19CH101– ENGINEERING CHEMISTRY

Unit-2 CORROSION AND ITS CONTROL

CORROSION

A continuous deterioration or degradation of metal due to their reactions with its environmental gases and other substances is called as Corrosion. It leads to a change in physical properties of the metal. Corrosion causes weakening of a material due to breaking of metal surface and shattering. In the field of engineering metals are generally used as fabrication or construction materials. The metal structures deteriorate if they are not properly maintained.

Causes of Corrosion

Metals occur in two different forms.

1. The native state.
2. The combined state.

Native state

An element is said to exist in the native state when it is in its elementary form. They occur in an uncombined state which is non–reactive towards the environment. Noble metals are good examples that exist as such in the earth's crust. They posses very good corrosion resistance and are less reactive, elements such as gold, platinum, etc., are found to be in the native state.

Combined State

An element is said to exist in the combined state when it exists in nature as a compound. Reactive elements occur in nature in the combined state. Expect noble metals, all other metals are reactive and react with environment to form a stable compound as their oxides or sulphides or chlorides or carbonates. They exist in the form of stable compounds called ores and minerals. A good example is, when iron is exposed to air that is moist it gets corroded and a layer of reddish-brown substance called as rust is formed on the surface. Rust is a chemically hydrated form of iron (III) oxide, Fe_2O_3. xH_2O. Copper metal when exposed to moist air gets coated forming a greenish white powdery substance which is copper carbonate

Effects of corrosion:

1. Wastage of metal in the form of its compounds.
2. The valuable metallic properties like conductivity, malleability, ductility etc. are lost due to corrosion.
3. Life span and efficiency of metallic parts of machinery and fabrications is reduced.

Theories of corrosion:

1. Dry corrosion
2. Wet corrosion

Dry corrosion or Chemical corrosion:

The direct chemical action of environment on the surface of metal in absence of moisture is known as dry corrosion.
This type of corrosion occurs mainly through the direct chemical action of atmospheric gases like O_2, halogens, H_2S, SO_2, N_2 or anhydrous inorganic liquid with the metal surface.
Example:
(i) Silver materials undergo chemical corrosion by Atmospheric H_2S gas.
(ii) Iron metal undergo chemical corrosion by HCl gas.

There are three types of chemical Corrosion:
1. Oxidation corrosion
2. Corrosion due to other gases
3. Liquid metal corrosion

Oxidation Corrosion:

Direct action of oxygen at low or high temperatures on surface of metals in absence of moisture is known as oxidation corrosion. Alkali metals and Alkaline earth metals are rapidly oxidized at lower temperatures. At high temperature all metals are oxidized (except Ag, Au, Pt).

Mechanism:
1) Oxidation takes place at the surface of the metal forming metal ions M^{2+}
2) Oxygen is converted to oxide ion (O^{2-}) due to the transfer of electrons from metal.
3) The overall reaction is of oxide ion reacts with the metal ions to form metal oxide film.

Mechanism:

Initially the surface of metal undergoes oxidation and the resulting metal oxide scale forms a barrier which restricts further oxidation. The extent of corrosion depends upon the nature of metal oxide.

Nature of the oxide formed:

It plays an important role in further oxidation corrosion process.
Metal + oxygen metal oxide (corrosion product)
When the oxide film formed is:

(a) Stable metal oxide layer

A stable layer is fine grained in structure and can get adhered tightly to the parent metal surface. Such a layer will be impervious in nature and hence behaves as protective coating, thereby shielding the metal surface. Consequently further oxidation corrosion is prevented.
E.g.: Al, Sn. Pb, Cu, etc. form stable oxide layers on surface thus preventing further oxidation.

(b) Unstable metal oxide layer

The oxide layer formed decomposes back into metal and oxygen. Consequently oxidation corrosion is not possible in such cases.
Eg: Ag, Au and Pt do not undergo oxidation corrosion.
Metal oxide Metal + oxygen

(c) Volatile Metal oxide layer

The oxide layer formed is volatile in nature and evaporates as soon as it is formed. There by leaving the under lying metal surface exposed for further attack. This causes rapid continuous corrosion, leading to excessive corrosion eg: Mo- molybdenum forms volatile MoO_3 layer.

Pilling Bedworth rule:

- To express the extent of protection given by the corrosion layer to the underlying metal Pilling Bedworth rule was postulated.
- It is expressed in terms of specific volume ratio.
- Specific Volume ratio = **Volume of metal oxide layer /Volume of parent metal**
- Smaller the specific volume ratio, greater is the oxidation corrosion
- Eg. The specific volume ratio of W, Cr, and Ni are 3.6, 2.0 and 1.6 respectively. Consequently the rate of corrosion is least in Tungsten(W)

- ➔ If the volume of the corrosion film formed is more than the underlying metal, it is strongly adherent, non-porous and does not allow the penetration of corrosive gases. No further corrosion.
- ➔ If the volume of the corrosion film formed is less than the underlying metal, it forms pores/cracks and allow the penetration of corrosive gases leading to corrosion of the underlying metal.