Corrosion control by modification of properties of metal

1. Alloying: Corrosion resistance of most metals is increased by alloying them with suitable elements like Al, Cr, etc. Chromium is the best alloying metal for iron.

2. Annealing: It is an optimized heat treatment route. It is otherwise known as stress relieving process.

3. Protective Coatings

In this route a thin layer of material (e.g.; metal, non-metal, polymer, etc.) is applied on the surface of another material which is to be protected from corrosion by various techniques such as spraying, hot dipping, electroplating, etc. In general there are two types of protective/surface coating:

1. Metallic coating (includes coating of Zn, Sn, etc. on iron)
2. Non-metallic coating: It is again classified as organic (e.g. paints, polymer, etc.) and inorganic coating (e.g. phosphate, chromate, cement coating, etc.)

A good coating material should have the following characteristics:

a. Coating should be non-porous, non-volatile, and continuous
b. Coating should be hard
c. Coating should be able to withstand direct attack of environment

Metallic Coatings

The materials in construction (iron and steel) are suffers from corrosion in acidic and alkaline environment. Construction materials should have high mechanical strength, high corrosion resistance and low cost. In order to make materials resistant against corrosion, their surfaces are coated with metals like, zinc, tin, copper, chromium, etc.

Depending on the nature of coating material, metallic coating is classified into two categories:

A. Anodic or Sacrificial Coatings, and
B. Cathodic or Barrier Coatings

*Anodic or Sacrificial Coatings:*In this method, an active or more anodic metal is coated over the base metal which is to be protected from corrosion. For

example, iron (Fe) is protected from corrosion by applying a coat of Zn. Here, active metal Zn protect the base Fe-metal sacrificially.

Galvanization: The process of coating of Zn-metal over the iron is known as Galvanization. It is an anodic coating. It can be done by spraying or hot dipping. Zn is active and acts as anode as its standard oxidation potential (0.76 V) is higher than that of Fe (0.44 V). Galvanization protects the iron by the following two ways:

(i) By providing a non-porous, non-volatile continuous oxide layer (ZnO) on the surface of iron, and
(ii) By sacrificially (i.e, Zn acts as anode and undergoes dissolution)

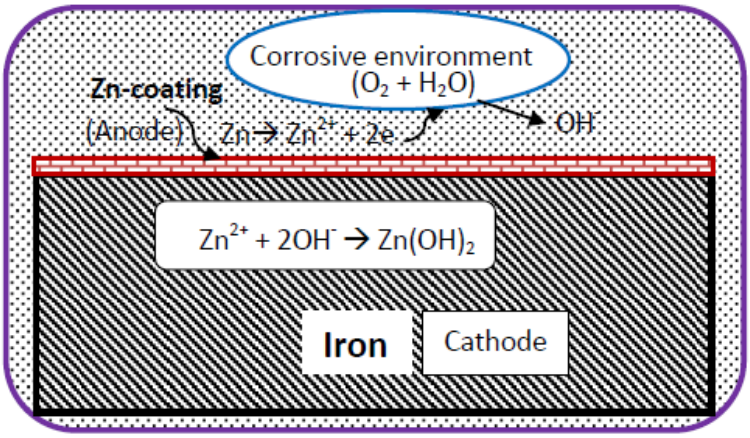


Fig. 10. Anodic coating (Galvanization of Iron)

So, *Galvanization* is a double protection route. As Zn is more anodic, it protects the underlying metal sacrificially when the protective oxide layer breaks at some point of time by the environment.

*Cathodic or Barrier coating:*In this method, a passive or less anodic metal is coated over the base metal which is to be protected from corrosion. For example, iron (Fe) the base metal is protected from corrosion by applying a coat of passive metals like Sn, Pb, or Ni. Here, less active or passive metal (Sn, Pb, or Ni) protect the more active base Fe-metal only by developing a protective oxide layer.

*** Remember that any breakage in the coating layer results in rapid corrosion. This happens because metal exposed at the breakage point acts as anode which has relatively very small area. When anodic area is much smaller than the cathodic area, rapid corrosion like pitting occurs on the surface.

Tinning: The process of coating of tin (Sn)-metal over the iron is known as Tinning. Sn is less active and acts as cathode as its standard oxidation potential (0.14 V) is lower than that of Fe (0.44 V). So, here base metal is more active than the coating metal. The coat metal protects the underlying metal Fe only by forming an impervious oxide layer of tin oxide (SnO_2). Any damage on this layer results in pitting or formation of cavity on the surface of iron. So, a lot of care should be taken to tin plated iron can otherwise leads to rapid corrosion. Tinning is a single protection method.

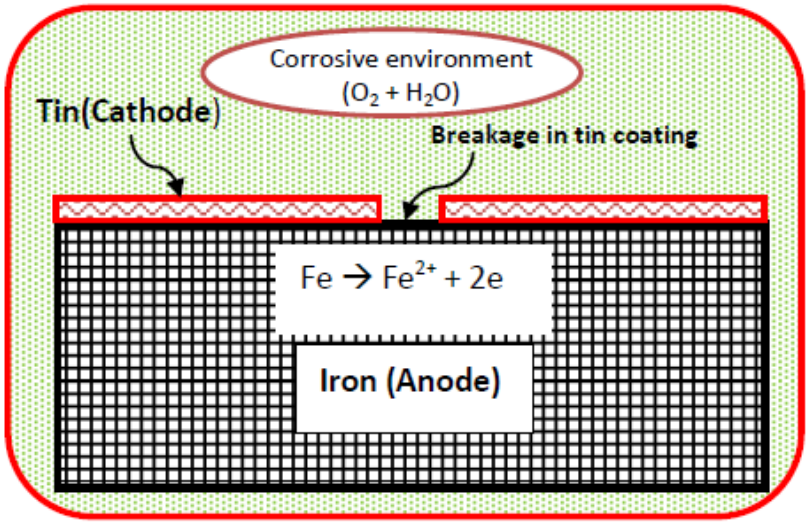


Fig. 11. Cathodic coating (Tinning of Iron)

Distinguish between Galvanization and Tinning

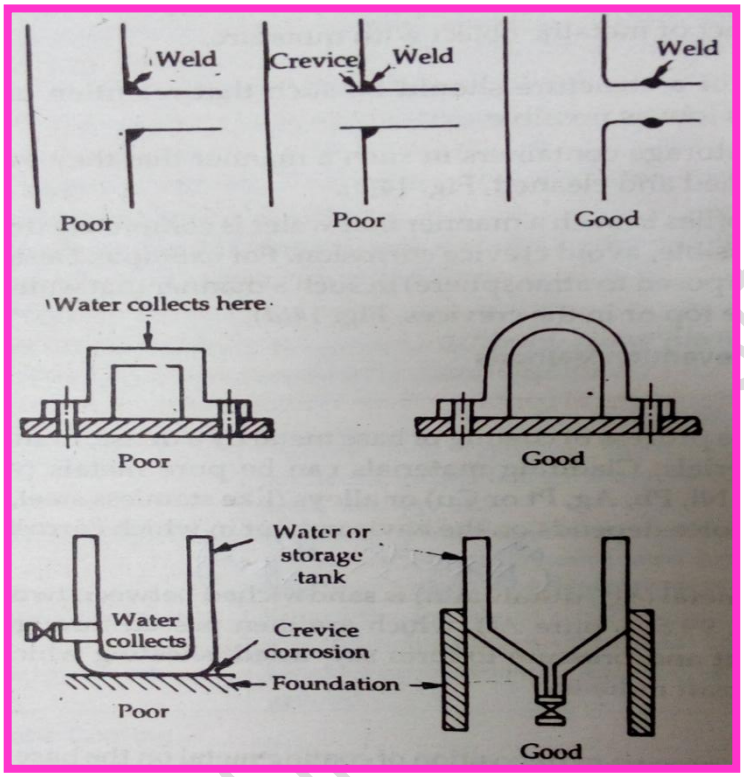
Sl.No.	Galvanization	Tinning
1	A process of covering the surface of iron by a layer of zinc (Zn)	A process of covering the surface of iron by a layer of tin (Sn)
2	Zinc protects the iron by both sacrificially and formation of protective oxide layer	Tin protects the iron only by formation of protective oxide layer
3	Double protection route	Single protection route
4	Galvanized iron (GI) containers are not safe to store foodstuffs as food acids reacts with Zn to form toxic masses. Always there is a chance of food poising.	Tin coated container is safe to store foodstuffs. No food poisoning occurs.

4. Proper designing

Some of design principles are as follows:

A. Keep the anodic area much larger than cathodic area

B. Anodic metal should not be painted or coated
C. Sharp corners, edges, etc. should be avoided (i.e., avoid L, T, V shaped profiles in constructions)



3. By suitable choose of Material

1. Avoid contact of dissimilar metals in presence of a corrosive environment
2. Use pure metal
3. Use noble metal if feasible
4. Choose two metals lies side by side in EMF of Galvanic series

5. Cathodic or Eletrochemical Protection

It is a technique applied to reduce corrosion of underground metallic structures by forcing it to behave like a cathode. There are two types of cathodic protection:

A. Sacrificial Protection
B. Impressed current method

Sacrificial Protection

We know that wet/electrochemical corrosion occurs via formation of separate anode and cathode. The existence of potential difference between anode and cathode causes loss of electron (oxidation) at anode. So, without cathodic protection, active metal suffers from corrosion. If a more active metal is connected via an insulated Cu-wire to a metallic structure which is undergoing corrosion then corrosion occurs at more active metal and the metallic structure can be protected. As the more active metal is sacrificed in the process of protecting the metallic structure, it is known as *sacrificial anode*. Examples of sacrificial anode are Zn (SOP- +0.76 V), Mg (2.36 V), Al (1.66 V), and their alloys.

Mechanism: (If Zn is used as sacrificial anode)

(i) Zn undergoes oxidation: $Zn \rightarrow Zn^{2+} + 2e$

(ii) Oxidant (O_2) in the atmosphere accepts these electrons to form anions
$1/2O_2$ (oxidant) + $H_2O + 2e^- \rightarrow 2OH^-$ (reduction)

(iii) Corrosion product forms by combination of cations and anions
$Zn^{2+} + 2OH^- \rightarrow Zn(OH)_2$

Sacrificial cathodic protection methods are widely used for the protection of relatively small structures like underground pipelines, storage tanks, etc.

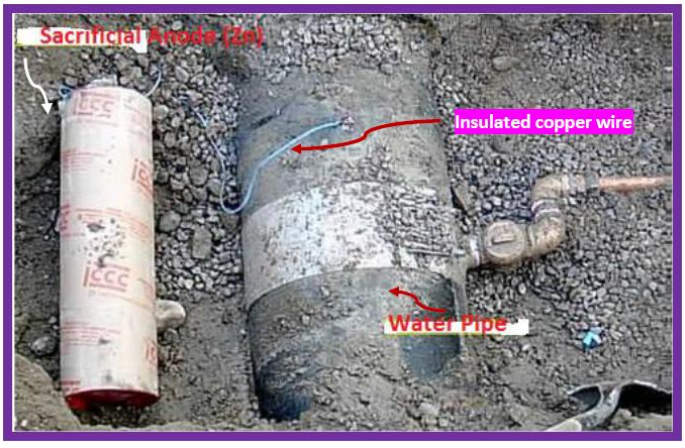


Fig. Sacrificial protection of buried water pipe.

- Preferred in remote areas where there is no power source.
- Used for small structures

Questions:

1. Mention some methods by which one can control corrosion by modification of properties of metal. [2]
2. How to control corrosion by suitable selection of material and proper designing? [5]
3. What is an anodic coating method? Describe galvanization with a suitable mechanism. [5]
4. What is cathodic coating? Describe tinning with a suitable mechanism. [5]
5. Differentiate between Galvanization and tinning. [3]
6. Describe Galvanization and Tinning with suitable mechanism. [7]
7. What is cathodic protection? Discuss sacrificial method with suitable mechanism. [7]
8. What is annealing? Wchich corrosion can be control by this process?[1]
9. Galvaninised articles are not prefereed for storing food items. Give reason. 1 mark