# Finishing Cycles & Types of Parts Plated*

**To develop an understanding of plating and metal finishing processes, an appreciation of the parts themselves is necessary. These are sometimes called base metals or substrates. Most parts are made of metals. Non-metallic parts may also be plated, but because these require very special treatments and knowledge, they will not be covered here.**

*The most common metal substrates plated are steel, brass or zinc. Steel and brass parts are fabricated by stamping, forging or casting; zinc parts are usually produced as die castings.*

## The Most Common Parts

**Steel parts are the most widely used,** because steel is the most economical metal, has good strength and can be worked (or shaped) in many ways. Parts can be stamped or machined from either cold- (most preferred) or hot-rolled sheets or bars. Hot-rolled steel is scaled, and this oxide layer must be removed before the surface can be plated or finished. Because forgings and castings have rough surfaces and are sometimes porous, they may give the plater some problems. Mechanical finishing (such as blasting or polishing) may provide smoother, more uniform surfaces, but this can be expensive. These parts are usually more difficult to plate than parts made from sheet or bar stock.

**Brass is an alloy of copper and zinc.** As with steel, brass parts are also made from sheet or bar stock, or by forging or casting. Similarly, parts made from sheets or bar stock are easier to plate than forgings or castings.

Brass is a ductile, easily formed metal and can be polished to a high lustrous (bright) finish. Because brass has lower structural strength than steel, it is much more expensive. It is reasonably corrosion resistant and is a relatively easy substrate to plate.

**Zinc can be hot-rolled** (at about 500 °F) and stamped into various shapes. Most zinc parts however, are made by die casting, which involves melting the metal and pouring it into a mold under pressure. Because the melted metal is actually a liquid, it can be used to produce complicated shapes, such as bathroom faucets and plumbing. These parts, however, are very brittle and can be easily damaged. The surfaces of zinc die castings are as smooth as the die surfaces, but they can be polished and buffed easily and take on a very smooth, bright finish.

**Aluminum parts** are usually finished for decorative purposes or to increase corrosion resistance, improve the adhesion of paints, or provide a good surface for adhesive bonding. Parts can be made using extrusion, die casting, machining or stamping methods. Aluminum parts require special pre-plate processing, because the surface has an oxide film that instantly re-forms when a cleaned part is exposed to air.

**Non-metallic substrates** such as plastic automobile grills, faucet housings and printed wiring boards are also commonly plated to provide conductivity, abrasion resistance, appearance effects, and numerous other properties. Non-metallic parts must undergo specialized processing to render the surface conductive to a low voltage DC current.

## How Parts are Formed

Parts that require surface finishing are manufactured by using one or more of these basic methods: stamping, forging, sand casting, die casting, metal drawing and extruding.

**Forgings** are made by "hammering" a portion of heated metal until it takes the desired shape. A well-known early example is the horseshoe made by the village blacksmith. Because the metal is severely deformed by the process,

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*Stampings such as this one are formed by the shearing action of a sharp-cutting die against a sheet of metal. Stampings are relatively easy to prepare for plating, because they usually have only cutting oils on the surface, and the metal is not significantly deformed by the operation.*

forgings can be difficult to process prior to plating, because oxides and other impurities have been pounded into the surface of the part.

**Sand castings** are made by pouring the molten metal into a form made from fine foundry sand. Sand castings can be particularly troublesome to process for plating because the surface of these parts may contain residual silicates (from the sand) and is porous, which tends to trap processing solutions.

**Die casting**—Another form of "casting" is to pour the molten metal into a cavity created by two mating "dies". After the metal solidifies, the mating dies open and the rough part is ejected. Before these rough parts show up at the metal finishing shop for plating, they will need to undergo de-flashing, rough grinding, vibratory deburring, polishing and buffing. Although numerous zinc, brass or aluminum consumer products are made using the die casting process, die castings are notoriously difficult to process for plating, especially if the die caster has not done a good job of gating, melt temperature and flow rates. In addition, the presence of die release agents, buffing compounds, surface defects and sub-surface porosity can result in a poorly adherent deposit.

In forming a part by the **metal "drawing" method**, a "blank" is held in place between a die block and a pressure pad. The punch then pushes on the blank until it stretches to the desired shape. Commonly known parts that are produced by this process include cans for food, which are formed from tin plated steel blanks, and the vessels for DC batteries, which are plated with nickel. Drawn parts are normally easy to plate because the metal is relatively free from surface defects and has only a light oil for corrosion protection. If the die is worn, or the metal is not of the proper composition, "puckering" can occur, yielding surface defects similar to scratches and tears.

**Extrusion parts** are formed by heating the metal (usually aluminum or magnesium) to the softening point and then pushing it through a die. Depending on the die shape, the extrusion can be a channel, tube or other shape. Extruded lengths of metal are then cut to size. The process usually produces a part that has few surface defects and only light lubricants are used. Poor control over the process or poor die maintenance can result in extrusions having surface tears and embedded lubricants, however, which create a surface that is almost impossible to plate properly.

## Know Your Alloys

When additional elements have been intentionally added to a pure metal, the mixture is called an alloy. The alloying elements give the metal additional desirable properties such as improved workability, increased hardness and strength and increased corrosion resistance. While the alloy composition and structure are beyond the plater's control, they can be important in influencing the plating cycle used, and the quality of plate produced.

- The main component of steel, for example, is iron, but steel is essentially an alloy of iron with carbon. Depending on the properties desired for a particular application, steel may contain many other elements. Stainless steels contain up to 18 percent chromium and eight percent nickel.

- Brass is an alloy of copper and zinc and may contain lead (leaded brass), which provides improved machinability.

- Bronze is an alloy of copper and tin. When phosphorus is added to provide "springiness," it is called a phosphor-bronze.

- White metal is a variety of zinc-based alloys from which statuary parts, such as the "Oscar" award, are made, as well as lamp and furniture parts.

- Nickel-silver, an alloy containing nickel and copper, bears its name simply because it has an appearance similar to silver.

- Sterling silver contains about five percent copper to add strength. Pure silver is very soft.

## Watch Out for Defects

Surface defects can develop during forming operations (stamping, rolling, forging, casting), heat treatments (hardening, softening or annealing, surface hardening), and the finishing operations (machining, grinding, blasting, polishing, buffing). The knowledgeable plater recognizes some of these defects that may cause plating problems.

Other surface defects are usually hidden and require an experienced eye or special instruments to detect. The possibility of one of these defects should be considered if plating and finishing problems occur but cannot be related to one of the more obvious defects:

*Commonly plated sand castings include gears.*


*These remaining soils must be removed before plating or the plate will be defective—non-adherent, non-continuous, pitted, rough, dull or a combination of several of these defects. The type of soil on the surface determines the cleaning steps required to produce acceptable plate.*


*The type of soil remaining on the surface after all manufacturing operations are completed determines the methods necessary to remove the soil. In most cases, more than one cleaning step is required. The usual cleaning processes are shown here.*

- Folded-over surfaces (called overlaps), caused by rolling operations on surfaces that have cooled too rapidly, can trap dirt and lubricants or solutions from pre-plate operations.

- Seams can develop dark areas, usually in straight lines, because of the inclusion of slag and other impurities present in the original ingot.

- Rolled-in carbon from soot and other soils can settle on the surfaces during various heating and rolling operations, resulting in non-metallic inclusions.

### *Surface Defects Usually Related to Castings:*

- Embedded lubricants or parting agents that may become carbonized and difficult to remove;

- Shrinkage or warpage, which indicate extremely rapid cooling of the casting and could result in entrapped soils;

- Excessive "fins," die marks or pronounced ejector marks that may indicate parts sticking in the dies, causing possible metal tears and lubricant burning.

## Pre-plate Cleaning Cycle

**Wet or dry blasting**, done with fine particles impinging on the surface of the part with a forced air blast, is a very effective way to remove solid particles and dirt. It also removes light scales from a previous heat treatment. Dry blasting is slightly more severe than wet blasting and the abrasive particles are usually metal shot, sand or glass beads. In wet blasting, the water acts as a cushion for the abrasive particles.

**Solvent cleaning** primarily removes oily soils. Organic solvents are usually heated to boiling in a special tank. The parts are lowered into the boiling liquid and then held in the vapor above the tank. This is called *vapor degreasing*. Special care must be taken to avoid getting the solvent on the skin and to avoid breathing the vapors. Degreasing is always followed by alkaline cleaning (or perhaps blasting).

**Spray or soak alkaline cleaning solutions** are water mixtures of various chemicals, usually proprietary materials. These contain caustic chemicals and detergents that are similar to soaps. Such cleaners leave the surface in a wettable condition. Because the cleaners are usually heated and are corrosive to the skin, they should be washed off as soon as possible after any accidental contact.

## Final Cleaning Step:

### *Cathodic or Anodic Electrocleaning*

In electrocleaning operations, if the part is connected to the negative terminal of the rectifier, it is called *cathodic* cleaning or *direct* cleaning. Hydrogen gas is produced on the surface and aids in scrubbing dirt and other soils from the surface of the parts. Because twice as much hydrogen is liberated at the cathode (when compared to oxygen at the anode at the same current density), more vigorous agitation for soil removal is provided. Another advantage is that any thin oxide films may be reduced by the hydrogen. The disadvantages of cathodic cleaning include the possibility of depositing loose smut, which causes problems as the cleaner becomes contaminated with metal ions from various sources. Some metals also have a tendency to adsorb some of the hydrogen and become brittle.

In *anodic* cleaning, the parts are connected to the positive terminal of the rectifier. Because this is the reverse of the connections in the plating tank, some platers refer to this as reverse cleaning. Oxygen is evolved at the surface and these bubbles scrub the surface clean in a manner similar to the hydrogen in direct cleaning. Anodic cleaning removes smut and is much more tolerant to


*Electrocleaners are usually alkaline (caustic) solutions similar to soak cleaners in that they contain a mixture of alkaline chemicals and detergents. Electricity (current) is used to assist the cleaning ability of the chemicals. The set-up is similar to a plating tank.*

## Typical Finishing Cycle

| Step | Purpose |
|---|---|
| 1. Cleaning | Remove interfering soils |
| 2. Water rinse | Remove cleaner film |
| 3. Acid dip (pickle) | Neutralize & remove residual cleaner; remove oxide film; lightly etch surface |
| 4. Water rinse | Remove acid film |
| 5. Strike | Provide additional cleaning; activate surface & deposit a thin, adherent plate |
| 6. Water rinse | Remove strike solution film |
| 7. Electroplate | Deposit desired coating(s) |
| 8. Water rinse | Remove last traces of plating solution |
| 9. Dry | Remove water film, facilitate handling |

the accumulation of metal impurities. In general, anodic cleaning offers advantages over cathodic cleaning and is usually preferred by most platers. The oxygen tends to react with the surface, producing thin oxide films. These can usually be removed in the next operation (acid dip). Certain metals have a tendency to become passive with this oxide film, however, and poor adhesion of the plate may result. Alloys with a high nickel content are generally cleaned cathodically because of this problem.

Alloys containing elements that form soluble alkaline compounds should not be subjected to prolonged anodic cleaning, if at all. These metals will dissolve (as anodes), leaving the surface etched and porous. For example, brass contains copper and zinc; zinc is readily attacked and dissolved in alkalies and can be selectively etched out.

The choice of anodic or cathodic cleaning depends on the alloy composition and the kinds of soils present. Sometimes both are used. By periodically alternating the polarity (*periodic reverse cleaning*), the best features of both can be achieved. Usually the anodic cycle is longer than the cathodic cycle and the parts should be removed during or at the end of the anodic part of the cycle. PR cleaning is very effective in smut removal.

## Acid Dip

An acid dip is sometimes called a *pickle*. It is used to remove light oxide, neutralize residual alkali from the cleaner, lightly etch the surface of the part, and remove residual smut left by the cleaner.

The most widely used acid dips are either solutions of sulfuric acid or hydrochloric acid (usually called muriatic acid). Sometimes, however, these common dips are not the best ones, or require additives to be effective. The reason for this is that what is on the surface of the part may not be compatible with these commonly used acid dips.

For example, if the surface contains lead particles, as in a solder joint or in lead containing steels or brasses (to make them "free machining"), a sulfuric acid dip might actually cause problems, because it would react to form a film of lead sulfate, which is not easily removed in water. Such a film left on the surface could cause poor adhesion and blistering of the plate. So, just as the proper cleaning steps must be selected, different acid dips may have to be chosen for certain metals.

Similarly, the acid dip chosen should be compatible with the next operation or following plating solution. Possible drag-over may cause adverse reactions or upset the plating solution. For example, a sulfuric acid dip preceding a (hard) chromium plating solution could upset the chromic acid/sulfate ratio, or if used prior to a lead or solder fluoborate plating solution, could cause precipitation (resulting in plate roughness).

## Other Pre-plating Steps

There are a number of other pre-plating steps that may be taken, depending on the substrate. Frequently a *strike*—usually copper, but sometimes another metal, such as nickel or gold—is applied before the desired plate. The strike can be considered a special plating solution that produces lots of gassing and provides additional cleaning and activation of the surface while depositing a thin, adherent deposit of the metal. This improves the adhesion of subsequent plates and can improve the quality of the final plate.

In some cases, especially in plating electronics parts, several strikes may be used, one after the other, before the final deposits are plated. In gold plating, for example, it is not unusual to lay down a copper strike, followed by a nickel plate, then a gold strike, before the final gold plate. In silver plating, a nickel strike usually precedes a silver strike.

In other plating processes, such as hard chromium, strikes are omitted and the plate is deposited directly on the substrates.

*Zincate dips* are used to obtain adhesion on aluminum and magnesium parts. These metals oxidize too rapidly to be able to clean and plate them under normal conditions. A zincate dip removes the oxide film and simultaneously deposits a thin layer of zinc metal, which then acts as a barrier to the oxidation of the base metal. A subsequent cyanide copper strike or high pH nickel plate is applied prior to the final plate(s).

There are many other dips and strikes that serve to prepare various metals for plating. Among these are bright dips for copper and brass, and de-smutting solutions for cast iron parts.

## Don't Forget to Rinse!

Water rinsing follows each step or operation in plating or finishing processes. These rinsing steps are just as important as the other steps, because their function is to remove the chemicals left on the surfaces by the previous step, and to prevent them from being dragged over into the solution in the next operation. Poor or inadequate rinsing may result in the contamination of processing and plating solutions, contributing to plating problems. Poor rinsing can also leave residual chemicals inside parts and on intricate areas, which can lead to premature corrosion failures.

Water is an important—and often expensive—resource, and because the use of large quantities of water makes pollution control and waste treatment difficult and very expensive, water management has become an important aspect of the plating process. The concept of counter-flow rinsing provides adequate rinsing with great reductions in water consumption. This concept is discussed in "The Art and Science of Rinsing," (an AESF Illustrated Lecture). In addition, papers have been published in *Plating and Surface Finishing* on the subject. Tip: Check the December indexes of any given year.

## Plating or Painting—
### *Same Principles Apply*

What has been discussed about plating applies to other kinds of surface finishing. In applying paint, for example, metal surfaces must be cleaned and activated. A new surface film to which the paint film will adhere must be provided. In these painting processes, phosphate or chromate films are substituted for plated coatings (or applied to plated coatings). This is done to provide a slightly acidic condition and give "tooth" to the surface, because one peculiarity of paint films is that they do not adhere well to metallic surfaces, which are naturally alkaline. ***P&SF***