METALLIC COATINGS

Metallic coating can be applied over metallic as well as non-metallic substrates. Sometimes non-metallic like plastics are coated to give metallic appearance. Some important metallic coating methods are described below.

Electroplating

Electroplating is also known as electro-chemical plating, is an electrolytic process. In this process metal ions in an electrolyte solution are deposited onto a cathode. In the electrolytic process, anode is generally made of metal being plated so it serves as source of coating metal. Workpiece where coating is to be applied made as cathode. Direct current from an external power source is passed through electrolyte solution. The electrolyte is an aqueous solution of acids, bases or salts. Electrolyte conducts electric current by the movement of plate metal ions in solution. For optimum results the parts to be plated should be chemically cleaned.

Working Principle

The process of electroplating is based on Faraday's law (two laws). According to these two laws it is stated that:

(a) the mass of a substance liberated in electrolysis is proportional to the quantity of electricity passed through the cell, and

(b) the mass of the material liberated is proportional to its electrochemical equivalent (ratio of atomic weight to valence).

Mathematically effect can be stated as

$$V = K I t$$

where V is the volume of metal plated in m^3,

I is the flowing current in ampere,

t is the time for which current passes through, and

K is a constant depending on electrochemical equivalent and density of electrolyte is $m^2/A - S$.

Methods of Electroplating

Large variety of equipment can be used for electroplating. Selection of electroplating equipment depends upon workpiece size, geometry, throughput requirements, electrolyte and metal to be plated. Main methods used for electroplating are:

(a) Barrel plating

(b) Rack plating

(c) Strip plating

Electroplating may have plating of different metals. Plating of some of important metals are described here.

Zinc Plating

Zinc plated steel products are fasteners wire goods, electric switch boxes and sheet metal parts. Zinc coating provide high resistant to corrosion. Zinc can also be plated on large area sheet metal wiring galvanization.

Nickel Plating

Normally nickel plating is done for corrosion resistant purpose and decorative purpose. In these cases brass, steel, zinc die castings serve as substrate material. Automotive trims are also plated with nickel.

Gold Plating

It is a method of depositing a thin layer of gold on the substrate of other metal. Most often substrate is silver or copper. It provides corrosion resistant and highly electrically conductive layer which is used in electrical connectors and printed circuit boards. The major problem in gold plating on copper is copper atoms have a tendency to diffuse through the gold layer, causing tarnishing of its surface and formation of an oxide/sulphide layer. To avoid this a layer of some barrier metal like nickel is applied before gold plating on the substrate of copper as nickel atoms do not defuse to good. Some metal may also be gold plated to improve their aesthetic value for ornamental purpose.

Chrome Plating

Chrome plating is a finishing treatment given to a metal surface using electrolytic deposition of chromium (chromium plating). A decorative bright chrome plating of thickness 10 μm over nickel plating is done on steels. It is used in case of metal furniture, automotive trims, etc. Chromium plating is a hard plating providing wear resistance properly to the surface.

Tin Plating

Tin plating is used for ferrous and non-ferrous metallic surfaces. Tin is a nontoxic, ductile and corrosion resistance material so it is widely used in food packaging. Sheet metal coated with tin can be processed further without any damage to their surface, this is possible due to excellent ductility of tin and its alloys. Electroplating of tin is also used in electronics industry because of its ability to protect the base metal from oxidation. It is used to protect solderability.

Alloy Plating

In some cases electroplating of two metals is done simultaneously, it is called alloy plating Nickel-Cobalt is a common electroplated alloy.

Electroless Plating

As indicated by its name it is a plating process done entirely by chemical reaction, no external source of electric current is required in this case. Deposition of metal onto a part surface occurs in an aqueous solution containing ions of the desired plating metal. The process uses a reducing agent, and the work part surface acts as a catalyst for the reaction. Normally, Ni and Ni alloys are used for this plating. It is costlier as compared to other similar methods. Nickel plating by this method is used to get high resistance to corrosion end wear. Electroless copper plating is used to plate through holes of printed circuit boards. Electroless plating has the following advantages too :

- Uniform thickness of plating even on complex part geometry. This is a problem in case of electroplating.
- This process can be used to both metallic as well as non-metallic substrates.
- No current is flowing in this process so DC power source is not required.

METAL SPRAYING:

Metal spraying is a process for covering a surface with a metallic coating using a spray of molten particles. Numerous variations of the technique exist, including:

- Flame spraying
- Wire arc spraying
- Plasma spraying
- Detonation spraying
- High velocity oxy-fuel coating spraying (HVOF)
- High velocity air fuel (HVAF)
- Warm spraying
- Cold spraying

These processes can also be labeled with a more general term, thermal spraying. However, the general term includes coatings created with not just metallic materials, but also oxides and ceramics.

Metal spraying works by first subjecting the source material to a high degree of heat to achieve a molten state. The molten material is then atomized into small particles and sprayed outwards onto a surface. The molten particles do not heat the surface because the heat of a particle is proportional to its size. On contact, the particle flattens out and adheres to the surface as it hardens.

Most applications of metal spraying are found in the anti-corrosion and engineering markets. Coatings are used in these industries to add finishing coatings, anti-corrosion layers and thermal

barriers, and to add wear resistance. Both flame spraying and arc spraying techniques are used to add these protective coatings.

ANODIZING

Anodizing is an electrolytic passivation process used to increase the thickness of the natural oxide layer on the surface of metal parts.

The process is called *anodizing* because the part to be treated forms the anode electrode of an electrolytic cell. Anodising increases resistance to corrosion and wear, and provides better adhesion for paint primers and glues than bare metal does. Anodic films can also be used for several cosmetic effects, either with thick porous coatings that can absorb dyes or with thin transparent coatings that add interference effects to reflected light.

Anodizing is also used to prevent galling of threaded components and to make dielectric films for electrolytic capacitors. Anodic films are most commonly applied to protect aluminium alloys, although processes also exist for titanium, zinc, magnesium, niobium, zirconium, hafnium, and tantalum. Iron or carbon steel metal exfoliates when oxidized under neutral or alkaline micro-electrolytic conditions; i.e., the iron oxide (actually ferric hydroxide or hydrated iron oxide, also known as rust) forms by anoxic anodic pits and large cathodic surface, these pits concentrate anions such as sulfate and chloride accelerating the underlying metal to corrosion. Carbon flakes or nodules in iron or steel with high carbon content (high-carbon steel, cast iron) may cause an electrolytic potential and interfere with coating or plating. Ferrous metals are commonly anodized electrolytically in nitric acid or by treatment with red fuming nitric acid to form hard black Iron(II,III) oxide. This oxide remains conformal even when plated on wiring and the wiring is bent.

Anodizing changes the microscopic texture of the surface and the crystal structure of the metal near the surface. Thick coatings are normally porous, so a sealing process is often needed to achieve corrosion resistance. Anodized aluminium surfaces, for example, are harder than aluminium but have low to moderate wear resistance that can be improved with increasing thickness or by applying suitable sealing substances. Anodic films are generally much stronger and more adherent than most types of paint and metal plating, but also more brittle. This makes them less likely to crack and peel from ageing and wear, but more susceptible to cracking from thermal stress.

Colour of the deposited layer depends upon selection of an acid as an electrolyte. Sulphuric acid provides a thin transparent film over the metal surface. The anodized metal exhibits its own natural colour after the process. Chromic acid can also be used as electrolyte to deposit oxide layer. It provides milky white colour to the surface and that can also be changed to grey colour depending upon variations of bath temperature. Copper and its alloys are not anodized by this

bath. Oxalic acid bath can provide a oxide film of light yellow colour. Thickness of the coating depends upon concentration of the bath, intensity of current passing through electrolyte, and its temperature.

The coating can be made stable by treating it with a hot and dilute aqueous solution of potassium chromate, nickel acetate or cobalt acetate. The porous deposition can also be sealed by applying oil of wax to it.

Anodizing of different type of metals is possible. Some of the useful commercial examples are discussed here.

- Anodizing of steel is done to make it wear and corrosion resistant. It appears as a block film over different types of steels.
- Several galvanized machine parts are anodized to improve their resistance for rusting and corrosion.

Mn, Brass, Copper, Bronze, Zinc, Silver parts can also be anodized.

<u>Main purpose of anodizing are listed bellow:</u>

- It provides protective coating on the metal surface which is corrosion resistant and wear resistant up to some extent.
- To provide decorative appearance to the surface.
- It can provide a specific colour base to a surface that can be a substitute of painting.
- Aluminium provides very good surface properties after anodizing.