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1:2 Corrosion theory

The meaning of the word corrosion is "the deterioration of the substance (usually a metal) or its properties because of a reaction with its environment". Normally it specifically applies to metals, although plastics and other non-metals such as concrete, bricks and timber also deteriorate in natural environments. Corrosion causes enormous losses, which rise yearly with the increased usage of metals in industrial development. The accepted concept of corrosion is that it is a result of an electrochemical reaction taking place on the surface of the metal where the metal is converted into metal oxides or other corrosion products.

With some metals, they produce a tight skin on the metal surface, which hinders further corrosion, and if this surface layer is broken it is self-healing. These metals are said to be passivated and include lead, nickel, cadmium, chromium and aluminium. Zinc corrosion products form a fairly tight layer on zinc and further corrosion is slow. A tight layer of iron and chromium oxides forms on the surface of stainless steel and is the reason for the resistance of this metal. Iron and steel, however, form rust as a corrosion product, which is porous, is not firmly adherent and does not prevent continued corrosion.

Corrosion mechanism

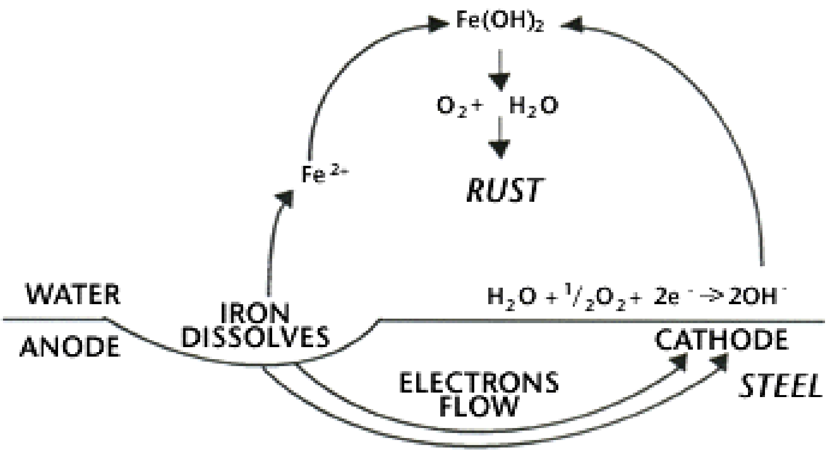
Steel is an alloy or mixture of iron and up to 1.7% carbon, sometimes with small quantities of elements such as manganese, phosphorous, sulphur and silicon. The corrosion resistance of steel is dominated by interactions between the constituents of the steel. The steel surface contains both anodic and cathodic sites. In the presence of a surface layer of water or other conducting solution an electric current passes between the anodes and cathodes. By convention the transmission of the current is by electrons, which are the electrical charges attached to atoms, and are generated at anodes. Their loss leaves the anodic areas deficient in electrons and iron goes into solution as ferrous ions viz.

Fe---------------------->	Fe^{+2}	+	$2e^-$	
Iron	Ferrous ions		Electrons	(anode reaction)

This reaction is the basis of the corrosion of iron. Electrons generated as shown above are consumed at the cathode area, and react there in various ways depending on the availability of oxygen. In normal atmospheric corrosion there is an ample supply of oxygen and the following reaction occurs.

Fe---------------------->		Fe^{+2}	+ $2e^-$	
Iron		Ferrous ions	Electrons	(anode reaction)
$H_2O + {}^1/_2\, O_2$	+	$2e^-$ ------------------->	$2OH^-$	
Water Oxygen		Electrons	Hydroxyl Ions	(cathode reaction)

The hydroxyl ions (OH^-) from the cathode combine with the ferrous ions (Fe+2) from the anode to form ferrous hydroxide, which is precipitated. This further reacts with oxygen and water to form hydrated ferric oxide, which is known as rust. This is shown as:



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The rate of rust formation rapidly increases if the transfer of electrons from the anode to the cathode can be made easier; which happens if the conductivity of the water increases. This can occur due to the presence of dissolved salts, such as sea salts, on the surface or sulphur products from pollution fallout.

In atmospheric corrosion it has been found that moisture is the controlling factor in the rate of rust formation and little rusting occurs unless the relative humidity is above 60-70%.

In contact with acids corrosion increases because of direct attack on the metal, while under alkaline conditions the rusting of iron is inhibited.

Prevention of rusting of iron and steel by painting

Three methods may be used.

1. An anti-corrosive priming paint applied direct to the steel surface and containing an inhibiting pigment will inhibit the occurrence of the anode reaction. This is the function of zinc or strontium chromate, barium metaborate and zinc phosphate pigments.
2. By applying a sufficiently thick layer of paint so that pores in the film do not form continuous capillary channels through the coating and water and oxygen are prevented from coming together to form the cathode reaction. This is the function of epoxy, vinyl and chlorinated rubber paints, which have high water impermeability.
3. By cathodic protection, that is, by employing another metal to be corroded or sacrificed instead of steel, such as the application of zinc rich paints, zinc being higher in the galvanic table, direct to the steel surface.

Galvanic series of metals

Anodic end - Greater tendency to corrode

1. Magnesium
2. Zinc
3. Aluminium
4. Cadium
5. Steel
6. Cast Iron
7. Stainless steels (A)
8. Lead/Tin solders
9. Lead
10. Tin
11. Nickel (A)
12. Iconel (A)
13. Nickel/Chromium alloys
14. Brasses
15. Copper bronzes
16. Nickel/Silver alloys
17. Copper/Nickel alloys
18. Monel
19. Silver solder
20. Nickel
21. Iconel
22. Stainless steels (P)
23. Silver
24. Graphite
25. Gold
26. Platinum

Cathodic end - Lesser tendency to corrode

(A) = Active metal surfaces
(P) = Passive metal surfaces