# CORROSION PREVENTION PRACTICES



# INTRODUCTION

- Corrosion of metals/alloys: not desirable
- It tarnishes the metals/alloys & reduces its strength, ductility, malleability, electrical conductivity etc.
- Protection against corrosion means not allowing corrosion reaction to take place

# METHODS OF CORROSION PREVENTION

1. Proper designing
2. Proper selection of materials for the environment concerned
3. Cathodic protection
4. Modification of the environment
5. Corrosion inhibitors
6. Protective coatings

# PROPER DESIGNING
# &
# MATERIAL SELECTION

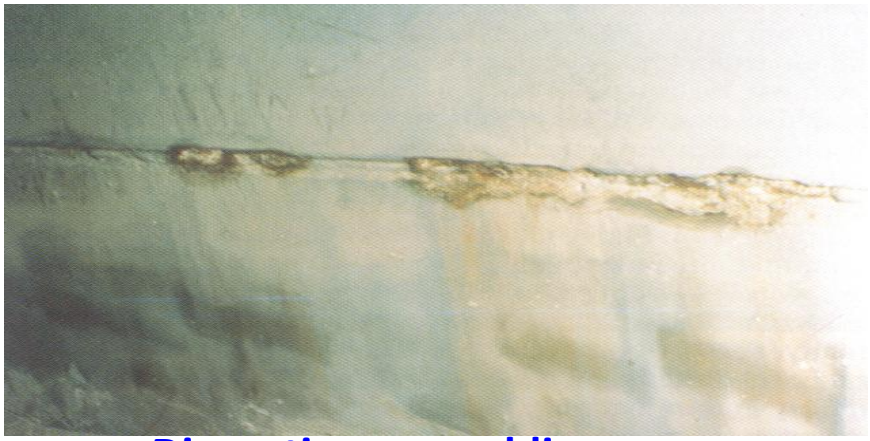
* Selecting the proper material is essential for long term corrosion control
* There is no material that withstands corrosive attack in all environment
* Materials must match to the environment that they will encounter in service

# DESIGN & MATERIAL SELECTION PRINCIPLE

- Avoid galvanic corrosion by following methods:-
  Dissimilar metal contact can not always be avoided because of weight, cost & functional issues.
  - Never join different metals & alloys, if not possible, insulate them with efficient moisture resistance electrical insulator.
    - Greater the separation, more rapidly anode will corrode
  - Never use a design, if relative sizes of the cathode & anode are widely different.
    - (area of anode/area of cathode>1)

# DESIGN & MATERIAL SELECTION PRINCIPLE

- Manufacture bolts, screws, nuts & riveting from a more noble materials than the members to be joined, [a small anode (the less noble metal such as Al) joined to a large cathode (the more noble metal such as SS)] will result in a high current density on Al & hence a high rate of corrosion
- No problem occurs, if the area of the anode is large compared to the cathode
- Continuous welds should be preferred, not intermittent (responsible for crevice corrosion)



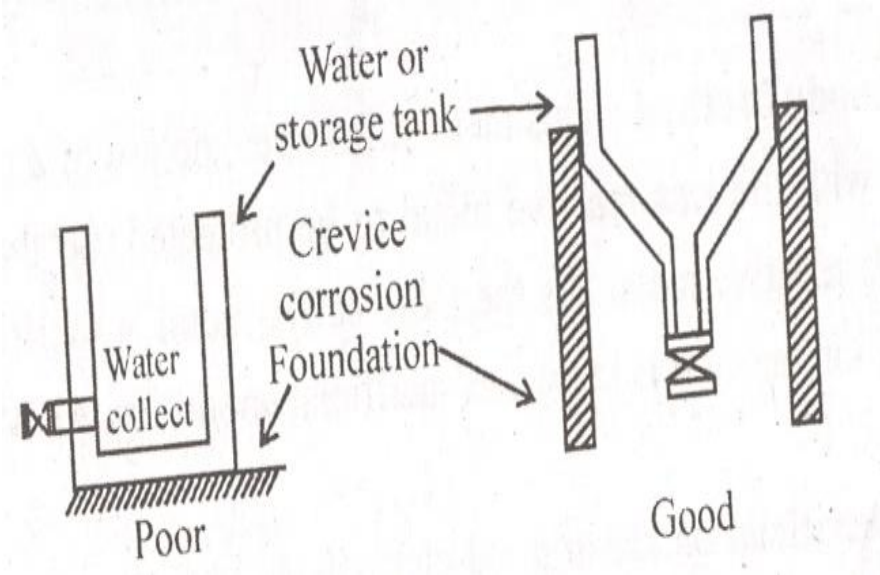
**Discontinuous welding**

# DESIGN & MATERIAL SELECTION PRINCIPLE

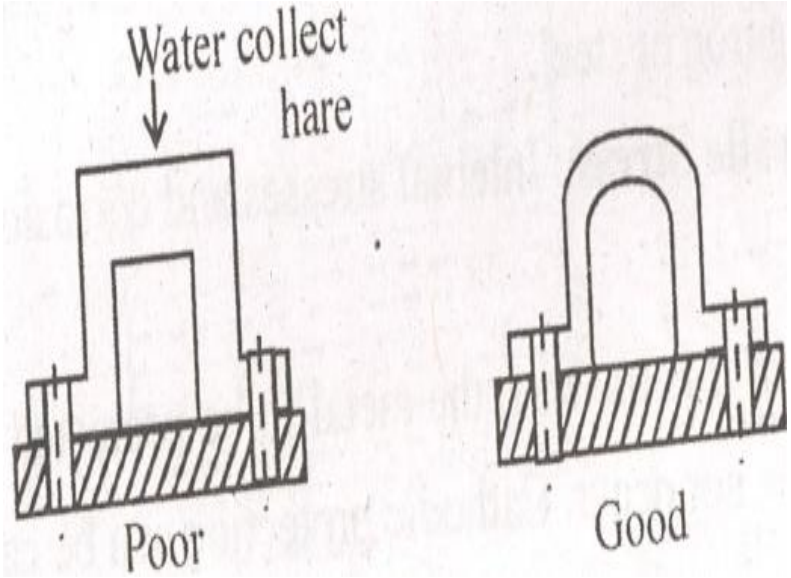
- Avoid L, T & U shaped profiles in constructions:
  - greater the no. of angles, corners & edges, it becomes more difficult for efficient surface treatment.
- Avoid improper insulation:
  - leakage of current can take place which causes anodic corrosion.
- Avoid the contact of metallic object with moisture: water can not be avoided but can be controlled with drain paths, drain holes, sealants & corrosion inhibiting compounds.
  - Design should be such that retention of moisture is as low as possible
  - Design the storage containers should be such that they can be completely drained & cleaned.

# DESIGN & MATERIAL SELECTION PRINCIPLE

## Water storage tank




## Water storage tank



# DESIGN & MATERIAL SELECTION PRINCIPLE

- Using of pure metal:-
  - Purity increases the corrosion resistance.
    - The rate & extent of corrosion increases with increase in impurities.

    Viz.-the corrosion resistance of Al depends on its oxide film formation, which is highly protective only on the high purity of metal
- Using of metal alloys:-
  - Suitable alloying increases corrosion resistance.
  - Use of various types of SS such as AISI:301, 304 (Austenitic); AISI: 409 M & 3Cr12 grade of IRS-M-44 (Ferritic)

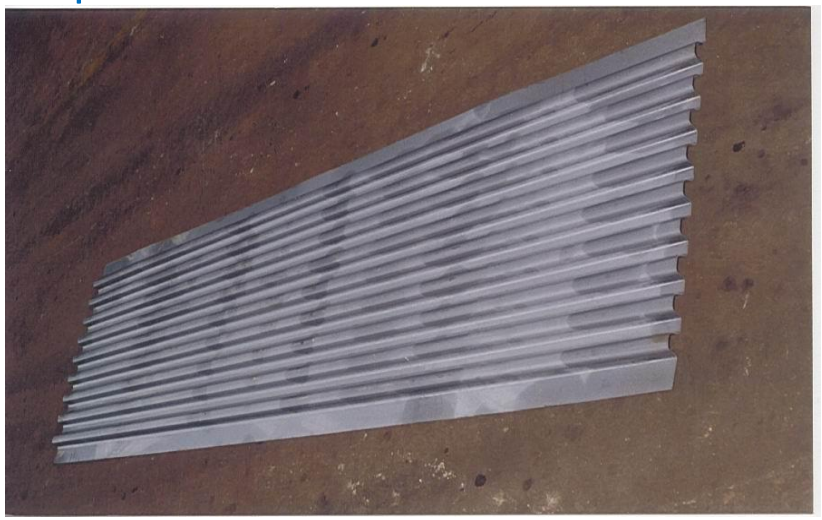
# DESIGN & MATERIAL SELECTION PRINCIPLE

- Use of HSLA (IRS:M-41 i.e. cor-ten steel (Weather resistant steel/ Atmospheric corrosion resistant steel): (C-0.10% Min, Mn-0.20-0.50, Si-0.25-0.75, Cu-0.25-0.55%, Ni-0.65% max, Cr-0,50-1,25%,P-0.075-0.145%) & Cu-bearing steel (IS:2062 WC).
- HCS are not widely used for structural work due to its lack of ductility & weldability
- For this purpose HSLA steels are used which has excellent ductility, YS & weldability which is obtained by decreasing C-content & adding alloying elements

- Elimination of tensile stress:-
  - Internal stresses & corrosion can be reduced by heat treatment like annealing.

# DESIGN & MATERIAL SELECTION PRINCIPLE

Trough floor - 1.7mm thick to Specn. AISI 301 with 2D finish



Body side Pillar - 2mm thick to Specn. AISI 301



SS Brake Pipes & Fittings



SS Lavatory Inlay - 2mm thick to Specn. AISI 304 with 2D finish



# DESIGN & MATERIAL SELECTION PRINCIPLES

## SS Lavatory Inlay - Western Style



## SS Bottle Holder



## SS Ceiling Fan



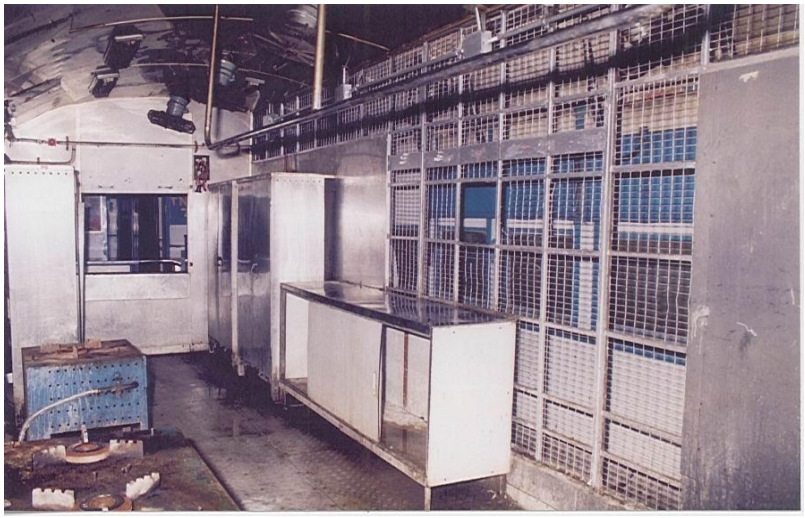
## SS Seat Frames





# DESIGN & MATERIAL SELECTION PRINCIPLE

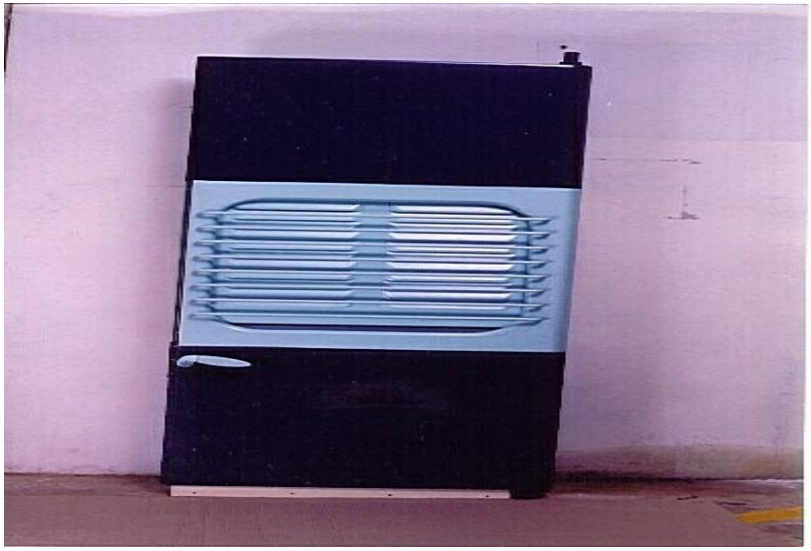
## A View Of Kitchen Area



## Service Counter



## FRP Body Side Door



## SS Shield For Window

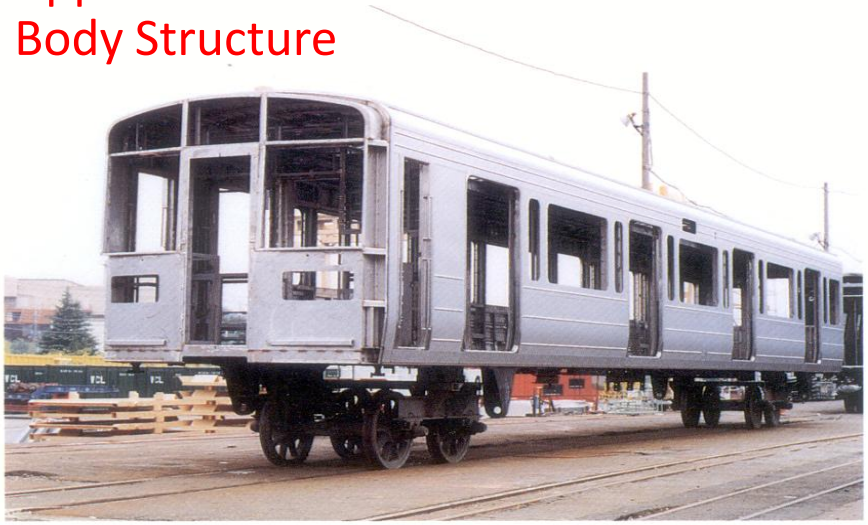


# DESIGN & MATERIAL SELECTION PRINCIPLE

Pantry Car Side wall, roof and partition in the kitchen area to Specn. AISI 304



Appearance Of Stainless Steel Body Structure



SS Body Structure



# CATHODIC PROTECTION

## Definition:-

‘’Cathodic protection is defined as the control of electrolytic corrosion by forcing the structure to be protected to behave like a cathode”.

- One of the most effective & economical method of preventing corrosion
- Can be effectively applied to control corrosion of surfaces that are immersed in water or exposed to soil
- Most commonly used system to protect steel, water or fuel pipe lines, ships, etc

## Methods:

1.Sacrificial anode method

2. Impressed current method

# SACRIFICIAL ANODE METHOD

- The method involves the use of a more reactive metal as sacrificial anode along with the less reactive metal to be protected
  - Sacrificial anodes are pieces of metal usually electrically connected by a conductive wire (usually Cu wire) to the surface to be protected
- CP with galvanic anodes uses the corrosion of an active metal such as Mg or Zn or Al or their alloys (available in variety of blocks, rods or wire form) to provide the required electrical current
- In this method, the active metal is consumed in the process of protecting the surfaces where corrosion is controlled
- The anodes must be periodically checked & replaced, if consumed completely

# MODIFICATION OF ENVIRONMENT

## Deaeration:

Deaeration is done to prevent corrosion due to oxygen, dissolved oxygen from water is removed by physical or chemical means.

*In modern practice, this is accomplished through the use of oxygen scavengers [sodium sulphite & hydrazine ($N_2H_4$)]

**Dehumidification:** Moisture from air is removed by dehumidification using silica gel to prevent corrosion.

**Neutralisation of acids:** Corrosive environment due to presence of acids(HCl, $SO_2$, $CO_2$, $H_2S$, etc) can be minimised by injecting alkaline neutralisers ($NH_3$, NaOH, Lime, etc)

# CORROSION INHIBITORS

- Reduce corrosion rate when added in small quantity
- Types of inhibitor:
  - Anodic: inhibits corrosion of anode
    - Some inorganic salts like metal silicate & borates
  - Cathodic: inhibits corrosion of cathode
    - Some reducing agents like sodium thio sulphate & some salts of Ni, Mg etc

# PROTECTIVE COATINGS

- Protective coatings are means for separating the surface that are susceptible to corrosion from the factors in the environment which cause corrosion to occur
- Most widely used corrosion control technique
- Coating of oil, grease can be used to give a temporary protective coating
- Organic polymers or rubber latex can be applied to give coatings which can be stripped off when required
- Paint: The most common coating
- Any protective coatings can never provide 100% protection of 100% of the surface

# CLASSIFICATION OF PROTECTIVE COATING

Types of coating applied on the metal surface:-

- Metallic coatings
- Chemical conversion coating
- Organic coating

# METALLIC COATINGS

- The metallic coatings used are:-
  - –Zn, Sn, Ni, Cu, Cr, Al & Pb.
- Coating separates the base metal from the corrosive environment & acts as an effective barrier

# METALLIC COATINGS

- Hot dipping:
  - Galvanization
  - Tinning
  - Aluminizing
- Cementation or diffusion coating:
  - Chromizing (coating of steel with Cr)
  - Sheradizing (coating of steel with Zn- used in Bridge girder)
  - Calorizing (coating of steel with Al-used in Ganga bridge)
- Electroplating:
  - Chromium plating
  - Nickel plating
  - Copper plating
- Cladding: (not used in Rlys)

# GALVANISING

- A corrosion protection process for steel or iron, in which the substrate is thinly coated with zinc.

## Process:

- Surface preparation:-
  - Degreasing/ caustic cleaning:
    - Immersing in acid degreasing bath or caustic solution to remove dirt, oil & grease
  - Pickling:
    - Immersing in acid tank filled with either dil HCl or $H_2SO_4$ at 60 -90°C for 15-20 mts to which removes oxides & mill scale & rinse with water
  - Fluxing:
    - Pass through a tank containing a combination of $ZnCl_2$ & $NH_4Cl$ (flux-slightly acidic) which cleans the steel from all oxidation products & to create a protective coating

# GALVANISING

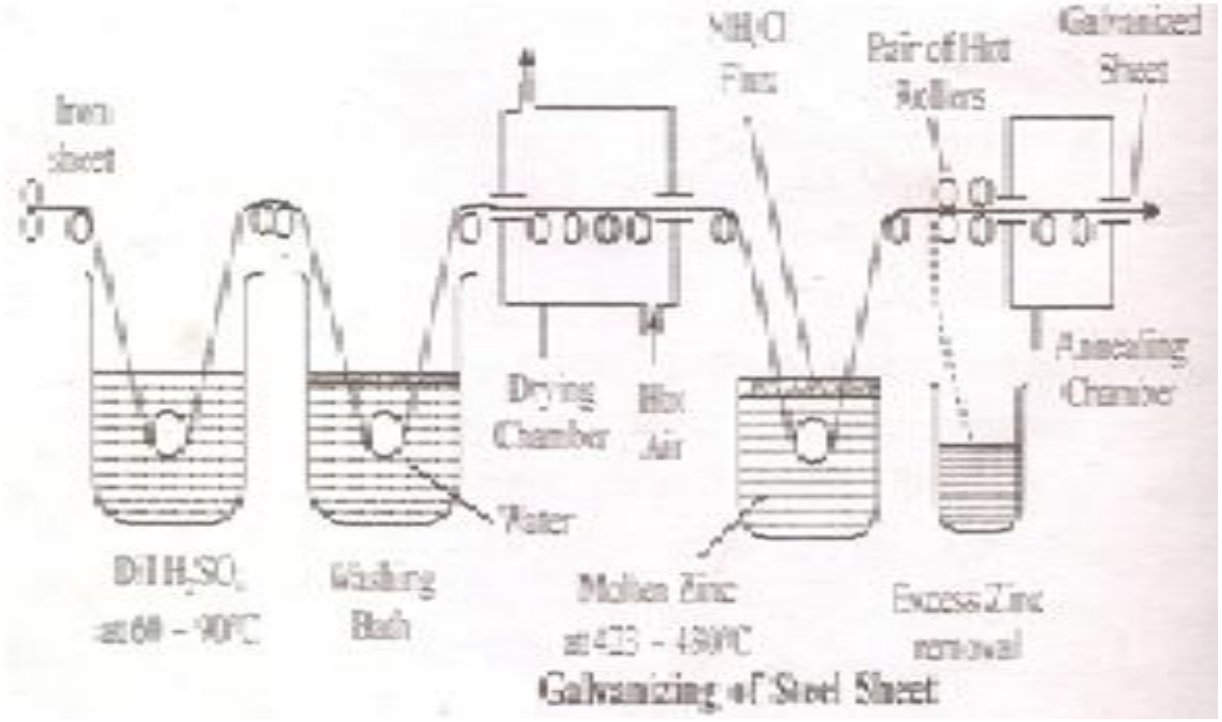
- Galvanising:-
  - Passing the well washed dried metals through a molten bath of Zn maintained at 425- 430°C covered with the flux (to inhibit oxidation of the cleaned surface upon exposure to air)
  - The iron reacts with molten Zn to form tightly bonded alloy coating that provides superior corrosion protection.
- Post treatment:-
  - Zn layered metal is passed through a pair of hot rollers to produce a thin film of uniform thickness & quenched in water added with some chemicals to create a passivation layer & to enhance the galvanised coating

  *when exposed to the atm, the pure zinc reacts with $O_2$ to form ZnO, which further reacts with $CO_2$ to form $ZnCO_3$, usually dull grey, fairly strong that stops further corrosion

# GALVANISING

- It produces a durable, abrasion-resistant coating of metallic zinc and zinc-iron alloy layers to the substrate and completely covers the work piece. No other coating for steel matches galvanization's unique combination of properties and advantages.
- Suitable for high-temperature applications up to 200 °C. The use of galvanized steel at temperatures above this will result in peeling of the zinc at the *intermetallic* layer
- Even if the surface becomes scratched and the base metal is exposed, the zinc is slowly consumed while the iron or steel remains protected from corrosion.
- It is a one-time process, ensuring maintenance-free use and long service life. It can be applied on wide range of products because of its low cost & ease of application
- The coating normally lasts at least 20 to 40 years in industrial environments and 50 to 100 years in less aggressive atmospheres

# GALVANISING




Galvanised parts

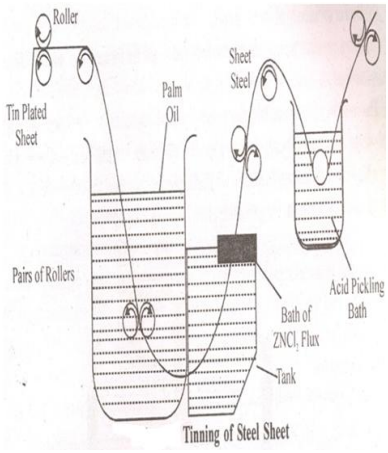


# TINNING

"Coating of tin on ferrous or non-ferrous articles"

- Tinning process:
- Surface preparation:
  - Cleaning of metals by pickling with dil $H_2SO_4$ to remove any scale, etc
- Tinning:
  - Pass the sheet through a tank of molten tin covered with Zinc chloride flux & finally through a series of rollers.
  - More resistant to corrosion & wear

*Does not protect iron/steel when the coat is scratched/porous because of iron is anodic to Sn



# CEMENTATION

- Base metal (steel) is heated with fine powdered coating metal (Zn, Cr & Al)
- The process is called:
  - Sheradising, if Zn is used;
  - Chromising, if Cr is used;
  - Calorising or Alonising, if Al is used.
- Very good bond is produced
- The process is limited to relatively small objects

# SHERADISING

Named in the honour of Sherad O Cowpercoles, An English Engineer.

## Process:

- The pre-cleaned component is packed with calculated mass of fine Zn- dust & an inert filler such as sand in a air tight sealed metal drum
- The drum is placed into a furnace & heated to just below MP of the coated metal (330-340°C for Zn). Above 330°C, Zn evaporates & diffuses into the metal object forming an alloy of Fe-Zn on the surface. At the same time the drum is rotated for a pre-determined length of time (2-4 hrs).
- The coating is smooth & uniform in thickness
- It is an ideal for small parts & part size is only limited by the drum size. Example-washers, fastener etc

# CHROMISING

## Process:

- The blasted/ cleaned base metal heated with fine powdered mixture of 55% Cr & 45% Alumina at 1300-1400$^0$C for 3-4 hrs in a closed drum
- The outer surface of base metal is converted to chrome alloy

# CALORISING

## Process:

- The sand blasted/ cleaned metal object is heated with fine powdered mixture of Al & $Al_2O_3$ together with a trace of Ammonium chloride as flux at 840-930$^0$C for 4-6 hrs in a tightly packed drum
- The layer formed has an approx composition of $Al_3Fe_2$[an iron-aluminum alloy (25% Al by weight)

# ELECTROPLATING

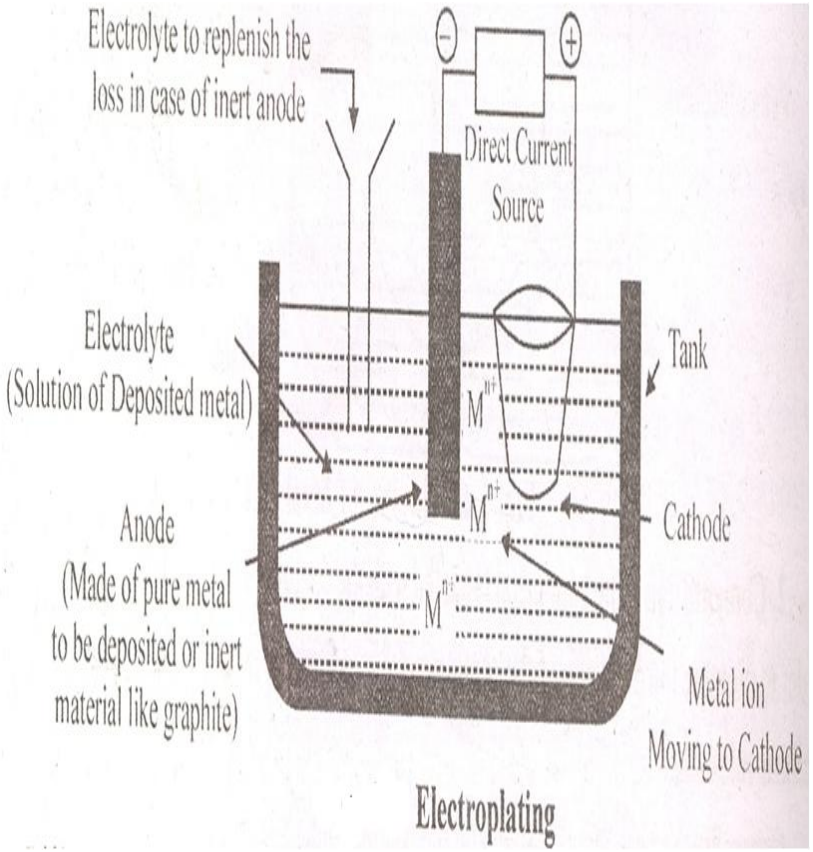
## Process:-

- The freshly cleaned metal is made cathode in a suitable electrolyte bath containing:-
  - A soln of the salt of the metal (electrolyte) to be electroplated
  - Buffer solution to maintain pH.
- Extra reagents to increase conductivity & to aid the formation of smooth, dense & coherent coating
- The concentration of the salt solution is controlled by the addition of metal salt at regular intervals.

# ELECTROPLATING

## Different electroplating:-

- Chromium plating
- Nickel plating
- Copper plating



# METAL CLADDING

"The process by which a dense, homogeneous layer of coating metal is bonded firmly to the base metal on one or both sides".

Cladding metals: Al, Cr & Ni

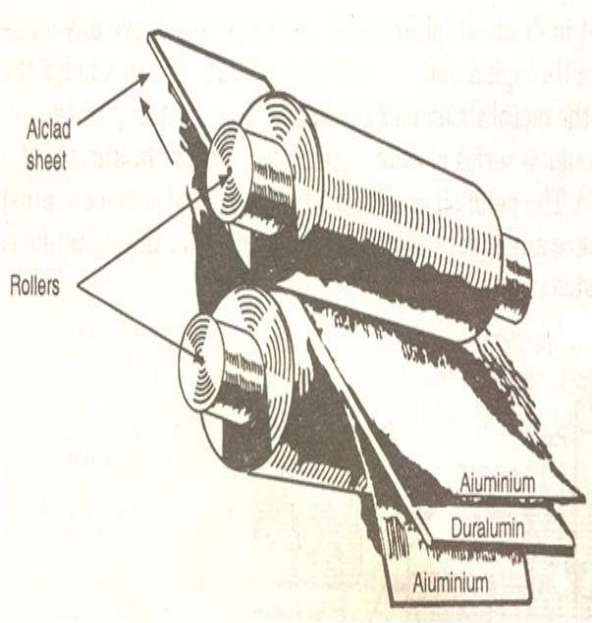
Cladding is done on:- mild steel, Al, Cu, Ni.& their alloys.

- It represents a great economic advantage in that the corrosion barrier or expensive material is relatively thin.

# METAL CLADDING

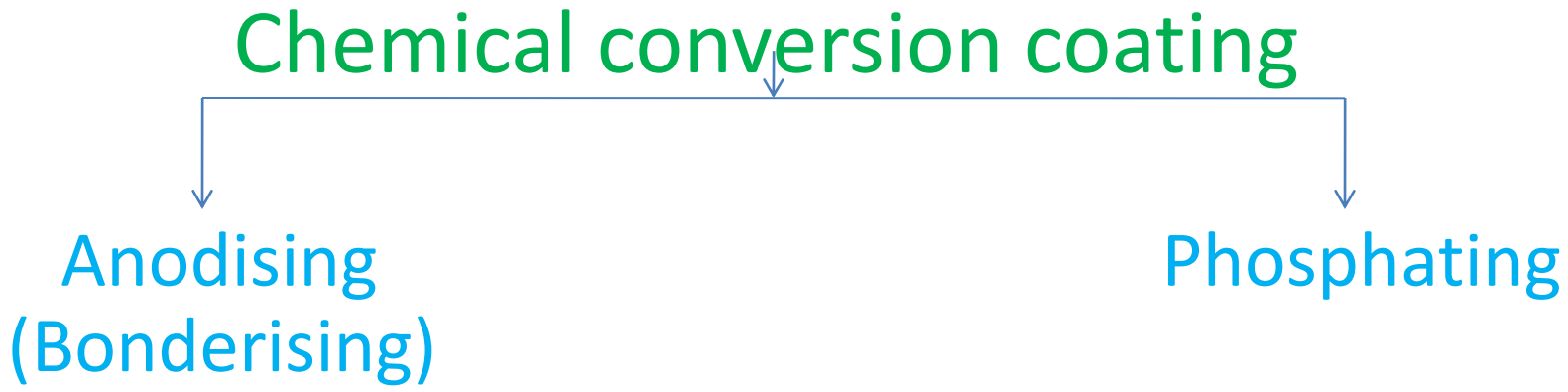
## Process:

Cladding is done by arranging thin sheets of coating metal & the base metal sheet in the form of a sandwich, which are then passed through rollers, under the action of heat & pressure.




The cladding of Duralamin

# CHEMICAL CONVERSION COATING




- Anodising: Al develops an oxide surface layer in air which offers some CR. This can be improved by thickening through an electrolytic process. This treatment is known as Anodising. The freshly formed anodic layer is porous & has to be sealed by immersion in boiling water to give max protection against atmospheric corrosion. This anodic layer increases surface hardness, abrasion resistance & CR.

# CHEMICAL CONVERSION COATING

- Phosphating :
- In this process, steel surfaces are treated with phosphoric acid or solutions containing phosphate ions
- The treatment results in the removal of surface rust & the steel surface is converted to metallic phosphate (protective).
- The coatings do not provide appreciable corrosion protection.
- They are useful mainly as a base for paints, ensuring good adherence of paint to steel.

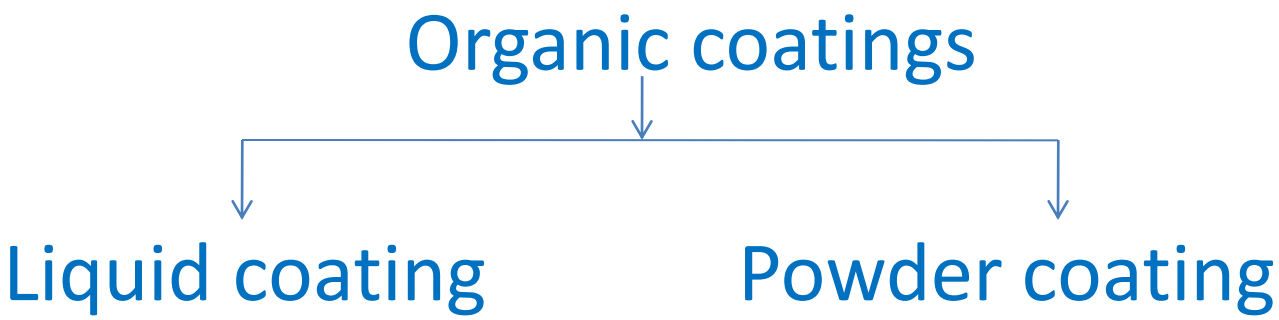
# PHOSPHATING

- Different steps involved in hot zinc phosphating process:-
  - Alkali degreasing
  - Cold swilling
  - De – rusting
  - Cold swilling
  - Hot phosphating
  - Cold swilling
  - Sealing/Passivation

# PHOSPHATING EQUIPMENT



# ORGANIC COATINGS



# DIFFERENT LIQUID PAINTS USED IN IR

ALKYD

PU

EPOXY PU




Pack ‘A’- Base

Pack ‘B’- Hardener

# Thank You

## Have a nice day !