Corrosion Control or Corrosion Management?
- Corrosion control is a process aimed at reducing the corrosion rate to a tolerable level (or predictable limits)
- Corrosion control focuses mainly on (i) materials and (ii) environments
- Corrosion management focuses on "people" and aims at improving the performance of engineering systems.
- So, effective corrosion control requires a complete management strategy involving people as much as equipment.

Methods of Corrosion Control
1. Design
2. Materials Selection
3. Coating
4. Modification of the environment (adding inhibitors)
5. Electrochemical Methods
   - Cathodic Protection
   - Anodic Protection

Since corrosion involves interaction between materials and environment, the approaches to control corrosion include
- Use of the most compatible material in a given environment
- Reduce the aggressiveness of the environment toward the material
- Use of protective coating to separate the material from the environment
- Cathodic and anodic protection are preventive measures based on electrochemical principles of corrosion
2. Materials Selection

- Technically, selecting a corrosion-resistant alloy would be the answer to corrosion problems.
- However, corrosion resistance is not the only property to be considered when selecting a material (it is of major importance in the chemical process industries).
- Economics (cost) dictate the selection of materials.

The most corrosion-resistant metal or alloy may not be always the optimum choice because of:
1. High cost
2. Low abundance
3. Difficult to manufacture
4. Unsuitability to meet the engineering requirement.

- The materials selection process is also influenced by whether the material is to be used for:

1. New design
   - Selection starts at the design stage
2. Modification of existing design
   - Principal decision factors are centred on delivery time and ease of fabrication (but less opportunity for redesign)

Modification of the environment

- Reduction of corrosion through modification of the environment can be achieved by:
  1. Change of operating variables
     - Temperature, pH, and velocity
  2. Removal of corrosive constituents
     - Oxygen, chloride, moisture
  3. Use of inhibitors
     - Adding chemical substances that slow down a chemical reaction
Protective Coatings

- The objective of a coating is to provide a barrier between the metal and the environment.
- The coating may also release substances that inhibit the corrosive environment or act as a sacrificial anode to protect the metal.
- Another advantage of protective coatings is that it is possible to combine the protective function with aesthetic appeal.

Metallic Coatings

- Coatings are classified into:
  1. Metallic coatings
  2. Non-metallic coating
     - Organic
     - Inorganic

Metallic Coatings

- Metallic coatings can be divided into noble and sacrificial.
- Noble metallic coating include Ag, Cr, Sn, Ni
- Sacrificial metallic coatings include Al, Zn and Cd
- Noble metallic coating should be pore – free. This is achieved by producing a thick coating.

How are Metallic Coatings Applied?

- Metallic coatings can be applied by several methods:
  - Electroplating: suitable for small components.
  - Hot dipping: immersion of metal in the molten bath of a low melting metal such as Zn, Sn and Al.
  - Spray coating (metallising): suitable for large structures such as bridges, ship hulls, tank cars and vessels.
  - Diffusion coating: formation of on the metal surface by high-temperature diffusion of the coating metal (Zn, Cr, Al)
  - Cladding: application of a surface layer of a corrosion-resistant metal (Ni, Cr, Cu, Ti, SS, usually by rolling) on a cheaper and stronger phase.

Zinc Coatings (on steel)

- Although Zn is more anodic to Fe, the Zn corrosion product (Zn oxide) form a thick, tough and protective metallic film on the steel surface, covering it from the corrosive environment.

- Several methods are used to apply metallic Zn coating on steel:
  - Hot dip galvanising, electroplating, sherardising (diffusion coating), spraying, Zn-rich coating (painting)
Hot Dip Galvanizing

- The extensive use of hot dip galvanizing is attributed to the nature of the coating which:
  1. Act as barrier coating
  2. Cathodic protection (galvanic protection)

- The corrosion resistance of galvanized Zn coating is determined by the thickness of the coating and varies with the severity of the environment

Electrochemical Techniques

1. Cathodic Protection
   - Make the metal (to be protected) the cathode
2. Anodic Protection
   - Can be applied only on metals that can passivate

1. Cathodic Protection
   - A procedure by which a structure (buried pipelines, ship hulls, oil drilling rig, etc) is protected against corrosion
A direct current is impressed onto the structure by means of a sacrificial anode or a rectifier.

The most common metal to be protected by CP is steel.

Thus, there are two systems for supplying the necessary current:

1. Sacrificial anode system (galvanic protection)
2. Impressed current cathodic protection system (ICCP)

### 1. Sacrificial anode system

- Common sacrificial anodes are:
  - Mg: buried pipelines
  - Zn and Al: submerged marine structures (oil platforms, ship hulls)
- A sacrificial anode must possess enough number of electrons per unit mass and capable of delivering these charges efficiently.
- Electrical output is given by the current capacity (A. hr/ kg).

#### Common sacrificial anodes:

- Mg: buried pipelines
- Zn and Al: submerged marine structures (oil platforms, ship hulls)

### 2. ICCP system

For larger structures, galvanic anodes cannot economically deliver enough current to provide complete protection.

ICCP system uses an external power supply.

In ICCP system the anode can not be less noble to the metal (steel) to be protected.

1. Platinum (Pt)
2. Titanium (Ti)
3. Graphite (semi-consumable anode)
4. High Si iron alloys (semi-consumable anode)
5. Scrap cast iron (consumable anode)
2. ICCP system