WEEK-03

Surface treatment, Corrosion - Types, Methods of reduction of corrosion, Surface coating processes - Traditional methods - Painting, electroplating, Galvanizing, Spraying. Advanced coating technologies - Physical vapor deposition, Chemical Vapor deposition, Laser treatment.

SURFACE TREATMENT:

Surface treatment is the process of altering a materials surface using physical, chemical or mechanical methods to improve its properties like hardness, corrosion, resistance and appearance without changing the inner core structure.

Methods of Surface treatments:

1. Mechanical: Shot peening, brushing, grinding to alter surface texture.
2. Chemical: etching, phospating, passivation, anodizing (for metals).
3. Thermal: case hardening.
4. Electrochemical: Electroplating (adding metal layers), electro polishing.
5. Coating: Painting, powder coating, vapor deposition.

Surface treatments are primarily used to:

1. Improve hardness & Durability.
2. Enhance performance: Modify characteristics like electrical and thermal conductivity, friction control or non-stick properties.
3. Refine Aesthetics: Change the color, texture or reflectivity of a product for decorative purpose.
4. Improve corrosion resistance.

CORROSION:

Corrosion is the slow destruction of metal due to chemical or electro-chemical reaction with the surrounding environment such as air, moisture or chemicals. This process leads to the formation of oxides, salt, hydroxides on metal surface, which weakens the metal, reduce its strength and appearance.

Example: Rusting of iron.

Types of Corrosion.

1. **Uniform corrosion:**

This corrosion occurs where metal or alloys is completely homogeneous both chemically and mechanically due to this the galvanic cells are established between any two points on the metals surface in the presence of acids or alkalies. In this case, the rate of corrosion is uniform.

Example: rusting of iron sheets or steel structure exposed to air and moisture.

Figure: Uniform Corrosion

2. Pitting Corrosion:

Pitting corrosion is a class of corrosion caused due to severe damage to metals. It is a localized form of corrosion because of which micro cavities or holes, pits are formed in metals. It is the most dangerous form of corrosion damage because it is more difficult to detect, predict and design against as the corrosion products often cover the pits.

Example: Stainless steel in contact with saltwater, Copper pipes in plumbing with imbalanced water.

Figure: Pitting Corrosion

3. Intergranular corrosion:

Intergranular corrosion is a localized corrosion that occurs at grain boundaries of metals, leading to the disintegration of alloys and loss ofstrength. It can be caused by impurities, variations in alloy composition, especially in environments like welding.

Example: Stainless steel after improper welding or heat treatment.

Figure: Intergranular Corrosion

4. Galvanic Corrosion:

Galvanic corrosion also known as bimetallic or dissimilar metal corrosion is an electrochemical process where one metal corrodes preferentially when it is in electrical contact with another, different metal in the presence of an electrolyte.

Example: Zinc corroding faster when in contact with copper in moist air.

Figure: Galvanic Corrosion

5. Stress Corrosion:

This type of corrosion occurs in the internally stressed engineering components used in corrosive environment and sustained tensile stress.

Example: Cracking in brass (season cracking).

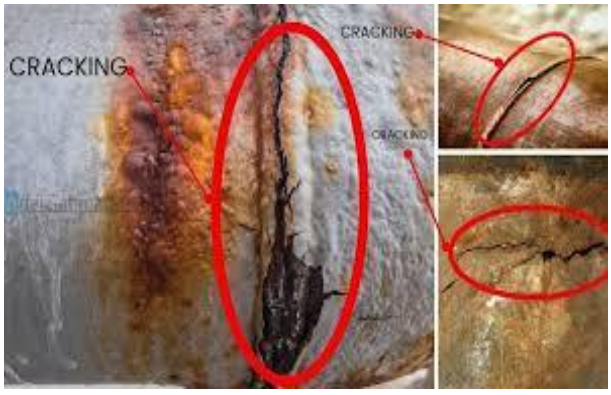

Figure: Stress Corrosion

METHODS OF REDUCTION OF CORROSION:

The following methods are generally adopted to prevent or control the corrosion of metals.

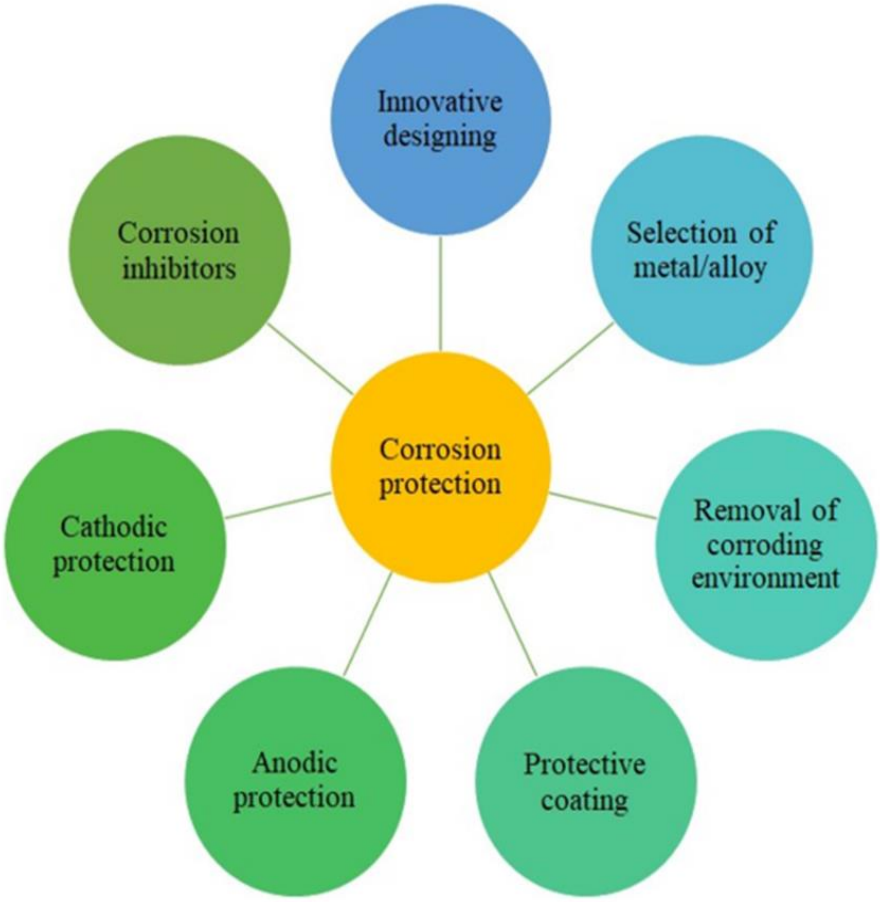

Figure: Methods of Reduction of Corrosion

1. **Suitable or Innovative Design:**

The corrosion can be prevented by selecting the suitable design and fabrication for a particular shape of the components.

2. **Selection of Materials/Metals/Alloys:**

This method involves selecting metals or alloys that are naturally resistance to corrosion in a given environment.

Examples: Stainless steel, Aluminium

3. **Protective Coating:**

In this method, the metal surface is covered with a protective layer to isolate it from corrosive surrounding.

Example: Painting, Galvanizing and Electroplating.

4. **Cathodic Protection:**

Cathodic protection is a technique that uses direct electrical current to prevent the corrosion of metal structures.

Example: Underground storage tanks and pipelines

5. **Corrosion Inhibitors/Use of Inhibitors:**

An inhibitor is a substance which is added to the electrolyte. In small quantity to reduce the rate of corrosion. The inhibitors may be organic or inorganic.

Examples: Used in Boilers, Cooling system. Common inhibitors are sodium nitrite, chromates and organic amines.

6. **Removal Corroding of Environment/ Modification of Corrosive Environment:**

The rate of corrosion can be greatly reduced by small changes in the corroding environment such as changes in composition, nature and temperature.

7. **Anodic Protection:**

Anodic protection is defined as the protection of a metal by maintaining it in a passive condition through the application of a fixed potential, which facilitates the formation of a passive film that shields the metal from corrosive environments.

8. **Alloying of Metals:**

This method involves adding specific alloying elements to a base metal to improve its corrosion resistance.

Example: Stainless Steel (iron+chromium+nickel) used in kitchen utensils.

TRADITIONAL SURFACE COATING PROCESSES:

Surface coating is a process where the metal parts are prepared to prevent or reduce the rate of corrosion to increase the life of the metal parts.

Surface of the metals can be protected by means of following processes:

1. Painting.
2. Electroplating.
3. Galvanizing.
4. Spraying.

1. **Painting Process:**

Painting is the process of applying a pigment liquid, paste or powder to a surface to protect it from corrosion and improve its appearance. The paint is a mixture of pigments, drying oil and a solvent thinner.

2. **Electroplating:**

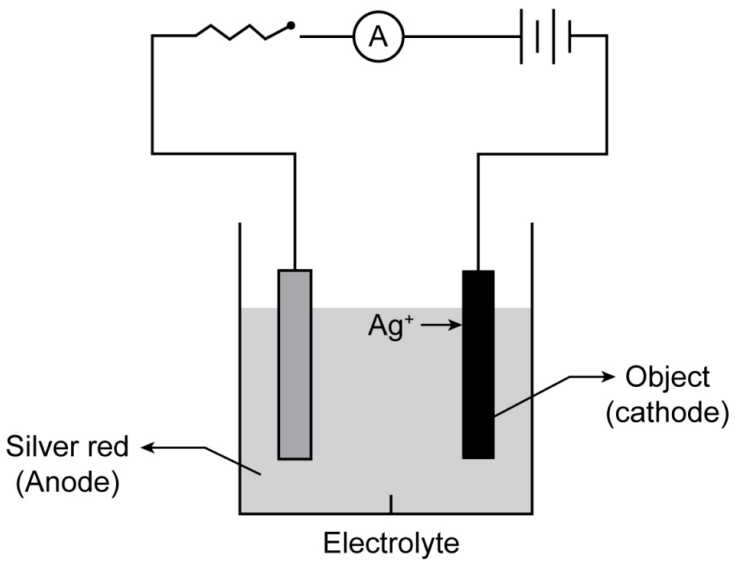

Figure: Electroplating

It is the process of depositing a very thin layer of metal coating, on the base metal by passing direct current through an electrolyte solution. In this process, the component of base metal (object to be coated) is made to act as cathode (negatively charged) where as the coating metal is an anode (positively charged) in a solution containing some salt of the metal. The commonly used coating materials are copper, nickel, silver, gold, chromium and tungsten etc.

Examples:

- Zinc plating on steel.
- Gold or Silver plating on jewelry, Watch, and Decorative items.
- Nickel plating on machinery parts.
- Silver plating on medical devices.

3. Galvanizing:

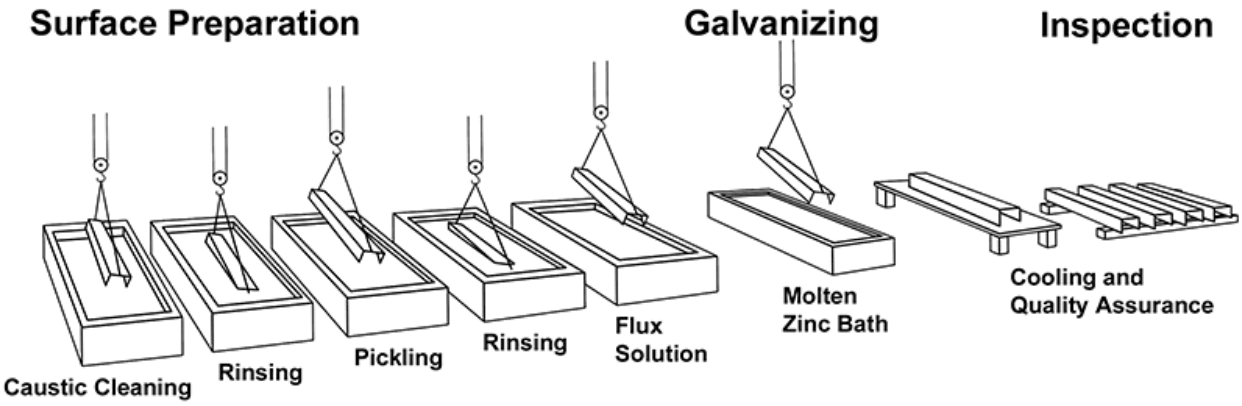

Figure: Galvanizing

Galvanization is the process of applying a protective zinc coating to steel or iron, to prevent rusting by dipping them in a bath of molten zinc. The prepared steel part immersed in a bath of molten zinc at a temperature of about 450°C. the steel part is taken out from bath and molten zinc solidifies on the surface, forming a layer of zinc on steel part surface. The galvanized steel is cooled and then inspected for any defects.

Examples:

- Steel pipes for plumbing.
- Steel poles for power lines.
- Steel beams and columns.
- Iron sheets, fencing, bolts and nuts.

4. Spraying:

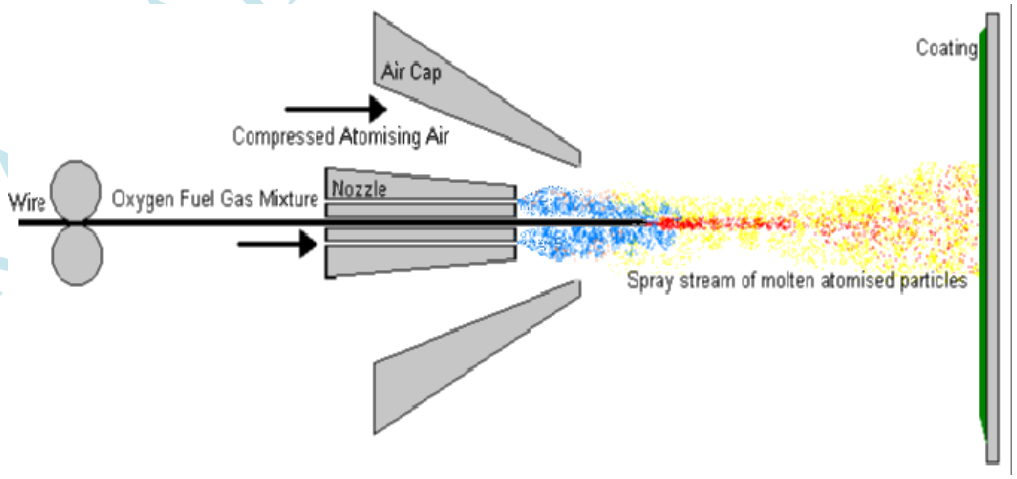

Figure: Spraying

The spraying is a process of providing a thin coating by depositing an atomized metal on the metal surface using compressed air or gas. The spraying can be used for applying coating of aluminium, brass, copper, zinc, tin etc.

ADVANCED COATING TECHNOLOGIES:

Some important advanced coating technologies are:

1. Physical Vapor Deposition Coating (PVD).
2. Chemical Vapor Deposition Coating (CVD).
3. Laser Treatment for Surface Coating.
4. Electron Bean Coating (EBC).
5. Iron-Beam Based Technique.

1. Physical Vapor Deposition Coating (PVD):

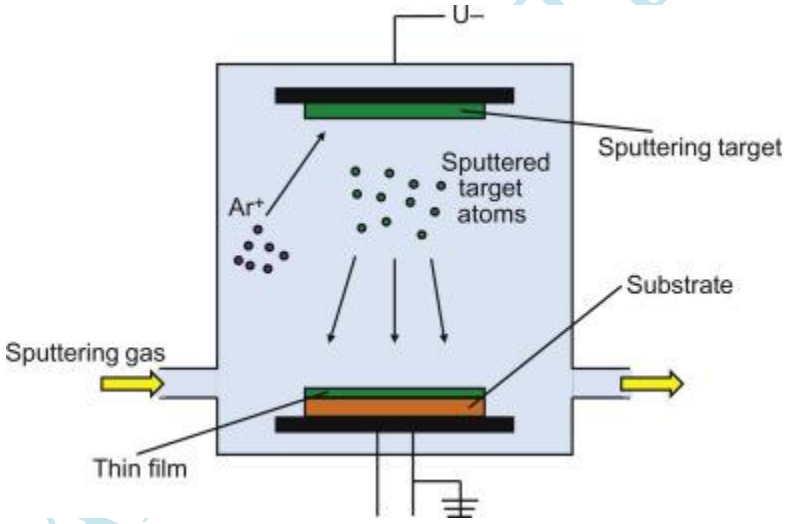

Figure: PVD

PVD uses physical process (such as heating or sputtering) to produce a vapor of material, which is then deposited on the object which is called physical vapor deposition. It consists of vacuum chamber as shown figure. The substrate whose surface is to be coated is placed on a bottom table, and is connected to an anode (+). The material which is to be heated and converted into vapor is fixed over the top plate, which is connected to cathode (-) of power supply unit. The sputtering gas like argon gas is circulated from one end for creating plasma through ionization, which bombard the coating material to vaporize it and deposited into substrate. Vaporized atoms travel through the vacuum toward the substrate. The vapor condenses on the substrate surface, forming a thin, dense and uniform coating.

2. Chemical Vapor Deposition Coating (CVD):

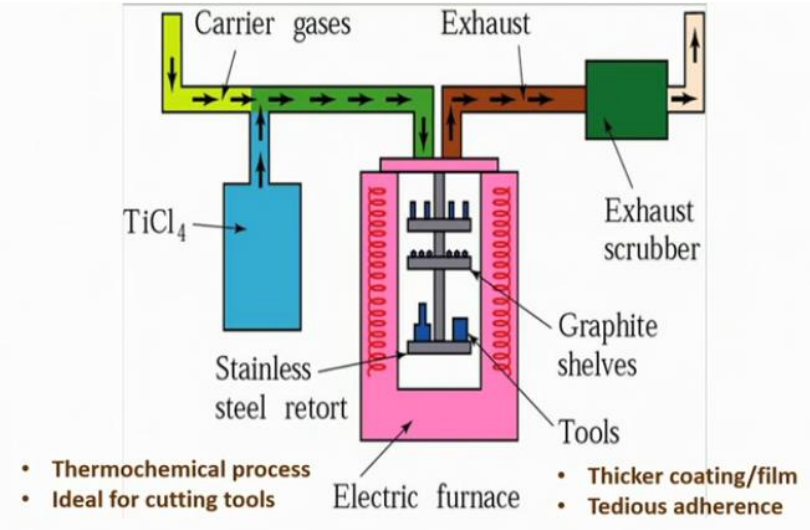

Figure: Chemical Vapor Deposition Coating

CVD involves formation of non-volatile thin solid film by reaction of ions in the vapor state and subsequent deposition. Reactant gases decompose and react on heated surface to form thin film. CVD involves exposing the heated substrate to one or more volatile precursors (reaction gas inlet), which react on the substrate surface to produce the film. CVD is a very versatile process to produce coating, poweder, fibers and monolithic parts.CVD produce almost any metallic/non metallic elements like carbon and silicon and compounds. CVD is widely used in the various industries such as semiconductor, fiber optics and coating, due to its ability to produce high quality thin film with controlled properties.

3. Laser Treatment for Surface Coating.

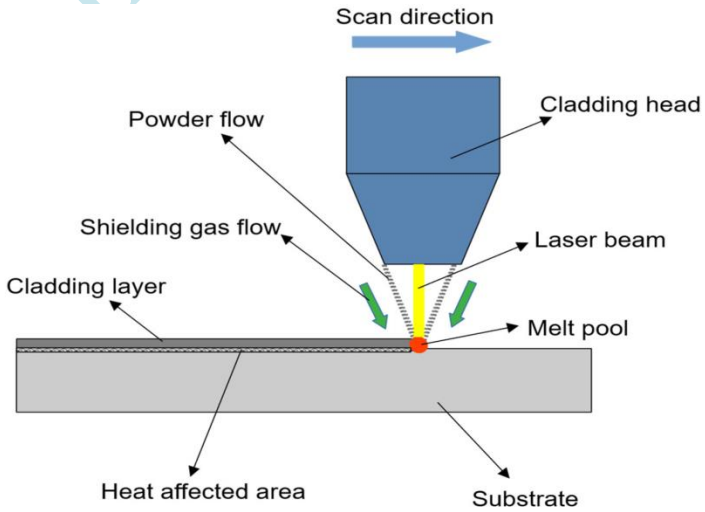

Figure: laser Treatment for Surface Coating

Laser treatment for surface coating involves using a laser to modify or add a layer of materials to surface, enhancing its properties like hardness, wear resistance and corrosion resistance. Laser treatment works on the principle of localized heating by a focused laser beam. The laser rapidly melts or heats the surface layer of the substrate, which solidifies with improved microstructure.

Laser treatment process:

1. **Surface cleaning:** remove dirt, grease and oxides from substrate better treatment sufficiency.
2. **Laser setup:** mount the substrate in the laser system and adjust laser parameters(power, scanning speed, beam focus and spot size) according to the material and desired surface properties.
3. **Surface Modification:** the molten or heated layer rapidly solidifies, forming a fine grained, hardened and wear resistance surface.
4. **Cooling and Finalization:** allow the treated substrate to cool naturally or using controlled method.
5. Inspect the surface for uniformity, hardenss and microstructure.

EXERCISES

MULTIPLE CHOICE QUESTIONS AND ANSWERS

1. Which type of corrosion occurs when two dissimilar metals are in electrical contact in the presence of an electrolyte?
   a) Stress corrosion cracking c) Galvanic corrosion
   b) Erosion corrosion d) Pitting corrosion

Ans: c)

2. CVD stands for:
   a) Chemical vapor deposition c) Coated vapor device
   b) Corrosion vapor diffusion d) Chromic vapor delivery

Ans: a)

3. In electroplating, the object to be plated is connected to:
   a) Anode c) Both
   b) Cathode d) Earth

Ans: b)

Review questions:

1. Define Electroplating.
2. Define corrosion. List its types.
3. Name any two methods to reduce corrosion in metals.
4. Write the purpose of spraying in surface coatings.
5. What are the types of corrosion and explain any one?
6. Explain the methods of reduction of corrosion.
7. What is surface coating? List the surface coating processes.
8. Explain Galvanizing process with its neat sketch.
9. Explain Electroplating process with its neat sketch.
10. Explain spraying process of metal coating.
11. Explain laser surface treatment process.
12. Explain Physical vapor deposition method of surface treatment.
13. Explain Chemical vapor deposition method of surface treatment.
14. Name any three advanced coating technologies.