



The Corrosion Prevention

There are two principal methods by which corrosion may be prevented or minimized. First, the metallic surface can be insulated from the corrosive medium by some form of protective coating. Such coatings include various types of paints and varnishes, metallic films having good corrosion-resistance and artificially thickened oxide films. All of these are generally effective in protecting surfaces from atmospheric corrosion, though zinc coatings are used to protect iron from the rusting action of water, whilst tin coatings offer protection against most animal and vegetable juices encountered in the canning industry.

In circumstances where corrosive action is severe, or where mechanical abrasion is likely to damage a surface coating, it may be necessary to use a metal or alloy which has an inherent resistance to corrosion. Such corrosion-resistant alloys are relatively expensive, so that their use is limited generally to chemical-engineering plant, marine-engineering equipment and other special applications.

There are many types of the protection from corrosion, which they are:-

1. The Use of a Metal or Alloy Which Is Inherently Corrosion-resistant

The corrosion-resistance of a pure metal or a homogeneous solid solution is generally superior to that of an alloy in which two or more phases are present in the microstructure. As mentioned above, the existence of two phases leads to electrolytic action when the surface of the alloy comes into contact with an electrolyte. Most of the alloys which are used because of their high corrosion-resistance exhibit solid-solution structures. Aluminum-magnesium alloys containing up to 7-0% magnesium fulfil these conditions and are particularly resistant to marine atmospheres. Stain less steel of the "18-8" type is completely austenitic in structure when correctly heat-treated, but faulty heat-treatment may lead to the precipitation of carbides and, hence, to corrosion. Although such corrosion is partly due to the impoverishment of the austenitic matrix in chromium (since it is mainly chromium carbide which is precipitated), this corrosion is accelerated by electrolytic action between the carbide particles and the matrix. "Weld-decay" in steels of this type occurs for similar reasons.

2. Protection by Metallic Coatings

Protection afforded by metallic coatings can be either "direct" or "sacrificial". Direct protection depends on an unbroken film of metal covering the article, and if the film becomes broken, corrosion may be accelerated by electrolytic action between the film and the metal beneath. In the case of sacrificial protection, however, the metallic film becomes the anode in the event of a break in the film, and thus dissolves in preference to the surface beneath. It follows that, when protection is limited to the direct type, as in the case of tin coatings on steel, the quality of the coating is most important, since acceleration, and not inhibition, of corrosion would follow a break in the film. In both cases, of course, protection of the direct type is the fundamental aim of the metal-coating process, and it is only in the possibility of the coating becoming broken that the effects of electrolytic action must be considered.

A number of methods are available for the production of metallic coatings. The most widely used are either electro-plating or dipping the articles to be coated into a bath of the molten metal. In some cases a successful coating can be produced by heating the articles to be coated in the finely powdered metal, whilst specialized use is made of the process known as "cladding".

2.1 Cladding.

This process is applicable chiefly to the manufacture of "clad" sheet. The basis metal is sandwiched between pieces of the coating metal, and the sandwich is rolled to the required thickness. "Alclad", which is duralumin coated with pure aluminum, is possibly the best known of these products, whilst "Ni clad" (nickel-coated steel) is also manufactured.



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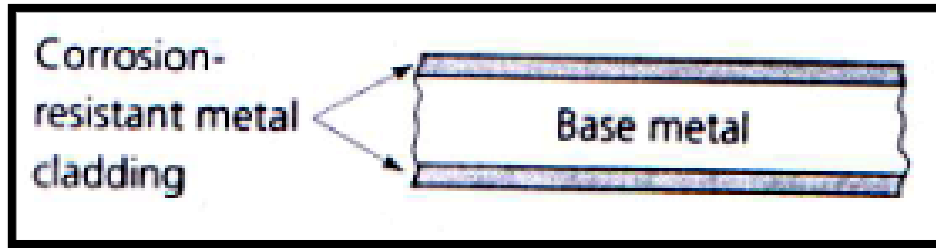


Figure 1. Sectional through clad metal composite.

2.2 Hot-dip Metal Coating

Tin and zinc are the metals most often used to produce metallic coatings in this manner, though increasing use is being made of aluminum.

- (a) Hot-dip Tinning.
- (b) Hot-dip Galvanizing
- (c) Hot-dip Coating with Aluminum.

2.3 Coating by means of a spray of molten metal

Metal spraying consists in projecting "atomized" particles of molten metal from a special pistol by a stream of compressed air on to a suitably prepared surface. Surface preparation usually involves blasting the surface with an abrasive; steel grit having replaced sharp silica sand for this purpose on account of the silicosis hazards involved when the latter is used. The metal most commonly used for spraying is zinc, though coatings of aluminium, tin, lead, solder, cadmium, silver, copper and stainless steel can be deposited in this way.

In yet another process invented by **Dr. Schoop**, the originator of metal spraying processes, electricity is used in place of gas for heating in those pistols which utilize zinc wire. In this pistol an arc is struck between two zinc wires so that their ends melt continuously as the wires are fed forward. The metal particles are carried forward by a stream of compressed air.

Metal spraying has wide application in view of its portability and flexibility; thus, large structures, such as storage tanks, pylons and bridges, can be sprayed on site. Notable recent examples include the Forth Road Bridge and the Volta River Bridge (Ghana), both of which were zinc coated using modern developments of the Schoop process.

2.4 Electro-plating

The formation of metal coatings by electro-deposition is well known, and a wide variety of metals can be thus used, including copper, nickel, chromium, cadmium, gold and silver. Tin and zinc can also be electro-deposited, and a coating thus formed has advantages over one produced by hot-dipping in respect of flexibility, uniformity and control of thickness of film.

In the actual process of electro-plating the article to be plated is made the cathode in an electrolytic cell. Sometimes the metal to be deposited is contained, as a soluble salt, in the electrolyte, in which case the anode is a nonreactive conductor, such as stainless steel, lead or carbon. In most cases, however, the anode consists of a plate of the pure metal which is being deposited, whilst the electrolyte will contain a salt or salts of the same metal. Then, the anode gradually dissolves and maintains the concentration of the metal in the electrolyte as it is deposited on to the articles forming the cathode.

The conditions under which deposition takes place are very important, so that the cell voltage, the current density (measured in amperes per square meter of cathode surface), the ratio of anode area to cathode area and the time of deposition, as well as the composition and temperature of the electrolyte, must all be strictly controlled if a uniform adherent and non-ferrous film is to be obtained.

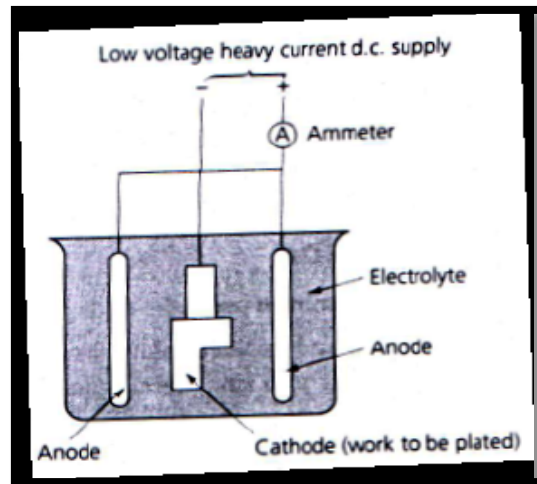


Figure 2. The electro plating.

3. Protection by oxide coating

In some instances the film of oxide which forms on the surface of a metal is very dense and closely adherent. It will then protect the metal surface beneath from oxidation. Stainless steels owe their resistance to corrosion to the presence of a high proportion of chromium, which is one of these elements that form oxide films impervious to oxygen. The "blueing" of ordinary carbon steel by heating it in air produces an oxide film of such a nature that it affords partial protection from corrosion.

Anodizing. Reference has already been made to the protection afforded aluminum by the natural film of oxide which forms on its surface. Anodic oxidation, or anodizing, is an electrolytic process for thickening this oxide film. This process may be applied for several reasons, such as to provide a "key" for painting, to provide an insulating coating for an electrical conductor or to provide a surface which may be dyed, as well as to increase the resistance of aluminum to corrosion.

Before being anodized the surface of the article must be chemically clean. Preliminary treatment involves sand-blasting, scratch brushing or barrel polishing, according to the nature of the component. This is followed by degreasing in either the liquid or vapor of electrolytic cleaning.

In the actual anodizing operation which follows, the aluminum article to be treated is made the anode in an electrolyte containing either chromic, sulphuric or oxalic acid; the cathode being a plate of lead or stainless steel. When an electric current is passed, oxygen is formed at the anode and immediately combines with the aluminum surface of the article. The layer of oxide thus formed grows outwards from the surface of the aluminum. The normal thickness of a satisfactory anodic film produced commercially varies between 0.007 and 0.015 mm., and a film having a thickness within these limits would be formed by anodizing a component in a 15% sulphuric acid solution at 20° C for about thirty minutes, using a current density of about 100 A/m² at a cell voltage of 15. A longer period of treatment produces a thicker, but soft and spongy, film which would be unsatisfactory in service. The thickness of the natural film produced on an aluminum surface by exposure to air at normal temperatures is of the order of 0.000 013 mm.

Anodizing

Aluminum and aluminum alloy components are cleaned and degreased. After which they are etched, wire-brushed or polished depending upon the surface texture required. The work is then made the anode of an electrolytic cell (see electroplating, where the work is the cathode) and a direct current is passed through the cell. The electrolyte is a dilute acid and varies with the finish and protection required. Colours may be integral or applied subsequently by dyeing. The purpose of the treatment is to increase the thickness of the natural, protective oxide film and improve the corrosion resistance of the metal.



4. Protection by other nonmetallic coatings

Coatings of this type usually offer only a limited protection against corrosion and are, more often than not, used only as a base for painting.

4.1 Phosphating

A number of commercial processes fall under this heading, but in all of them a coating of phosphate is produced on the surface of steel or zinc-base alloys by treating them in or with a solution of acid phosphates. In order that the metal shall be made rust-proof a finishing treatment with varnish, paint, oil or lacquer is required.

4.2 Chromating

Chromate coatings are produced on magnesium-base alloys, and on zinc and its alloys, by immersing the articles in a bath containing potassium bichromate along with various other additions. The colour of the films varies with the bath and alloy, from yellow to grey and black.

5. Cathodic protection

This method of protection against corrosion can be used for buried or submerged pipe-lines and other structures. The pipe-line is made to act as a cathode by burying near it pieces of a metal which is much more electropositive than the iron of the pipe-line. These pieces of metal will therefore be anodic towards the iron of the pipe-line and will corrode sacrificially.

Alternatively, a current from D.C. mains can be passed through the soil or water on to the metallic surface concerned so as to keep it at a slightly negative potential with respect to its surroundings. When electric power is available this will be the cheaper method, since electricity can be obtained more cheaply from the mains than from any electro-chemical source. To protect the whole surface of a pipe-line by this means, however, would be expensive, but if the pipe has already been coated with paint or some other non-metallic substance, so that it is only necessary to protect any defective areas, the power cost is small, since very small currents only are necessary. In some parts of America the current is generated by dynamos driven by windmills.