

DRY CORROSION

INTRODUCTION

- Metals and alloys are used as construction and fabrication materials in engineering. The action of atmospheric gases, moisture and other chemicals on these metallic structures causes slow deterioration which is called corrosion.

- Corrosion reduces the useful properties of metals such as strength, ductility, electrical conductivity.



Corrosion causes the metals to lose strength, ductility, electrical conductivity.

- Corrosion is defined as the destruction of metallic structure through unwanted chemical or electro chemical attack by its environment, starting at its surface.
- Corrosion is a chemical phenomena that ends with chemical products. Ex. Rusting of iron by moisture to hydrated ferric oxide.

WHY CORROSION OCCURS?

- Corrosion is only concentrated on metals and some alloys. But not on wood, plastics or other chemically inert materials. Why?
- Metals are extracted from their respective ores which are in lower energy state. We convert the ores into metals at the expense of heat energy, chemical energy, electrical energy, etc. i. e. by spending huge amount of energy.
- With these higher energy state, metals are not stable and tend to lose the excess energy to revert back to its original stable state. This will be possible only by means of chemical reactions. So corrosion is a chemical phenomenon. Yes, Nature always remains to be stable with lesser energy state.

CORROSION - CLASSIFICATION

- Dry Corrosion
(Chemical Corrosion)



- Wet Corrosion
(Electrochemical Corrosion)



DRY CORROSION

- This type of corrosion occurs through direct chemical action of dry corroding agents such as oxygen, halogen, hydrogen sulphide, sulphur dioxide, etc. Sometimes metals are corroded by anhydrous metal liquids too.
- Hence dry corrosion is further classified into
 1. Corrosion by oxygen
 2. Corrosion by other gases
 3. Corrosion by liquid metals

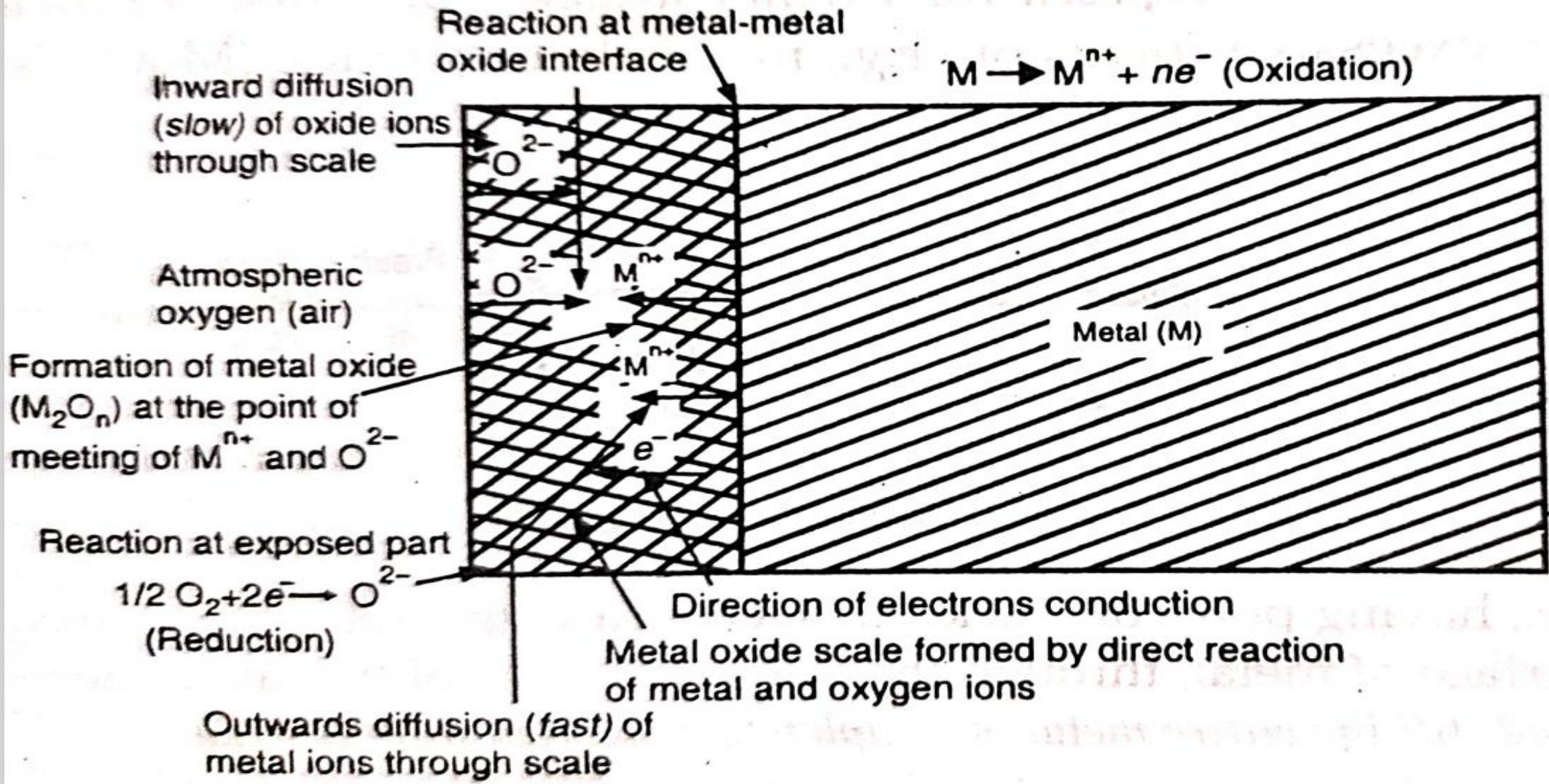
Corrosion by Oxygen (Oxidation Corrosion)

- As oxygen is active in the atmospheric gases, this type of corrosion is quite common.
- This is brought about by the direct chemical attack of oxygen on metals in the absence of moisture.
- At ordinary temperatures, metals are slightly attacked by oxygen. Alkali and alkaline earth metals undergo corrosion at room temperature.
- At high temperatures, almost all metals undergo oxidation corrosion except the noble metals.

Mechanism

- Oxidation occurs first at the surface of metal where atmospheric oxygen and metal atoms meet together. Corrosion starts at the metal surface i.e. corrosion is a surface phenomenon.
- Initial corrosion is decided by the affinity between the metal and the oxygen. The reactions are :





- The reaction between the metal and oxygen form metal oxide molecule which covers the surface of the metal as a layer.
- For the oxidation to continue, either the metal must diffuse ***outwards*** through the oxide layer to the surface or the oxygen must diffuse ***inwards*** through the layer to the underlying metal.
- Both transfers occur but the outward diffusion of metal ions is generally more rapid owing to small sized metal cations compared to larger oxide anions.
- Also the thin oxide layer decides the further corrosion based on the nature of the layer.

The nature of oxide layer may be

- **Stable** : It is fine grained and adhered strongly to parent metal surface. Hence the stable layer is impervious in nature which prevents further corrosion. Such a layer behaves as protecting layer and metals like Al, Sn, Pb, Cu, etc., form these kind of layers.
- **Unstable**: Here, the formed oxide layer decomposes back into metal and oxygen.



Ag, Au and Pt metals give unstable oxide layer and thus do not undergo oxidation corrosion.

- **Volatile:** Sometimes, the metal oxide layer volatilizes as soon as it is formed, thereby leaving fresh underlying metal surface exposed for further attack. This leads to rapid corrosion, causing excessive corrosion. For ex. MoO_3 is volatile.
- **Porous:** If the oxide layer possesses pores and/or cracks, the access for both ions through the layer is possible. So corrosion continues unobstructed till the entire metal is converted to its oxide.
- Thus the nature of oxide layer decides further corrosion. Both stable and unstable layers protect the metals from further corrosion while volatile and porous layers could not protect the metals from further corrosion.

Corrosion by other gases

- The other gases like SO_2 , Cl_2 , H_2S , F_2 etc., also cause corrosion on metals but the extent of corrosion depends on the affinity between the gas and the metal.
- The degree of attack, once again depends on the nature of the layer.
- If the layer is protective, like AgCl , (the attack of Cl_2 on Ag) the intensity of the attack is decreased.
- On the other hand, non-protective film will permit the corrosion to continue. The dry Cl_2 gas forms volatile SnCl_4 film on tin metal where corrosion continues.

Corrosion by liquid metals

- This happens when flowing liquid metal at high temperatures on solid metals and alloys.
- Liquid metals such as Na, Li, Pb and eutectic alloy of Pb-Bi are used as coolants in advanced nuclear energy systems. These will react with structural material causing liquid metal corrosion.
- Corrosion depends on two factors. They are i) metal based factors and ii) environment based factors.
- Hence the rate of corrosion reactions can be minimized by modifying metal and environment based factors.