Corrosion :-

Corrosion can be define as the destructive attack of a metal by chemical or electrochemical reaction with its environment.

SIGNIFICANCE AND COST OF CORROSION

Corrosion compromises structure safety and is a leading factor in the catastrophic failure in bridges, nuclear facilities, airplane components, and equipment used in chemical, petrochemical, transportation, and construction industries. Corrosion is a spontaneous, slowprogressing phenomenon.

Corrosion is a major expense in estimating production cost and investments in any industry.

According to a recent study, the direct cost of corrosion is estimated to be approximately $276 billion in the United States . These losses are sustained by industry and government and constitute 3.2% of the gross domestic product (GDP). The ***direct cost*** of corrosion is considered the cost of replacing corroded structures and labor. ***Indirect losses*** add billions of dollars. The following losses are considered indirect costs: product loss, shutdown, efficiency loss, product contamination, metal and food and structure and equipment over design, for example, using more expensive, overqualified materials.

Why metal corrode?

The corrosion occurs because of the natural tendency for most metals return to their natural state; e.g. , iron in the presence of moist air will revert to its natural state , iron oxide.

Metals can be corroded by the direct reaction of metal to a chemical;e.g. , zinc will react with dilute sulfuric acid, and magnesium will react with alcohols.

The driving force that makes metals corrode is a natural sequence of their temporary existence in the metallic form.

Thermo denamically: corrosion is the ability of the metal to revert to compounds which are more stable, i.e. , present in the nature initially.

Metal atoms in nature are present in chemical compounds (i.e. minerals). The same amounts of energy needed to extract metals from their minerals are emitted during the chemical reactions that produce corrosion. Corrosion returns the metal to its combined state in chemical compounds that are similar or even identical to the minerals from which the metals were extracted. Thus corrosion has been called extractive metallurgy in reverse .

Corrosion science and engineering

Corrosion science is the study of the chemical and metallurgical processes that occur during corrosion.

Corrosion engineering is the design and application of methods to prevent corrosion. Ideally , science should be associated with engineering so as to invent new and better methods of prevention and apply existing methods more intelligently and effectively .

Position of some metals in order of energy required to convert their ores to metals.

Least energy required

Au
Pt
Ag
Cu
Pb
Ni
Co
Cd
Fe
Cr
Zn
Al
Mg
Na

Most energy required K

Basic Causes of Corrosion

Electro chemical corrosion is the most important classification of corrosion. Four conditions must be exist before electrochemical corrosion can be proceed:- 1- There must be something that corrodes (the metal anode).

2- There must be a cathode.

3- There must be a continuous conductive liquid path (electrolyte, usually liquid, condensate, salts, other contaminations).

4- There must be a conductor to carry the flow of electrons from anode to cathode. This conductor is usually in the form of metal –to – metal contact as in bolted or riveted joints.

The elimination of any one of the four conditions will stop corrosion .An unbroken (perfect) coating on the surface of the metal will prevent the electrolyte from connecting the cathode and anode so the current cannot flow. Therefore, no corrosion will occur as long as the coating is unbroken.

Definition of Anode and Cathode

Anode :-as the electrode at which current leaves to return to the electrolyte (oxidation reaction).

$Zn \longrightarrow Zn^{2+} + 2e$ Oxidation reaction anodic reaction

Cathode : as the electrode at which current enters from the electrolyte . The common cathodic reaction are:-

$2H^+ + 2e \longrightarrow H_2 \uparrow$ Hydrogen evolution(H ER)

$O_2 + 4H^+ + 4e \longrightarrow 2H_2O$ O_2 reduction(acid solution)

$O_2 + 2H_2O + 4e \longrightarrow 4OH^-$ O_2 reduction(or basic solution)

$M^{+3} + e \longrightarrow M^{+2}$ Metal ion reduction

$M^+ + e \longrightarrow M$ Metal deposition

Classification of Corrosion

Corrosion has been classified in many different ways. One method divides corrosion into low- temperature and high – temperature corrosion. Another separates corrosion into direct combination (or oxidation) and electrochemical corrosion. The preferred classification here is

(1) Wet corrosion and (2) Dry Corrosion.

(1) Wet Corrosion: Occurs when a liquid is present. This usually involves aqueous solutions or electrolytes and accounts for the greatest amount of corrosion by far. A common example is corrosion of steel by water.

(2) Dry Corrosion: occurs in the absence of a liquid phase or above the dew point of the environment. Vapors and gases are usually the corrodents. Dry corrosion is most often associated with high temperatures. An example is attack on steel by furnace gases.

The presence of even small amounts of moisture could change the corrosion picture completely. For example, dry chlorine is practically non corrosive to ordinary steel, but moist chlorine, or chlorine dissolved in water, is extremely corrosive and attacks of the common metals and alloys.

Forms of Corrosion

It is convenient to classify corrosion by the forms in which it manifests itself, the basis for classification being the appearance of corroded metal. Each form can be identified by mere visual observation. In most cases the naked eye is sufficient but sometimes magnification is helpful or required. Valuable information for the solution of a corrosion problem can often be obtained through careful observation of the corroded test specimens or failed equipment.

Examination before cleaning is particularly desirable.

Some of the eight forms of corrosion are unique, but all of them are more or less interrelated.

The eight forms are:

1- Uniform (or General) attack.
2- Galvanic (or Tow- metal) .
3- Crevice corrosion .
4- Pitting.
5- Filiform corrosion
6- Intergranular corrosion . 7- Erosion corrosion 8- stress corrosion.
9- Corrosion fatigue cracking