**Metal finishing**

**1.8.1 Introduction**

Metal objects such as car components, kitchen utensils, juice cans, window frames, railings and so on which we see in everyday life will have undergone a surface modification, referred to as finishing. It covers a wide range of processes carried out to modify the surface properties of a metal. The process involves deposition of a layer of another metal or a polymer, conversion of a surface layer of atoms into oxide film or any other inorganic compound film or any process which can finally improve the surface characteristics. Metal finishing is done by electroplating, electroless plating, grinding wheels and honing, lapping and burnishing tools to obtain a smooth surface of a component with desired characteristics. Metal finishing is a process of electro deposition of an adherent metallic film of uniform thickness on the surface of the substrate for the purpose of modifying its surface properties.

The metal finishing techniques were originally introduced in the industry for improving the physical appearance of the metal objects by imbibing a decorative appeal. Since then a wide range of technological developments in the field was taken place for imparting additional desirable surface properties to the material other than their intrinsic properties to enhance the utility of the metal. Some of them are

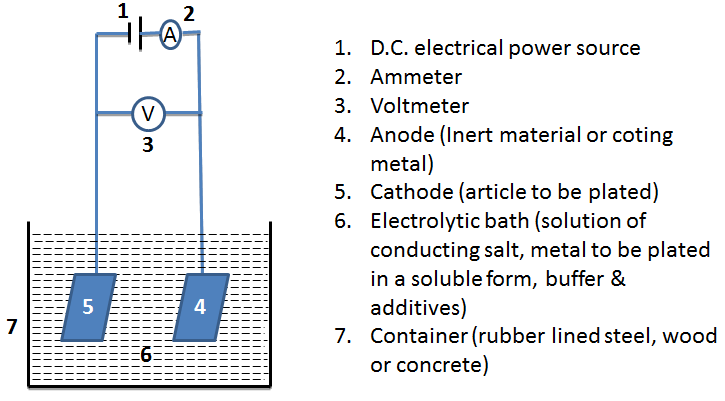
* Improving resistance to corrosion
* Enhancing resistance to chemical attack, abrasion and wear
* Imparting thermal resistance and resistance to impact
* Improving thermal and electrical properties
* Increasing hardness, thermal and optical reflectivity to the surface
* Making the surface resistant for moisture attack

**1.8.2 Electroplating**

The techniques of metal finishing include electroplating of metals and alloys and Electroless plating of a modified surface. Electroplating is the process by which coating metal is deposited on the base metal by passing a direct current through an electrolytic solution, containing the soluble salt of the coating metal. It is primarily used for depositing a layer of material to bestow a desired property (e.g., abrasion and wear resistance, corrosion protection and aesthetic qualities) to a surface that otherwise lacks that property and sometimes to build up thickness on undersized parts. The common metals used for coating purpose are Zn, Cu, Ni, Cr, Ag, Au and Pt.

**1.8.3 Theory of electroplating**

Electroplating is the process of coating a metal on a substrate made up of another metal, alloy or non-metal by the process of electrolysis. The process used in electroplating is called electrodeposition and the principle is electrolysis. The electroplating device is an electrolytic cell in which two electrodes (anode and cathode) are dipped in an electrolytic solution. The part to be plated is the cathode of the circuit. In one technique, the anode is made of the metal to be plated. Both components are immersed in a solution called an electrolyte containing one or more dissolved meal salts as well as other ions that permit the flow of electricity. A rectifier supplies a direct current to the anode, oxidizing the metal atoms that compromise it and allowing them to dissolve in the solution. At the cathode, the dissolved metal ions in the electrolyte solution are reduced at the interface between the solution and the cathode, such that they ‘plate out’ on to the cathode. The rate at which the anode is dissolved is equal to the rate at which the cathode is plated, ie equal to the current flowing through the circuit. In this manner, the ions in the electrolyte bath are continuously replenished by the anode. Other electroplating processes may use an inert anode such as lead or graphite. In these techniques, ions of the metal to be plated must be periodically replenished to maintain proper coating metal ion concentration in the bath. The device used for electroplating is an electrolytic cell in the form of a tank having two electrodes immersed in the electrolyte solution. The schematic representation of various components of the electroplating unit is shown in Fig. 1.8.3.



**Fig. 1.8.3** Schematic of the electroplating bath

Essential components include:

* An electroplating bath containing a conducting salt and the metal to be plated in a soluble form as well as a buffer and additives.
* The article to be plated - electronically conducting cathode.
* The electronically conducting anode, the coating metal itself, or an inert material of good electrical conductance like graphite.
* An inert vessel to contain the above mentioned materials made up of either rubber lined steel, concrete or wood.

Suppose the anode is made of coating metal itself. During electrolysis, the concentration of the electrolytic bath remains unaltered, since the metal ions deposited from the bath are replenished continuously by the reaction of free anions with the anode metal. As an example, if the CuSO4solution is used as an electrolyte, it ionizes as

CuSO4→ Cu2+ + SO42−

On passing current, Cu2+ ions go to the cathode and get deposited there.

* Cu2+ + 2e − → Cu

The free SO42- ions migrate to the copper anode and dissolve an equivalent amount of copper to form sulfate.

* Cu + SO42- → CuSO4 + 2e

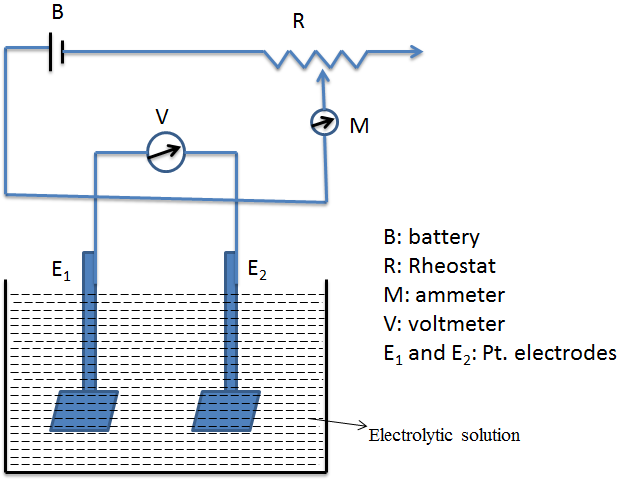
Thus there is a continuous replenishment of electrolytic salt during electrolysis. If however, the anode is made of some inert material like graphite, then electrolytic salt is added continuously in order to maintain proper coating metal ion concentration in the bath. Moreover the process of electroplating goes on nonstop, since the anode is not consumed and its replacement is not required. The process involves the passage of current and electrolysis of conducting media. Three important factors governing the electroplating process include decomposition potential (ED), polarization and overvoltage.

**1.8.3.1 Decomposition Potential (ED):**

When an electric current is passed through the electrolyte solution the electrolysis starts and the products formed, gather around the electrodes. Concentration in the vicinity of the electrodes changes and a back emf sets in. e.g., in the electrolysis of water, if a small voltage (~ 0.75V) is applied between two platinum electrodes immersed in the 1M sulphuric acid solution, the electrolysis starts, proceeds to some extent and then decreases rapidly finally to stop. The reason for this observation is the initial passage of current causing release of a small amount of hydrogen and oxygen at the cathode and anode respectively. The gases are adsorbed at the surface of electrodes and the inactive platinum electrode is converted into active gas electrodes. This produces a back emf of the polarization current, which resists the emf of the battery or applied voltage. At potential below 1.7V the back emf counterbalance the effect of applied emf and the process of electrolysis is not sustained. If the applied voltage is slowly increased, there is a slight increase in the current until the applied voltage just exceeds the back emf (1.7 V), the current suddenly increases appreciably at that point. Thus, the minimum external potential or voltage, at which the electrolysis current begins to increase appreciably and continuous electrolysis sets in is known as decomposition potential of the electrolyte. It is equal to back emf.

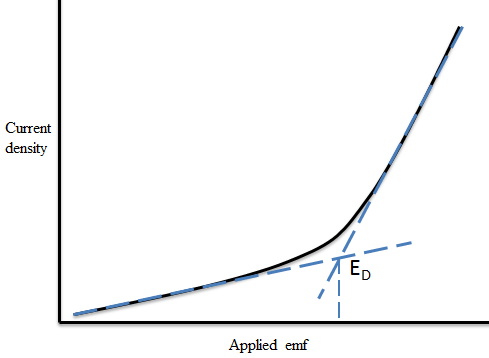
***Measurement of decomposition potential (ED):***

The schematic diagram for the determination of decomposition potential is shown in Fig.1.8.3.1a The electrolytic cell consists of two platinum electrodes (E1 and E2) dipped in the electrolytic solution. The applied voltage (V) is measured at different resistance and the corresponding current is measured with the help of milliammeter (M).



**Fig.** 1.8.3.1a Setup for measurement of decomposition potential

A series of readings for current passing through the electrolyte cell at corresponding applied voltage is recorded and a graph is plotted to measure the electrode potential. A graph between applied emf and the current density is shown in the following Fig.1.8.3.1b



**Fig.** 1.8.3.1b A graph of external voltage applied vs current density

The linear portions of the graph are extended, until they intersect. Voltage corresponding to the point of intersection is the ED of the electrolyte.

***Factors influencing decomposition potential:***

Decomposition potentials of different electrolytes are different. Even the ED of an electrolyte is not a constant. It depends upon the following factors;

* Strength of the current flowing through the cell
* Chemical nature of the electrodes
* Physical nature of the electrodes
* Activity of the electrolyte
* Absolute temperature.

***Use of decomposition potential values:***

* Knowledge of ED value enables the calculation of actual emf which is required for setting in continuous electrolytic processes, electroplating and electrorefining.
* It helps in predicting the sequence of discharge process to occur.
* Used in the separation of a mixture of metal ions from a solution by electrolysis.

**1.8.3.2 Overvoltage**

The decomposition potential of an electrolyte is approximately equal to the emf of the galvanic cell formed due to the discharge of products at the electrodes. The decomposition of an electrolyte is therefore expected to start as soon as applied potential reaches the value of reversible emf of the cell. This is true with respect to metal ions. But when products discharged at the electrodes are gases, then the actual decomposition potential is invariably much higher than its theoretical reversible electrode potential. The excess voltage is referred to as overvoltage (η) of the gas. It may occur at both the electrodes.

Overvoltage (η) is the difference between the actual applied emf to bring about continuous electrolysis and the theoretical emf needed for such electrolysis. For instance, the reversible potential of oxygen gas with smooth Pt electrode is 1.23 V. But actual gas evolution takes place at a potential of 1.68 V. The excess 0.45 V is the overvoltage of oxygen on smooth Pt surface. The following factors influence the overvoltage of an electrolyte;

* Nature of the electrode surface (or material)
* Current density and temperature
* Nature of the electrolyte

Overvoltage is believed to be a surface phenomenon at the electrodes. Of the many steps involved in gas evolution at electrodes, at least one is rather a slow process and requires energy. The extra energy is supplied by the applied voltage and this extra energy is related to overvoltage.

e.g., electrolysis of water

(i) H+ (aq.) + e-  H (fast)

(ii) H + H H2 (slow)

The step (ii) being slow, consumes energy and accounts for overvoltage. Hydrogen overvoltage is the measure of the tendency of hydrogen to be liberated at the cathode. Higher the value of overvoltage more difficult is the liberation of hydrogen on that metal.

**1.8.3.3 Polarization**

Since the electrolysis is a non spontaneous process, the minimum energy required to carry out such a process is equal to the free energy increase accompanying the change. However, in irreversible conditions, the potential to be applied for electrolysis is higher than the reversible emf of the cell. A cell that requires excess voltage over the theoretical is said to be polarized and the phenomenon is referred to as polarization. Electrolytic processes occur at the electrodes of the cell. Polarization sets in the cell when the electrode processes become slow and irreversible. Thus polarization in the cell is due to polarization at the electrodes. Magnitude of overpotential is directly proportional to the extent of polarization. The observed polarizations are of two types.

(a) Concentration polarization (b) Kinetic polarization

***Concentration polarization:***

An electrochemical reaction occurs only at the surface of the two electrodes. Reactant concentration decreases in the electrolyte adjacent to the electrode surface. The reactant species are transported to the electrode surface by processes like diffusion, migration and convection from the bulk of the solution. When the rate of transport is insufficient to match the rate of electrode reaction, current flowing through the cell drops. A higher potential than the theoretical value is required to maintain the current at the necessary level. This phenomenon is called concentration polarization. The steps involved in electrolytic processes are

* 1. Diffusion of reactant species towards the electrode and
  2. Diffusion of product away from the electrode, cause concentration polarization.

Concentration polarization can be eliminated or at least minimized by increasing the convection, by raising the temperature or mechanical agitation of the solution.

***Kinetic or Activation polarization:***

Activation polarization is caused when steps

1. Adsorption of the reactant on the electrode
2. Charge transfer across the metal-solution interface and
3. Desorption of the product from the electrode become slow and need activation energy.

A higher potential than the theoretical value is to be applied to maintain current at the necessary level. It is not possible to eliminate or minimize kinetic polarization by any means. Activation polarization is normally very low, when metal deposition or metal dissolution is the electrode process. When the electrode process is a gas (H2 and O2) evolution, kinetic or activation polarization is usually very high.

***Factors influencing polarization:***

* Size and nature of the electrode
* Nature of ions accumulated on electrodes
* Electrolytic concentration
* Temperature
* Conductivity of electrolytic solution
* Stirring of electrolytic solution
* Use of depolarizer

***Importance of polarization effect****:*

An impervious or non-porous film, contributes to the increase of polarization at an electrode. Considerable polarization effect can also be seen where loosely adhering and even porous films are formed. Such films either formed naturally (during manufacturing) or artificially (by the application of special coatings or products of corrosion) are important in determining the rate of corrosion of a metal or an alloy and also for the protection from corrosion.

**1.8.4 Applications of electroplating**

* *Plating for aesthetic appearance*:
* *Plating for protection*
* *For electroforming*
* *Plating on non-metals*

**1.8.5 Characteristics of a good deposit**

* + The deposit should be bright and lustrous
  + The deposit should be continuous, uniform, non porous and adhesive
  + It should be hard and ductile
  + It should be of fine grained nature

**1.8.6 Factors influencing the nature of the deposit**

There are several factors which affect the nature of an electro deposit.

***(a) Current density***

Higher the current density, more the deposition rate but will enforce the poor adhesion and loose and brittle plating quality. There is the possibility of a burnt and spongy deposit. Whereas low current density takes extra time to finish the job and is uneconomical. Therefore, optimum moderate current densities should be applied.

***(b) Metal ion concentration***

As the electroplating involves the discharge of free metal ions, the concentration of free metal ions plays an important role. If the concentration of metal ion is low the crystal size will be smaller and a fine adherent film may be coated. Thus the ideal situation is low free metal ion concentration in a concentrated solution of a metal compound which can be attained by addition of a compound with a common ion or by the formation of complex compound and ions. e.g., when copper is deposited from an electroplating bath containing copper sulphate solution, sulphuric acid is added to increase the concentration of sulphate ion. The concentration of cupric ions is reduced due to common ion effect.

***(c)*** ***Temperature*:**

Generally, the solution to be deposited is used at room temperature. However, warm baths are used for increasing solubility of electrolyte and current density. The size of the crystals increases with increasing temperature and renders lower adherence. But on the other hand the solubility and metal dissociation increase at higher temperature leading to the higher conductance of the solution. Also, the mobility of ions increases at a higher temperature and decreases the viscosity of the electrolyte solution so that the cathode film is replenished at a faster rate. This increases the current density for a given voltage and reduces the tendency towards treeing. There are disadvantages also of using high temperatures. Since, the possibility of corrosion of equipment, decomposition of the organic addition agent and evolution of hydrogen gas at cathode would increase at a higher temperature. So the optimum range of temperature needs to be selected.

***(d) pH of the electrolyte***

The pH of the electrolyte solution should be properly maintained. The range of the pH varies for different types of the plating bath. If pH is more towards the acidic side the nature of the deposit will be affected adversely as the evolution of hydrogen gas is expected at cathode thereby forming a burnt deposit. If pH is more towards the basic side the plating is delayed, so uneven and thick deposit is obtained. Suitable buffers may be used for maintaining the appropriate pH.

***(e) Presence of additives***:

To obtain electroplate with desire qualities and specifications, additional substances called additives are added in small quantities to the electrolyte bath. These additives have the capacity to modify the structure, appearance and characteristics of the deposit. The different types of additives used are

*(i) Complexing agents:*

*(ii) Brighteners:*

*(iii) Levellers:*

*(iv)Wetting agents:*

*(v) Structure modifiers:*

***(f) Throwing power of the plating bath***

Throwing power is defined as the degree of uniformity of metal distribution or evenness of deposit thickness obtained on a cathode of irregular shape. If the distribution of the deposit is uniform throughout the surface of the article to be coated, the throwing power is considered good.

**1.8.7 Methods of cleaning the metal surface**

It is essential to clean the surface of base metal before the application of the electroplated coating. The common impurities found on the metal surface are grease, oil, oxide layer and other extraneous matters. The following methods are employed to clean the metal surfaces.

* 1. ***Physical (Solvent) cleaning:-*** Physical cleaning is done with the help of solvents to make the surface free from oil, grease, superficial dirt, and buffing, polishing and fatty substances. The commonly used solvents such as chlorinated hydrocarbons, xylene, toluene, aqueous cleaning agents are used with or without electric current. Solvent cleaning is made more effective by vapour degreasing. An organic volatile solvent like trichloroethene is heated and vapours are passed over the metal surface to be cleaned. The vapours condense on the surface and condensed liquid dissolves and washes away the oil, grease and other organic matter from the surface. The emulsifying agents are also added to the solvent to remove organic impurities from the surface of the metal.

***(ii) Chemical*** *(****Alkali) Cleaning:***  It is used to remove the minute residue of soil and grease and for removal of tarnish and oxide film. The commonly used alkali cleaners consist of a number of alkalies, soap, chelating agents like Na2O3, sodium phosphates, NaOH etc. Alkali cleaning is made more effective by passing current through a hot alkaline solution, with the article to be cleaned constituting the cathode. The evolution of H2 at the cathode and O2 at the anode, metal helps to dislodge the greasy substance. It is followed by thorough rinsing with water and then immersing in a very dilute solution of acids to remove traces of alkali after cleaning is completed.

***(iii) Mechanical Cleaning:*** Involves removal of the oxide layer (tarnish), loose rust and other inorganic deposits from the surface to obtain better appearance, protection and optimum effects. This is done by hand cleaning with bristle brush and some abrasives like sand papers, polishing tools (grinding with grinding stone), scratch rubbing with chisel, knife, scrapers, wire brush or a abrasive stone or paper and detergent.

***(iv) Pickling:*** The oxides sometimes cannot be removed by simple alkali or mechanical cleaning. The extraneous fragments like heavy scales of oxides, scratches and strains can be removed from the surface by dissolving in the acid solution. The acid pickling involves the removal of such oxides; rust or tarnish by immersing the material (except Al) in acid like dil. HCl or dil.H2SO4 or dil. HNO3. Pickling of Al is done in alkaline solution, whereas pickling of Cu, Ni or brass articles are accomplished in a solution of dil. HNO3 or a mixture of dil. HNO3 and dil. H2SO4. Pickling is usually followed by polishing and buffing.

***(v)******Electro polishing :-*** In this method, the metal to be cleaned is made anode in a suitable solution. During the process, a surface layer of the metal gets dissolved along with the impurities. It also helps to remove minor surface irregularities. The most commonly used baths for electro polishing contain sulphuric acid, phosphoric acid, chromic acid, nitric acid etc. After the process, the metal is thoroughly rinsed with water, dried and used for electroplating.

**1.8.8 Electroplating of chromium**

Chromium plating is a finishing treatment utilizing the electrodeposition of a thin layer of chromium on a metal object. This layer can be decorative or corrosion protective to the base surface. The process of chromium plating includes degreasing to remove heavy soiling, manual cleaning to remove all residual traces of dirt and surface contamination and various pretreatments depending on the objectives of the coating. Different etching solutions such as hydrochloric, hydrofluoric, sulphuric acid and ferric chloride are used. Further, the treated base material is placed into the chrome plating bath for electroplating of desired thickness.

* Chromium coatings are generally thinner and have micro pores in it. As the thickness of the coating increases, cracks develop in the coatings. Hence, chromium coatings are always plated on nickel/copper undercoates. Ni gives protection and chromium gives a decorative finish.
* Chromium anodes are not used in electroplating of chromium on account of two difficulties. These electrodes become passive in acidic medium and they result in a black deposit.
* Chromium has higher electrode potential and can be easily coated on the iron to protect from rusting/corrosion
* The anode efficiency is nearly 100 % whereas cathode efficiency is at best around 20 %. It may be inferred that metal going into the solution is five times of the metal getting deposited, resulting in building up of excessive chromic acid concentration. This disturbs the ratio of Cr(III) to Cr(VI) and the conductivity of the bath and dull deposits called burnt deposits are obtained. To avoid this, inert material is used as anode and chromium electrolyte in the bath.

There are two types of chromium plating-Decorative coating and hard coating

**Table 1.8.8** Comparison of decorative and hard coating of chromium

|  |  |  |
| --- | --- | --- |
|  | Decorative coating | Hard coating |
| Bath composition | Chromic acid (250 g) +  H2SO4 (2.5 g) +  Trivalent chromium (1g) | Chromic acid (250 g) +  H2SO4 (2.5 g) +  Trivalent chromium (1 g) |
| Operating Temperature | 45 – 55 °C | 45 – 55 °C |
| Anode | Insoluble anodes like  Pb – Pb : 6%  Sb - Pb--7%  Sn | Lead – lead : 6%  Sb – Pb: 7%  Sn |
| Cathode | Article to be coated | Article to be coated |
| Current density | 145--430 A/ft2 | 290--580 A/ft2 |
| Cathode efficiency | 10 – 15 | 17 – 21 |
| Applications | Decorative applications with corrosion resistance finish on cycles, automobiles, furniture, household fittings, aircraft, surgical and dental instruments. | Coating of industrial components like gauges, dies, cutting tools, piston rings and hydraulic rams. |

**Working-**

On passing current, Cr3+ ions go to the cathode and get deposited there.

* Cr3+ + 3e − → Cr

**1.8.9 Electroless plating**

Electroless plating is a method of depositing a metal film on a substrate surface (conductor or non-conductor) from metal salt solution using a suitable reducing agent without using electrical energy. The reaction can be depicted as

Metal ions + Reducing agent Metal + Oxidized product

The method involves the deposition of metals such as Cu, Ag, Ni, Au or Pd on the surface of the base material by means of a reducing agent. Electroless plating results in a fine grained metal deposit that has similar finishing as that of traditional electrodeposit finishing. In industries, such process is used for plating on non-conductors like plastic, electroformed dies, hard memory disks, printed circuit boards (PCBs) or to obtain an extremely uniform plate. This technique is also used for the prevention of corrosion.

***Process of electroless plating:*** The process of electroless plating involves the following steps:

**(i)** ***Preparation of active surface***: This is the most important step and the surface is activated by any of the following ways.

(a) etching – by acid treatment

(b) electroplating with a thin layer of metal or insulators like plastic surfaces followed by heat treatment

(c) Alternate treatment with SnCl2 and PdCl2 on the plastic surface

SnCl2 + PdCl2 Pd + SnCl4

Pd is coated on plastic.

**(ii)** ***Preparation of plating bath:***

(a) Metal to be coated in the form of chloride or sulphate solution

(b) Reducing agents like formaldehyde and sodium hypophosphate for reduction of metal ion to metal

(c) Complexing agents like EDTA, tartrates, citrates to form metal complexes to prevent excess deposition

(d) Stabilizers like thiourea, calcium ions to prevent decomposition of the bath and to impart stability to the solution

(e) Exaltants (accelerators) like succinates, glycinates and fluorides to increase the rate of plating

(f) Brighteners like thiosulphate to give a lustrous appearance

(g) Buffers like boric acid to maintain the pH

**(iii)** ***Reduction step***: Active surface is dipped in the bath and deposition is carried out. The plating is carried out in a series of tanks where the object is immersed to plate the desired metal. The rate of deposition is controlled by the amount of reducing agent present and the type of chelating agent used. The deposition rate is normally 12.5 – 25 µm, although, it has been done up to 650 µm in thickness.

***Advantages of electroless plating***

The following are main advantages of electroless plating

* More uniform coating on the surface of object whatever shape it may have. Even the objects having irregular shapes, holes, recesses, internal surfaces, valves or threaded parts get uniform deposit since it has better throwing power than electroplating.
* Electrical power and other accessories are not required.
* Coating is harder than regular plating and better wear resistance.
* Deposits have compatible wettability for oils, inherent lubricity and non-galling characteristics, unlike electrolytic nickel.
* Deposits are much superior to electroplated nickel and hard chrome, as they are less porous and provide better corrosion protection to steel substrates.
* Electroless plating of Ni on aluminum substrate enhances the solderability together with providing a non-magnetic under lay in magnetic components. The deposits are less porous and possess unique characteristic chemical, mechanical and magnetic properties.
* Additives or levelers are not required in the process nor the complex filtaration method requirement.
* It is a simple process, so requires simple equipment.

***Disadvantages of electroless plating***

The main disadvantages of the process are the following;

* Due to speedy chemical renewal, cost of waste treatment is high.
* The frequency of dumping electroless bath is high as it is sensitive to contamination
* Costs per unit weight of the deposited metal are more.
* It needs pure chemicals.
* Chemical reductants are more expensive than electricity.
* Metal salts and reductant used in electroless plating solutions are thermodynamically not stable.
* Impurities or dust or colloidal matter (even if present in trace amount) promote the decomposition of bath components.

***1.8.9.1 Electroless plating of Copper***

It is an auto-catalytic reaction used to deposit a coating of copper on a substrate without the use of electrical energy. It is commonly used to plate plastic for decorative purposes and parts for engineering applications, particularly to render conductivity for electronic and printed circuit boards.

Reducing agents generally react with the plating bath, resulting in slow, deposition rates and poor deposit quality. It can be prevented by rejuvenating the bath at regular intervals. The bath solution undergoes spontaneous decomposition, resulting in an additional waste stream of copper and etching solution as copper built up on the tanks from the bath solution, must be stripped with an etchant such as sulphuric acid and hydrogen peroxide.

Electroless plating bath for copper includes;

* Coating solution : CuSO4 soln
* Reducing agent : HCHO
* Buffer: NaOH & Rochelle salt
* Complexing agent: EDTA di sodium salt
* Optimum pH: 11
* Optimum temperature: 25 °C

The reactions involved at two electrodes are

At cathode:

* Cu2+ (aq) + 2e- Cu (S)

At anode:

* 2HCHO + 4OH-(aq.) 2HCOO-(aq.) + 2H2O(l) + H2(g) + 2e-

Overall reaction:

Cu2+(aq.) + 2HCHO + 4OH-(aq.) 2HCOO-(aq.) + 2H2O(l) + H2(g)

Since Cu2+ ions and HCHO are consumed during the redox reaction, these are replenished periodically. The redox reaction involves consumption of hydroxyl ions and pH of the solution decreases as the reaction progresses. Hence addition of buffer is essential. Usual plating rate is 1-5 µmh-1.

***Applications of electroless plating:***

* Electroless copper plating is widely used for metalizing printed circuit boards (PCBs)
* It is used as a base coating for subsequent conventional electroplating
* It is used for producing through hole connections and for decorative plating on plastics. When double sided PCBs are fabricated then holes are drilled for making electrical connections. These holes are plated by electroless plating.

**1.8.10 Comparison of electroplating and electroless plating**

**Table 1.8.9** Comparison of electroplating and electroless plating

|  |  |  |
| --- | --- | --- |
| *Property* | *Electroplating* | *Electroless plating* |
| Driving force | Electric current | Autocatalytic redox reaction |
| Anode reaction |  |  |
| Cathode | Article to be plated | Article to be plated with a catalytic surface |
| Anode | Separate anode | Article to be plated |
| Reducing agent | Electrons bring about | Chemical reagents bring about reduction reaction |
| Anode reactant | M or H2O | R, the reducing agent in solution |
| Nature of deposit | Pure metal or alloy | Usually metal contaminated with species derived from the redox reaction |
| Thickness limit (µm) | 1 - 100 | 1 – 100 |
| Applicability | Applicable to conductors only | Can be used for conductors and non-conductors |
| Throwing power | Less throwing power; cannot be used for irregular shapes and intricate parts | More throwing power and can be used for irregular and uneven shaped objects |