

CORROSION AND ITS PROTECTION

A Review paper

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Abstract

This paper review theory and Mechanism of Corrosion as well as ways of prevented method. Corrosion is one of the greatest civil engineering challenges all over the world. Corrosion is caused by steel over time restoring to its natural state of iron steel. Several protection methods against Corrosion have been developed including cathodic protection and using inhibitors and coating. Hot wax dip method and sealing service with poly sulfide are two popular protection methods of corrosion.

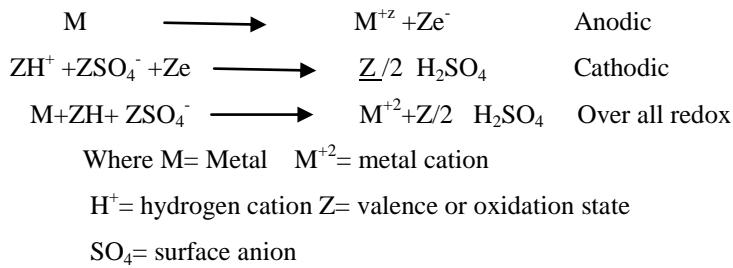
Keywords: Corrosion, causes, Coating, health effects

INTRODUCTION

Corrosion is defined as the destruction of materials caused by chemical or electro chemical action of the surrounding environment. These environments phenomena are experienced in day to day living .The most Common example of corrosion include rusting, discoloration and tarnishing. Corrosion is an over happening material disease. For example automobiles ships, underground pipe lines and house-hold applications would not require coatings. The stain less steel industry would disappear and copper would be used for electrical applications [1].

Corrosion can be fast or slow, sensitized 18-8 stain less steel is badly attacked in hours by acid. Railroad tracks usually show slight rusting not sufficient to affect their performance over many years [2]. Corrosion is a destructive phenomenon that besides its economic effect is determined to the appearance of metal and in same causes can cause equipment failure. It occurs in particularly all environments. Corrosion metal take several ways, Firstly an overall surface attack slowly reduces the thickness or the weight of the metal. Second instead of an overall surface attack only isolated areas may be affected producing the familiar located corrosion. Third it is also occurs along grain boundaries or other lines of weakness because of a difference in resistance to corrosive destruction. Metals and their alloys are tends to enter in to chemical union with the element of corrosive medium to form stable compounds similar to these found in nature. When metals loose occurs the compound formed is referred to as the corrosion product. Most corrosion process involves at least two electro chemical reaction (anodic and cathodic). Thus study of corrosion process involves the use of many the same tools that electro chemistry use [3].

The word corrosion stands from material or metal deterioration or surface damage in aggressive environments. The environment may be a liquid, gas or hybrid soil- liquid. These environments are called electrolyte since they have their own conductivity for electron transfers. An electrolyte is analogous to conductive solution, which contains positively and negatively charged. Ions called cations and anions respectively. Thus the corrosion process requires at least two reactions that must occur in a partial corrosive environment. These reactions are classified as anodic and cathodic reaction. Hence metal oxidation occurs through an anodic reaction and reduction is through a cathodic reaction as shown bellow [4].



Corrosion can occur due to difference in the electrolyte. These differences may be in the soil resistivity, oxygen concentration moisture content and various ion concentrations. The variations produce current flow from one location through the electrolyte to another portion of the same metallic structure. Electrolyte corrosion and galvanic corrosion are similar in that corrosion always occurs at the anodic areas [5].

1. OBJECTIVES

General Objective

The main objective of this review is to study the effect of corrosion and it's Cathodic Protection.

Specific Objective

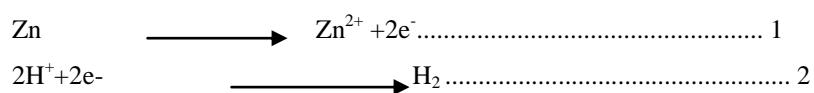
Under this general objective the specific objectives; describing corrosion, identifying the mechanism and electro chemical nature of aqueous corrosion, understand the causes of corrosion and its effect for human health and investigate the ways of corrosion protection are included.

2. LITERATURE –REVIEW

2.1 The Definition of corrosion

Corrosion is a chemical reaction. A metallic surface is consumed it react with the environment through oxidation reduction (redox) reaction [6].

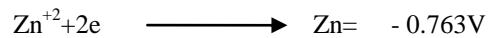
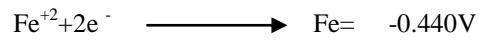
Example



The first reaction is oxidation reaction and the second reaction is reduction reaction.

Corrosion of potential reduction reaction has higher potential than the corrosion potential of oxidation reaction.

Example



$$\Delta V = -0.440 - (-0.763)$$

$V = \frac{+0.323V}{\Delta}$ Relative measure of corrosion.

2.2 Corrosion Mechanism

According electro chemistry the corrosion reaction can be considered as taking place by two simultaneous reactions. The oxidation of a metal at an anode and the reduction of a substance at the cathode, in order for the reaction to occurs the following conditions must exist [7].

1. A chemical potential difference must exist between adjacent sites on a metal surface (between alloys of a different compositions)
 2. An electrolyte must be present to provide solution conductivity and as a source of material to be reduced at the cathode
 3. An electrical path through the metal or between metals must be Available to permit electron flow.

Electro chemical corrosion of iron in contact with water is an example of case that can be used to describe the electro chemical reactions. In an early neutral or slightly acid environment, the water is dissociated in to hydrogen ions (H^+) and hydroxyl ions (OH^-) as



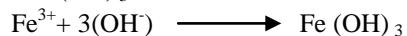
When metal is placed in contact with a liquid surface ionization occurs because of the electric charge difference at the solid liquid interface. For example iron dissolves in water in the form of positively charged ferrous ions (Fe^{2+}) where³



Electro chemically a chemical substance is oxidized when it loses electrons to a second substance. The electrode at which oxidation takes place is called anode. A chemical substance is reduced when it acquires electrons. The electrode at which reduction takes place is called cathode. Hence oxidation reactions results in the formulation of positive charge ferrous iron at the anode. Ferrous ions moving away from the metal surface are further oxidized to ferric ions (Fe^{3+}) as follow.



The positively charged ferric ion are attracted to the negatively charged hydroxyl ions and from the corrosion product Fe(OH)_3



The rust consists of iron hydroxide or iron oxide hydrates in various states depending on the degree of oxidation and dehydration. The reduction reaction at the cathode must be take place concurrently in order to continue the corrosion process. Several reactions are possible and the one that occurs is determined by the environment. Without the presence of air or oxygen hydrogen ions can be reduced by the

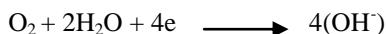
excess of electrons at the cathode surface and evolves as molecular hydrogen by;



If hydrogen is not removed from the surface the cathodic reaction decreasing and the corrosion rate is reduced with the presence of air the more likely reaction is the reduction of oxygen. Two possible reaction occurs [7].



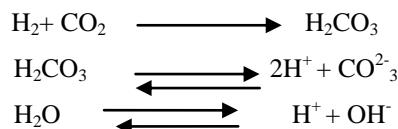
Hydrogen evolution or oxygen reduction within the formation of water is likely to occur in acid media on the other hand oxygen reduction with formation of hydroxyl ion is more dominant in a neutral or alkaline environment. In either case there is an increase in alkalinity of the solution at the cathode



2.3 Causes of Corrosion

Corrosion can be caused by reactivity of metals. The following are the common causes of corrosion [8].

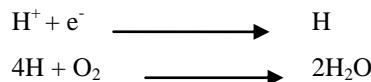
1, water on the metal surface dissolves CO₂ and O₂



2, Fe in contact with dissolved CO₂ and O₂ under goes oxidation



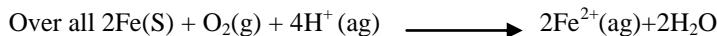
3, Electrons lost by Fe are taken by H⁺



On multipoint the first equation by 4 and adding to the second



The dissolved O₂ can take electrons directly also



4, Fe²⁺ reacts with dissolved O₂ and water



This chemical formula of rest (Fe₂O₃. nH₂O) is caused in the presence of salt accelerates or speed up the rate of Corrosion. Generally Corrosion can be caused by different types of factors those are reactivity of metal, presence of impurities, presence of electrolyte, presence of air moisture gas like O₂ and CO₂ [8].

2.4 Effect of Corrosion on Human Health

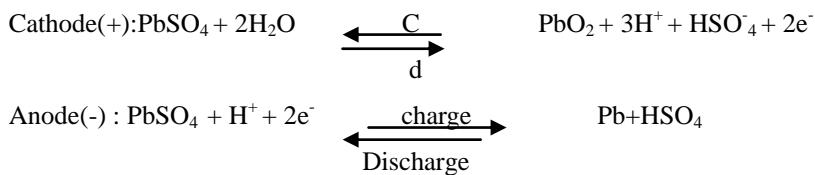
Exposure to extreme pH values result in irritation to the eye, skin and mucous membrane. Eye irritation and exacerbation of skin disorder have been associated with pH values greater than eleven. In

addition solutions of pH 10-12.5 have been reported to cause hair fibers to swell. In sensitive individuals' gastro intestinal irritation may also occur. Exposure to low pH values can also result in similar effect. Below 2.5 pH can affect the degree of corrosion of metals as well as dissection efficiency, it may have an indirect effect on health [9].

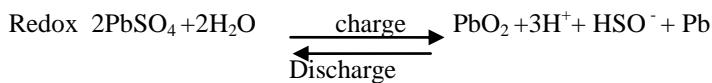
All material compounds are toxic and they affect many organ systems both during pre-metal and post metal development and in adulthood. Mercury compounds are neurotoxic. Same are immunologically active. The main toxicity stems from the binding of mercury to salt dry groups of enzymes and other proteins, there by disruption their structure and function. This interferes with basic cellular process and damages or kills cell. The different forms of mercury differ in their ability to penetrate membranes and gains the neuron toxicity, that is of greatest importance although same forms of mercury damage the kidneys and same compounds are highly corrosive to skin and mucous membrane [9].

2.5 Types of Corrosion

i) Galvanic Corrosion often referred as dissimilar metal corrosion occurs in galvanic couples where the active one corrodes. EMF series and galvanic series (kenetic) could be used for predication of this type of corrosion. Galvanic corrosion occurs in multiple phase alloy. Lead- Acid battery the basic operation of lead-acid ($\text{Pb-H}_2\text{SO}_4$) battery is based on group of positive and negative plate immersed in an electrolyte that consists of diluted sulfuric (H_2SO_4) and water. Hence the mechanism of this type battery is based on the electro balanced anodic (-) and cathodic (+) reaction the ideal electrode reactions are reversed during charging (c) and discharging (d) [10].

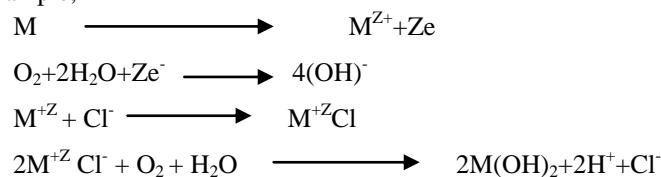


The redox reaction in lead batteries is the sum of the above half cell reaction



ii) Pitting Corrosion:-is an extremely localized Corrosion mechanism that cause destructive pits[10].

Example,



where H^+ Cl^- is the free hydrochloric acid that forms at the bottom of the pits increasing the acidity at these location this implies that the hydrogen ion concentration $[\text{H}^+] =$ in mol/Liter is increased the degree of

acidity can be defined by $\text{PH} = -\log [\text{H}^+]$

iii) Crevice Corrosion:- is a simpler types of corrosion that occur in stain less steel, it is localized corrosion resulting from a concentration difference between the electrolyte within the crevice and the electrolyte outside the crevice due to stagnation of electrolyte. Possible concentration difference in (i) Inside the crevice :- low concentration of O_2 and high Concentration of H^+ and ions such as Cl^- (More negative Electrolyte Corrosion is anode) and (ii) Outside the crevice high concentration of O_2 and low concentration of H^+ and ions suchas Cl^- (more negative Electrolyte corrosion is cathode) [11].

iv) Uniform corrosion: - is very common form found in ferrous metals and alloys that are not reduced nor protected by surface coating or inhibitors. A uniform layer of rust on the surface is formed when exposed to corrosive environmental atmosphere corrosion is typical example on this type [11].

v) Erosion Corrosion: - is the deterioration of metals and alloys due relative movement between surface and corrosive fluids. Depending on the rate of this movement abrasion takes place.

2.6 ways of corrosion prevention

Corrosion can be protected using different methods like;

(i) Cathodic protection: when metallic iron stands in the vicinity of its upper metal in the standard reduction potentials the upper metal for example (Zinc) is the cell anode and permanently oxide and corrode. This method uses to protect the water, piper's hulks, staves, pipelines [12].

Example,



(ii) Sacrificial Protection: is the protection of iron or steel against corrosion by using more reactive metal. Pieces of Zinc or magnesium alloy are attached to pump bodies and pipes. The protected metal becomes the cathode and does not corrode. The anode corrodes there by proving the desired sacrifice protection. The iron pipe will be connected to a more reactive metal such as magnesium through copper wires the magnesium will donate it's electronic to the iron preventing it from rusting. Iron which is oxidizes will immediately be reduced back to iron [12].

Example, $\text{Mg} \rightleftharpoons \text{Mg}^{2+} + 2\text{e}^-$ anodic reaction
 $\text{Fe}^{2+} + 2\text{e}^- \rightleftharpoons \text{Fe}$ cathodic reaction

(iii) Corrosion inhibitors: According to surface chemistry, the presence of foreign molecule affects the surface reactions. Corrosion processes are also a type of surface reactions. These can be controlled by foreign compound which are known as inhibitor. The inhibitor gets adsorbed on the reacting metal surface. It attaches directly to the surface. The inhibitor can work in different ways .It may block the active sites of corrosion and restrict the rate of anode and cathodic process or it may increase the electrode potential. Sodium benzoate is used as inhibitor for anodic reactions, similarly oxidizing agent like nitrate, chromate, red lead, amines, urea...etc are also used as corrosion inhibitor [12].

(iv) Coating:- are widely used for corrosion control with the general approach being to isolate the metal from the electrolyte point and a wide variety of synthetic coating (epoxy, resins, plastics) are applied directly protective oxide films are formed by inducing a chemical reaction between the metal surface and the electrolyte [12].

CONCLUSION

In this paper review theory and cause of corrosion as well as its preservation methods were described briefly. Corrosion is a destructive phenomena's that besides its economic effects is detrimental to the appearance of metal and in some cases can cause equipment failure, it occurs in particularly all environments . Corrosion is a great economic importance; it limits the useful life of metallic objects and often presents a risk of accidents and of population. Corrosion can be prevented effectively by different ways like use of inhibitors, by using coating and cathodic protection.

Recommendation

A comprehensive corrosion control program is recommended to minimize the corrosion change and to increase the equipment readiness availability and service life. The program should include corrosion survey condition based on maintenance, use of advanced storage technologies, and use of new coating repair techniques.

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