# A Universal Phenomenon 'Corrosion' and the ability to manage it efficiently in Industry

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***Abstract***

*Corrosion can be viewed as a universal phenomenon, omnipresent and omnipotent. It is present everywhere, air, water, soil and in every environment, we encounter.*

*Corrosion has a huge economic and environmental impact on all facets of national infrastructure; from highways, bridges, buildings, oil and gas, chemical processing, water and waste water treatment and virtually on all metallic objects in use. Other than material loss, corrosion interferes with human safety, disrupts industrial operations and poses danger to environment. Awareness to corrosion and adaptation of timely and appropriate control measures hold the key in the abatement of corrosion failures. This paper presents a perfect combination of well established strategies for control and minimization of different types of corrosion in various industries.*

**Keywords-** *Corrosion, Types of corrosion, Corrosion Remedial measures.*

## I. INTRODUCTION

The three main global challenges for twenty first century are energy, water and air, that is, sufficient amount of energy is required to meet the upcoming standards of living, clean water to drink, and pure air to breathe. The ability to manage corrosion is a central part of using materials effectively and efficiently to meet these needs.

As the policy of our respected Prime Minister, Shri Narendra Modi "Zero defect, Zero effect" has been adopted by some management systems, so for translating this policy into reality engineers need to manage corrosion using a combination of well established strategies , innovative approaches and when necessary , experimental trials.

Corrosion is defined as an unintentional deterioration or destruction of metals and alloys in presence of an environment by chemical or electrochemical means. In simple, corrosion process involves reaction of metal with its Environment. It usually starts at external material surface. Corrosion resistance of metals and alloys is a basic property related to the easiness with which these materials react with the given environment. This is a natural process that seeks to Reduce the binding energy in metals, and is of electrochemical in nature.

Metals and its alloys tend to make a chemical reaction with the elements of a corrosive medium so as to form stable compounds that are similar to those found in the nature. Therefore when in this way, loss of metal occurs compound thus formed is referred to as the corrosion product.

**Fig (1) - Corrosion Affected Gears**

Corrosion is affected by a variety of parameters such as:

- Impurities
- Nature of metal
- High Temperature
- Microbes
- Nature of corrosive environment
- Films
- Velocities of fluids
- Oxidizing agents

## II. FORMS OF CORROSION

| SEVERAL FORMS OF CORROSION | | |
|---|---|---|
| AN OVERALL SURFACE ATTACK THAT DECREASES THE WEIGHT AND THICKNESS OF METAL | ISOLATED AREAS AFFECTED THAT PRODUCES A FAMILIAR LOCALISED CORROSION | ALONG THE GRAIN BOUNDARIES DUE TO DIFFERENCE IN RESISTANCE TO CORROSIVE DESTRUCTION |

## III. VARIOUS TYPES OF CORROSION

There are various types of corrosion as:

### A. Uniform Ccorrosion

#### 1) Occurrence

This is a type of corrosion which occurs over the exposed surface area.

#### 2) Cause

As the name suggests, this corrosion occurs over the entire surface with an equal intensity.
The result of this type of corrosion is the formation of film or scale on the surface.
This is the most common forms of corrosion which is easy to monitor and is less damaging than the other forms.

#### 3) Remedy

- Painting is a solution for this type of corrosion

Fig (2) - Uniform corrosion

### B. Fretting corrosion

#### 1) Occurrence

This type of corrosion occurs in the mechanical components.

#### 2) Cause

When the rubbing action occurs between the two oxides coated films or rusted surfaces, the oxide film is mechanically removed from the high spots between the contacting surfaces. These points that are exposed become active anodes compared to the rest of the surface and thus initiate corrosion.

#### 3) Remedy

- Lubricating the surfaces.
- Regularly inspecting and maintaining the lubrication.

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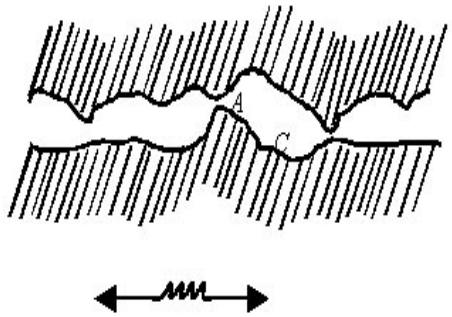



**Fig (3) - Mechanism of Fretting Corrosion.**

### C. Biological Corrosion

#### 1) Occurrence

Biological corrosion occurs in offshore structures, pipelines and buried structures.

#### 2) Cause

This type of corrosion occurs in soil and water as a result of the microbial activity. The main causes of this corrosion are algae, bacteria and fungi. They lead to wood rot and corrosion of the metal.

#### 3) Remedy

- Inhibition of fungal growth by impregnation with toxic salts can be a solution to prevent wood rot.
- By covering the cooling tower for preventing sunlight from reaching the tower water.
- Mechanically cleaning the surface by sandblasting.
- Chemically treating the surfaces with potassium permanganate, chlorine etc.

**Fig. (4) - View of Biological Corrosion**

### D. Crevice Corrosion

#### 1) Occurrence

This corrosion occurs in recesses and crevices.
It is the type of corrosion that is most common in the areas of lower concentration.

#### 2) Cause

When there occurs a concentration difference between the two surfaces of the same metal component then this type of corrosion failure occurs.

*3)* ***Remedy***

- Welded joints must be preferred instead of using bolts and rivets.
- Care should be taken to avoid the development of concentration gradient.
- Proper drainages must be provided.
- Junctions should be properly designed so as to avoid the crevices.

**Fig (5) - Telltales of Crevice Corrosion Through Bolts.**

### *E. Intergranular Corrosion*

*1)* ***Occurrence***

Occurs along the grain boundaries of varying chemical composition than other grains. This type of corrosion is also due to concentration gradient.

*2)* ***Cause***

When some of the grain boundaries possess a different chemical composition than the rest of the Grains, then such type of corrosion occurs.

*3)* ***Remedy***

- Decreasing the content of carbon.
- Providing suitable heat treatment to the metals.
- Adding the alloying elements which readily form carbides.

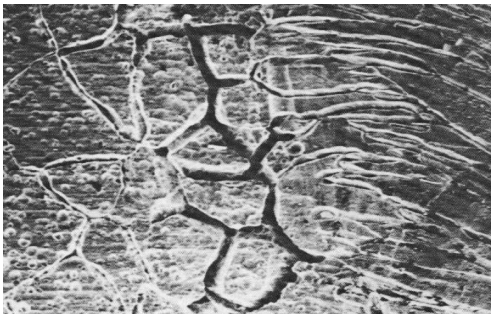


**Fig (6) - A View of Intergranular Corrosion.**

### *F. Selective Leaching Corrosion*

*1)* ***Occurrence***

Occurs where loss of nickel (Ni), chromium (Cr), tin (Sn) takes place.

*2)* ***Cause***

This involves preferential removal of solid alloy by corrosion process. It occurs due to loss of Ni, Cr, and Son occurs in Copper alloys, Ni from steel alloys, Fe from Cast iron. Therefore, the mechanical properties of the material are destroyed because the material becomes porous.

*3)* ***Remedy***

- Change of environment.
- Using the cathodic protection.
- Change in composition.

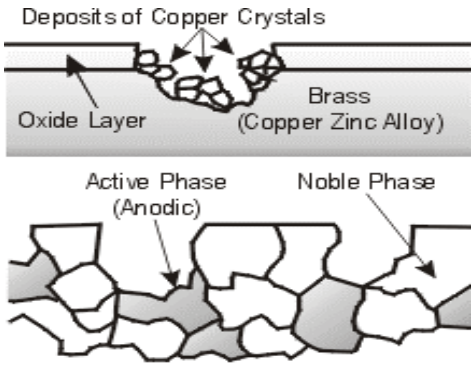



**Fig (7) - The Selective Leaching Process of Corrosion.**

### *G. Erosion Corrosion and Cavitations*

*1)* ***Occurrence***

This type of corrosion has a greater influence on the metals which passivate by forming a protective film. Also occurs on softer metals like Pb and Cu. But, practically all metals and alloys are prone to this type of corrosion.

*2)* ***Cause***

This corrosion is defined as the acceleration of corrosion attack in a metal because of the relative motion of a corrosive fluid and a metal surface i.e. this is the result of combined action of chemical attack and mechanical wear and abrasion.

*3)* ***Remedy***

- Provide gradual changes and avoid abrupt changes in the flow directions.
- Appropriate designing should be done to decrease the velocity and reduce turbulence.
- Removal of bubbles and impurities from the fluid to decrease the erosive effects.
- Choosing another different metal for the component.

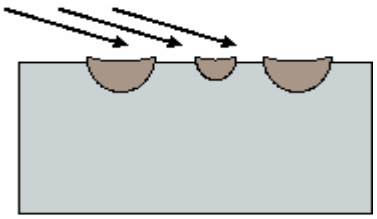


**Fig (8) - Erosion Corrosion.**

### H. Pitting Corrosion

#### 1) Occurrence

This type of corrosion occurs in a direction perpendicular to the exposed surface. This is often seen when mild steel is immersed in water or oil. Therefore, as the name suggests this area forms small holes and pits at the place of occurrence.

#### 2) Cause

When the surface is exposed constantly to alternate or varying wetting and drying, then it comes in contact with moisture. Due to the presence of moisture on the surface this type of corrosion takes place.

#### 3) Remedy

- Drying the surface by allowing free flow of the air.
- This corrosion can be reduced by polishing the surfaces.
- Providing proper drainage system would also help in preventing this type of corrosion.

**Fig (9) - An Industrial Sink Unit Where Chlorine Containing Cleaner has Caused Pitting Corrosion.**

### I. Stress Corrosion

#### 1) Occurrence

Underneath the simultaneous impact of a static tensile stress and a specific corrosive environment, this type of corrosion occurs.

#### 2) Cause

During Stress corrosion, the metal's surface is usually attacked very little while highly localized cracks propagate through the metal section. The stresses which cause this corrosion can be residual or applied stresses. Only certain combinations of alloys and environments cause stress corrosion.

#### 3) Remedy

- Alloy changing if neither the environment nor the stress level can be changed.
- Alloys should be made more resistant.
- Chlorides must be eliminated from the environment.
- Inhibitors should be added for protecting cathode.
- Tensile stress should be removed.

**Fig (10) - Stress Corrosion**

### J. Galvanic Corrosion

#### 1) Occurrence

Occurs where large cathode areas comes in contact small anode areas.

#### 2) Cause

This corrosion occurs when two metals of different chemical composition are electrically connected in presence of an electrolyte. Out of these two metals, the metal which is less inert will get corroded, while the other will not.

#### 3) Remedy

- Favourable cathode to anode ratio.
- Not creating smaller anodes with larger cathodes.
- Metal which are close together in EMF series must be chosen.
- Use a third metal to protect the remaining two metals.

**Fig (11) Galvanic Corrosion.**

### K. Hydrogen Embrittlement

#### 1) Occurrence

Mostly occurs in bolts and fasteners. This is a failure more than a corrosion phenomenon.

#### 2) Cause

This type of corrosion results from the hydrogen produced from corrosion. This hydrogen produced may get absorbed into the surfaces of fasteners. This hydrogen moves towards the areas of stress concentration, on the application of stress.

#### 3) Remedy

- Less susceptible coatings must be chosen.

- Proper heat treatment should be done to decrease the strength of the alloy.
- Protection of cathode should be avoided (steels in acid Environments).
- Removing the source of hydrogen.

**Fig (12) - Hydrogen Embrittlement.**

### *L. Waterline Corrosion*

#### *1) Occurrence*

This type of corrosion occurs just below the line of water.

#### *2) Cause*

This type of corrosion is observed in the water tanks where water remains collected for a long time**.**

#### *3) Remedy*

- Water must not be allowed to remain collected for a long period.

**Fig (13) - Waterline Corrosion**

### *M. Soil Corrosion*

#### *1) Occurrence*

This corrosion occurs on those objects which are buried under soil.

#### *2) Cause*

This type of corrosion occurs due to dissolved oxides, microorganisms, and presence of moisture.

Example: underground water pipes.

#### *3) Remedy*

- Providing a protective coating like paint on the surface of underground pipes.

### *N. High Temperature Corrosion*

#### *1) Occurrence*

This corrosion occurs in those components that operate at a very high temperature like gas turbines and jet engines.

#### *2) Cause*

This corrosion involves degradation of metal which results into the deposition of salts or other compounds on the surface of material.

#### *3) Remedy*

- Preventing the deposition of nitrides and sulphides on the surface of metal.
- Preventing the surface from oxidation and carburization.

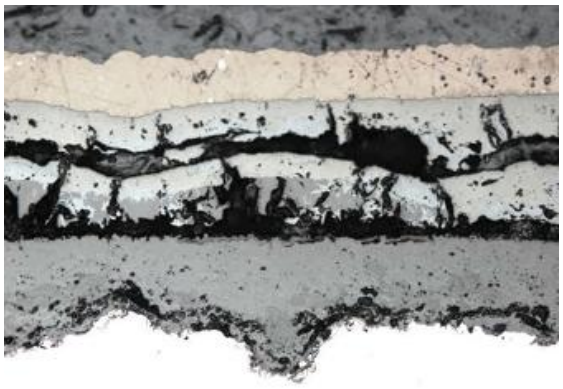


**Fig (14) - Degradation Due to High Temperature Corrosion.**

### *O. Filiform Corrosion*

#### *1) Occurrence*

This corrosion occurs on the surfaces of metal which are covered with thin organic coatings which are 0.1mm thick.

#### *2) Cause*

It is a special form of corrosion that occurs under some thin coatings in the form of thread like structures or filaments. These are fine tunnels composed of corrosion products underneath the budged and cracked coating.

#### *3) Remedy*

- Making use of brittle coatings.
- By controlling the relative humidity.

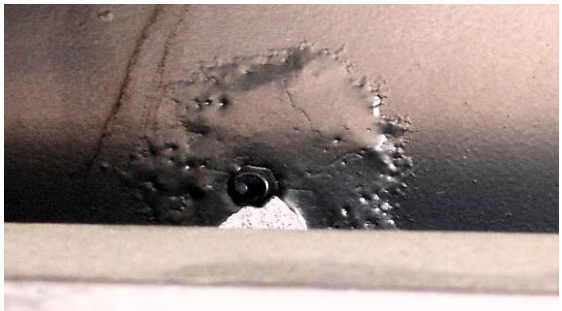


**Fig (15) - Filiform Corrosion in an Aircraft Part.**

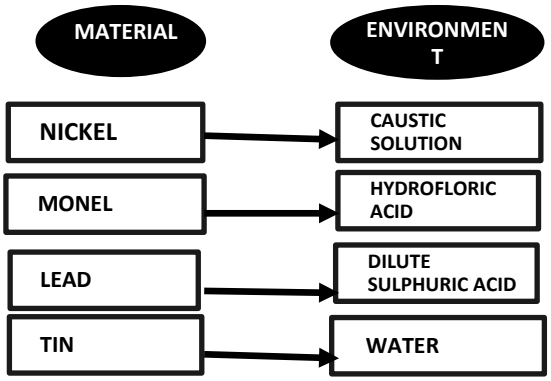
## IV. GENERAL RECOMMENDED REMEDIAL MEASURES FOR CONTROLLING THE PROCESS OF CORROSION

The methods of corrosion protection are governed by the actual environmental conditions as:

- Material selection
- Design
- Protective coatings
- Surface treatments
- Inhibitors and environmental allowances

### A. *Material Selections*

Material choice must be made in accordance with the environment.




### B. *Design*

Proper design of equipment is a very necessary tool for preventing the surfaces from corrosion

- During the design of equipment, baffles, valves, and pumps fitting are to be considered.
- Providing proper drainage holes for easy drainage of water entrapped.
- Completely eliminating the crevices.
- Facilitate easy access to inspection and maintenance
- Avoid bimetal contacts – Insulation of Joints.

### C. *Protective Coatings*

Application of coatings to the surfaces of the elements acts as a barrier between the environment and the metal.

- Metallic coatings like metal spray coating, galvanizing, vapor deposition, metal cladding etc.
- Sacrificial coatings like Zinc, Aluminum, and Cadmium on steels.
- Noble coatings like Copper, Chromium, Silver, Tin, Lead etc.

### D. *Surface Treatments*

Various surface treatments are done prior to any sort of coating.

#### 1) *Sandblasting*

It is the process of shooting bits of material to a surface at a high pressure.

#### 2) *Wire Brushing, Sanding*

Use a hand brush or a wire wheel brush and drill. Normally a few quick passes will remove the loose material.

#### 3) *Cleaning*

Next the surface must be cleaned and degreased, paints and coatings do not bond well to dirty or greasy surfaces. A washing with a strong detergent followed by a thorough rinsing is required.

#### 4) *Acid Pickling*

This involves the immersion of steel in a bath of suitable acids to remove rust. Usually this is done before hot dip galvanizing (explained in the next section).

## V. CONCLUSION

From the above discussion, it is clear that, the main interest of the structural designers is to prevent the formation of this universally present phenomenon ‘corrosion’. As each form of corrosion has its own occurrence and own specific remedies. Therefore several ways to prevent this phenomenon of corrosion have been discussed in this paper which will be very useful in structural work of engineers for proper functioning of materials, higher service life of the components and lower maintenance costs.

## REFERENCES

[1] Puckorious P.R., “controlling corrosive microorganisms in cooling water systems”. Chem. Eng., Oct 1978, p 171

[2] Kirby, G.N., “Corrosion performance of carbon steel”.Chem.Eng, Mar 1979, p 72.

[3] Charng, T., Lansang, F., “Review of corrosion causes and corrosion control in a technical facility”.

[4] Minova,T., Yashikawa,M. , **“**Improvement of the corrosion resistance on Nd-Fe-B magnet with nickel plating” IEEE Trans on Magnetics, Volume:25 , Issue: 5 ,Sep 1989, pp 3776-3778.

[5] Flowers, G.T., Fie Xie, “vibration threshold for fretting corrosion in electrical connectors” IEEE Trans on Components and Packaging Technology, volume: 27, issue: 1, March 2004, pp 1521-3331.

[6] Lee. A, Mao. A, “Fretting corrosion of tin at elevated temperatures” IEEE Trans on Electrical Contacts, Sep 1988, pp 87-91.

[7] Chudnovsky, B.H. “Degradation of power contacts in industrial atmosphere: silver corrosion and whiskers” IEEE Trans on Electrical Contacts, 2002, pp 140-150.