Types of corrosion

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Types of Corrosion

1. Uniform/general attack Corrosion
2. Galvanic or two-metal Corrosion
3. Pitting Corrosion
4. Crevice Corrosion
5. Intergranular Corrosion
6. Stress Corrosion
7. Erosion Corrosion
8. Cavitation Damage
9. Fretting Corrosion
10. Selective Leaching
11. Hydrogen Damage

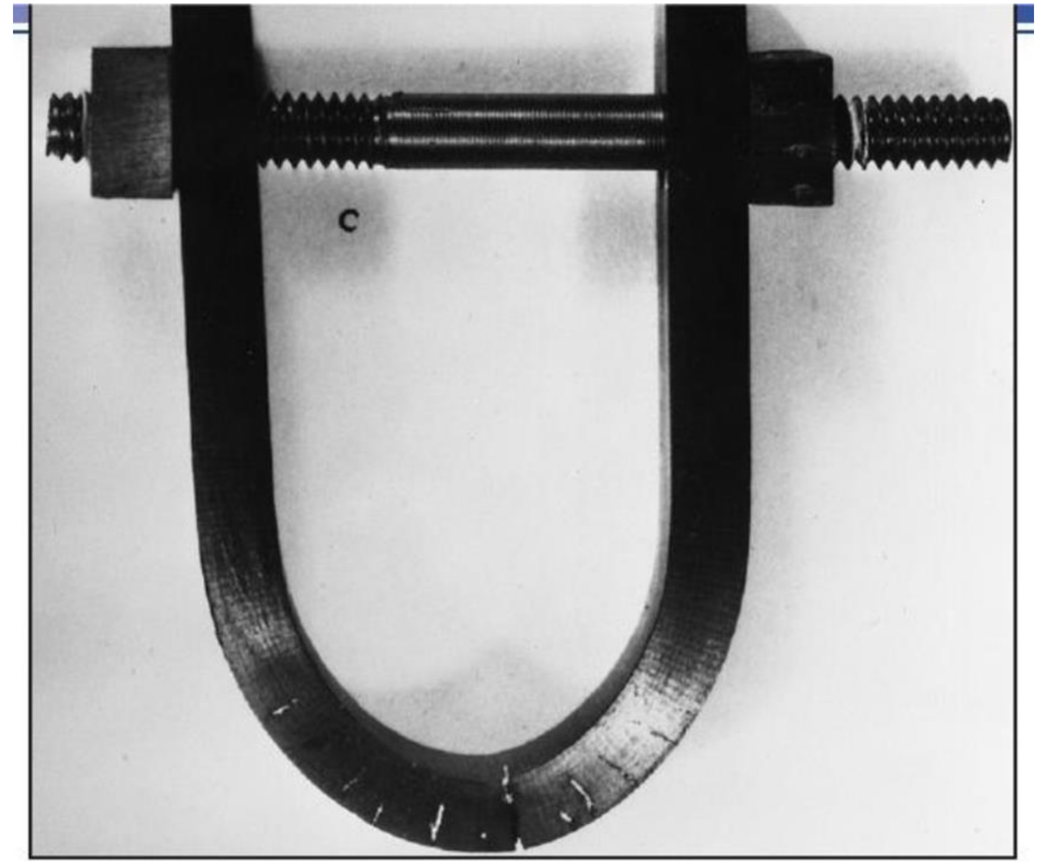
6. Stress Corrosion

- It results from the combined action of an applied tensile stress and a corrosive environment.

- Some materials that are virtually inert in a particular corrosive medium become susceptible to this form of corrosion when a stress is applied.

- Small cracks form and then propagate in a direction perpendicular to the stress resulting in failure.

- Failure behaviour is characteristic of that for a brittle material, even though the metal alloy is intrinsically ductile.



Photograph showing a bar of steel that has been bent into a "horseshoe" shape using a nut-and-bolt assembly. While immersed in seawater, stress corrosion cracks formed along the bend at those regions where the tensile stresses are the greatest. (Photograph courtesy of F. L. LaQue. From F. L. LaQue, *Marine Corrosion, Causes and Prevention.* Copyright © 1975 by John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc.)

Stress Corrosion

- The cracks may form at relatively low stress levels, significantly below the tensile strength.
- For example, most stainless steels stress corrode in solutions containing chloride ions, whereas brasses are especially vulnerable when exposed to ammonia.

The stress that produces stress corrosion cracking need not be externally applied;
it may be:

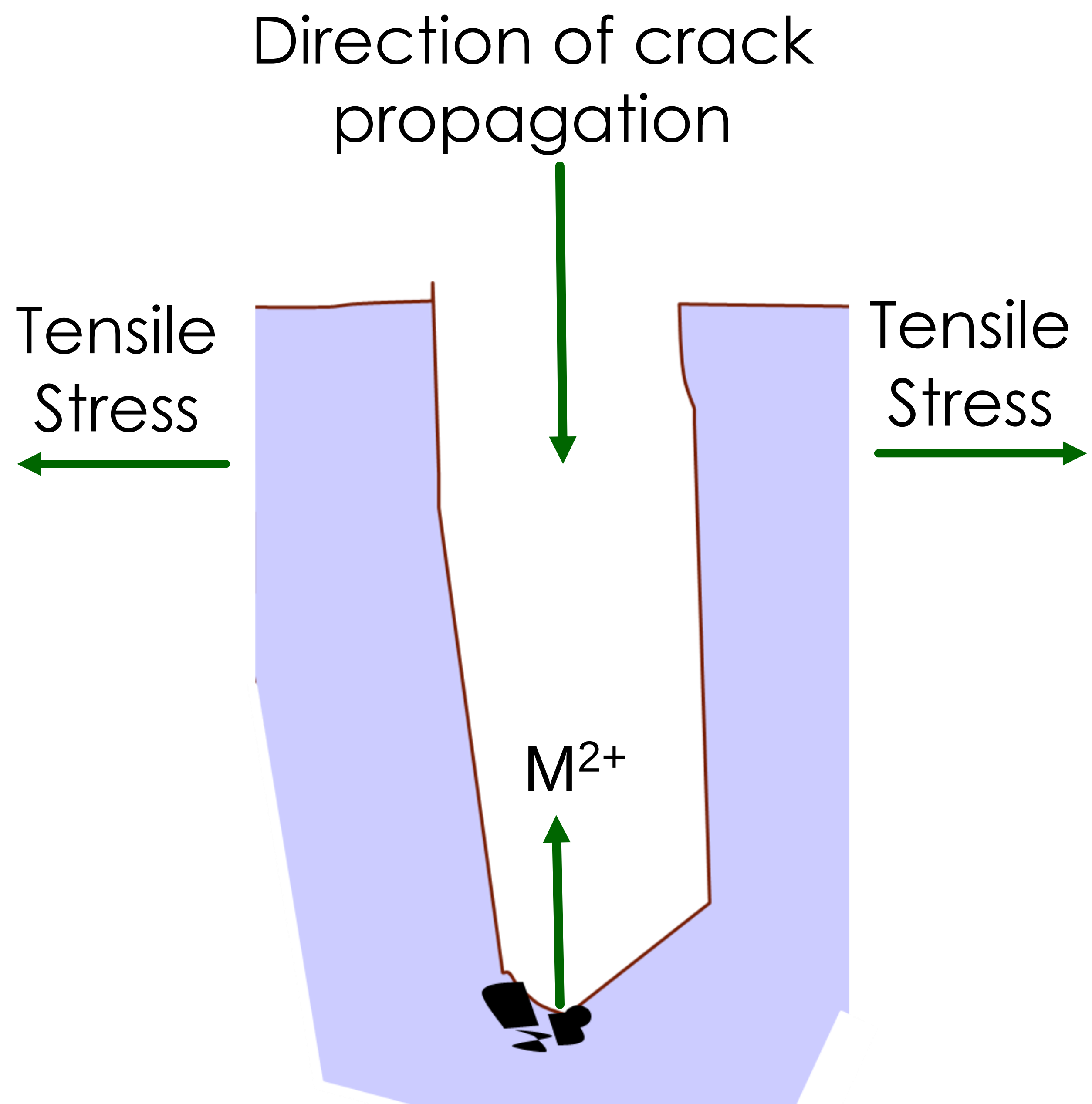
- a residual one that results from rapid temperature changes and uneven contraction,
- for two-phase alloys in which each phase has a different coefficient of expansion
- gaseous and solid corrosion products that are entrapped internally can give rise to internal stresses.

Stress corrosion

Prevention

Probably the best measure to take in reducing or eliminating stress corrosion is to lower the magnitude of the stress:

- This may be accomplished by reducing the external load. Increasing the cross-sectional area perpendicular to the applied stress.
- Furthermore, an appropriate heat treatment may be used to anneal out any residual thermal stresses.
- Eliminate the corrosive environment.
- Change the alloy.



Anodic dissolution of metal at the tip of the crack

7. Erosion corrosion

It arises from the combined action of chemical attack and mechanical abrasion or wear as a consequence of fluid motion

- All metal alloys are susceptible to erosion–corrosion.
- It is especially harmful to alloys that passivate by forming a protective surface film; the abrasive action may erode away the film, leaving exposed a bare metal surface. If the coating is not capable of continuously and rapidly reforming as a protective barrier, corrosion may be severe.

Usually it can be identified by surface grooves and waves having contours that are characteristic of the flow of the fluid.

Erosion corrosion

Erosion–corrosion is commonly found in piping, especially at bends, elbows, and abrupt changes in pipe diameter—positions where the fluid changes direction or flow suddenly becomes turbulent. Propellers, turbine blades, valves, and pumps are also susceptible to this form of corrosion.

Figure 17.20 Impingement failure of an elbow that was part of a steam condensate line. (Photograph courtesy of Mars G. Fontana. From M. G. Fontana, *Corrosion Engineering,* 3rd edition Copyright © 1986 by McGraw-Hill Book Company. Reproduced with permission.)

Erosion corrosion

Prevention

1. One of the best ways to reduce erosion–corrosion is to change the design to eliminate fluid turbulence and impingement effects.
2. Use materials that inherently resist erosion.
3. Removal of particulates and bubbles from the solution will lessen its ability to erode.

8. Cavitation Damage

- It is caused by the formation and collapse of air bubbles / vapour filled cavities in a liquid near a metal surface.

- The rapidly collapsing vapour bubbles can produce localized pressures as high as 60, 000 psi.

- It is sufficient to remove surface films, tear metal particles from the surface resulting in increased corrosion rates and surface wear.

- It occurs where high velocity liquid flow and pressure changes exist. Pump impellers and ship propellers.

9. Fretting Corrosion

- It is caused at the interface of materials under load subjected to vibration and slip.

- The metal between the rubbing surfaces is oxidized. The oxidized film is torn. And the oxide particles so formed act as abrasive.

- Appears as grooves / pits surrounded by corrosion product.

- Tight-fitting surfaces: between shafts and bearings or sleeves.

10. Selective Leaching

It is the preferential removal of one element of the solid alloy by the corrosion process.

e.g. : Dezincification of Brass leaving spongy weak matrix of Cu.
Method: dissolution followed by re-plating of Cu while Zn remains in the solution.

Prevention:

1. Lower zinc content.

2. Change the alloy

3. Change the environment

4. Cathodic protection

11. Hydrogen Damage

Load carrying capability of metallic component is reduced due to interaction with atomic or molecular hydrogen usually in conjunction with residual or externally applied tensile stresses.

Hydrogen Embrittlement: Hydrogen damages directly related to loss of ductility.

- Hydrogen environment embrittlement: Occurs during plastic deformation of metals such as steels, stainless steels and titanium alloys.

- Hydrogen stress cracking: Brittle fracture in a ductile material such as carbon and low alloy steels.

- Loss in tensile ductility: Significant reduction in elongation capability and reduction area in steel and aluminium alloys.

Hydrogen Damage

Hydrogen attack:

High temperature mode of attack in which hydrogen enters metals such as steels and reacts with carbon to produce methane gas resulting in formation of cracks or decarburization.

Blistering:

atomic hydrogen diffuses into internal defects and precipitates as molecular hydrogen which produces high internal pressure resulting in local plastic deformation and blistering.

Prevention

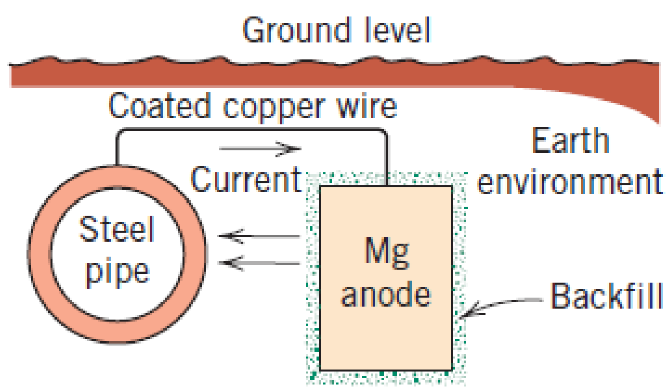
1. Change the material susceptible.
2. Reverse hydrogen contamination: Bake out.

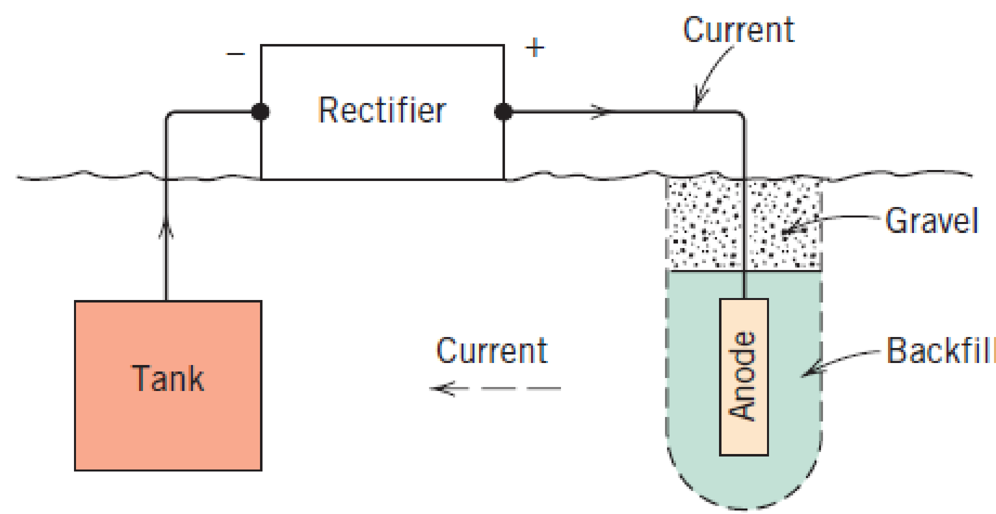
Prevention of Corrosion

- Metallic coating such as tin, zinc, aluminium on steel
- Use Inhibitors (substances that, when added in relatively low concentrations to the environment, decrease its corrosiveness)
- Cathodic Protection
- Non-metallic coating such as oil, paint, tar
- Avoid physical contact between dissimilar metals

Cathodic Protection

- This involves supplying electrons from an external source to the metal to be protected, making it a cathode.
- The process of *galvanizing* is simply one in which a layer of zinc is applied to the surface of steel by hot dipping: type of sacrificial protection.





High-conductivity backfill material provides good electrical contact between the anode and surrounding soil.
A current path exists between the cathode and anode through the intervening soil, completing the electrical circuit.
Cathodic protection is especially useful in preventing corrosion of water heaters, underground tanks and pipes, and marine equipment.

Prevention of Corrosion

Basic goal → Protect the metal → Avoid localized corrosion

1. Give preference to noble metals.
2. Avoid electrical/physical contacts between metals with very different electrode potentials (avoid formation of a galvanic couple).
3. If dissimilar metals are in contact make sure that the anodic metal has a larger surface area/volume.
4. In case of microstructural level galvanic couple, try to use a course microstructure (where possible) to reduce number of galvanic cells formed.

Prevention of Corrosion

5. Modify the base metal by alloying.
6. Protect the surface by various means.
7. Modify the fulfil in contact with the metal (a) remove a cathodic reactant (e.g. water) (b) add inhibitors which from a protective layer.
8. Cathodic protection

   (a) use a sacrificial anode (as a coating or in electrical contact)

   (b) Use an external DC source in connection with a inert /expendable electrode.

Summary

1. Stress corrosion is due to more tensile stress corrosive environment.
2. Erosion corrosion is caused by fluid motion and mechanical abrasion.
3. Cavitation damage is caused by air bubbles near metal surface.
4. Fretting corrosion is caused due to the movement of loose mechanical parts.
5. The removal of Zinc from brass is called as dezincification.
6. Hydrogen damage is caused by atomic or molecular hydrogen.
7. Cathodic protection is supply of extra electrons to the anode to make it cathode and prevent corrosion.