CORROSION

CORROSION → The destruction of a metal by Chemical or electrochemical reaction with its environment is Called Corrosion.

Example: Rusting of iron, Tarnishing of Silver, green deposition over Copper etc.

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CONSEQUENCES (परिणाम) of Corrosion :

(1.) Enormous waste of machines & machinery parts.
(2.) Machinery failure, which may leads to dangerous situation
(3.) Causes Contamination (प्रदूषित) of water.
(4.) Causes leakage of inflamable gas from Corrodal pipelines.
(5.) Metals & alloys due to corrosion lose their look, strength, ductibility & other desirable properties.
(6.) Economic loss to the country. (Nearly 300 billion dollar per annum loss in the form of wasted iron & coins)

Types OF CORROSION : It is of following 2 types.

Dry Corrosion
OR
DIRECT CHEMICAL CORROSION

(Dry Corrosion occurs due to direct Chemical attack of gases such as O_2, H_2, H_2S, SO_2, N_2 on the metal Surface), in absence of moisture.

- 'dation rrosion
- Corrosion by other Gases
- liquid metal Corrosion.

WET CORROSION
OR
IMMERSED CORR
OR
ELECTRO-CHEMICAL CORROSION

(Electro chemical or wet Corrosion takes place in aqueous medium (जलीय) & is electro-chemical in nature. Also known as Immersed Corrosion.

- Evolution of H_2 mechanism
- Absorption of Oxygen mechanis

OXIDATION CORROSION :→ This type of Corrosion occurs by the direct attack of O_2 on the metal surface at low or high temp. in absence of moisture, ex. All alkali (Li, Na, K, Rb—) & alkalin earth metals (Be, Mg, Ca, Sr——)

i) **CORROSION BY OTHER GASES** :→ This type of Corrosion occurs by the direct attack of gases like (So_2, Co_2, Cl_2 H_2S, F_2--) on the metal surface. The extent of Corrosion depends upon chemical affinity of metal & the gas involved. eg. H_2S attacks steel, forming FeS.

3.) **liquid-metal Corrosion** :→

This type of Corrosion is due to action of a flowing liquid on solid metals or alloys at higher temperature., example liquid sodium which is used as heat transfer media in nuclear reactors Causes Corrosion of metal carrier tubes.

FACTORS INFLUENCING RATE OF CORROSION

1.) Purity of METAL : The rate of Corrosion, increases with increase in impurities. BECAUSE OF difference in purity (heterogeneity) an electrochemical cells is formed & the anodic Part gets corroded.

2.) Position in Galvanic Series : The metal placed higher in galvanic series, has higher oxidation Potential, becomes anode & Suffers Corrosion.

3.) Nature of Oxide film : Oxide film is Protective or non-porous — less Corrosion Rate
If Oxide film is non-protective - or porous it is non-protective — more Corrosion rate.

4.) TEMPERATURE : Higher Temp., increases electrochemical reaction, therefore higher is the Corrosion rate.

5.) Humidity : Corrosion Increases with humidity.

6.) Presence of Impurities in atmosphere : More polluted is the air, higher is Corrosion

7.) Effect of PH :→ lower the PH, higher is Corrosion. Corrosion ∝ acidic medium.

PILLING - BEDWORTH RULE :→ The oxide layer formed on a metal surface can be protective or non-protective, depends upon the ratio of volume of metal oxide to the volume of metal consumed. This is also known as PILLING-BEDWORTH Ratio.

> PILLING BEDWORTH RATIO = VOLUME OF METAL OXIDE FORMED / VOLUME OF METAL CONSUMED.

There are two conditions according to this rule.

i.) If the volume of oxide layer formed is less than the volume of metal consumed, i.e. if the ratio is less than unity, then the oxide film or layer formed will be non-protective (porous) in nature.

i) If the volume of oxide layer formed is equal or greater than the metal from which it is formed, ~~then~~ i.e. if the ratio is equal or greater than unity, then the oxide layer formed will be protective (non-porous) in nature.

DIFFERENT TYPES OF OXIDES LAYER FORMED :→

1.) STABLE FILM OR LAYER :→ STABLE oxide film is fine grained, adheres tightly to the metal surface, thus preventing entry of oxygen to the metal.
example: Oxides film on Al, Cr, Cu, Pb, Sr Sn.

2.) Unstable film : If the oxide film or layer formed on the surface of metal decomposes back into metal & oxygen then the film is called unstable film. eg. oxide layer on Au, Ag, Pt

metal oxide ⇌ metal + oxygen.

3.) VOLATILE FILM (वाष्पशील) :→ If the metal oxide film volatizes from the metal surface, as soon it is formed
example: a film of molybdenum oxide (MoO_3)

4.) Porous film : If the oxide film formed develops cracks, due to which diffusion of oxygen takes place through pores causing furthe oxidation. example: oxide film of alkali & alkaline earth metals

MECHANISM OF DRY CORROSION

It can take place under following conditions.

1.) The oxygen is adsorbed on the metal surface by physical adsorption.

2.) When temperature rises physical adsorption changes to chemical adsorption & finally metal gets oxidized to metal ion

$$M \longrightarrow M^{n+} + ne^-$$

3.) The electrons are taken up by oxygen which gets reduced to oxide ion.

$$nO_2 + 2ne^- \longrightarrow 2nO^{--}$$

The complete reaction can be written as:

$$2M \longrightarrow 2M^{n+} + 2e^- \quad \text{(oxidation of metal)}$$

$$nO_2 + 2ne^- \longrightarrow 2nO^{--} \quad \text{(Reduction of oxygen)}$$

$$2M + nO_2 \longrightarrow 2M^{n+} + nO^{--}$$

metal — oxygen — metal ion — oxide ion

metal oxide (M_2O_n)

ELECTROCHEMICAL CORROSION OR WET CORROSION

This types of metal corrosion takes place in aqueous medium & seems to be electro-chemical in nature.

It generally takes place under following conditions :

(1.) A metal is in Contact with moist air or any liquid medium
(2.) There must be a Cathode and an anode.
(3.) There must be an electric-potential develops between the anode & Cathode.
(4.) The Cathode & anode must be immersed in an Electrically Conducting medium.
(5) A metallic path must be formed Connecting the Anode & Cathode.

- If following above Conditions Satisfied then Corrosion takes place as below :

(A.) ANODIC REACTIONS :→ At Anode Oxidation reaction takes place. The metal atom lose their electrons & pass into the solution by changing into metallic ions.

$$\underset{\text{(metal)}}{M} \longrightarrow \underset{\text{(Metal ion)}}{M^{n+}} + ne^-$$

(B.) CATHODIC REACTIONS : Depending upon the nature of Corrosive medium and the presence or absence of oxygen Cathodic reactions are of two types :.

(1.) Evolution of Hydrogen (H_2) (2.) Absorption of oxygen (O_2)

Evolution of Hydrogen mechanism : (Anodic Area should be large)

In absence of oxygen & in acidic medium, evolution of hydrogen takes place.

The H^+ ions of acidic solution takes up electrons released at the anode, & hydrogen gas is formed.

$$2H^+ + 2e^- \longrightarrow H_2 \uparrow \text{ (in Acidic medium)}$$

In alkaline or neutral medium & in absence of oxygen, the Cathodic reaction will take place as:

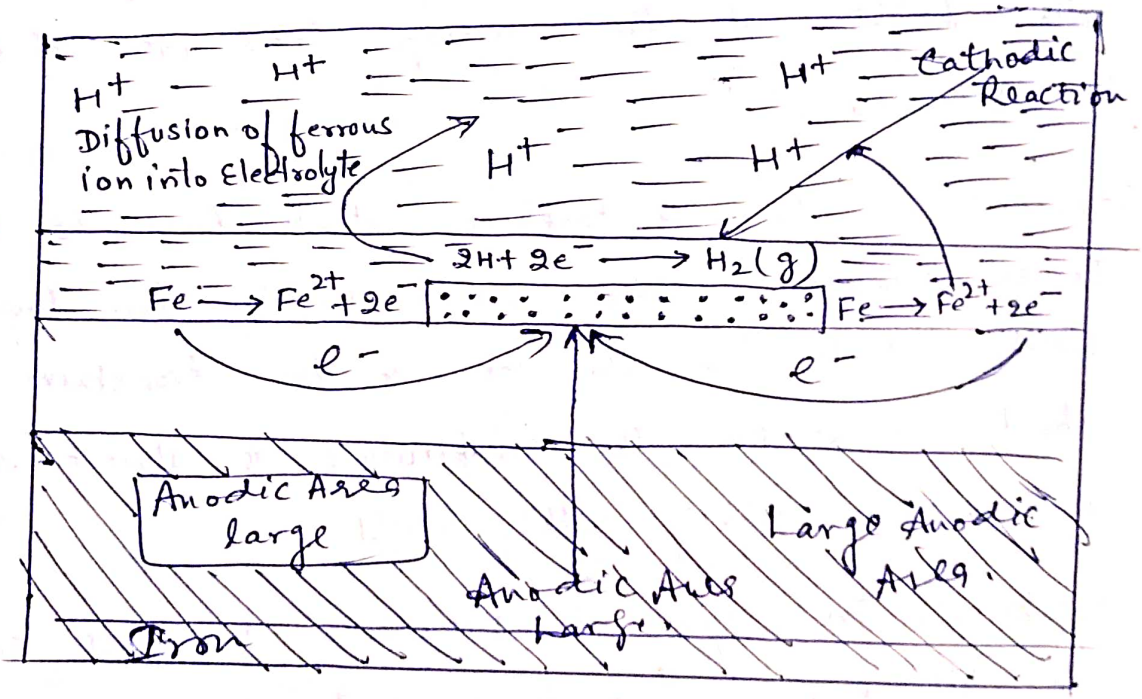
$$2H_2O + 2e^- \longrightarrow H_2 + 2OH^- \text{ (In Neutral or Alkaline medium)}$$

Example Rusting of iron in Acidic medium & in absence of oxygen takes place as:

At anode : $Fe(s) \longrightarrow Fe^{2+} + 2e^-$

At Cathode : $2H^+ + 2e^- \longrightarrow H_2 \uparrow$

Overall Reaction $\Rightarrow$ $Fe(s) + 2H^+ \longrightarrow Fe^{2+} + H_2 \uparrow$



* Mechanism of Wet or Electrochemical Corrosion by Hydrogen Evolution method.

WET CORROSION OR ELECTRO-CHEMICAL CORROSION BY Oxygen Absorption Method :→

This type of corrosion reaction takes place in presence of atmospheric oxygen.
In neutral or alkaline solution containing oxygen following reaction takes place at Cathode.
The oxygen is reduced & forms OH^- ions

At Cathode : $2H_2O + O_2 + 4e^- \longrightarrow 4OH^-$

Example : Rusting of iron in neutral ~~or Alkaline~~ aqueous solution & in presence of oxygen, can be shown as :→

$$Fe_{(s)} \longrightarrow Fe^{2+} + 2e^- \quad \text{(Anode Reaction)}$$

$$\frac{1}{2}O_2 + H_2O + 2e^- \longrightarrow 2OH^- \quad \text{(cathodic Reaction)}$$

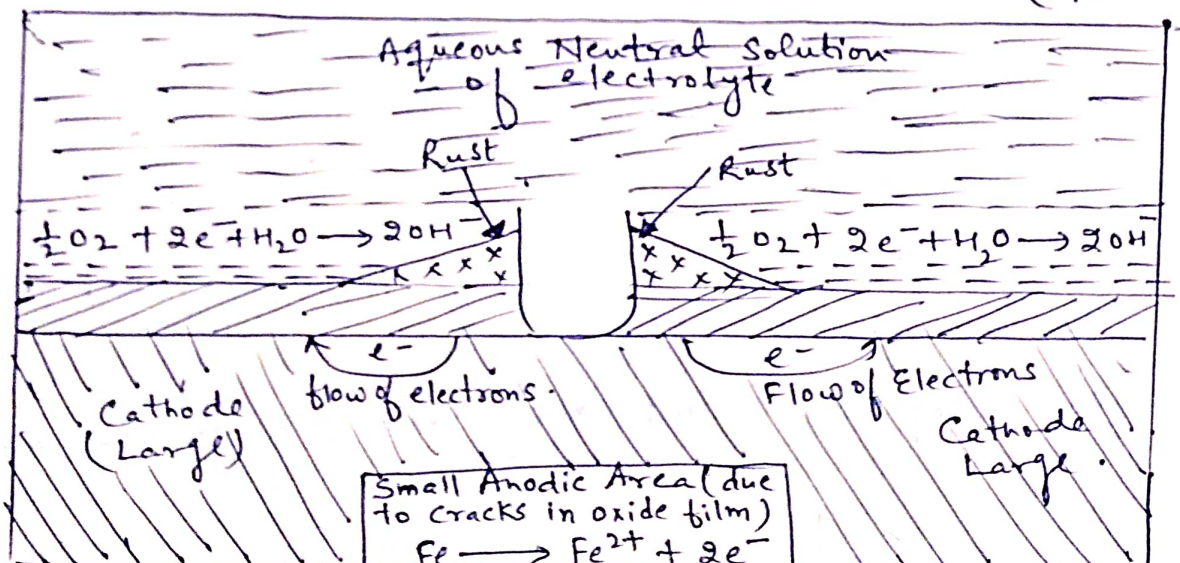
$$Fe_{(s)} + H_2O + \frac{1}{2}O_2 \longrightarrow Fe^{2+}_{(aq)} + 2OH^- \quad \text{(Overall Reaction)}$$

The Fe^{2+} produced at anode reacts with OH^- & formed $Fe(OH)_2$

$$Fe^{2+} + 2OH^- \longrightarrow Fe(OH)_2 \downarrow$$

This $Fe(OH)_2$ is further oxidised to form Rust

$$Fe(OH)_2 + O_2 + 2H_2O \longrightarrow 4Fe(OH)_3 \text{ or } 2Fe_2O_3 \cdot 3H_2O \quad \text{(Rust)}$$



* Mechanism of WET CORROSION BY OXYGEN ABSORPTION METHOD.

PROTECTION OR PREVENTION FROM CORROSION : (CORROSION CONTROL)

Various METHODS SUGGESTED FOR the CONTROL OF CORROSION ARE

(1.) **Protection by proper designing** ; CORROSION can be controlled by proper designing of equipments, ~~due to~~ to avoid any collection of dust or dirt in the article.

2.) **MATERIAL SELECTION** :→

(A.) USING Pure metals free from impurities.

(B.) Using metal alloys instead of using metal alone.

3) **Use of Corrosion Inhibitors** .

(A.) Anodic Inhibitors.

(B.) Cathodic Inhibitors.

4.) **modification / modifying the environment**

5.) **Modification in the properties of a metal.**

6) **Use of protective Coatings**

(1.) Metallic Coatings.

(2.) Non-metallic Coatings.

Metallic Coatings includes :→

(A.) Electroplating :

(B.) Metal cladding.

(C.) Dipping.

(D.) Tarnishing.

(E.) Spraying

(F.) Galvanizing

(G.) Tinning.

Non metallic Coatings includes :

(A.) Organic Coatings → eg. Paints, Varnish, enamels

(B.) Chemical conversion coatings :

Phosphate Coating, Chromate Coating etc.