

UNIT 6: METALLIC CORROSION

6.1 Definition, causes of corrosion:

➤ **Definition:** Corrosion is a natural process in which pure metal (unstable) except noble metals is converted into chemically stable compounds like oxides, sulphide, hydroxide, carbonates, etc.. due to attack of atmospheric gases on the surface of metals. It is an irreversible process. Although corroded metal is thermodynamically more stable than pure metal but due to corrosion useful properties of a metal like malleability, ductility, hardness, luster and electrical conductivity are lost. The most common corrosion is rusting of Iron. A layer of reddish scale and powder of oxide (Fe_3O_4) is formed on the surface of iron.

➤ **Causes of corrosion:** When metals are used in various forms, they are exposed to environment, and the exposed metal surface begins to decay i.e. gets converted to more stable compound. This is the basic reason for metallic corrosion. Some of the main and popular causes of corrosion are as follows:

- ✓ Too much humidity or condensation of water vapour on metal surfaces are the primary causes of corrosion.
- ✓ Corrosive gases such as chlorine, hydrogen oxides, ammonia, sulfur oxides, amongst others can result in corrosion of parts of electronic equipment, etc.
- ✓ Corrosion can also occur due to hydrogen and oxygen exposure.
- ✓ Corrosion in steel can occur when it is placed under too much stress and the material develops a crack in it.
- ✓ Metals exposed to electrical currents for a long time can experience electronic corrosion.

- ✓ Exposure to dirt and bacteria can cause corrosion in metals.

6.2 Factors affecting corrosion rate:

- Reactivity of metals:
If metal is more reactive then it undergoes corrosion more readily.
- Strain in metal:
Corrosion takes place readily at cuts and bend area of metals.
- Presence of impurities:
If impurities are present in the pure metal then metal undergoes corrosion more readily.
- Presence of electrolyte:
In saline water(electrolyte) metal readily corrodes.
- Air and moisture:
Metals undergo corrosion more readily when exposed to air and moisture.
- pH:
 $\text{pH} < 7$ is more corrosive than basic or neutral medium.
- Temperature:
At higher temperature rate of corrosion becomes increased.

➤ **Different types of corrosion:**

Corrosion can be classified by the eight forms in which it manifests itself, the basis for this classification being the appearance of the corroded metal. Some of these eight forms are unique and distinct but all of them are to varying degrees interrelated. These are

- Uniform attack or general corrosion
- Intergranular corrosion
- Pitting
- Galvanic or two-metal corrosion.
- Dezincification.
- Erosion- corrosion
- Stress- corrosion

❖ **GALVANIC CORROSION:**

When two dissimilar metals are in contact with each other(or otherwise electrically connected) and exposed to a corrosive liquid or conductive solution, a potential is set up between these two metals and a current flows. Corrosion of one metal is often accelerated and of the other reduced, as compared to the behavior of these metals when they are not in contact. The historic voltaic cell and the ordinary dry cell battery are examples of such action, planned to produce current. Because of the electric currents and dissimilar metals involved, this form of corrosion is called galvanic or two-metal corrosion.

6.3 Explanation of rusting of iron:

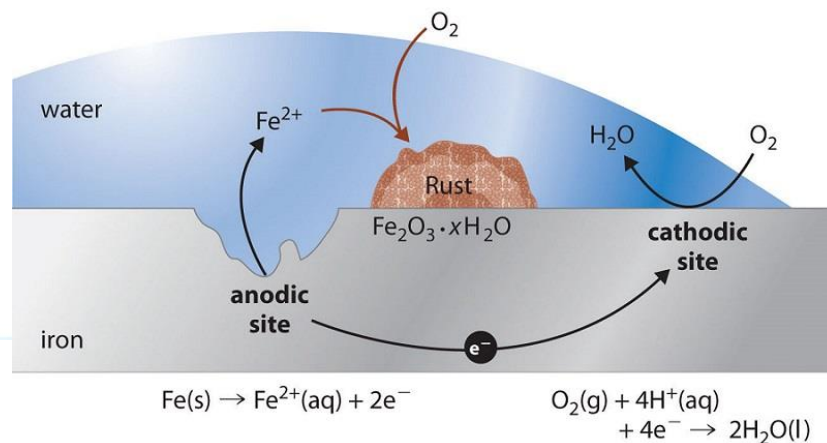
Wet corrosion involves reactions in aqueous medium. The conducting surface of the metal undergoes an electrochemical reaction with the moisture & oxygen present in the atmosphere. Ex: Rusting of Iron. Wet corrosion can be better explained on the basis of electrochemical theory.

✓ Electrochemical theory of corrosion:- According to electrochemical theory, corrosion of metals occurs due to the following changes, when they are exposed to the environment.

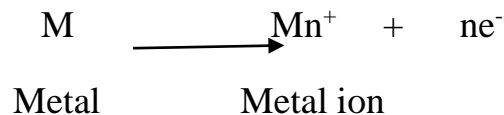
1) A large number of minute galvanic cells are formed which acts as anodic and cathodic areas.

2) At anode the metal undergoes oxidation and electrons are liberated which migrates towards cathodic region

3) Oxygen of the atmosphere undergoes reduction at cathodic area in the presence of moisture forming hydroxyl ions at the cathode.



Anodic reactions: At anode the metal undergoes oxidation-liberating electrons

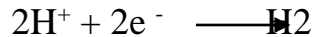


Ex: when iron is exposed to the environment it undergoes oxidation as



Cathodic reactions:- The electrons released at anode migrate to the cathodic area and reduces oxygen to hydroxyl ions. The different cathodic reactions are,

- a) In acidic medium: In acidic medium and in the absence of oxygen, hydrogen ions are reduced to hydrogen gas.



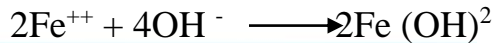
- b) In alkaline and in the absence of O₂. If the solution is alkaline and in the absence of oxygen the cathodic reaction is,



- c) In neutral and aerated medium: when the solution is neutral and aerated, hydroxyl ions are formed as follows.



- d) Formation of corrosion product: The hydroxyl ions migrate towards anode and react with metal ions (Mⁿ⁺ ions) and forms corrosion product. In the case of iron OH⁻ reacts with Fe²⁺ ions and forms an insoluble hydrated ferric oxide known as brown rust.

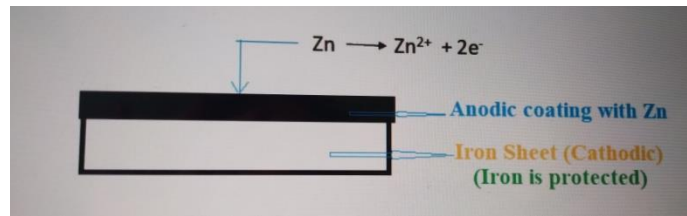


6.4 Methods of corrosion control:

- a) Metal Coating: In order to protect base metal from corrosion metal coating process has been adopted. The coating of metal can be achieved by following processes.

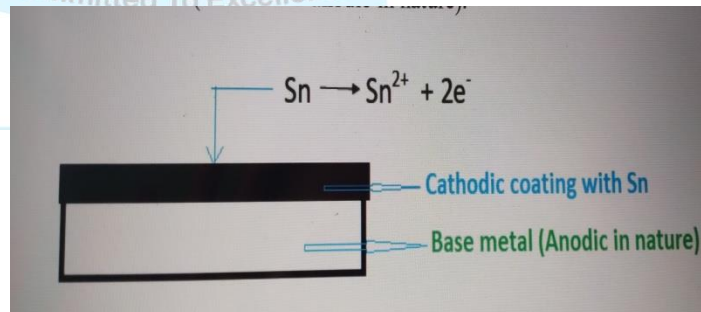
- i) Anodic metal coating (Galvanization): Metal coating which is anodic to base metal, known as anodic metal coating. In order to protect a metal from corrosion, any metal (anodic in nature) which is higher in the galvanic

series like Zn is coated on the surface of metal (base metal/ cathodic in nature).



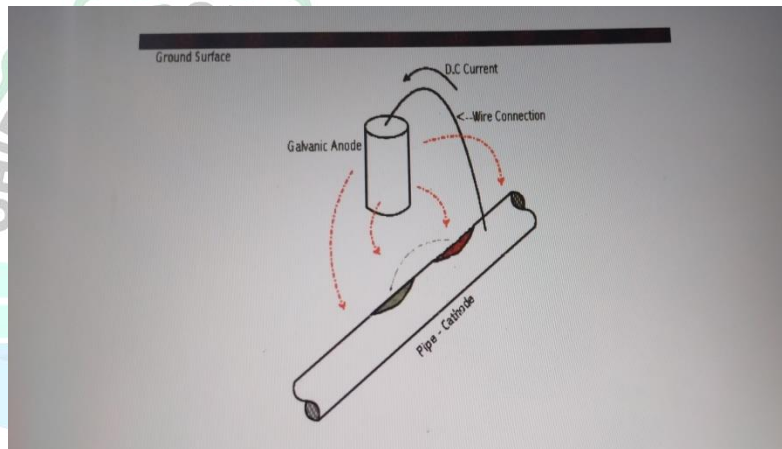
The best example of anodic metal coating is Galvanization. Galvanization is a process in which coating of base metal (to be protected) takes place by dipping the base metal (cathodic in nature) into the molten zinc (anodic in nature).

ii) Cathodic metal coating (Tinning): Metal coating which is cathodic to base metal, known as cathodic metal coating. In order to protect a metal from corrosion, any metal (cathodic in nature) which is lower in the galvanic series like Sn, Cu, Ni etc, are coated on the surface of metal (base metal/ anodic in nature).



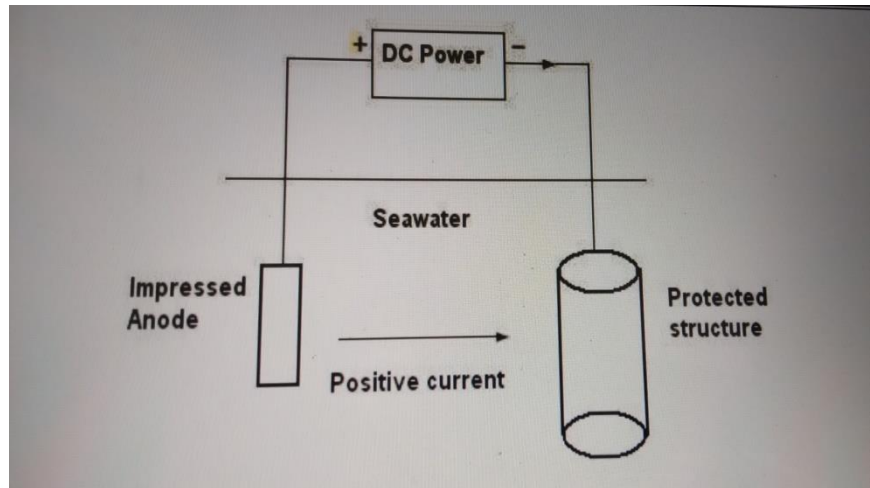
The best example of cathodic metal coating is Tinning. Tinning is a process in which coating of base metal (to be protected) takes place by dipping the base metal (anodic in nature) into the molten Tin (cathodic in nature).

b) Scarification anodic protection: In this protection method, the metallic structure to be protected (base metal) is connected by a wire to a more anodic metal so that all the corrosion occurs at that anodic metal and metallic structure (cathode) is protected. The more active metal so employed is called sacrificial anode. The corroded sacrificial anode is replaced by a fresh one, when consumed completely. Metals commonly employed as sacrificial anode are Mg, Zn, Al and their alloys which possess low reduction potential (more reactive) and occupies higher end in electrochemical series. The underground water pipelines and water tanks are also protected by sacrificial anode method.



c) Impressed cathodic protection: In this method, an impressed current from external source is applied in opposite direction to neutralize the corrosion current, and convert the corroding metal from anode to cathode. Thus the anodic corroding metal becomes cathodic and protected from corrosion. The impressed current is deriving from the

external DC source. The negative terminal of DC source is connected with metal to be protected whereas the positive terminal of DC is connected to the anode. Here anode may be graphite, stainless steel scrap iron etc. The impressed current protection method is used for water tanks, water & oil pipe lines, transmission line towers etc.



- d) **Electroplating:** In electroplating, electro-deposition of metal (anode) by means electrolysis over surface of metals and alloys (cathode or base metal). The two electrodes are dipped in the electrolyte solution which contains the metal ions to be deposited on the base metal. When a direct current is passed from an external source, the coating metal ions migrate towards cathode and get deposited over the surface of base metal in the form of a thin layer. In electroplating metal like Au, Ag, Zn, Sn, Cr, Ni etc. can be placed on the surface of base metal (Cathode).

