



Corrosion

Presented by

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Corrosion: Introduction

- Any iron article when exposed to moist air it forms a reddish-brown film/layer on its exposed part. That layer on the exposed part of article is mostly of metal oxide or hydroxide.
- In similar manner when silver article exposed to acidic medium/conditions, article turn black.
- These are the common cases of rusting of metal. Corrosion/rust product is formed by consumption of metal.
- Rusting of metal may called as corrosion, that weakens the metal, reduces durability and working capacity of metal and even alloys.

Corrosion: Introduction



- Corrosion is natural phenomenon observed due to interaction of metal with medium/environment.

Definition of Corrosion: It can be defined as a phenomenon in which decay or destruction of metal and alloys takes place due to chemical or electrochemical reaction that takes place between the exposed surface of metals and environment or medium.

- This medium may be moisture, air, water, sea water, acids, alkalis, salts, steam, oxygen, microorganisms, temperature strain, stress etc on metal.
- Basically corrosion is slow process but as it occur in a continuous manner it leads to loss of metal structures , equipments, machine parts, marine plants etc.



Corrosion: Classification

Based on the medium to which the metal structure is exposed, corrosion can be broadly classified into two main **types**.

1. Dry/Atmospheric/Direct/Chemical/Oxidation Corrosion.
2. Wet/ Electrochemical/Immersed Corrosion.

Wet corrosion is again sub divided based on kind of reaction into following types:

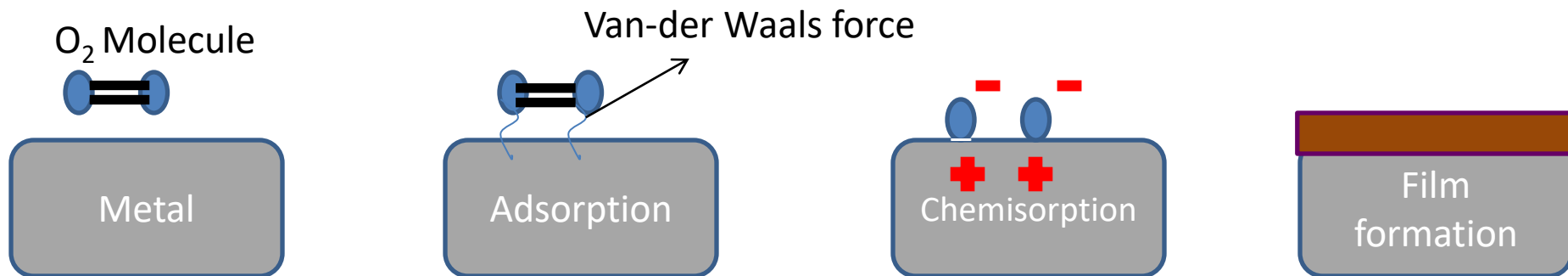
- i) Wet corrosion by **Evolution of Hydrogen gas**
(medium-acidic)
- ii) Wet corrosion by **Absorption of Oxygen**
(medium-neutral or alkaline)

Dry Corrosion



- Dry Corrosion occurs by direct attack of atmospheric oxygen or other gases in absence of conducting solution on the surface of metal.
- Dry corrosion occurs due to chemical reaction between metal surface and atmospheric gases like O_2 , SO_2 , H_2S , NH_3 , NO_2 , CO_2 .
- The gases like oxygen, halogens, hydrogen sulphide etc are responsible for this corrosion.

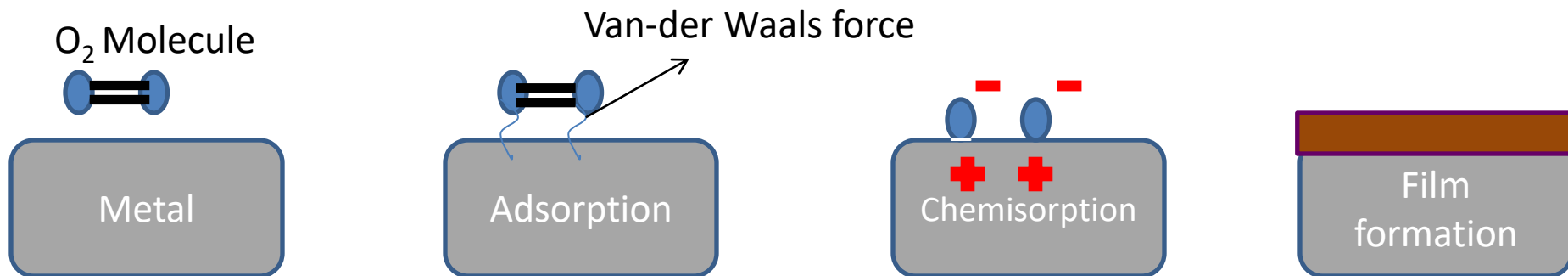
Corrosion due to Oxygen: Also called as Oxidation Corrosion



Mechanism of Corrosion by Oxygen (Oxidation Corrosion)



- Out of these gases oxygen is the most abundant gas in atmosphere leading to corrosion of metal.
- Atmospheric oxygen directly attacks at low and high temperature in absence of moisture.
- At low temperature IA, IIA group elements while at higher temperature almost all metals except noble shows this type of corrosion.
- Corrosion due to oxygen takes place by following steps



Mechanism of Corrosion by Oxygen



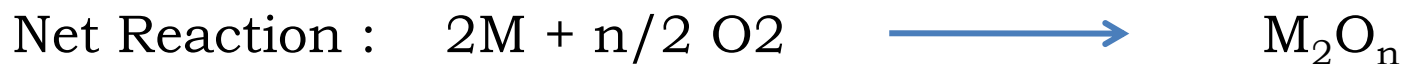
Steps of Oxidation Type of Corrosion:

- 1) Adsorption of oxygen – Oxygen molecules are held by free electrons of metal on metal surface.
- 2) Dissociation of oxygen molecules over the metal surface.
- 3) Chemisorption – At higher temperature loss and gain of electrons forms metal ions and oxygen ions.
- 4) Oxide film formation- Metal ions and oxygen ions combine to form metal-oxide as corrosion/rust product.

Mechanism of corrosion by Oxygen (Oxidative corrosion)



- When metal is exposed to oxygen, metal surface undergo oxidation by losing electrons and forms metal ions.
- These electrons are accepted by oxygen, it undergo reduction and forms oxygen ions.
- The metals ions and oxygen ions combine to form metal-oxide on the exposed part of metal as corrosion product.



Here Fe forms Fe_2O_3 , Cr forms Cr_2O_3 etc. Oxide Film gets formed



Pilling-Bedworth Rule (PBR)

- The oxide layer formed on the metal surface will decide the further course of corrosion
- One governing rule is given regarding nature of oxide layer and further course called as **Pilling-Bedworth Rule**
- **Statement:** If the volume of metal oxide formed is less than the volume of metal consumed in metal oxide formation, then the film formed is porous in nature and vice a versa

$$\text{Pilling-Bedworth Ratio (P.B.R.)} = \frac{\text{Volume of metal oxide}}{\text{Volume of metal consumed}}$$

- For $\text{PBR} < 1$ - Porous film
- If $\text{PBR} > 1$ & $< 1.45/2$ – Non-porous film and
- If $\text{PBR} > 2/3$ Volatile film

For example: $\text{Na}_2\text{O}:\text{Na} = 0.57$; $\text{Al}_2\text{O}_3:\text{Al} = 1.28$
 $\text{CuO}:\text{Cu} = 1.68$; $\text{Mo}_2\text{O}_3:\text{Mo} = 3.4$

Nature of oxide film

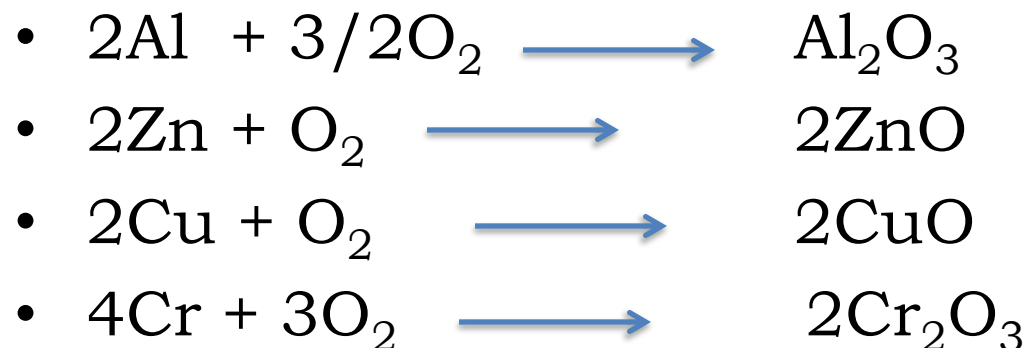


Types of the oxide film:

1) Stable and protective film:

The volume of oxide layer is sufficient to protect the underlying metal. Strong nonporous film, it stops further corrosion of metal.

Ex. – Cr, Ni, Cu, Zn, Al, Pb, steel, bronze etc.



Nature of oxide film



2) Porous and non-protective film:

In such oxide layer the volume of film is not sufficient to protect the underlying metal. Small hair-cracks, pores get developed on the film through which oxygen attacks.

- For ex: Na, Mg, K, Fe, Ca, Rb, Be, Sr



3) Unstable oxide film: Oxide layer is unstable and decomposes back to metal and oxygen, therefore oxidation corrosion does not occur. Noble metals do not allow oxygen to attack on them.

- For ex: Ag, Au, Pt, Pd



Nature of oxide film



4) Volatile oxide film: The oxide film is volatile, consumes metal and evaporates. The underlying fresh metal is exposed for further attack by oxygen. Rapid corrosion occurs.

For example: Molybdenum



Nature of oxide film



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Corrosion due to other gases



1. Halogens

- Generally halogens reacts with metal surface to form metal halides and metal chlorides are porous in nature.
- Presence of moisture enhances the rate of corrosion
- Noble metals are not affected by chlorine at room temperature but above 100 °C they gets corroded by chlorine.
- First row transition metals except Fe and Cr are resistant to halogens.

2. Corrosion by gases containing sulphur

- Combustion of fossil fuel produces sulphur containing gases such as H_2S , SO_3 , SO_2
- These gases at higher temperature attacks machinery, refinery metal, cracking units causing problems.
- These gases are acidic and are more corrosive in presence of moisture.

Corrosion due to other gases



3. Decarburization and hydrogen embrittlement

- Decarburization: it is the process of removal of carbon or carbide from the metal by action of hydrogen , at higher temperature.
- Hydrogen produced in gas streams in refinery, cracking systems and combustion of oil at higher temperature penetrates in steel or stainless steel in the form of atomic hydrogen.
- This hydrogen reacts with carbon or carbide to form CH_4 .
- As carbon is used to increase the mechanical strength of steel decarburization decrease the mechanical strength of steel.



- This CH_4 formed deposits in internal voids in steel and decreases the cohesive force between iron atoms and produces minor cracks in steel.
- To avoid lowering in mechanical strength Chromium and Molybdenum additions is preferred over carbon.

Corrosion due to Other Gases



H₂ embrittlement

- Breaking of metal at weakened region by accumulation of H₂ in metal is called as H₂ embrittlement.
- Here at higher temperature hydrogen infiltrate into internal voids or intergranular spaces leading to localized weakening of cohesive strength and leads to mechanical fractures.

CO and CO₂

- At higher temperature a CO and CO₂ atmosphere is capable of carburizing as well as decarburizing steel or other metal alloy.



- In presence of moisture, CO₂ is acidic and leads to faster corrosion.



Electrochemical/Wet Corrosion

- Corrosion of a metal due to presence of electrolytic solution with formation of cathodic and anodic areas.
- Here anodic area will undergo corrosion either by dissolving into electrolytic solution or by depositing on cathode.
- The corrosion may occur either by galvanic cell formation or by differential aeration cell formation
- Two types:
 - Galvanic Corrosion
 - Concentration/ differential aeration corrosion

Electrochemical/Wet Corrosion

- Galvanic Corrosion
 - The corrosion occurring due to formation of a galvanic cell in presence of aqueous conducting medium is called as galvanic corrosion
 - The formation of galvanic cell takes place in following situation
 - Contact between two dissimilar metal
 - Stressed and unstressed parts on the same metal
 - Impurities in metal
 - Partial immersion of metal
 - Partial burial in ground
 - Partially ruptured oxide film on the metal surface

Electrochemical/Wet Corrosion



- Contact between two dissimilar metal
 - When two dissimilar metals are in contact with each other and electrolytic solution is present in between them then the metal higher in galvanic series will act as anode while the other will act as cathode.
 - Here galvanic cell formation takes place and anodic metal will undergo corrosion **e.g. Tap of brass fitted to stainless steel.**
- Stressed and unstressed parts on the same metal
 - Working on metal disturbs the grain structure metal
 - Worked part of metal is under stress and act as anode
 - Unworked part of metal is unstressed and act as cathode
e.g. threaded part of pipe, bent part of rod or plate.
- Impurities in metal
 - Improper alloying of metal or presence of impurity on metal, leads to formation of tiny galvanic cells on the metal surface in presence of aqueous media.
 - Hence impurity and metal will behave as anode and cathode depending their position in galvanic series.
 - It leads to formation of small pits on metal surface

Electrochemical/Wet Corrosion



- Partial immersion of metal
 - » When metal is partially immersed in aqueous solution concentration cell formation takes place
 - » Part of metal in solution is poorly oxygenated and act as anode
 - » Metal part exposed to higher oxygen concentration act as cathode
 - » Ship, water in metal tank, metallic installation in water, water drop on metal
- Partial burial in ground
 - » Here underground metal part acts as anode and gets corroded
 - » Metal part exposed to air acts as cathode
- Partially ruptured oxide film on the metal surface
 - » Part of metal exposed due to crack is more oxygenated and act as cathode; Part of metal under oxide film acts as anode

Electrochemical/Wet Corrosion



- Concentration cell corrosion
 - The cell formed due to varying oxygen concentration on metal surface are called as differential aeration cell and corrosion occurring is called as differential aeration corrosion
 - Part of metal in contact with less O_2 or lower electrolyte concentration acts as anode and vice a versa.

Mechanism of Electrochemical Corrosion



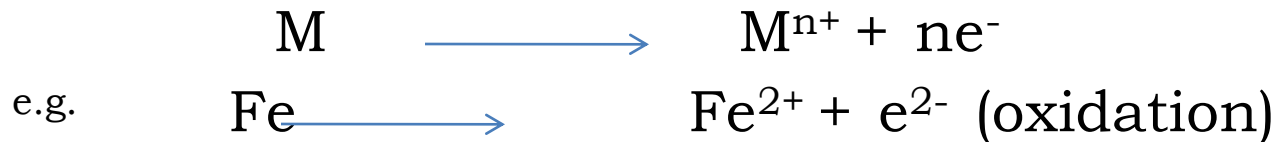
- In electrochemical corrosion oxidation occurs at anode i.e. the anodic metal or anodic part of metal undergo corrosion.
- This anodic metal after corrosion gets deposited on the cathodic area near the anode or dissolves into electrolytic solution in the form of metal ions
- The anodic metal gives electrons and these electrons travel from anode to cathode
- Further these electrons are captured in between for formation of corrosion product.
- Depending on the nature of environment the formation of corrosion product takes place by two mechanisms
 - 1. Hydrogen evolution mechanism**
 - 2. Oxygen absorption mechanism**

Mechanism of Electrochemical Corrosion



- **Hydrogen Evolution Mechanism:**

- The corrosion by this mechanism takes place in acidic medium
- Here at anode



- These electrons at cathode reduces H^{+} to liberate H_2 gas
- at cathode



- Hence the product of corrosion is liberation of H_2 gas
- The corroding media contains the dissolved compound of anodic metal.

Mechanism of Electrochemical Corrosion



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Mechanism of Electrochemical Corrosion



1) Hydrogen Evolution Mechanism: The corrosion by this mechanism takes place in acidic medium

1) At anode:



These electrons at cathode reduces H^+ to liberate H_2 gas

2) At cathode:



Hence, the product of corrosion is liberation of H_2 gas

The corroding media contains the dissolved compound of anodic metal.

(Details are already discussed in previous content)

Mechanism of Electrochemical Corrosion



2) Oxygen Absorption Mechanism: The corrosion by this mechanism takes place in Neutral or alkaline medium and in presence of dissolved oxygen.

E.g. Consider a metal plate with an oxide film with a crack in presence of droplet of water and Oxygen in the atmosphere

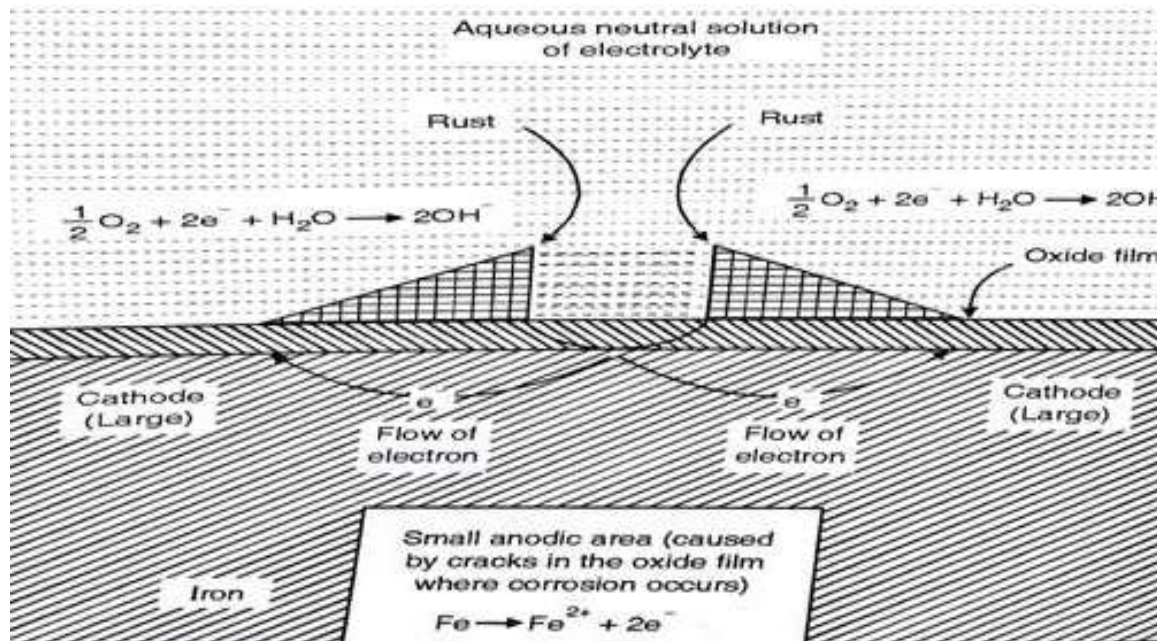


Figure: Oxygen Absorption Mechanism

Mechanism of Electrochemical Corrosion



Oxygen Absorption Mechanism:



These electrons at cathode is captured by oxygen in presence of H_2O leading to absorption of oxygen

At cathode:



In presence of excess of oxygen in medium ferrous hydroxide



gets oxidized to Ferric hydroxide rust (Yellow rust or $Fe_2O_3 \cdot H_2O$). The corroding media contains the dissolved compound of anodic metal. If O_2 is limited, the corrosion product will be black anhydrous magnetite, Fe_3O_4 . If corrosion product is soluble in aq. Media then it will remain in dissolved form otherwise it gets precipitated near cathodic region.

Mechanism of Electrochemical Corrosion



Oxygen Absorption Mechanism:

If environment is aqueous solution of NaCl containing dissolved Oxygen:

At Cathode: $\text{Na}^+ + \text{OH}^- \longrightarrow$ NaOH and

At Anode: $\text{Fe}^{2+} + \text{Cl}^- \longrightarrow$ FeCl_2 Ferrous Chloride

Both the products NaOH, FeCl_2 are soluble in water. They react with each other and ferrous hydroxide precipitates which further oxidises to Ferric Hydroxide $\text{Fe}(\text{OH})_3$



$\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$ Yellow Rust

Forms of corrosion



- **Underground or soil corrosion**

- Corrosion of underground metallic structure by soil action, It depends upon acidity of soil, electrical conductivity, moisture and soil texture etc.

- **Pitting corrosion**

- When there is breakdown or cracking in the metallic or oxide protective film on the metal surface, strong localized attack on these regions leads to formation of cavities or pits due to small anodic area called as pitting corrosion
- This leads to destruction of vessels leakages in pipes and tubes

Forms of corrosion



- **Erosion corrosion**
 - This type of corrosion takes place due to flow of liquids or gases on metallic surface.
 - Its is a combined effect of corrosion and abrasion
- **Microbiological corrosion**
 - The bacteria like sulphate reducing bacterial, film forming bacteria etc. during metabolic activity leads to corrosion of metal
- **Waterline corrosion**
 - This corrosion is due to differential aeration cell formation on the metal surface.
 - The area under aq. phase is less oxygenated and acts as anode, while area above aq. Phase is more oxygenated hence act as cathode
 - Here maximum corrosion takes place along the line just beneath the aqueous solution level

Factors influencing Corrosion



Nature of metal

➤ Position of metal in galvanic series

- Higher the position of metal in galvanic series, higher will be tendency to behave as anode and more will be corrosion
- Larger the positional difference between two metals in the galvanic series larger the rate of corrosion.

Factors influencing Corrosion



Nature of metal

➤ **Relative areas of anode and cathode**

- Larger the area of anode lesser will be rate of corrosion
- Larger the area of cathode higher the rate of corrosion
- For better design anodic metal should have larger area

Factors influencing Corrosion



Nature of metal

➤ Purity of metal

- Pure metal is less prone to corrosion
- Impurity increases the rate of corrosion
- Passive impurity leads to low rate of corrosion but active impurity leads to severe and localized corrosion

Factors influencing Corrosion



Nature of metal

➤ Physical state of metal

- Physical state of metal means grain size and orientation of grains, stressed and unstressed part of the metal
- Smaller the grain size; larger is the rate of corrosion
- Areas under stress acts as anode and easily gets corroded

Factors influencing Corrosion



Nature of metal

➤ Nature of oxide film

- If oxide film formed on the metal surface is non-porous then it will protect the metal from further corrosion
- If it is porous then corrosion will continue till metal is completely corroded
- If oxide film formed is unstable then, metal oxide decomposed back to metal and oxygen
- If oxide film formed is volatile, then severe or excessive corrosion takes place

Factors influencing Corrosion



Nature of metal

➤ Overvoltage

- Metal having higher position in galvanic series than hydrogen under goes corrosion by hydrogen evolution mechanism
- During hydrogen evolution tiny bubbles of hydrogen gas adhere the metal surface, subsequently the acidic solution loses contact with metal surface, leading to lower corrosion rate.
- Hence metal behaves as if it is having lower position in galvanic series. To restore the position of metal in galvanic series some extra voltage is needed to apply and this extra voltage is called as overvoltage.
- The Metals which do not have tendency to adsorb hydrogen, corrode at its usual rate.
- Metals like Zinc, Chromium, Lead have overvoltage
- Reduction in the overvoltage accelerates the corrosion

Factors Affecting Corrosion

Nature of Environment



Temperature

- Higher the Temperature of corroding medium Higher will be rate of corrosion as attacking environmental constituent as well as metal surface gets activated at higher temperature
- According to Nernst's equation for electrode potential, at higher temperature potential of metal is higher hence rate of corrosion will be high

Moisture

- Moisture is one of the important factor in deciding the rate of corrosion. Critical Humidity is the relative humidity above which dry corrosion increases sharply
- Oxygen and other gases corrodes metal at higher rates than absence of moisture
- High relative humidity in the form of fog, mist causes electrochemical corrosion of anodic metal
- Moisture in the soil and presence of water leads to electrochemical corrosion and this corrosion occurs rapidly than the dry corrosion

Factors Affecting Corrosion

Nature of Environment



pH:

- Acidic environment is more corrosive than the alkaline, Amphoteric metals like Al, Zn, Pb etc. are more prone to corrosion in alkaline media. At pH 5.0 steel has minimum rate of corrosion which increases at lower pH in oxygen free water.
- Every metal has certain passivity pH above and below that corrosion of metal is faster
e.g. Zn at pH 11, Sn at pH 8.5, Al at pH 5.5 has lowest rate to corrosion

Conductivity of corroding medium:

- Higher the conductivity of a corroding medium higher is the rate of corrosion

Nature of ions in medium:

- Cl^- , NO_3^- ions has ability to break the non porous oxide film, hence enhances the rate of corrosion
- While presence oxalate, phosphates and silicate ions lower the rate of corrosion

Methods of Corrosion Control



Cathodic Protection:

Principle: The metal to be protected is forced to behave as if cathode

Types of Cathodic Protection:

- Sacrificial anode method
- Impressed current method

Sacrificial Anode Method:

- Here the metal which is to be protected is connected to a metal, having higher position in the galvanic series by insulated wire
- The metals like Zn, Mg, Al are used as anode and they get corroded for protecting the metallic structure, hence called as sacrificial anode method
- The anodic metal is placed in backfill (coal and NaCl) to increase the electrical contact.

Applications: To protect ship hull, buried pipelines, buried cables, hot water tanks from corrosion

Impressed current method



- The metallic structure to be protected is externally connected to –ve terminal of a D. C. battery
- Metallic structure is converted into cathode by applying an equal and opposite current to nullify corrosion current
- The insoluble anode like graphite, stainless steel are used and kept in backfill composed of gypsum or coke breeze.

Applications: To protect buried water and gas pipeline, open water box coolers, water tanks, condensers, transmission line towers, laid-up ships, marine pipes etc.

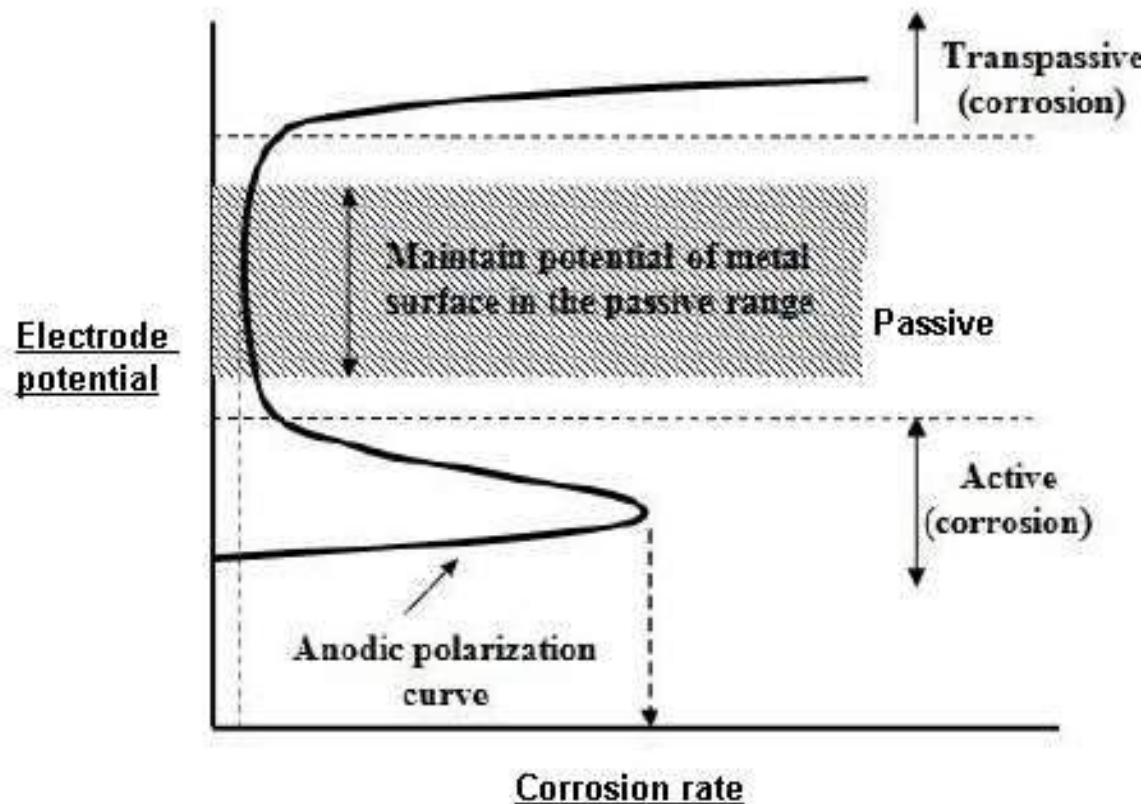
Limitations of Cathodic Protection:

- High capital investments and maintenance costs
- Stray current
- Problems associated with H_2 evolution or O_2 absorption

Anodic Protection:



Certain metals like Al, Cr shows passivity in certain range of potential & every metal has such property, but not all have wide range of passivity, At this potential range metal becomes Passive towards corrosion

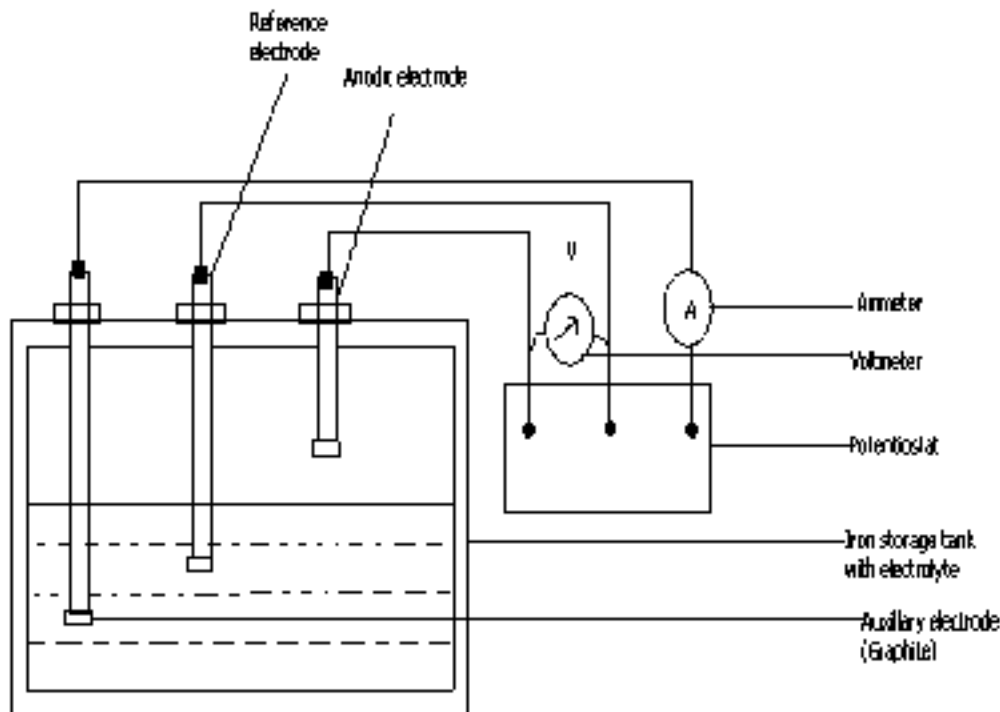


Anodic Protection:

Principle: Metal or alloy (wider range of passivity) is made anodic and voltage is applied over it to control its corrosion even by strongly corroding media. E.g.: Chemical Reactors

Construction and Working:

- By using reference electrode and auxiliary electrode the metallic structure under protection is made anodic,
- **Potentiostat is used to provide desired passive potential** and is measured by voltmeter.
- **Ammeter measures the corrosion current** minimum or negligible current by ammeter indicates protection of metal by anodic method
- Graphite is used as auxiliary electrode and Cathodic metal used is high corrosion resistant metal or Platinum
- Electrical connections are removed immediately for out of corrosion control



Applicable only to the metals which show active passive behavior

Anodic Protection



Applications

- For protection of Chemical reactors
- Protecting water coolers and metal condensers in industries
- Complex metallic structures above and under ground
- Pipe lines carrying corrosive liquid or corrosive solutions

Advantages

- This method is applicable to highly corrosive environment
- Operating cost is low
- Feasibility of method can be predicted in laboratory
- It is a unswerving method to protect complex structure
- Corrosion rate can be predicted by value of protection current

Limitations

- Only few metal showing active passive behavior can be protected by this method
- High starting current and installation cost
- High rate of corrosion observed if system goes out of control

Metallic Coatings



- Coatings acts as barrier between coated metal and environment
- Before coating, surface is to be cleaned to have uniform and adhering coating
- Surface cleaning can be done by Solvent cleaning, alkali cleaning, acid cleaning, water washing and drying, Sand blasting, flame cleaning and mechanical cleaning.

There are two types of metallic coatings

Anodic and **Cathodic** Coating

❑ **Anodic Coating**

- Coating base metal with the metal having higher position in galvanic series is called as Anodic Coating e.g. Coating steel with Zn, Al ,Cr.
- Cracks in the anodic coating lead to formation of anodic and cathodic area, coating acts as an anode while base metal act as cathode and protected from corrosion
- Hence anodic coatings always preferred

❑ Cathodic Coating



- Coating base metal with the metal having lower position in galvanic series is called as cathodic coating
e.g. Coating steel with tin, gold or silver on brass.
- Cracks in the cathodic coating lead to formation of anodic and cathodic areas, base metal acts as an anode while coating metal acts as cathode and intense corrosion of base metal will take place

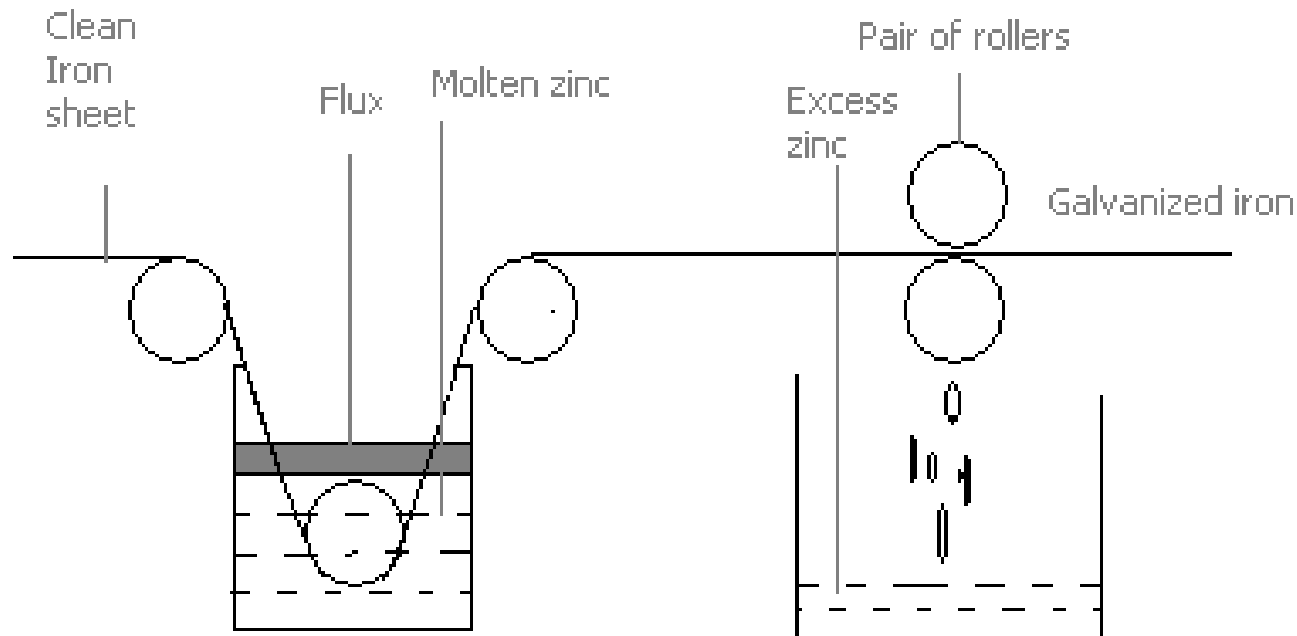
Anodic Coating	Cathodic Coating
CM placed higher up in EMF Series than BM	CM placed lower up in EMF Series than BM
BM remains same as long as CM present on BM; Most Preferred	BM undergoes severe/fast corrosion, if coating is ruptured to produce cracks/pits; Less preferred
Eg: Zn, Al, Cr on Steel	Tin on steel, Silver/Gold on Brass

Methods of Applying Metallic Coatings



A) Hot Dipping: Process of coating base metal by dipping it into the molten mass of a coating metal

Galvanization: Coating the base metal with zinc using hot dipping process is called as galvanization. It is an anodic coating.





Galvanization Process:

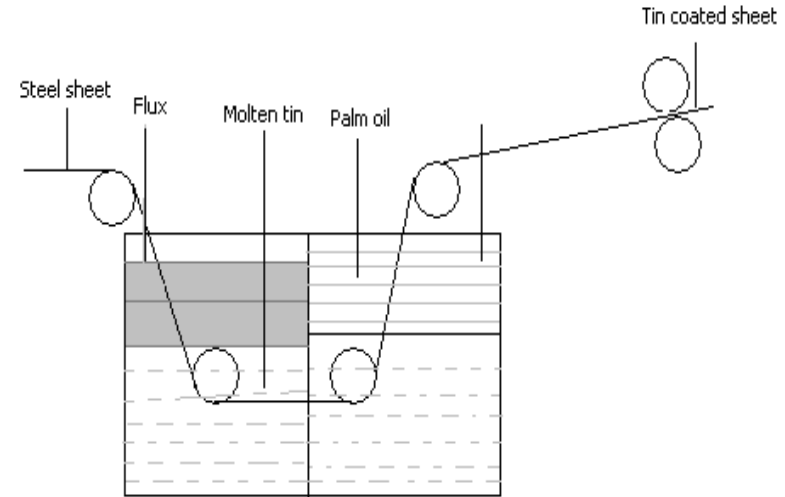
- Base metal generally steel or iron is treated with dilute H_2SO_4 , washed with water and dried so as to remove surface impurities.
- Metallic article to be coated is then dipped into molten mass of zinc maintained at $425\text{--}450\text{ }^\circ\text{C}$ (as zinc has M.P. $419\text{ }^\circ\text{C}$) and covered with NH_4Cl flux so as to avoid oxidation of zinc.
- The coated article is then passed through pair of rollers to remove excess zinc and to have uniform coating. Further the article is cooled slowly.

Applications: iron or steel galvanized articles are roofing sheets, nuts, bolts, wires, pipes, bucket, tubes nails.

Disadvantages: Galvanized articles cannot be used to store food as zinc forms poisonous products by action of food.

Tinning: Tinning is a process of coating Tin (MP: 232°C) on steel. It is a cathodic coating.

Surface of the steel article to be coated is first cleaned. Then it is passed through bath of molten tin at 240°C , and further through palm oil. This layer of palm oil on tin Layer avoids the oxidation of tin during process.



Molten tin mass is covered with flux to avoid oxidation of tin. Finally excess of tin is removed by passing the coated article through rollers.

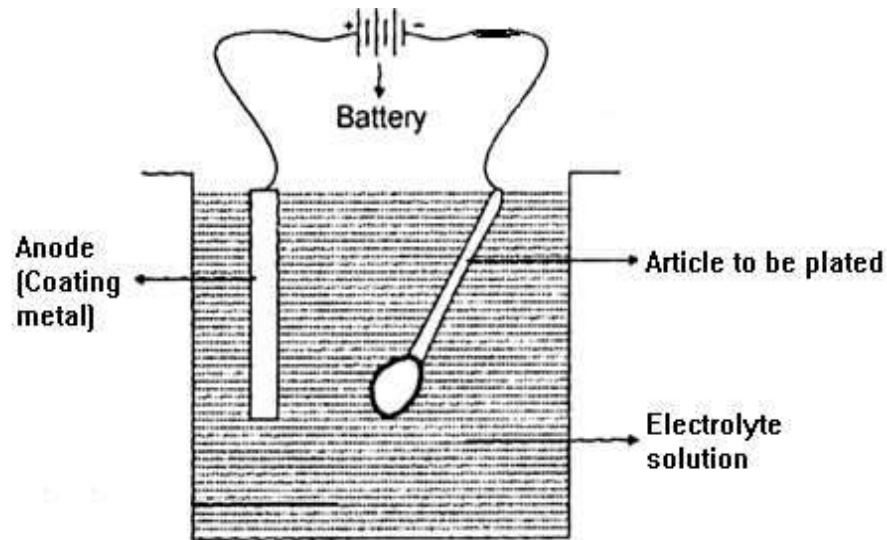
–Applications:

- Tinned containers are used to store the food materials as it do not form poisonous product.
- Tinned utensils are used to cook food and refrigeration utensils.
- Copper wires are tinned before insulation as it avoids the attack of sulphur on copper.

B) Electroplating: Works on the principle of electrolysis



- Here electroplating is carried out in a non conducting pot.
- Electrolyte is a aqueous solution of metal salt to be coated.
- Anode is made of coating metal, while article to be coated (base metal) is connected at cathodic end.



At Anode (for Cr plating)



At Cathode (for Cr plating)



- The metal ions from electrolyte migrate towards the cathodic metal article and gets deposited on base metal by accepting electrons.
- The concentration of metal ion in electrolyte is maintained by attaching anode made of coating metal

Electroplating



Advantages:

- Used to coat the article of any size and shape
- Precious metals like gold, silver, platinum can be coated by electroplating.
- Non metallic article can be electroplated

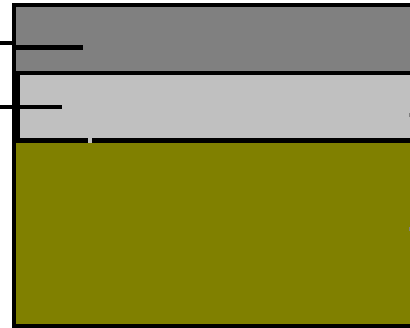
Applications:

- Used to have coating of precious metals like gold, silver
- For decorative purpose
- For conducting surface for wood plastic, glass.
- For electroforming of many parts of machines by electro-deposition
of thick layer

C) Cementation: Process of formation of thick layer of alloy by base metal and coating metal on the base

metal surface

Poor in base metal and
rich in coating metal
Poor in coat metal and
rich in base metal



Cementation coat

**Base
metal**

Process: The base metal is packed in the powder of coating metal and heated just below the melting point of low melting metal (i.e. coating or base metal).

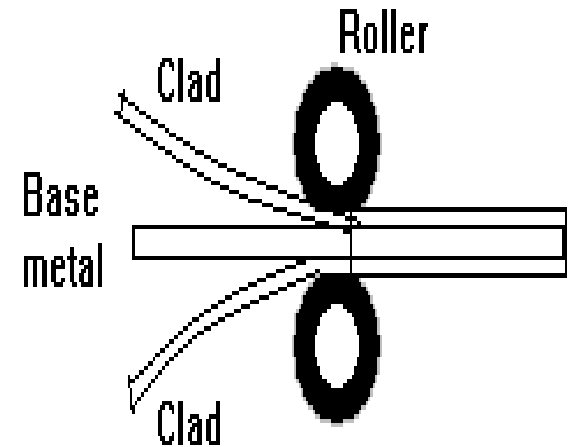
The coating metal diffuses into base metal and alloy formation takes place. The upper layer of alloy have high concentration of coating metal and it decreases towards lower layer with increase in concentration of base metal.

Applications: Applicable to protect small steel article like nuts, bolts, screw, spanners, screw driver, threaded parts, furnace parts, turbine blades etc.

D) Metal Cladding: Thin sheets of a coating metal is firmly bonded to base metal either on one or both sides by use of heat and pressure is called as cladding



Process: Base metal is clubbed between coating metal and this sandwich is passed through rollers, under the influence of heat and pressure. Thus, clad is fixed mechanically on the base metal.



Clad metal: Pb, Ni, Cu, Ag, Cr, Al

Base metal: Steel, Brass, Duralumin

Applications: Steel table tops, mild steel doors clad with brass, window panels, mild steel pipe clad with brass, aluminum clads with duralumin to be used for aero-plane body etc.