# Unit-5

# Pharmaceutical Engineering

**UNIT-V** **10 Hours**

**Materials of pharmaceutical plant construction, Corrosion and its prevention:** Factors affecting during materials selected for Pharmaceutical plant construction, Theories of corrosion, types of corrosion and there prevention. Ferrous and nonferrous metals, inorganic and organic non-metals, basic of material handling systems.

## Materials of pharmaceutical plant construction, Corrosion and its prevention:

- In Pharmaceutical industry different types of material, equipment are used which is made by different -2 materials.
- A wide variety of materials can be utilized for the can be utilized for the construction of equipment.

## Factors affecting during materials selected for Pharmaceutical plant construction:

The selection of material for plant construction is depends upon three factors.

1. **Chemical Factor**
2. **Physical Factor**
3. **Economics**

## 1. Chemical Factor:

Chemicals are exposed to the construction material of containers and equipment each time they are placed in them. Because of this, the construction material may contaminate the product (contamination) or may cause the product to corrode (corrosion).

### Corrosion of Materials of Construction

- There may be corrosive products present. Their reaction with the material can damage the material. Destroying the material will reduce its lifespan.
- A strong acid, a strong alkali, a powerful oxidizer, tannins, etc., react with these materials, so alloys with special chemical resistance are being used to resist strong acids, strong alkalis, powerful oxidizers, etc.

### Contamination of Products

- Products contaminated with iron can change color (like gelatin capsules), and catalyze some reactions which can accelerate decomposition.
- Aqueous products can become alkaline after leaching of glass. By using an alkaline medium, the product may decompose faster. Penicillin is inactivated by heavy metals like lead.

## 2. Physical Factor

### a. Wear Properties

- Friction between two surfaces causes the softer surface to disappear and contamination to occur. A worn-out grinding surface, for example, can contaminate the powder during milling and grinding.
- The use of ceramic and iron surfaces for grinding pharmaceutical products of high purity is not recommended.

### b. Thermal Expansion

- If the material of the equipment has a high thermal expansion coefficient, its shape will change as the temperature increases.
- Inequal stresses result, causing fractures. Therefore, equipment should be made from materials that can maintain their shape and dimensions at working temperatures.

**c. Mass**

- Materials that are lightweight are used in packaging for transportation.
- Pharmaceuticals are packaged with materials such as plastic, aluminum, and paper.

**d. Thermal Conductivity**

- The materials that are used in evaporators, dryers, stills, and heat exchangers need to have excellent thermal conductivity. Graphite, copper, or iron tubes are used in this case for efficient heat transfer.

**e. Strength**

- To withstand pressure and stress, the material must be sufficiently strong. These properties can be met by steel and iron.
- In order to handle extremely high pressure, the punching machine, die, and upper and lower punches are made of stainless steel. Although strong, glass is fragile.
- A tin container covered with some polymers (lacquered) is used for aerosol containers because of the high pressure they must withstand. Some packaging materials, such as blister packs, have been made from plastic materials due to their weakness.

**f. Cleaning**

- Surfaces that are smooth and polished are easier to clean.
- In order to ensure that the next product is not contaminated by the previous one, the equipment is thoroughly cleaned after the operation. Stainless steel and glass surfaces can be polished and smoothed.

**g. Ease of Fabrication**

- Equipment is made from a variety of materials that undergo a variety of processes, such as casting, welding, and forging.
- Glass and plastic, for example, can easily be molded into containers of any size and shape.
- It can be used in reaction vessels as an insulating material.

**h. Sterilization**

- In the production of parenteral, ophthalmic etc sterilization is an essential step. So material should be Stable with it.

## 3. Economic Factors

- Initial equipment costs are determined by the materials used. Construction can be done with several materials, but only the least expensive one is used.
- It is more economical long-term to use materials with low maintenance costs. Materials used for building a plant can be divided into metals (ferrous and non-ferrous) and nonmetals (organic and inorganic).



# Corrosion:

- It is a natural process in which the metal surface after reaction atmosphere converted into most stable form of metal such as metal oxide, metal hydroxide etc.
- It is basically defined as a natural process that causes the transformation of pure metals into undesirable substances when they react with substances like water or air.
- This reaction causes damage and disintegration of the metal, starting from the portion of the metal exposed to the environment and spreading to the entire bulk of the metal.

## Theories of Corrosion:

- Acid Theory
- Dry (Chemical Theory)

### Acid Theory

- In this theory states that the acid cause corrosion of a metal Co2, atmospheric oxygen and moisture are responsible for corrosion.
- Rust represented as $Fe_2O_3$ X $H_2O$.

**1. Carbon dioxide** react with water in atmosphere form carbonic Acid which convert iron to iron bicarbonate.

$$Fe + 2CO_2 + H_2O + H_2O_2 \rightarrow fe(HCO_3)_2$$

**2. Ferrous bicarbonate** is the oxidized by atmospheric oxygen to formed hydrated ferric oxide.

$2fe\ (HCO_3)_2 + {}^1/_2\ O2 \rightarrow 2fe\ (OH)\ (CO3) + 2CO_2 + 2H_2O$

$2fe\ (OH)\ (CO_3) \rightarrow fe_2O_3 + 2CO_2 + H_2O$

$Fe_2O_3 + x\ H_2O \rightarrow fe_2O_3\ .\ xH_2O$

## Chemical or Dry Theory of Corrosion:

- This theory states that corrosion is due to the reaction of atmospheric gases such as oxygen halogens, Sulphur oxides etc.
- Eg: Alkali and alkaline earth metals reacts with oxygen at room temperature and forms corresponding oxides.

## Types of Corrosion:

a) General Corrosion [uniform attack corrosion]
b) Localized Corrosion
   - Pitting corrosion
   - Crevice corrosion
   - Fretting corrosion
   - Galvanic Corrosion

- Corrosion fatigue

c) Structure Corrosion
d) Biological Corrosion

**General Corrosion:**

- It is most common type of corrosion and is caused by chemical or electrochemical reaction that damage the entire surface of metal.
- It is also known as uniform attack corrosion.

**Localized Corrosion**

- This types of corrosion occurs at any particular (local) area on metal surface.

**Pitting corrosion:**

- Pitting corrosion occurs when a small hole or cavity is formal in the metal surface that area becomes anodic while a remaining metal become catholic, produce localized galuonic reaction it produce corrosion.

**Fretting Corrosion:**

- It occurs as a result of repeated wearing/sliding/vibration of metal on an uneven rough surface.

**Galvanic Corrosion:**

- It occurs when two different metals are together in a corrosive electrolyte.

**Corrosion fatigue:**

- Due to repetition, metal surface get corroded by corrosive media because, the protective oxide film that prevent corrosion get raptured.

**Structural corrosion:**

- In this type of corrosion, structural strength of metal get reduced due to corrosion.
- Eg: alloys are the mixture of many metals.

**Biological Corrosion:**

- This type of corrosion due to metabolic activity of microorganism which Cause deterioration of metal.

**Prevention of Corrosion:**

- Corrosion is an natural process, but it can be controlled by using effective method.

**Painting and coating (Polished)**

- Iron is painted or given a suitable coating to exclude the atmosphere (Prevent metal surface from environment).

**Alloying:**

- Alloying of iron with metal like Ni, Cr, V etc. make it resistant to corrosion.

**Catholic protection:**

- In this process the metal that is to be protected from corrosion is made the cathode in an electrochemical cells.

**Design of equipment:**

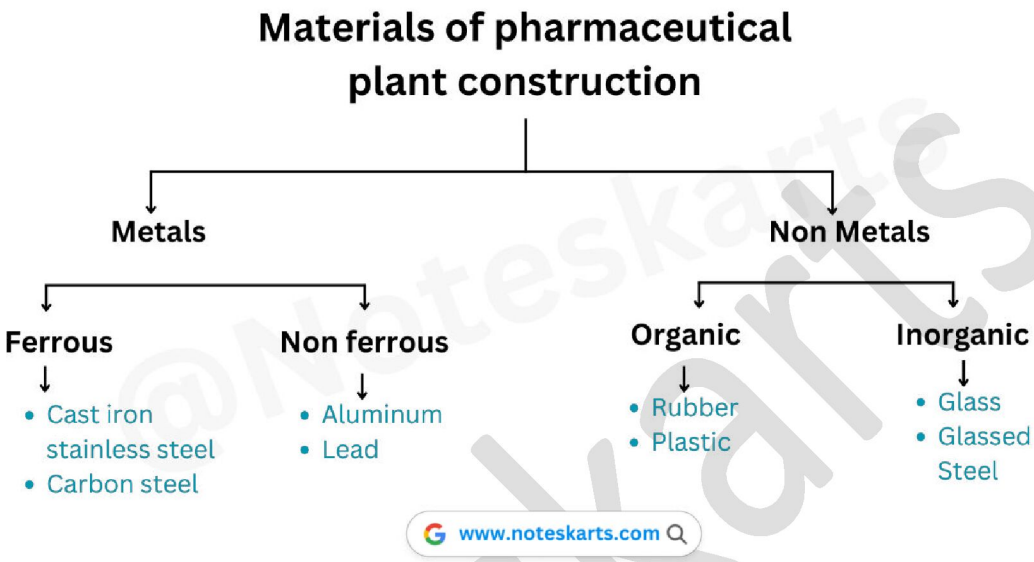
- The proper design reduce corrosion and time and cost which is required for corrosion maintenance so eliminate or minimize the dead spaces or crevices.

**Use of Corrosion inhibitors:**

- They are used to decrease corrosion of metals, but used in only critical amount (less than 0.1% by weight).
- Eg: Chromates, phosphates and silicates are used to protect iron and steel in aqueous solutions.

**Ferrous and nonferrous metals, inorganic and organic non-metals, basic of material handling systems.**

**Classification of materials for plant constructions:**




## Ferrous Metals:

- They are widely used as construction materials because it is mechanically strong, easy available and economical.

**1. Cast iron:**

- It is combination of iron with carbon content greater than 2%.
- It is cheap and available easily so greater in demand.
- It has low thermal conductivity.
- **Uses:** It is used to jacketed steam pans.
- It is used as lining material with plastic.

**2. Stainless Steel:**

- It is an alloy of iron.
- It contain 12-30% chromium, 0-2% Nickel low % of carbon, columblan, Copper, molybdenum, and titanium.
- **Used:** it is widely used in industries because it is heat resistant, corrosion resistant easily fabricated and have high tensile strength.

**Carbon steel:**

- It is an iron alloy having low percentage of carbon content.
- It is cheapest & easy to fabricate.

- It contain 0.4% carbon, 0.7% manganese, 1.85% Nickel, 0.8% chromium and 0.25% molybdenum.
- It is used for construction of pipes and plate.
- It also used as supporting structure for plant vessels.

## Non-ferrous metals:

- A non-ferrous metal is a metal, including alloys, that does not contain iron in appreciable amounts.

**1. Aluminium:**

- It is available in large number of alloys.
- It is cheap and light in weight.
- It has sufficient mechanical strength.
- It is used for manufacturing of container, tanks, rail tankers and barrels.

**2. Lead:**

- It is used in less % because in large amount it produce toxicity. So it is generally used for non food products.

## Organic Non metals:

**Rubber:**

- It is used as lining material. Both natural and synthetic rubber are used.
- Natural rubber is naturally occurring polymer, which is obtain as later from rubber tree.
- It include soft and hard rubber, Soft rubber is used as lining material for plants as it can bond easily to the steel.
- Hard rubber is used for making gloves, bands, tubes.

**Synthetic rubber** are more resistance to oxidation, solvent oils and other chemicals.

- It includes neoprene, nitrile rubber, butyl rubber.
- Neoprene used as insulating materials in electrical cables, rubber stoppers etc.

**Plastic:**

- It is most commonly used material.
- It is light in weight and variety of shapes.
- Not used in case of higher temperature.

**Inorganic Non-metals:**

**Glass:**

- Glass container is widely used in daily life.

- It is composed of sand (pure silica), soda ash (Sodium carbonate), limestone (calcium carbonate) and cullet (broken glass)
- Glass in its solid state is considered as super cooled liquids.
- Attraction in appearance inert cheap etc.
- It is widely used in pharmaceuticals industries and labs in glassware.

**Glassed Steel:**

- It is inorganic condition of fusion. It is cooled to rigid condition without crystallization.
- Used in heavy vessels.
- Excellent resistant to all acid.

## Basic of Material Handling Systems:

**Objectives:**

- To minimize the cost of the product.
- To increase the production capacity by effective utilization of capacity.
- To assure safety in material handling through improvement in working conditions.
- To utilize material handling equipment to its maximum level.
- To prevent damages to materials under handling.
- To lower investment in process inventory.

**Principles:**

- Materials should be moved as little as possible.
- Re-handling and back tracking of materials should be avoided.
- Design of materials handling equipment should be such that it can increase the effectiveness.
- Periodically repairing, maintenance and checkup of existing materials handling equipment.
- As a process material handling incorporates a wide range of manual, semi-automated and automated equipment.

**Conveying:**

- It is the process of transport of material from one place to another.
- Most commonly equipment used for material handling are conveyors.