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Common Forms of Metal Corrosion

Reference: Corrosion

Common Forms of Metal Corrosion

The type of corrosion likely to form on a particular metal surface is dependent primarily on the exposure environment and the metal's physical and chemical properties.

Corrosion is defined as the deterioration of a material because of chemical reactions between it and the surrounding environment.

The Most Common Types of Corrosion

Corrosion consists of a series of usually complex chemical reactions and may be initiated by several different mechanisms that are dependent on the surrounding environment. This has given rise to the various classifications of corrosion.

All corrosion is not equal. The key to effective corrosion prevention and mitigation lies in a basic understanding of the type of corrosion being dealt with and the factors that are responsible for its formation.

Uniform Corrosion

Uniform corrosion is the most common type and is characterized by attacks over the entire surface area of the metal exposed to a corroding agent. This type of corrosion is typically caused by chemical or electrochemical reactions that cause the metal to be consumed while forming oxides or other compounds over large visible areas. These reactions cause the metal to lose thickness over time and can continue until the metal has been dissolved entirely.

Galvanic/Bimetallic Corrosion

Bimetallic corrosion, also known as galvanic corrosion, is the corrosion that occurs when two dissimilar metals are directly or indirectly in contact with each other. Visually, this type of corrosion is characterized by the accelerated deterioration of one metal, while the other remains unaffected.

Bimetallic corrosion is a purely electrochemical reaction driven by the difference in electrode potentials between the two metals. When exposed to an electrolyte, the two metals form a type of cell known as a bimetallic couple, where one metal acts as the anode and the other as the cathode. The movement of electrons from the anode to the cathode initiates an oxidation reaction at the anode that causes it to be dissolved, i.e., corrode.

This type of corrosion is affected by the magnitude of the potential difference between the two metals.

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Crevice Corrosion

Crevice corrosion is a highly penetrative type of localized corrosion that occurs in or directly adjacent to gaps or crevices on the surface of a metal. These crevices can be the result of a connection between two surfaces (metal to metal or metal to non-metal), or by an accumulation of deposits (dirt, mud, biofouling, etc.). This type of corrosion is characterized by deterioration in the area of the crevice while the surrounding areas of the metal substrate remain unaffected.

One of the main criteria for the development of crevice corrosion is the presence of stagnant water within the crevice. This lack of fluid movement gives rise to the depletion of dissolved oxygen and an abundance of positive ions in the crevice. This leads to a series of electrochemical reactions that alters the composition of the fluid and makes it acidic in nature. The acidic liquid in the crevice breaks down the metal's passive layer and renders it vulnerable to corrosion attack.

Pitting Corrosion

Pitting corrosion, also known as pitting, is another localized form of corrosion that occurs on metal surfaces. Pitting typically manifests itself as small diameter cavities or holes on the object's surface while the remainder of the metallic surface remains unattacked. This form of corrosion is also highly penetrative and is considered to be one of the most dangerous types of corrosion because it is difficult to predict and has a tendency to cause sudden and extreme failures.

Pitting usually originates on areas of the metal surface where inconsistencies in the protective passive film exist. These inconsistencies may be due to film damage, poor coating application or foreign deposits on the metal surface. Areas where passivity has been reduced or lost now become the anode while the surrounding regions act as the cathode. In the presence of moisture, the anode and cathode form a corrosion cell where the anode (i.e., the areas unprotected by the passive film) corrodes. Because the corrosion is confined to a localized area, pitting tends to penetrate the thickness of the material.

Intergranular Corrosion

Intergranular corrosion involves accelerated corrosion along the grain boundaries of a metal, while the bulk of the metal surface remains free from attack. Some alloys, when subjected to improper heat treatment, can have impurities segregated at the grain boundaries that can make passivation at these areas difficult. The grain boundaries now represent a path of high corrosion vulnerability. For example, austenitic stainless steels can be susceptible to intergranular attack if they are heated in the 500°C to 800°C (930°F to 1470°F) range. At these temperatures, chromium carbide can become precipitated at the grain boundaries, therefore reducing the local chromium concentration at the boundaries. The grain boundary is then unlikely to form an effective passive film and is now susceptible to corrosion attack.

Selective Leaching

In specific corrosive environments, some metal alloys can experience a type of corrosion where only one element of the alloy is deteriorated and removed by corrosion. This discriminatory removal of a specific element is known as selective leaching or dealloying.

The most common example of this phenomenon is the selective removal of the less noble zinc element in brass alloys, also known as dezincification. Alloys composed of metallic elements that are furthest apart in the galvanic series are the most susceptible to this type of corrosion.

Erosion Corrosion

Erosion corrosion is defined as the accelerated deterioration of a metal that results from the relative movement between a corrosive liquid and a metal's surface. As the fluid flows along the surface (usually at high velocities), the metal's passive oxide layer may be removed or dissolved, leaving the

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alloy susceptible to damage. During this process, the metal may be removed in the form of dissolved ions or as corrosion products that are mechanically swept from the metal surface due to the force of the flowing fluid.

Erosion corrosion is visually recognizable by the appearance of grooves, gullies, craters and valleys in a directional pattern on the metal substrate.

Stress Corrosion Cracking

Stress corrosion cracking (SCC) is a form of corrosion marked by the formation of fine cracks on specific areas on the metal surface while the metal remains unattacked over most of its surface area. This cracking is usually due to the simultaneous presence of tensile stresses in a corrosive environment. SCC is considered to be an insidious form of corrosion because the damage is sometimes not immediately detected during inspections and can result in sudden catastrophic failures.

Welding, heat treatments and cold deformations can induce residual stresses on an object that can initiate SCC. One situation where SCC can occur is along grain boundaries that have been corroded by intergranular corrosion. Because the grain boundaries have become weakened by the segregation of impurities, applied residual tensile forces can result in fine cracking in the microstructure.

Conclusion

Corrosion exists in many forms and can be triggered by numerous mechanisms. There are many other, albeit lesser known, types of corrosion.

The type of corrosion likely to form on a particular metal surface is dependent primarily on the exposure environment and the metal's physical and chemical properties. It is, therefore, essential that the mechanisms involved in each type of corrosion be understood to ensure that the most effective prevention and mitigation measures are employed where necessary.

REFERENCES:

- Corrosion

- ATTACHMENTS: No.

Kindest Regards,

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