

## **CORROSION**

Corrosion is the deterioration or destruction of metals and alloys in the presence of an environment by chemical or electrochemical means. In simple terminology, corrosion processes involve reaction of metals with environmental species.

The annual cost of corrosion in India is around Rs. 600 crores. The loss due to corrosion include the cost of repair or replacement of the corroded component or equipment. By making proper use of existing corroded materials and techniques for corrosion prevention, about 25% of the estimated amount (Rs.150 crores in India) can be saved.

### **FACTORS AFFECTING CORROSION**

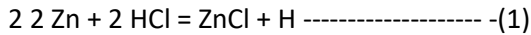
- a) **Reactivity of metal:** If metal is more reactive then it undergoes corrosion more readily.
- b) **Strain in metal:** Corrosion takes place readily at cuts and bends area of metal.
- c) **Presence of impurities:** If impurities present in the pure metal then metal undergoes corrosion more readily.
- d) **Presence of electrolyte:** In saline water (electrolyte) metal readily corrodes.
- e) **Air and moisture:** Best example rusting of Iron.
- f) **pH:**  $\text{pH} < 7$  is more corrosive than basic or neutral medium. g) **Temperature:** At higher temperature rate of corrosion become increased.

### **CORROSION DAMAGE**

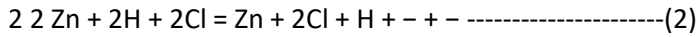
- Disfiguration or loss of appearance
- Loss of material
- Maintenance cost
- Extractive metallurgy in reverse- Loss of precious minerals, power, water and man-power ' Loss in reliability & safety
- Plant shutdown, contamination of product etc.

## ELECTROCHEMICAL REACTION IN CORROSION

DISSOLUTION OF ZN METAL IN HYDROCHLORIC ACID,

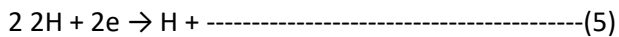
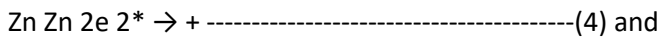


Written in ionic form as,



The net reaction being,  $2 \text{Zn} + 2\text{H}^+ = \text{Zn}^{2+} + \text{H}_2 \text{-----} \text{(3)}$

Equation (3) is the summation of two partial reactions,



Equation (4) is the oxidation / anodic reaction and

Equation (5) is the reduction / cathodic reaction

### Types of Corrosion

Corrosion may be classified in different ways Wet / Aqueous corrosion & Dry Corrosion Room Temperature/ High Temperature Corrosion.

WET & DRY CORROSION

**Wet / aqueous corrosion** is the major form of corrosion which occurs at or near room temperature and in the presence of water.

**Dry / gaseous corrosion** is significant mainly at high temperatures.

### WET / AQUEOUS CORROSION

Based on the appearance of the corroded metal, wet corrosion may be classified as:

#### Uniform or General Corrosion

Corrosion over the entire exposed surface at a uniform rate. e.g.. Atmospheric corrosion.

Maximum metal loss by this form.

Not dangerous, rate can be measured in the laboratory.

#### Galvanic or Two-metal Corrosion

When two dissimilar metals are joined together and exposed, the more active of the two metals corrode faster and the nobler metal is protected. This excess corrosion is due to the galvanic current generated at the junction ' Fig. Al sheets covering underground Cu cables.

### **Crevice Corrosion**

Intensive localized corrosion within crevices & shielded areas on metal surfaces.

Small volumes of stagnant corrosive caused by holes, gaskets, surface deposits, lap joints

### **Pitting Corrosion**

A form of extremely localized attack causing holes in the metal.

Most destructive form of corrosion.

This corrosion has Autocatalytic nature

It is Difficult to detect and measure

### **Intergranular Corrosion**

The grain boundaries in metals are more active than the grains because of segregation of impurities and depletion of protective elements.

So preferential attack along grain boundaries occurs.

E.g. weld decay in stainless steels

### **PREVENTION OF CORROSION**

- The huge annual loss due to corrosion is a national waste and should be minimized.
- Materials already exist which, if properly used, can eliminate 80 % of corrosion loss
- Proper understanding of the basics of corrosion and incorporation in the initial design of metallic structures is essential

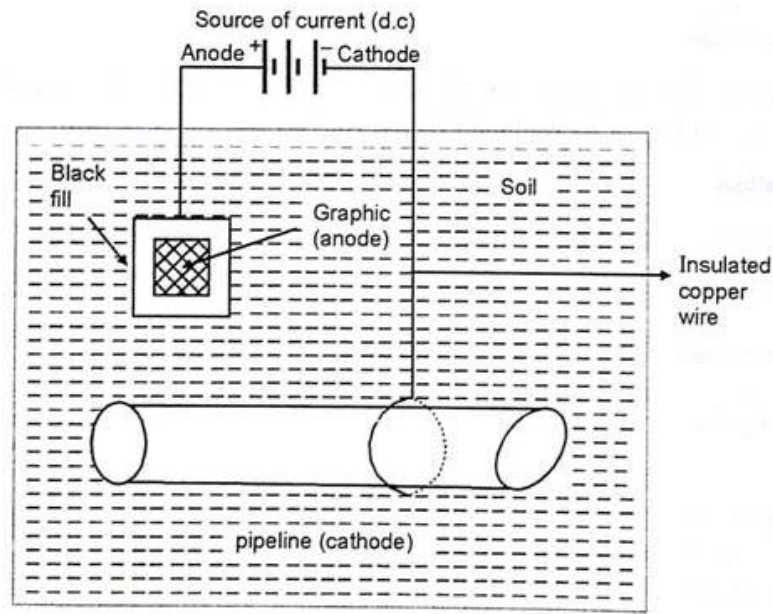
### **CORROSION CONTROL METHODS**

The corrosion is controlled by the following methods.

- (i) Sacrificial anodic protection
- (ii) Impressed current cathodic protection
- (iii) Control of corrosion by modifying the metal
- (iv) Corrosion Inhibitors.

### Sacrificial anodic protection

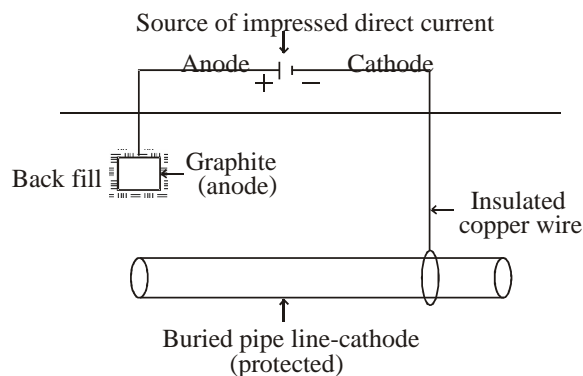
In this method, the metallic structure to be protected is made cathode by connecting it with more active metal (anode metal). So that all the corrosion will concentrate only on the active metal. The artificially made anode thus gradually corroded protecting the original metallic structure. Hence, this process is otherwise known as sacrificial anodic protection. Aluminium, Zinc, Magnesium are used as sacrificial anodes.



### Impressed current cathodic protection

In this method, an impressed current is applied in the opposite direction of the corrosion current to nullify it, and the corroding metal is converted from anode to cathode.

This can be done by connecting negative terminal of the battery to the metallic structure to be protected, and positive terminal of the battery is connected to an inert anode. Inert anodes used for this purpose are graphite, platinised titanium. The anode is buried in a “back fill” (containing mixture of gypsum, coke, breeze, sodium sulphate).



**Fig. 3.13 Impressed current cathodic protection**

## **Corrosion inhibitor**

A corrosion inhibitor is a substance which reduces the corrosion of a metal, when it is added to the corrosive environment.

### **Types of Inhibitors**

#### ***1. Anodic Inhibitors***

Anodic inhibitors are those that prevent the corrosion reaction, occurring at the anode, by forming an insoluble compound with the newly produced metal ions. These precipitates are adsorbed on the metal (anode) surface, forming a protective film and reducing the corrosion rate.

#### ***2. Cathodic Inhibitors***

In an electrochemical corrosion, the cathodic reactions are of two types depending upon environment.

##### **(a) In An Acidic Solution**

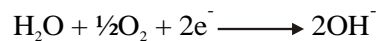
**Examples :** Organic inhibitors heterocyclic nitrogen compounds, heavy metal soaps.

##### **(b) In a Neutral Solution**

**Examples :**

Sodium sulphite ( $\text{Na}_2\text{SO}_3$ ), hydrazine ( $\text{N}_2\text{H}_4$ ).

In a neutral solution, the cathodic reaction is:



## **FACTORS AFFECTING CORROSION RATE**

### **I. Nature of the Metal**

#### ***(a) Position of metal in the EMF series***

Metals higher (-) in the galvanic series undergo strong corrosion and lower (+) in the EMF series undergo less corrosion.

#### ***(b) Relative areas of anode and cathode***

Corrosion will be severe if the anodic area is small and the cathodic area is large. Larger cathodic area of the cathode will create demand of more electrons, which can be met by the smaller area of the anode only by undergoing more corrosion.

#### ***(c) Over potential***

Corrosion is very slow if hydrogen over voltage of the cathodic metal is high. The over potential of a metal in a corrosive environment is inversely proportional to corrosion rate.

***(d) Nature of the surface film***

Stable oxide film restricts further corrosion. Unstable, volatile and porous oxide films enhances further corrosion.

***(e) Purity of the metal***

Impurity present in pure metal creates heterogeneity and leads to galvanic corrosion. If the percentage of purity increases the corrosion rate decreases.

***(f) Stress***

Metals part under stress can become anode and undergo corrosion. This type of corrosion is called stress corrosion.

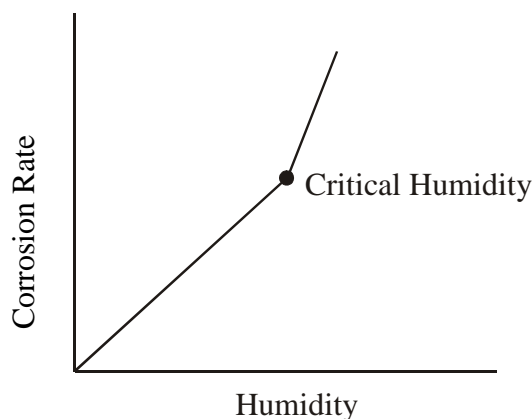
**II. Nature of the Environment**

***(a) Temperature***

Increase of temperature increases diffusion of ions in the corrosive medium and thus rises the corrosion rate.

***(b) Humidity***

Concentration of water vapour present in the atmosphere is known as humidity. If the humidity increases the corrosion rate increases, at a particular point a sudden increase in the corrosion rate is observed, that is called critical humidity.



**Fig. : 3.10 Critical Humidity**

***(c) Presence of Corrosive gases***

Corrosive gases like  $\text{SO}_2$ ,  $\text{H}_2\text{S}$ , fumes of  $\text{HNO}_3$ ,  $\text{H}_2\text{SO}_4$ , acetic acid etc, enhances the corrosion rate.

***(d) Presence of suspended solids***

Suspended particles like chemically active, chemically inactive and chemically neutral dust particles enhances the corrosion rate.

***(e) pH***

The corrosion rate is maximum when the environment is more acidic ( $\text{pH}=5$ ) and minimum when the environment is more alkaline ( $\text{pH}=11$ ). In general, acidic medium is more corrosive than alkaline or neutral medium.