Plating Techniques

Metal plating technique

Introduction: In most of the engineering works, they need an IDEAL METAL that fulfills (obey) all the properties Viz corrosion resistance, wear resistance, tear resistance, mechanical, thermal, and electrical properties, but none of the metal posses all the properties. Depending upon the engineering work/applications, metal surfaces are modified in order to satisfy their lacking properties, and this surface modification is called metal finishing.

Definition: Metal finishing is defined as a surface phenomenon that involves the deposition of a thin layer of noble metal on a polymer or on a base metal or conversion of a thin layer of the surface into the oxide of the metal.

Technological importance of metal finishing

Metal finishing techniques are widely used in industry. In the early days, the primary object was to give a decorative appearance to the metal object. In recent times the emphasis (stress) is on providing desirable characteristics such as

1) Corrosion resistance
2) Hardness
3) Abrasion resistance
4) Any other physical and chemical properties, simultaneously improving the appearance of the surface.

There are a number of technological applications of a metal finishing viz; it is used
1) to increase in resistance to corrosion, wear and tear
2) to impart thermal and electrical conductivity
3) to increase abrasion and impact resistance
4) to increase the hardness of the surface
5) to increase the solderability
6) to produce thermal and optical reflectivity.

Apart from these, metal finishing also used in

1) the manufacture of electrical and electronic components like Printed Circuit Board (PCB), Capacitors, and conductors

2) electrochemical etching, polarizing, and engraving
3) electroforming of objects
4) electro typing
5) material restoration

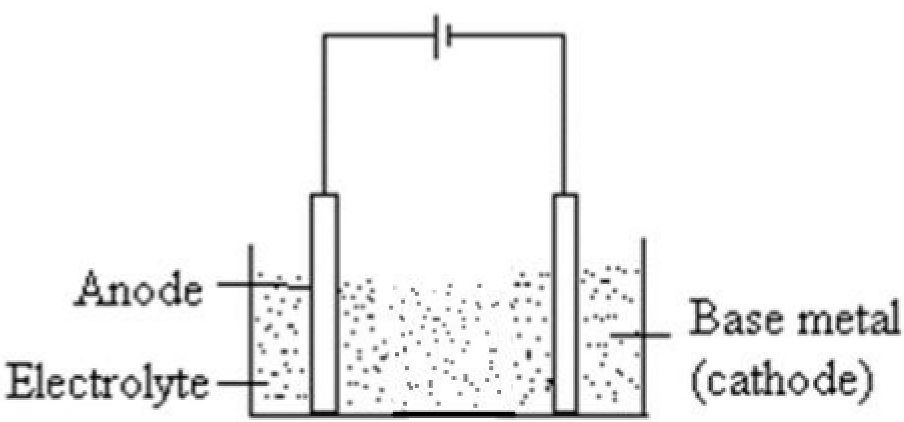
Methods of metal finishing

1) Electroplating
2) Electroless plating
3) Immersion plating
4) Chemical conversion coating

Electroplating

It is a process of depositing one metal over another with the help of electric current by electrolytic deposition. An electroplating device is an electrolytic cell; it consists of two electrodes; anode and cathode.

A cathode is a base metal on which plating is carried out. An anode is a coating metal or inert metal like platinum or graphite. The electrolyte is a soluble salt of the coating metal and acids/ base



During electroplating, at decomposition potential

$$MA \longrightarrow M^{+n} + A^{-n}$$

Plating Techniques

Cations move towards the cathode, and anion moves towards the anode. At cathode reduction reaction is taking place, and the metal is deposited on the cathode (base metal).

$$M^{+n} + ne^{-} \longrightarrow M$$

If the anode is a coating metal, the oxidation reaction is taking place, and the salt of the coating metal is formed in the electrolyte

$$\text{i.e. } M \longrightarrow M^{+n} + ne^{-}$$

$$M^{+n} + A^{-n} \longrightarrow MA$$

If an anode is an inert metal, the salt of the coating metal is added continuously in the bath solution; thus, there is a continuous replenishment of electrolyte during electrolysis.

Following are the factors that influence (affecting) the nature of electrodepositing.

*Current density

* Plating bath solution

* PH

*Temperature

*Throwing power of the bath solution

Throwing power (TP) of the bath solution

It is defined as the ability of the bath to produce uniform and even deposit on the entire surface of the substrate.

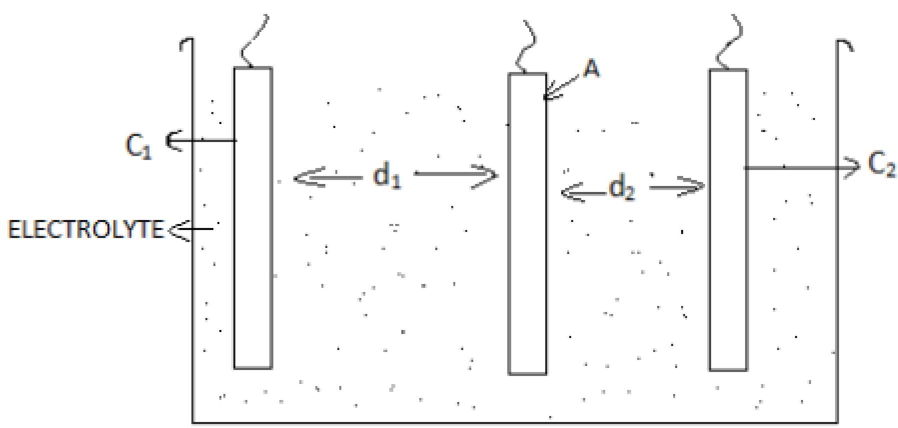


Fig. Haring-Blum cell

Plating Techniques

Experimentally it is determined by using the Haring-Blum cell; It is an electrolytic cell, as shown in fig. It consists of C_1 and C_2 are two cathodes kept at a distance d_1 and d_2 from the anode "A," where $d_1 > d_2$. Before electroplating, the initial weight of the cathodes is noted, and then electroplating is carried out for sufficient time. After the electroplating process, the cathodes are weighed again.

Let, W_1 is the weight of the coated metal on C_1.

W_2 is the weight of the coated metal on C_2.

In this process, W_1 will be less than W_2 because $d_1 > d_2$

$$\% \text{ of TP} = \frac{x-y}{x+y-2} * 100$$

$$\text{Where } x = \frac{d1}{d2} = \frac{\text{higher value}}{\text{lower value}}$$

$$Y = \frac{W2}{W1} = \frac{\text{higher value}}{\text{lower value}}$$

Problems

1) Calculate the throwing power of the plating bath solution in a Having-Blum cell if the distance between the two cathodes is 4.0 cm and 6.6 cm from the anode and the weight of the plating on the cathodes is 55 mg and 52 mg, respectively.

Solution: $d_1 = 6.6$ cm, $d_2 = 4.0$ cm, $W_1 = 52$ mg, $W_2 = 55$ mg

$$\% \text{ of TP} = \frac{x-y}{x+y-2} * 100$$

$$\text{Where } x = \frac{d_1}{d_2} = \frac{6.6}{4} = 1.65$$

$$Y = \frac{W2}{W_1} = \frac{55}{52} = 1.06$$

Therefore $\% \text{ of TP} = \frac{1.65-1.06}{1.65+1.06-2} * 100 \quad = 83\%$

2) The TP of an electrolyte in an Harinh Blum cell is 75%. In an experiment, 68 mg of the metal was deposited at the nearest cathode, kept at a distance of 4.8 cm from the anode. At what distance must the cathode at a longer distance be kept if the metal deposited in it is 64 mg.

Solution: % of TP = 75, W_1 = 64 mg, W_2 = 68 mg, d_2 = 4.8 cm, d_1 = ?

$$\% \text{ of TP} = \frac{x-y}{x+y-2} * 100$$

$$\text{Where } x = \frac{d_1}{d_2} = \frac{d_1}{4.8}$$

$$Y = \frac{w_2}{w_1} = \frac{68}{64} = 1.0625$$

$$X\text{-}Y = \frac{\% \text{ of TP} * (X+Y-2)}{100}$$

$$X\text{-}Y = \frac{75 * (X+Y-2)}{100}$$

$$X\text{-}Y = 0.75\,X + 0.75\,Y - 1.5$$

$$X - 0.75\,X = 0.75\,Y + Y - 1.5$$

$$X\,(1-0.75) = Y\,(1 + 0.75) - 1.5$$

$$X*0.25 = Y*1.75 - 1.5$$

$$X*0.25 = 1.0625*1.75-1.5 \qquad \because Y = 1.0625$$

$$= 1.859375 - 1.5$$

$$X*0.25 = 0.359375$$

$$X = \frac{0.359375}{0.25}$$

$$X = 1.4375$$

$$\frac{d_1}{d_2} = 1.4375$$

$$d_1 = 1.4375*4.8$$

$$\because d_2 = 4.8 \text{ cm}$$

$$d_1 = 6.9 \text{ cm}$$

Electroplating of gold using acidic cyanide bath and its applications

Gold is a soft and heavy metal (specific gravity 19.3) with yellow color. It is used for decorative purposes on jewelry articles, but later it found application in the industries for various purposes.

Generally following are the four bath compositions used for gold plating and are represented as A, B, C, D.

Plating Techniques

1) Bath A is an Alkaline Cyanide Bath used for the low thickness of gold (0.02 to 0.25 μm)

2) Bath B is an Alkaline Cyanide Bath used for the large thickness of gold up to 40 μm

3) Bath C is a Neutral Cyanide Bath used for less porous coating

4) Bath D is Acidic Cyanide Bath; it is used for less porous coating; this bath produces a 99.9999% yield

Acidic cyanide bath

It is used for less porous coating; the following bath compositions are used for gold plating

1) Potassium gold cyanide	6.0 - 18.0 g/lit
2) Monopotassium dihydrogen phosphate	20 g/lit
3) Potassium citrate	50 g/lit
4) PH	3 - 6
5) Temperature (^{0}C)	40-70
6) Current density A/m^2	1-20
7) Cathode efficiency	80-90
8) Anode	Pt, Platinized Ti, Carbon
9) Cathode	Base metal

10) Reactions: $Au^+ + e \longrightarrow Au$

Applications

*It is used for decorative purpose in jewelry

*In the electrical industry; printed circuits, contacts, and connectors are gold plated

*In electrons industry; transistors and integrated circuit parts are gold plated

*In the aerospace industry; instrument coverings and external surfaces exposed to radiation in space are gold plated

*Conductor tubes that are present in the reactors and heat exchangers are gold plated.

Plating Techniques

Electroless plating

Electroless plating is defined as the deposition of a metal from its salt solution on a catalytically active substrate surface by reducing agent without the use of electrical energy

$$\text{Metal ions + reducing agent} \xrightarrow[\text{Substrate surface}]{\text{Catalytically active}} \text{Metal deposited on the surface of catalytically active substrate}$$

In this process, a decrease in the free energy of the redox reaction is responsible for coating.

The surface of the substrate to be coated should be made catalytically active, which can be achieved by

*Acid treatment
*electroplating the surface
*plastics, ceramics, glass, etc. are activated by treating them with $SnCl_2$ and $PdCl_2$

Difference between electroplating and electroless plating.

Particulars	Electroplating	Electroless plating
*Driving force	Electrical energy	Decrease in free energy of redox reaction
*Anode	Inert metal or coating metal	Reducing agent
*Anode reaction	If coating metal is anode $M \longrightarrow M^{+n} + ne^-$	Reducing agent $\longrightarrow$ ne^- + oxidized product
*Nature of deposit	Pure metal or an alloy	Metal with reducing agent and oxidized product

Advantages of electroless plating

*Electrical power and electrical contacts are not required

Plating Techniques

*Insulators like plastics and semiconductors can also be plated

*Throwing power of the electroless plating bath is high, and hence the objects of irregular shapes can be plated uniformly

*Electroless plating is less porous, compact, and highly adherent, and has unique chemical, mechanical and magnetic properties.

Electroless plating of copper for preparation of PCB

Preparation of PCB, plastic plate is treated with $SnCl_2$ and $PdCl_2$ and then placed in a bath solution. The composition and condition of the bath solution is given below

1) Soluble metal salt: $CuSO_4$ 12 g/lit

2) Reducing agent: Formaldehyde 8 g/lit

3) Complexing agent: EDTA 20 g/lit

4) Buffer solution: NaOH 12 g/lit. and Rochelte salt 14 g/lit

5) PH ——— 11 to 12

6) Temperature ——— 25°C

Reactions:

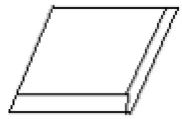
$$2H\text{-}CHO + OH^- \longrightarrow 2H\text{-}COO^- + 2H_2O + H_2 + 2e^-$$

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

This copper is coated on the plastic plate.

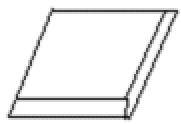
Diagrammatic representation of the preparation of PCB as follows

First, the plastic plate is treated with $SnCl_2$ and $PdCl_2$



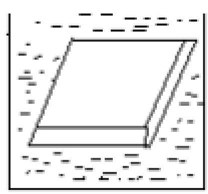
Plastic plate

$\downarrow$ SnCl2 and PdCl2

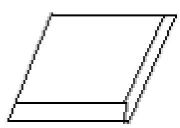


Surface activated Plastic plate

$\downarrow$

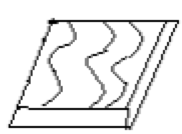


Bath solution



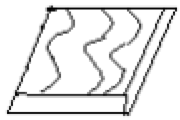
Copper coated plastic plate

The selected area of the copper is protected by an electroplated image, and the remaining area of the copper is removed by an etching process.



Copper circuits pattern is formed on the plastic plate

Plating Techniques



The connection between both sides of the laminate is made by drilling the holes at required points and plantings the holes with copper by the electroless method.

The electroless plating technique is

1) Used for metalizing PCB
2) Used for producing plating through hole
3) Used for plating on nonconductors
4) Used for decorative plating on plastic