

## □ TYPES OF CORROSION

### [1] Uniform and Galvanic Corrosion

This is the most common form of corrosion and can be dry or wet, chemical or electrochemical. When two different metals (e.g., zinc and copper) are electrically connected and exposed to an electrolyte, the metal higher in electrochemical series undergoes corrosion. Such type of corrosion is called **galvanic corrosion**. In this corrosion, a uniform decrease in the volume of a metal takes place as a result of chemical action and soluble corrosion products are formed. The metal then gets converted into soluble corrosion product at a constant rate which can also be controlled to some extent. Galvanic corrosion generally occurs by the action of acids on metals and by the action of amphoteric metals such as Zn, Pb, Al etc. on strong alkalies.

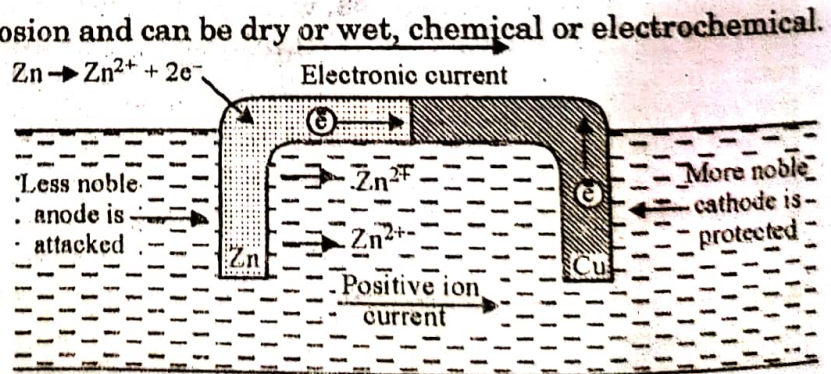


Fig. 5. Volatile oxide layer



### [II] Erosion Corrosion

It is caused by the combined effect of the abrading action of turbulent flow of gases, vapour and liquids and the mechanical rubbing action of solids over a metal surface. The major cause for its corrosion is the removal of protective surface film. Erosion corrosion can be minimized by using harder metals and design changes to avoid excess of friction and using proper lubrication.

### [III] Crevice Corrosion

It is a local corrosion and is usually created by dirt deposits, corrosion products, crack in paint coatings etc. It is usually attributed to changes in acidity in the crevice, lack of  $O_2$  in the species in the crevice and concentration of a detrimental ionic species in the crevice. Selection of resistant materials, proper design to minimize crevice and maintaining clean surfaces are the measures taken to control crevice corrosion.

### [IV] Pitting Corrosion

Pitting corrosion is, usually due to the breakdown or cracking of the protective film on a metal at specific points. It is a localized accelerated attack, resulting in the formation of cavities around which the metal is relatively unattached and this corrosion results in the formation of pinholes,

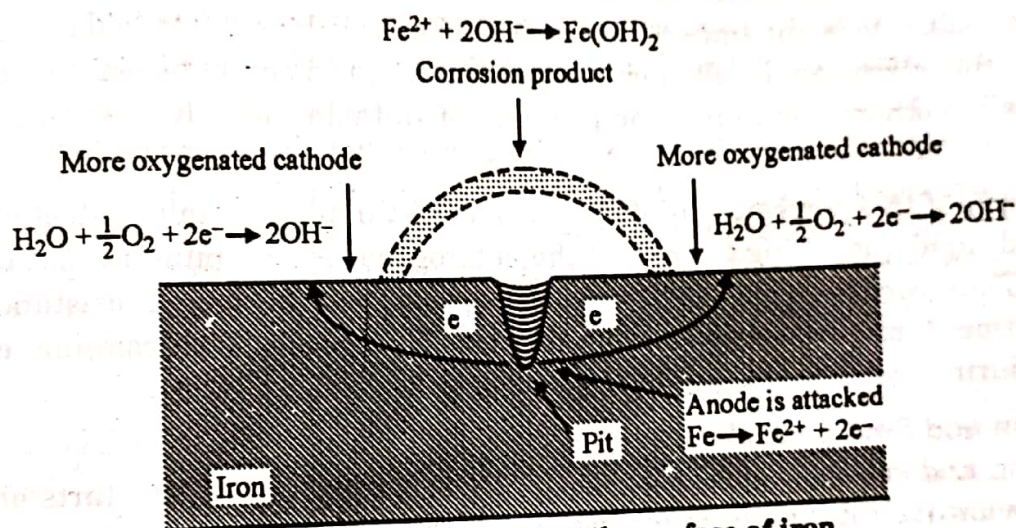


Fig. 6. Pitting corrosion at the surface of iron

pits and cavities in the metal. Pitting corrosion gives rise to the formation of small anodic and large cathodic areas. Breakdown of the protective film may be caused by,

- (i) Surface roughness or non-uniform finish
- (ii) Local straining of metal, due to non-uniform stresses
- (iii) Scratches or cut edges
- (iv) Sliding under load
- (v) Alternating stresses
- (vi) Impingement attack
- (vii) Chemical attack

A pure and homogeneous metal with a highly polished surface will be much more resistant to pitting than the one with many inclusions, defects and a rough surface. Surface cleanliness and selection of proper materials known to be resistant to pitting in the given environment are the usual methods to combat this problem.

Owing to the differential amount of oxygen in contact with the metal (Fig. 6), the small part, beneath the impurity becomes the anodic areas, while the surrounding larger parts become the cathodic areas. So, just beneath the impurity intense corrosion starts. As soon as a small pit is formed, the rate of corrosion is also increased.



### [V] Intergranular Corrosion

Intergranular corrosion occurs along grain boundaries and only where the material, especially sensitive to corrosive attack exists, and corrosive liquid possesses selective character of attacking only at the grain boundaries, but leaving the grain interiors untouched or only slightly attacked. This type of corrosion is due to the fact that the grain boundaries contain material, which shows electrode potential more anodic than that of the grain centre in the particular corroding medium. This may be due to the precipitation of certain compounds at the grain boundaries.

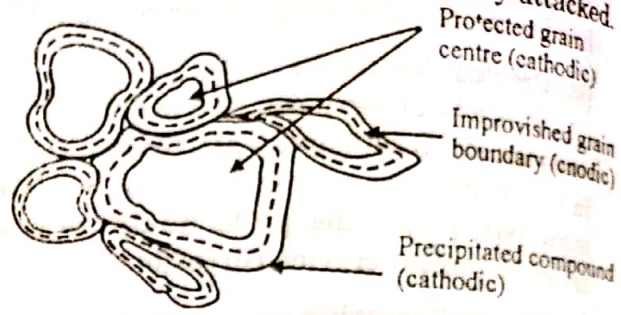


Fig. 7. General intergranular attack

Grain boundaries are generally more susceptible for attack by a corrodent because of segregation of specific elements or the formation of a compound in the boundary. In extreme cases of grain-boundary corrosion the affected grains are totally dislodged due to complete deterioration of their boundaries. This type of corrosion causes brittleness or weakness in the underlying metal and generally encountered in alloys. The primary condition for the corrosion is an alloy concentration gradient between the grains and grain boundaries, while other condition is the presence of suitable electrolyte, so that local cell may be completed.

The remedy of this corrosion in alloys such as Al-Cu alloy, stainless steel etc, is proper heat treatment and rapid quenching to prevent the heterogeneous precipitation that takes place due to slow cooling. Thus, corrosion in welded steel is not serious and corrosion resistance can be restored by heat treatment method. As a result of heat treatment the chromium carbide which is precipitated during welding is dissolved.

### [VI] Exfoliation and Selective Leaching

Exfoliation and selective leaching is a sub-surface corrosion which starts on a clean surface and spreads below it. It differs from pitting in that the attack has a rather laminated appearance and whole layers of material are corroded. The attack is usually recognized from a flaky or blistered surface. This type of corrosion is known to take place in Aluminium alloys and can be avoided by heat treatment and proper alloying.

Selective leaching (parting) is the removal of one of the elements in an alloy. De-zincification from copper-zinc alloys is the most common example. This type of corrosion is highly undesirable as it yields a porous metal with poor mechanical properties. This can be remedied by the use of non-susceptible alloys.

### [VII] Stress-Corrosion Cracking

Stress corrosion is the combined effect of static tensile stresses and the corrosive environment on a metal stresses that cause cracking result from residual cold working and quenching, welding, thermal treatment or due to applied loads during service. In such cases, the metal under stress become more anodic and tend to increase the rate of corrosion. For stress corrosion to occur presence of tensile stress and a specific corrosive environment are necessary. The corrosive agents are highly specific and selective such as :

- (i) Caustic alkalis and strong nitrate solution for mild steel,
- (ii) Traces of ammonia for brass, and
- (iii) Acid chloride solution for stainless steel.



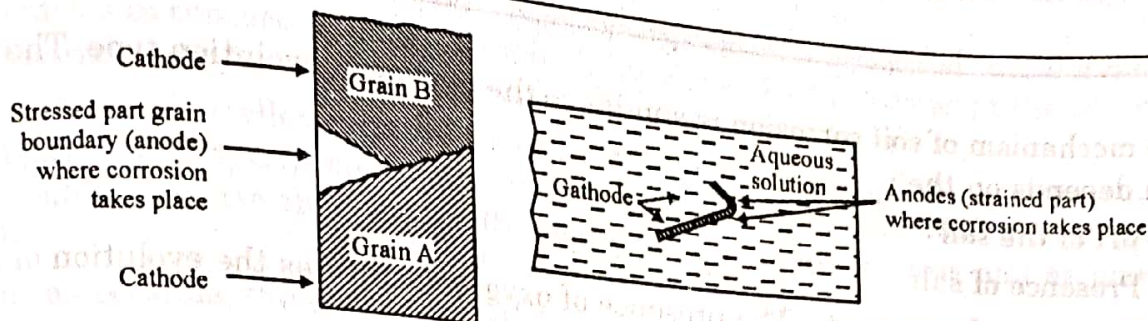


Fig. 8. Stress corrosion

This type of corrosion involves in a localized electrochemical corrosion, occurring along narrow paths, forming anodic areas with respect to the more cathodic areas at the metal surface. Presence of stress produces strains, which result in localized zones of higher electrode potential. These become so chemically active that they are attacked, even by a mild corrosive environment, resulting in the formation of a crack, which grows and propagates in a plane (perpendicular to the operating tensile stress), until failure occurs or it may stop, after progressing a finite distance.

### [VIII] Waterline Corrosion

Waterline corrosion results from differential aeration leading to the formation of oxygen concentration cells. It has generally been observed that maximum corrosion takes place in a steel tank containing water along a line just beneath the level of water, because access of oxygen is much less there (Fig. 9). The area above the waterline is highly oxygenated and hence acts as cathodic

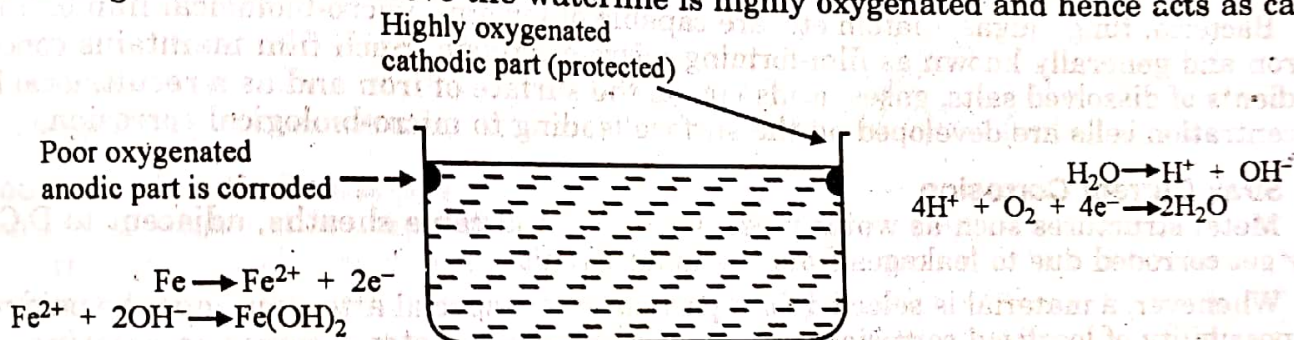


Fig. 9. Waterline corrosion occurs just underneath the meniscus and the water level

area. Consequently, it is not corroded. However, little corrosion takes place when the water is relatively free from acidity.

Waterline corrosion is also caused in marine ships and is accelerated by marine plants which are attached to the sides of the ships. This type of corrosion is prevented to a great extent by painting the sides of the ships by special anti-fouling paints.

### [IX] Soil Corrosion

Corrosion by soils is very important in case of water mains, electric cables and other underground structures, which are embedded in the soil. The various factors that are responsible for soil corrosion include the following :

- |                               |                                       |
|-------------------------------|---------------------------------------|
| (i) Acidity of the soil       | (ii) Moisture content                 |
| (iii) Content of electrolytes | (iv) Micro-organisms present          |
| (v) Content of organic matter | (vi) Physical properties of the soil. |

Soil corrosion is purely electrochemical in character. The texture of a soil is determined by the percentage of particles of various sizes. According to particle size, soils are classified as.

(a) Gravelly or sandy soils are very porous and strongly-aerated. If a metal pipe is buried in such a soil, corrosive conditions are similar to those under wet condition and the corrosion rate will be governed by the amount of moisture content in the soil.

(b) In water-logged soils, the amount of free oxygen available is very small, but various bacteria and micro-organisms can grow, which may lead to microbiological corrosion. In acidic



soils, the mechanism of soil corrosion is similar to the hydrogen evolution type. The rate of such a corrosion depends on the :

- (i) pH of the soil
- (ii) Presence of salt
- (iii) Presence of oxygen etc. The presence of oxygen facilitates the evolution of hydrogen and hence, accelerates the rate of attack.

(c) Intermediate character soil may produce a localized and intense corrosion. If air-pockets are present, differential aeration corrosion may occur in different parts.

#### [X] Micro-biological Corrosion

Corrosion caused by the metabolic activity of various micro-organisms, is called **microbiological corrosion**. The micro-organisms can develop in an environment with or without oxygen and are classed as aerobic or anaerobic.

Anaerobic bacterias such as *microspira* or *vibrio desulfuricans* reduce sulfates to sulfur which is used to prepare their protoplasm. During this process, it is supposed that these bacteria convert the  $O_2$  from the sulfates into such a form which brings about a depolarization effect on the corrosion of iron. When these organisms die, sulfur is liberated as  $H_2S$  which converts a portion of the corrosion than the oxide or hydroxide. This type of intense and localized corrosion is come across with cast iron in presence of sulfates and organic matter under anaerobic conditions.

Bacteria, fungi, algae, diatom etc. are capable of forming micro-biological film on the surface of iron and generally known as film-forming micro-organism. Such film maintains concentration gradients of dissolved salts, gases, acids etc. on the surface of iron and as a result, local biological concentration cells are developed on the surface leading to micro-biological corrosion.

#### [XI] Stray Current Corrosion

Metal structures such as water pipes, gas pipes and cable sheaths, adjacent to D.C. circuits may get corroded due to leakages from the main circuit.

Whenever, a material is selected for a particular job, special attention must be paid regarding the possibility of localized corrosion, particularly, pitting and stress corrosion cracking.