UNIT-V

A number of equipment are used in the manufacture of pharmaceuticals, bulk drugs, antibiotics, biological products, etc.

- A wide variety of materials can be utilised for the construction of equipment.

Factors Affecting During Material Selected for Pharmaceutical Plant Construction

The selection of a material for the construction of equipment depends on:-

① Chemical factors
② Physical factors.

① Chemical Factors:-

The material should be inert because if the material of equipment reacts with drug than it change the properties of drugs.

ⓐ Contamination of the product:-

The material such as glass, silica, lead, cast iron, steel, tinned iron and a variety of alloys are used in the construction of a chemical plant and most of them produce contamination.

- If the impurities are present in this traces amount, than they can cause decompe to products.

ⓑ Corrosion of material:- The material used for construction of equipment should be non-corrosive in nature.

Because, if the material should corrosive they react with drug and equipment get corroded result losing its strength and durability.

e.g. Some drug such as strong acid, strong basic, alkaloid are corrosive in nature and degrade equipment.

⇒ Mostly use stainless steal to prevent this.

② Physical Factors :-

ⓐ **Strength :-** The material should be sufficient strength because in manufacturing process of pharmaceuticals involves high pressure and high stress condition.
So, the material used for equipment has ability to tolerate these stress.
eg- Iron, Stainless Steel.

ⓑ **Mass :-** The material should be light in weight because many times equipment are transported or moved.
So, it is possible (easy) when material is light in weight.

ⓒ **Wear properties :-** There are possibility of friction b/w moving parts (materials) and their are chance that some surface of material of equipment can contaminate into drugs.
So, it is also important in seleting materials.

ⓓ Thermal conductivity :-

In some process (drying, evaporation etc.), their are use of high heat or temp. and this types of process may be damages or fracture materials (plastic, rubber etc.).
So, we move to use thermostable material for that types of process. (eg. stainless steel, iron etc.).

ⓔ Ease of fabrication :- During fabrication, the material undergoes various process such as casting, forging and welding.
So, the material used can be easily moulded.
eg. Glass, plastic.

ⓕ Cleansing :- The material should have smooth and polished surface for easy cleaning.
Stainless steel and glasses etc.

ⓖ Sterilization :- In the production of parenterals, ophthalmic etc, sterilization is an essential step.
So, material should be stable with it.

ⓘ Economic factors :- Before manufacturing, material's budget (cost) must be considered.
Initial costs and maintainance of plants must be economical.

Corrosion

Corrosion is defined as the process of decomposition or destruction of metallic materials in the presence of environment through any electrochemical reaction.

⇒ It occurs may be in the presence of gases or vapour (dry corrosion), or due to attack of aqueous media (wet corrosion).

e.g. Iron rust etc.

Theories of Corrosion

1. Acid theory
2. Dry (chemical theory)
3. Electrochemical theory (galvanic theory)

(1) Acid theory :-

This theory starts that the acid cause corrosion of a metal. CO_2, atmospheric Oxygen and moisture are responsible for corrosion.

- Rust ~~respons~~ represented as $Fe_2O_3 \cdot xH_2O$.

(i) Carbon dioxide react with water in atmosphere from carbonic acid, which convert iron to iron ~~co~~ bicarbonate.

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

(ii) Ferrous bicarbonate is the oxidized by atmospheric oxygen to formed hydrated ferric oxide (rust).

$$2Fe(HCO_3)_2 + 1/2\,O_2 \longrightarrow 2Fe(OH)(CO_3) + 2CO_2 + 2H_2O$$

$$2Fe(OH)(CO_3) \longrightarrow Fe_2O_3 + 2CO_2 + H_2O$$

$$Fe_2O_3 + nH_2O \longrightarrow Fe_2O_3 \cdot nH_2O \text{ (rust)}$$

(2) Dry or chemical theory of corrosion :-

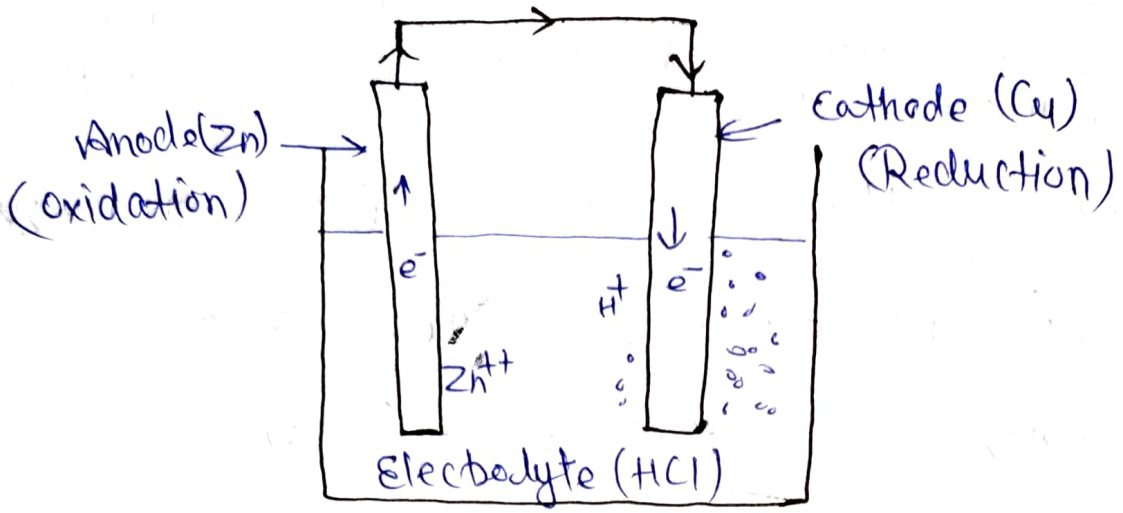
This theory states that, corrosion is due to the reaction of atmospheric gases such as oxygen, halogens, sulphur oxide etc.

eg. Alkali and alkaline earth metals reacts with oxygen at room temperature and forms corresponding oxides.

(3) Galvanic theory of corrosion (electrochemical) :-

When the metal or two ~~in distnt~~ dissimilar metal dipped partialy or fully in conducting liquid.

- this cause formation of a galvanic cell on the metal surface.
- Some part of metal surface act as anodes and rest as cathode.
- Chemicals in environment act as electrolyte and cause oxidation of anodic part (corrosion at anode) while reduction at cathode.
- So formation of corrosion takes place at metals.



- It occurs when current flow from anode to cathode.

⇒ Two metal (Zn) anode and (Cu) cathode when dipped electrolytic solution, they for galvanic cells.

⇒ When these two electrode are connected to wire, spontaneous reaction occurs.

⇒ At anode (oxidation):- Indicate rough surface

$$Zn \longrightarrow Zn^{++} + 2e^-$$

⇒ At cathode (reduction) :- formation of bubbles at surface.

$$2H^+ + 2e^- \longrightarrow H_2\uparrow$$

- When current flow, the anode metal get corroded.

Types of Corrosion :-

1. General Corrosion (uniform attack corrosion)
2. Localised corrosion → Pitting corrosion
   → Crevice corrosion
   → Fretting corrosion
   → Galvanic corrosion
   → Corrosion fatigue
3. Structural corrosion
4. Biological corrosion

① General Corrosion :- Also known as uniform attack corrosion.

- It is most common type of corrosion and is caused by chemical or electrochemical reaction that damage the entire surface of metal

② Localised corrosion :- This types of corrosion occurs at any particular (local) area of metal surface.

(i) Pitting corrosion :- Pitting corrosion occurs when a small holes or cavity is formed in the metal surface. that area becomes anodic, while a remaining metal become cathodic, produce localised galvanic reaction it produce corrosion.

$Fe^{+2} + 2OH^- \rightarrow Fe(OH)_2$

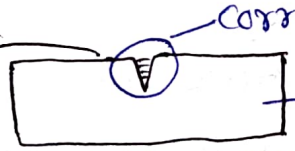


Fig. Pitting corrosion at the surface of iron.

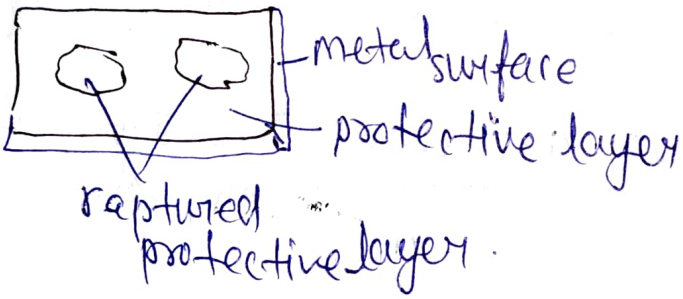
(ii) Crevice corrosion :- Similar to pitting, crevice corrosion occurs at a specific location.

- Solution get deposited to crevice and drying of liquid takes more time, as a result crevice corrosion occurs.

(iii) Fretting corrosion :- It occurs as a result of repeated wearing, sliding/ vibration of metal on an uneven rough surface.

(iv) Galvanic corrosion :- It occure when two different metal are found together in a corrosion electrolyte

(v) Corrosion fatigue : Due to repetition, metal surface get corroded by corrosion media, because the protective oxide film that prevent corrosion get raptured.



(3) Structural corrosion :-

In this type of corrosion, structral strength of metal get reduced due to corrosion.

eg. Dezincification (De-alloying)

Alloys are the mixture of many metals.

It is a process which selectively remove zinc from an alloy (basically copper alloy).

④ Biological Corrosion :-

This type of corrosion occurs due to metallic activity of microorganism which cause deterization of metal.

eg. Anaerobes sulphate-reducing bacteria - in the soil produces hydrogen sulphite and calcium sulphite.

When these compound comes in contanct with underground pipes, convert iron to iron sulphide (rust)

Sulphates $\xrightarrow[\text{Anaerobic}]{\text{Reducing bacteria}}$ Hydrogen sulphite + Calcium sulphite

Temp: 25 to 30°C
pH : 5 to 9

on iron in soil

Iron sulphite
(corrosion product black colour.)

Prevention of Corrosion

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

① Painting and Coating (Polished) :-

Iron is painted or given a suitable coating to enclude the atmosphere (prevent metal surface from environment).

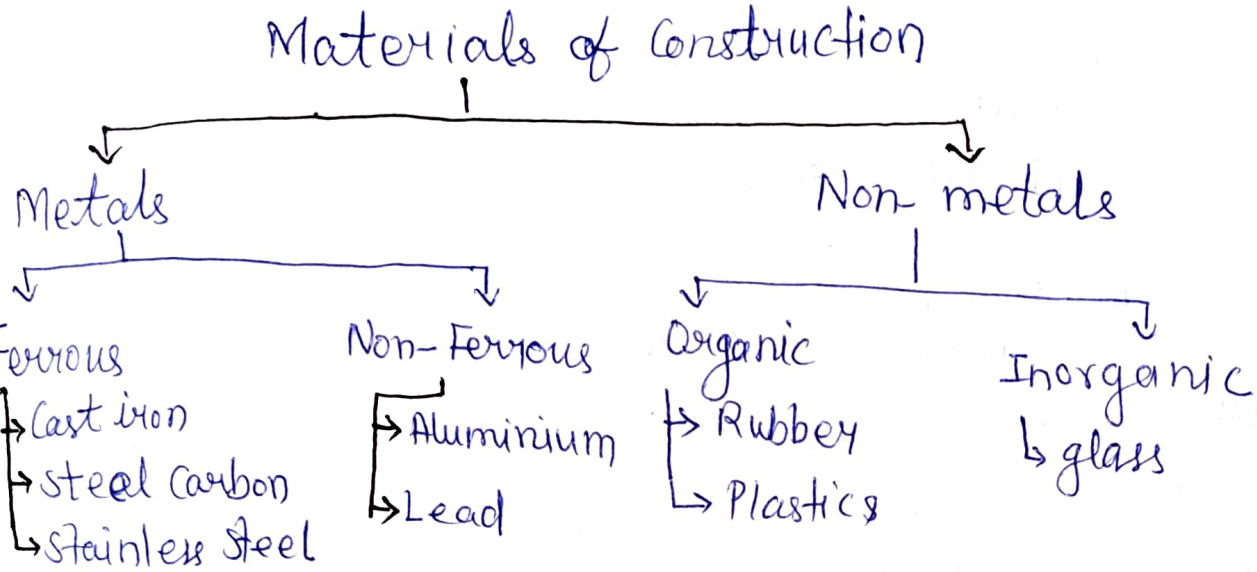
(ii) Alloying :- Alloying of iron with metal like Ni, Cr, V etc make it resistant to corrosion.

(iii) Cathodic protection :- In this process the metal that is to be protected from corrosion is made the cathode in an electrochemical cells.

(iv) Design of equipment :- The proper design reduce corrosion and also time & cost which is required for corrosion maintainance.
So, eliminate or minimize the dead spaces or crevices.

(v) 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.

Classification of Materials for plant Construction



⇒ **Ferrous metals :-** They are widely used as construction material 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 commonly used for the construction of:-

⇒ Supports for plant.

⇒ Jackets of steam pans.

⇒ Linings with enemel, plastic or suitable protective material.

(ii) **Steel Carbon :-** It is an iron alloy having low percentage of carbon content.

• It is cheapest and easy to fabricate.

⇒ It contains 0.4% carbon, 0.7% manganese, 1.85% nickel, 0.8% chromium and 0.25% molydenum.

Carbon → 0.4%
Maganese → 0.7%
Nickel (Ni) → 1.85%
Chromium (Cr) → 0.8%
Molybdenum (Mb) → 0.25%.

Uses: It is used for construction of pipes and plates.

⇒ Also used as supporting structure for plant vessels.

(iii) Stainless Steel:- It is an alloy of iron.

- It contain 12-30% Chromium, 0-2% Nickel, low percentage of carbon, columbian, copper, molybdenum, selenium, tantalum and titanium.

Uses:- It is widely used in industries because it is heat resistant, corrosion resistant, easily fabricated, and have high tensile strength.

eg. martensitic, ferritic and austenitic.

— Non-Ferrous Metals:- A non-ferrous metal is a metal, including alloys that does not contain iron in appreciable amount.

① Aluminium:- It is available in large number of alloys.

⇒ It is cheap and ~~in~~ light in weight.
⇒ It has sufficient mechanical strength.
⇒ Their maintenance and cleaning is easy.
⇒ It is resistant to corrosion.

Uses:- It is used for manufacturing of container, tanks, rail tankers. ~~and b~~.
• Also used for doors.

(ii) Lead :- It is used in less percentages because in large amount it produce toxicity.
So, it is generally used for non-food products.
⇒ It is cheap.

⇒ Organic non-metals:-

Mainly two materials are widely used in plant construction-
(i) Rubber (ii) Plastic.

(i) Rubber :- It is used as lining material.
• Both natural and synthetic rubber are used.
• Natural rubber :- is naturally occuring polymer, which is obtain are latex 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 & other chemicals.

- It includes neoprene, nitril, rubber, butyl rubber:
- Neoprene used as insulating material in electrical cables, rubber stoppers etc.
⇒ Butyl rubber is used for closure of freeze dried product containers because of its low water vapour permiability.
⇒ Silicon rubber is resistant to high & low temp.

(ii) Plastic :- It is most commonly used material.
⇒ It is light in weight & variety of shapes.
- Not used in case of higher temp.

Two types of plastic –

(a) thermoplastic :- They get softend with application of pressure and heat but regain their original shape on cooling.
eg. polyethylene, Pete.

(b) thermosetting :- They are permanently shaped to rigid structure when pressure and heat is applied.
eg. Phenol-formaldehyde.

Uses :- It is used to made pipes and tubing.
- Used for storage of inorganic salts and weak acid.
- Used as insulating material

plastic do not corrode in air and water.

Inorganic Non-Metals :-

(i) **Glass :-** Glass container is widely used in daily life.

⇒ It is composed of sand (silica), soda ash (sodium carbonate), limestone (calcium carbonate) and cullet (broken glass).

⇒ Glass in its solid state is considered as supercooled liquids.

⇒ Attractive in appearance, inert, cheap etc.

Uses : It is widely used in pharmaceuticals industries and labs in glasswares.

⇒ It is fagile in nature and damaged by thermal shock. (disadvantage).

(ii) **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.

⇒ Suitable in case of transparent pipes.

Basic of Materials Handling systems

Material handling is the movement, protection, storage and control of materials products during manufacturing, storage, distribution, consumptions and disposal.

⇒ There are different types of handling instruments are required for different types of materials.

Importance:-

- To provide better working conditions.
- To increase storage conditions.
- To reducing manufacturing cycle time.
- To lowers unit materials handlings cost
- Function of production control.
- concern with scheduling of production controls.

Applications:-

- Materials should be moved as little as possible.
- Rehandling 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 incarporates 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.