be required. But unfortunately, magnesium has to be imported in our country, and its casting technique is more difficult than that of the other two. Thus the use of magnesium alloy anodes is 8 to 10 times more costlier than the other two metals even when magnesium anodes are some how procured. Zinc anodes are ideally suited for this type of protection; although it is imported, it is not as difficult to procure as magnesium. But the metal will have to be atleast 99.95%

pure, (the iron content to be practically zero), otherwise these anodes will become passivated and will loose their capacity to discharge current. An aluminium alloy has been used extensively now for the purpose of cathodic protection for marine structures and its use in sewage treatment has also met with reliable results.

A suitable section of mild steel is cast integrally with the blocks of zinc or aluminium alloys and these inserts are welded to the structure to be protected such that the anodes are below the lowest water line. The spacing between each anode has to be worked out depending on the size of the anodes used and of course the metallurgy of the anodes. Fig. 1 gives a view of aluminium anodes fitted to the moving arms in a sewage treatment plant.

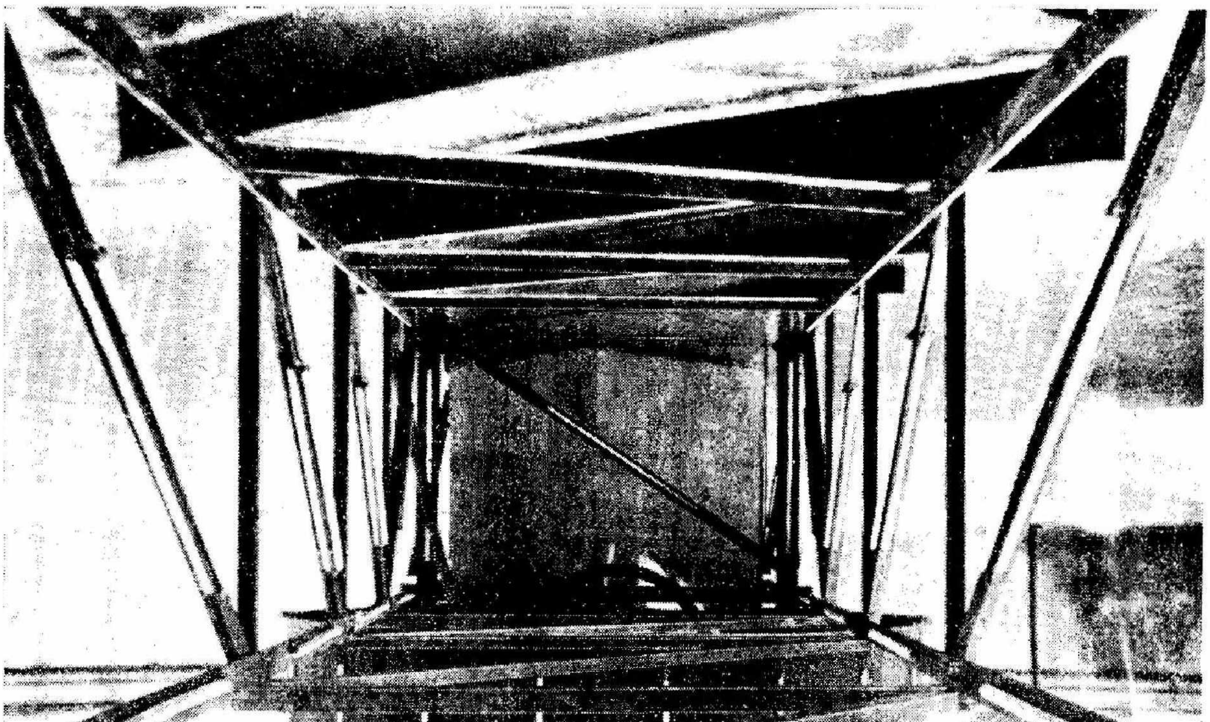

FIG. 1

Impressed current system

This system can use rods preferably of high silicon cast iron or of mild steel connected to the positive terminal of the D.C. source of electric power. Since, the discharge capacity of these anodes is very much larger than the sacrificial anodes, only a few such anodes are required; but because of higher voltage available, the anodes have to be perfectly insulated from the structure to be protected. The negative terminal is connected to a stationary point of the structure and the rotating or moving parts are connected to it by suitable rotating or brush gear connections. The D.C. power is obtained mostly from rectifiers operating on normal 230 V or 440 V supply The voltage needed for the system will be less than 12 V and power consumption of about Rs. 40.00 per month.

Limitations of the system

Those structural members having complicated configuration, small corners or areas having shielding effect by other structural members, cannot be protected by this method unless special attention is paid to the location of anodes. It is difficult to install anodes in small corners and thus such parts will not get complete protection. If these get partial protection, the corrosion rate will be retarded to that extent. The impressed current system may involve the use of a brush-gear for the rotating arms and these tend to develop loose contact. These parts may get jammed due to the corrosive atmosphere and would require regular cleaning.

Cost

As explained earlier, the current required for cathodic protection is the function of (a) total dissolved solids in the liquids, (b) the quality of the paints system, (c) the turbulence of the water, (d) and the size of the structure. The cost will also depend on the system used, that is whether a sacrificial anode system or an impressed current system is employed. These variables would demand that each system should be, as is generally a practice in all cathodic protection designs, evaluated individually so far as the cost is concerned. However, only as a guideline, it can be said that the cost in Bombay of reliable protection on a bare surface will be approximately Rs. 12-50 per sq. m. for one year's protection using sacrificial anode system with no power consumption, whereas the cost with impressed current system will be approx. Rs. 5.00 per year's protection and the power cost will be about Rs. 0.10 per sq. m. per month, if the electrical energy is available at about Rs. 0.25 per unit. This cost is worked out on a structure with a surface area of approximately 400 sq. m. The cost of protection on a large area will tend to become less, and on smaller area, this cost will be very much increased. For a well coated mild steel surface the cost would be about 1/4 th of the cost mentioned above.

Conclusions

Corrosion is a continuous process and the corrosion of mild steel areas immersed in sewage, which are not easily accessible for repairs or painting, can only be prevented successfully by cathodic protection. The prevention of corrosion will enhance the life of the structures which operate in a very corrosive environment. The degree of success however will be measured in terms of the reliability of materials used and the ingenuity of the designs.