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OCCURRENCES OF CORROSION: CAUSES AND PREVENTION

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ABSTRACT

Corrosion of metal is a ubiquitous phenomenon that occurs in various forms. Atmospheric or uniform, galvanic, crevice, pitting, and microbial corrosion are most familiar forms of corrosion. This note briefly demonstrates these five classes of corrosion with some practical examples. This note also discusses the rational causes of the five aforementioned forms of corrosion, and provides several preventive measures to protect the metals.

Key words: Atmospheric corrosion, Crevice, Galvanic corrosion, Microbial corrosion, Pitting.

I. INTRODUCTION

Corrosion is the destructive result of electrochemical reaction between a metal or alloy and its surrounding environment [1]. The metals are generally in high energy state because some energy is added during their manufacturing process from the ores. Low energy-state ores are more stable than the high energy-state metals. For this reason, the metals tend to release the energy and go back to their original form. Hence, the metals revert to their parent state or ore under a suitable corrosive environment. This conversion phenomenon is nothing but the corrosion. The electrochemical process involved in corrosion is by nature opposite to the extractive metallurgy involved in manufacturing of the metals [2], as can be seen in Figure 1. Therefore, corrosion is sometimes considered as the reverse process of extractive metallurgy.

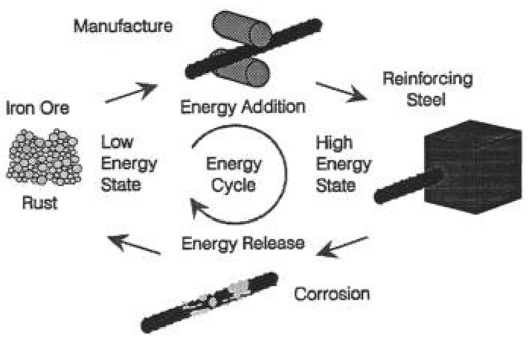

Figure 1: Corrosion process and extractive metallurgy [From reference 2].

Corrosion of metal is indeed an omnipresent phenomenon. It can occur wherever an active corrosive environment is present. However, the forms of corrosion differ based on the factors that affect the corrosion process. The form of corrosion could be either more general such as pitting and crevice or more specific such as hydrogen embrittlement and stress corrosion cracking [1, 3]. This note mainly presents very common cases of atmospheric, galvanic, pitting, crevice and microbial corrosion. In addition, this note points to the rational causes of corrosion, and suggests possible solutions for protecting the metals with regard to the depicted cases.

II. ATMOSPHERIC CORROSION

Atmospheric corrosion is a most common form of corrosion that can be seen almost everywhere. It is also known as uniform or general corrosion. An example of atmospheric corrosion can be seen in Figure 2. It shows the atmospheric corrosion that occurred uniformly on a manhole top.

The rational causes of the atmospheric or uniform corrosion on manhole top are as follows:

a. Corrosive urban atmosphere
b. Uniform exposure to air and its pollutants
c. Equal exposure to sunlight
d. Uniform distribution of temperature
e. Favorable humidity and wetness
f. Damp moisture films over metal surface
g. Uniform adsorption of water molecules
h. Wet films of dew and rainwater

i. Road salts associated with splashed water, specially for cold-region countries

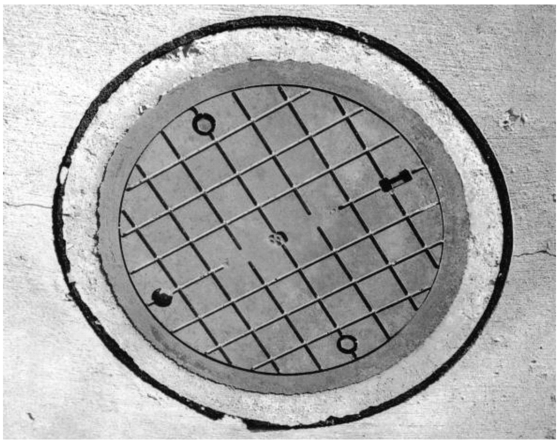

Figure 2: Atmospheric corrosion on manhole top.

The probable solutions for preventing the atmospheric corrosion illustrated in Figure 2 are given below:

a. Use galvanized manhole top
b. Do painting or polymer coating
c. Use glass and cement coatings
d. Use corrosion resistant metal or alloy
e. Select non-metallic materials
f. Reduce attack time with good drainage
g. Reduce atmospheric pollutants
h. Use suitable corrosion inhibitors

III. GALVANIC CORROSION

Galvanic corrosion generally occurs between two unlike metals. It is also known as bimetallic corrosion. The intensity of galvanic corrosion mainly depends on the electrical activity of the coupled metals. A case of galvanic corrosion can be seen in Figure 3. It shows the galvanic corrosion that occurred between iron part and stainless rim of a car.

Figure 3: Galvanic corrosion on a car.

The rational causes of the presented case of galvanic corrosion are as follows:

a. Formation of galvanic corrosion cell
b. Electrochemical contact of two dissimilar metals under corrosive environment
c. Extensive exposure to corrosive environment
d. Disparity in corrosive environment
e. Greatest anodic activity on iron part compared to stainless steel rim
f. Coating defects or coating damage
g. Large cathode to anode area ratio
h. Chloride road salts stimulating the corrosivity of the environment, particularly in cold regions

The possible solutions for preventing the galvanic corrosion showed in Figure 3 are given below:

1. Make both car components with the same metal
2. Place a separable metal piece of intermediate potential or sacrificial anode between two metals
3. Select bimetals with minimum potential difference
4. Avoid contact between dissimilar metals using good insulation
5. Reduce cathode to anode area ratio
6. Avoid coating defects and repair coating damage
7. Use a suitable coating material on corroded area
8. Use a suitable corrosion inhibitor on corroded area

IV. CREVICE CORROSION

Crevice corrosion usually occurs in crevices, splits, and gaps or cracks present in metal structures. It is also a widely occurring form of corrosion. An example of crevice corrosion has been shown in Figure 4. In this case, the crevice corrosion mostly happened between train rails and metal connectors.

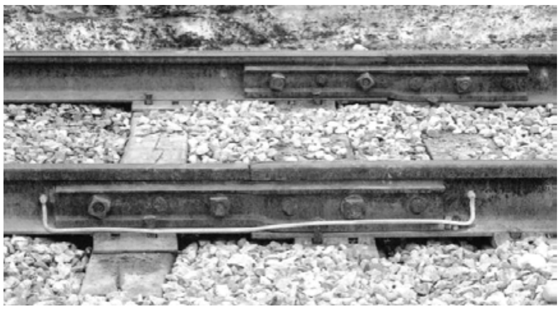

Figure 4: Crevice corrosion between train rails and metal connectors.

The rational causes of the crevice corrosion cited above are as follows:

a. Presence of crevices or shielded areas
b. Disparate micro and macro environments
c. Failure of passive films
d. Stagnant corrosive solutions
e. Lack of oxygen within crevices
f. Moisture entrapped in crevices
g. Occasional chloride contamination
h. Deposition of corrosive pollutants from air

The probable solutions for preventing the crevice corrosion cited in Figure 4 are given below:

a. Minimize number of crevices
b. Avoid using bare metal connectors
c. Use coated metal connectors, nuts, and bolts
d. Use insulating washers in bolted connections
e. Employ crevice corrosion resisting alloys
f. Use non-metallic rail connectors
g. Use polymer clad metal connectors
h. Include impervious rubber or teflon gaskets
i. Remove debris and surface deposits
j. Ensure good drainage

V. PITTING

Pitting is a well known form of corrosion that causes a lot of pits on metal surfaces. The pits are primarily very small in size but they become bigger with time. Generally, the pits become deeper and wider, as the corrosion process continues. The growing rate of pitting depends upon the corrosivity of the surrounding environment. A case of pitting corrosion has been presented in Figure 5. It shows the severe pitting corrosion that occurred on backend of a pickup car.

Figure 5: Pitting corrosion on a pickup car.

The rational causes of the illustrated case of pitting corrosion are as follows:

a. Localized breakdown of protective coating and passive film
b. Presence of moisture film in coating defects
c. Penetration of corrosive agents through defects
d. Rapid anodic dissolution by autocatalytic process in presence of corrosive agents
e. Low content of dissolved oxygen
f. Higher temperature
g. Poor maintenance

The possible solutions for preventing the pitting corrosion showed in Figure 5 are given below:

a. Do regular surface cleaning
b. Use anti-corrosion foam or liquid spray over corroded area
c. Avoid coating defects
d. Select pitting resistant materials
e. Add corrosion inhibitors
f. Use protective coatings
g. Passivate the corroded metal by strong acid such as nitric acid

VI. MICROBIAL CORROSION

Microbial corrosion is another form of corrosion that often occurs in metals contacted with soil or sludge. A case of microbial corrosion has been illustrated in Figure 6. It shows the severe microbial corrosion beneath the train rails that became in contact with underlying soil.

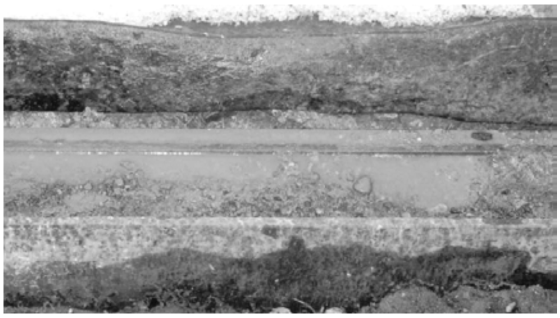

Figure 6: Microbial corrosion underneath train rails.

The rational causes of the illustrated case of microbial corrosion are as follows:

a. Direct contact with damp soil
b. Dominant de-aerated sheltered environment
c. Aerobic and anaerobic soil microbes

d. Dominant presence of sulfate-reducing bacteria
e. Highly resisting and waterlogged condition of soil
f. Long residence time of water on metal surface
g. Higher clay content of soil
h. Poor drainage facility
i. Removal or leaching of iron
j. Catalyzing effect of biological slime deposits

The probable solutions for preventing the microbial corrosion cited in Figure 6 are given below:

a. Avoid contact with soil using a thick layer of gravel or crushed stone
b. Clean the surface by mechanical means and treats with biocides
c. Employ cathodic protection
d. Use alternative metal or alloy toxic to microbes
e. Replace the cross timber supports of the train rails when necessary
f. Avoid sludge deposition
g. Allow complete drainage

VII. CONCLUDING REMARKS

Corrosion of metal occurs ubiquitously in various forms. However, the rational causes are not the same for all forms of corrosion. Also, the expected form of corrosion depends on many factors including the corrosivity of the surrounding environment. Therefore, the choice of preventive measures for protection of metals also differs for different forms of corrosion.

VIII. REFERENCES

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