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Review Article

CORROSION: - A BASIC REVIEW

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Abstract

- The objective of this paper is to provide an overview about corrosion and its related information. The issue of the effects of corrosion on structural integrity of metal surfaces has been a question of concern for some time. The uses of chemical corrosion inhibitors are common in production and processing operations. Various parameters like, effect of surfactant concentration and mechanism of corrosion inhibition are also discussed in this review article..

Keywords: Cast iron, Corrosion, Mechanism and Form of corrosion.

Cast iron is a generic term that identifies a large family of ferrous alloys. Cast irons are primarily alloys of iron that contain more than 2% carbon and 1% or more silicon with a wide variety of properties. Cast irons are complex materials with stable and meta-stable phases and have elements in the solution which influence the extent and stability of the desirable properties not obtained by other alloys. Cast irons are intended to be cast to shape rather than formed in the solid state. Cast irons have low melting temperature, high fluidity when molten, don't form undesirable surface film when poured due to less reactivity with molten materials and have slight to moderate shrinkage during solidification and cooling. However, cast irons have relatively low impact resistance and ductility which may limit their use [1].

Mechanical properties of cast irons like strength, ductility, and modulus of elasticity depend strongly on structure and distribution of micro structural constituents. Physical properties such as thermal conductivity and damping capacity are strongly influenced by microstructure. Cast irons popularity stems from an ability to cast complex shapes at relatively low cost and the wide range of properties that can be achieved by careful control over composition and cooling rate without radical changes in production methods [2].

Cast Iron has, for hundreds of years, been the preferred piping material throughout the world for drain, waste, and vent plumbing applications and water distribution. Gray iron can be cast in the form of pipe at low cost and has excellent strength properties. Unique corrosion resistance characteristics make cast iron soil pipe ideally suited for plumbing applications [3].

Corrosion: -

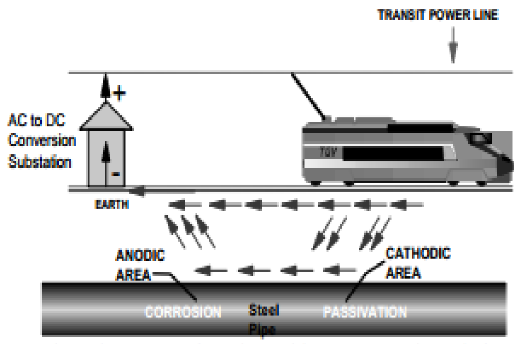
Corrosion of reinforcement has been established as the predominant factor causing widespread premature deterioration of concrete construction worldwide, especially of the structures located in the coastal marine environment [4]. The most important causes of corrosion initiation of reinforcing steel are the ingress of chloride ions and carbon dioxide to the steel surface. After initiation of the corrosion process, the corrosion products (iron oxides and hydroxides) are usually deposited in the restricted space in the concrete around the steel. Their formation within this restricted space sets up expansive stresses, which crack and spall the concrete cover. This in turn results in progressive deterioration of the concrete. As a result, the repair costs nowadays constitute a major part of the current spending on infrastructure. Quality control, maintenance and planning for the restoration of these structures need non-destructive inspections and monitoring techniques that detect the corrosion at an early stage. Corrosion loss consumes considerable portion of the budget of the country by way of either restoration measures or reconstruction. There have been a large number of investigations on the problems of deterioration of concrete and the consequent corrosion of steel in concrete. Properly monitoring the structures for corrosion performance and taking suitable measures at the appropriate time could effect enormous saving. Moreover, the repair operation themselves are quite complex and require special treatments of the cracked zone, and in most instances the life expectancy of the repair is limited. Accordingly, corrosion monitoring can give more complete information of changing condition of a structure in time [5-8].

Mechanism of Corrosion: -

There are two basic mechanisms by which metals in electrolytes corrode

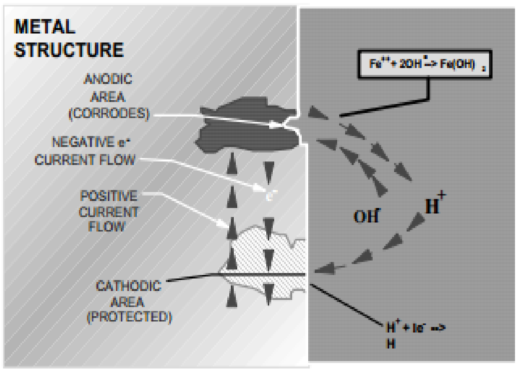
1. Electrolytic Corrosion
2. Galvanic Corrosion

Electrolytic corrosion is a result of direct current from outside sources entering and then leaving a particular metallic structure by way of the electrolyte. Where current enters the structure, that part is usually unaffected or is provided with some degree of protection. Where current leaves the structure, corrosion occurs. In underground work, this type of corrosion is often referred to as stray current corrosion and results from currents entering the soil from sources of DC such as electric railway systems or DC machinery. Current will be generated when two dissimilar metals are electrically connected and immersed in an electrolyte. One of the metals will corrode. The path of the current will be from the corroding metal, through the electrolyte (soil) to the non-corroding metal and then back through the connection (conductor) between the two metals. The corroding metal is the one where the current leaves to enter the electrolyte and is called an anode. The metal that receives the current is called the cathode. Corrosion can occur due to differences in the electrolyte. These differences may be in the soil resistivity, oxygen concentrations, 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. [9]



Galvanic corrosion is self-generated activity

Figure No 1



GALVANIC CORROSION OF A SINGE METAL.

Figure No 2

Form of corrosion: - [10]

Corrosion occurs in several widely differing forms. Classification is usually based on one of three factors:

Nature of the corrodent: Corrosion can be classified as “wet” or “dry.” A liquid or moisture is necessary for the former, and dry corrosion usually involves reaction with high-temperature gases.

Mechanism of corrosion: This involves either electrochemical or direct chemical reactions.

Appearance of the corroded metal: Corrosion is either uniform and the metal corrodes at the same rate over the entire surface, or it is localized, in which case only small areas are affected.

Classification by appearance, which is particularly useful in failure analysis, is based on identifying forms of corrosion by visual observation with either the naked eye or magnification. The morphology of attack is the basis for classification.

Figure 3 illustrates schematically some of the most common forms of corrosion. Eight forms of wet (or aqueous) corrosion can be identified based on appearance of the corroded metal.

These are:

1. Uniform or general corrosion
2. Pitting corrosion
3. Crevice corrosion, including corrosion under tubercles or deposits, filiform corrosion, and poultice corrosion
4. Galvanic corrosion
5. Erosion-corrosion, including cavitation erosion and fretting corrosion
6. Intergranular corrosion, including sensitization and exfoliation
7. Dealloying, including dezincification and graphitic corrosion

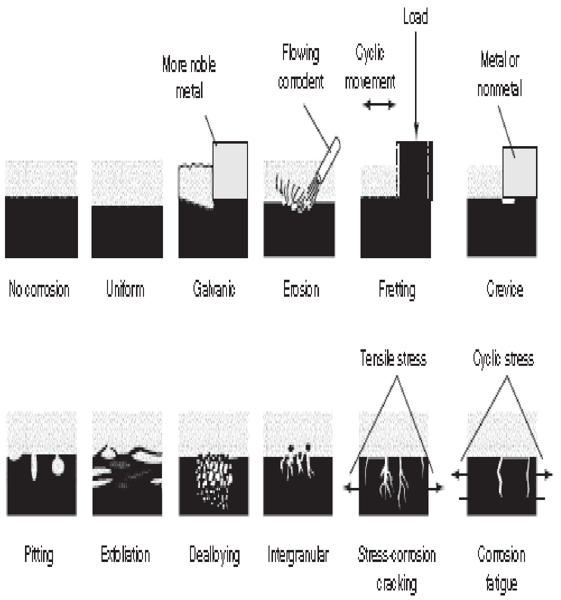


Figure No 3: - Common forms of corrision

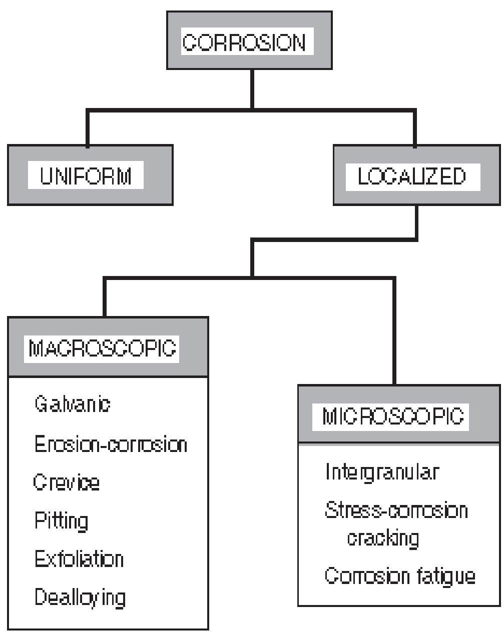


Figure No 4: - Macroscopic versus microscopic forms of localized corrision.

Methods to Control Corrosion

There are five primary methods of corrosion control:

1. Material selection
2. Coatings
3. Inhibitors
4. Cathodic protection
5. Design

1.Material Selection

Each metal and alloy has unique and inherent corrosion behavior that can range from the high resistance of noble metals, for example, gold and platinum, to the low corrosion resistance of active metals, for example, sodium and magnesium. Furthermore, the corrosion resistance of a metal strongly depends on the environment to which it is exposed, that is, the chemical composition, temperature, velocity, and so forth.

The general relation between the rates of corrosion, the Corrosivity of the environment, and the corrosion resistance of a material is:

$$\frac{\text{corrosivity of environment}}{\text{corrosion resistance of metal}} \approx \text{rate of corrosive attack}$$

2.Coating

Coatings for corrosion protection can be divided into two broad groups—metallic and nonmetallic (organic and inorganic). With either type of coating the intent is the same, that is, to isolate the underlying metal from the corrosive media.

a. Metallic Coatings

The concept of applying a more noble metal coating on an active metal takes advantage of the greater corrosive resistance of the noble metal. An example of this application is tin-plated steel. Alternatively, a more active metal can be applied, and in this case the coating corrodes preferentially, or sacrificially, to the substrate. An example of this system is galvanized steel, where the sacrificial zinc coating corrodes preferentially and protects the steel

b. **Organic Coating**

The primary function of organic coatings in corrosion protection is to isolate the metal from the corrosive environment. In addition to forming a barrier layer to stifle corrosion, the organic coating can contain corrosion inhibitors. Many organic coating formulations exist, as do a variety of application processes to choose from for a given product or service condition.

c. Inorganic coatings

Include porcelain enamels, chemical-setting silicate cement linings, glass coatings and linings, and other corrosionresistant ceramics. Like organic coatings, inorganic coatings for corrosion applications serve as barrier coatings. Some ceramic coatings, such as carbides and silicides, are used for wear-resistant and heatresistant applications, respectively.

3. Inhibitors

Just as some chemical species (e.g., salt) promote corrosion, other chemical species inhibit corrosion. Chromates, silicates, and organic amines are common inhibitors. The mechanisms of inhibition can be quite complex. In the case of the organic amines, the inhibitor is adsorbed on anodic and cathodic sites and stifles the corrosion current. Other inhibitors specifically affect either the anodic or cathodic process. Still others promote the formation of protective films on the metal surface. The use of inhibitors is favored in closed systems where the necessary concentration of inhibitor is more readily maintained. The increased use of cooling towers stimulated the development of new inhibitor/water-treatment packages to control corrosion and biofouling. Inhibitors can be incorporated in a protective coating or in a primer for the coating. At a defect in the coating, the inhibitor leaches from the coating and controls the corrosion.

4. Cathodic Protection

Cathodic protection suppresses the corrosion current that causes damage in a corrosion cell and forces the current to flow to the metal structure to be protected. Thus, the corrosion or metal dissolution is prevented. In practice, cathodic protection can be achieved by two application methods, which differ based on the source of the protective current. An impressed-current system uses a power source to force current from inert anodes to the structure to be protected. A sacrificial-anode system uses active metal anodes, for example, zinc or magnesium, which are connected to the structure to provide the cathodic-protection current.

5. Design

- ✓ The application of rational design principles can eliminate many corrosion problems and reduce the time and cost associated with corrosion maintenance and repair. Corrosion often occurs in dead

spaces or crevices where the corrosive medium becomes more corrosive. These areas can be eliminated or minimized in the design process. Where stress-corrosion cracking is possible, the components can be designed to operate at stress levels below the threshold stress for cracking. Where corrosion damage is anticipated, design can provide for maximum interchangeability of critical components and standardization of components. Interchangeability and part standardization reduce the inventory of parts required. Maintenance and repair can be anticipated, and easy access can be provided. Furthermore, for the large items that are critical to the entire operation, such as primary pumps or large fans, redundant equipment is installed to permit maintenance on one unit while the other is operating. These practices are a sampling of rational design principles.

Strategies for Effective Corrosion Management [11,12]

Understanding the corrosion and controlling it along with the process conditions that cause damage can only achieve effective corrosion management. An effective corrosion management is of utmost importance today, which, if better managed, can improve company's profitability considerably. The following strategies may be considered for effective corrosion management.

- ✓ Establish the existence of corrosion
- ✓ Determine the contributory causes of corrosion.
- ✓ Monitor corrosion activity in real time along with the process conditions that can cause the damage.
- ✓ Multi technique corrosion monitoring approach, a combination of modern electrochemical techniques may be adopted to evaluate the corrosion behavior of a material and to get more realistic picture of corrosion in the pipeline
- ✓ Adopt systems integration approach for correlating data in real time to refine production-operating practices, chemical treatment programs and optimize costs.
- ✓ Practice an effective Data management approaches in the form of records before installation and removal of corrosion

greatly monitoring devices.

- ✓ Correct and appropriate condition assessment techniques should be used to avoid premature failure and ensure maximum safety.
- ✓ Continuously review the corrosion status of materials on-line and in conjunction with process data using multi-technique electrochemical corrosion monitoring.
- ✓ Review the periods between inspections using this level of control in place and the corrosion rate known and extend the periods between inspections to further reduce operation and maintenance costs.
- ✓ Device strategy for effective control of corrosion.
- ✓ Develop a feedback mechanism to assess the effectiveness of the corrosion control mechanism

Type of Corrosion : -

Many powerful techniques were offered to measure corrosion inhibition such as anodic or cathodic protection, coating layer on the metal, oxidizing or phosphatizing treatment, the application of inhibitors, etc have been used to reduce the corrosion of metal [13-26]. Different types of familiar corrosion forms, which damages the materials by different process are given below:

1. Surface corrosion: - Usually the surface corrosion is caused by the natural oxidation process of aluminum and its reaction to oxygen and external contaminants and obviously electron flow. The aluminum has ability to oxidize is the very thing that keeps it from rusting, and one of the most vital reasons for its use in airplane structures. If anybody has a metal polished airplane should remember that the beautiful shine of the plan is short-lived. Two or three days after polishing the airplane you can reject it with an aluminum polish rag will be black from oxidation that has built in that very short period. If we left it as unpolished surface will lose its luster and begin to develop a thin light grey haze, results the chalky powder on the surface after few months, which then becomes a crusty coating. Later on, it will begin to pit and erode the aluminum if left for indefinite time. Surface corrosion is very sensitive to moisture, for instance humidity and polluted rainwater. When certain impurities mix with water, water behaves as an electrolyte that increases the electron flow results corrosion. faster. I case of stainless steel long-standing impact of water/humidity causes the surface corrosion. This is a common situation, especially in airplanes that are stored in a humid environment. Surface corrosion is not limited to the airframe.

2.Filliform corrosion: - This corrosion develops beneath a coating such as paint. It is usually caused by contaminants that were left on the surface or trapped between two mating surfaces before the primers and paint were applied. Once trapped by the paint, the corrosion develops and has the appearance of a spidery growth or a lake bed pattern under the painted surface.

3.Fretting corrosion: - This type of corrosion results from the normal causes of corrosion exacerbated by friction when two surfaces scrape against one another. It is common to see this type of corrosion where cowlings vibrate against airframes, doors rub against doorjambs, etc. The oxides form a powder that accelerates the corrosion of the material as the parts rub together, mechanically forcing the corrosive oxides into the metal.

4.Inner granular corrosion: - This corrosion is not caused by surface contaminants but is caused primarily by differential metal content of the alloy or a contaminant that became imbedded in the alloy during the manufacturing process. These dissimilar materials cause a very high level of inner electron flow (galvanic action) in the metal, resulting in the formation of internal corrosion and oxidation, and eventually making the metal swell as the pressure from the inner granular corrosion oxides try to push the molecules apart. At a very advanced stage, the metal begins to crack and split open, revealing the presence of powdery gray oxide.

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