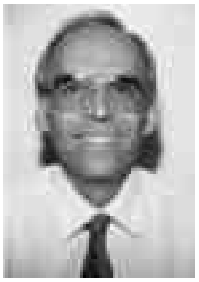

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Mechanical Processing—An Alternative To Traditional Plating

The first half of the twentieth century was a springboard to many technical innovations. Manned flight, communications, energy (nuclear and conventional), health, medicine, manufacturing, and transportation are but a few of these. By researching each, I'm certain specific disciplines in plating and surface finishing contributed to the critical growth, success, and expansion of each. Many treatment and finishing processes were developed to meet new and tougher requirements. Improvements and refinements continue as "the bar of expected accomplishment" rises.

There are systems in place that offer the flexibility to build and branch out, while still retaining their individual cycles and methodology. One of these is mechanical plating, also referred to as peen plating. With its advent in the post-World War II years, it has retained the basic sequence of steps, but has refined the state of its art.

What It Is

Mechanical plating is simply a tumbling procedure by which metallic dusts are cold-welded or bonded onto the base substrate. Normally, parts for conventional barrel plating can be mechanically plated. Deposited metals include: zinc, aluminum, copper, alloys (such as zinc-nickel), tin, precious (gold and silver), and cadmium (although now much limited due to its toxicity). Coated substrates may be ferrous, castings, stainless steel, or copper. Each step in the cycle differs in varying degrees compared to conventional surface preparation, plating, and post finishing. The biggest and most critical differences are the use of one process vessel and fresh make-up solution for most steps in the mechanical plating cycle. The vessel, similar to an oblique tumbling barrel or cement mixer, becomes our primary process "tank." This column will focus on a typical cycle.

How It's Done

1. Parts Cleaning. Accomplished in bulk, off line, by immersion in a suitable hot alkaline cleaner. The cleaned parts would be rinsed and transferred to the mechanical plating line for additional surface preparation. Alternatively, the parts may, by previous test confirmation, be tumble cleaned in the mechanical plating cycle process barrel.
2. Surface Conditioning (I). This critical first step combines the action of a special chemical additive and media. The balanced chemical and mechanical action develops a rust- and scale-free surface, readily accepting a metal deposit. The chemical additive consists of surfactants, inhibitors, and inorganic acids. Media is a glass bead type, primarily composed of silica, carbonate, and limestone. This material offers a relatively long service life, contributing very little friction to the operating process.
3. Surface Conditioning (II). The second step completes this critical treatment by depositing a thin, tightly adherent copper film. Deposition of copper promotes a uniform surface metal profile and forms a mechanical barrier between base metal and hydrogen (2–7 min).
4. Promoter (or accelerator). A proprietary additive. It standardizes conditions for deposition of the metal of choice. It will control agglomeration of the yet-to-be-added metal powder and maintain its cleanliness (2–3 min).
5. Flash Coat. The first aliquot of metal powder to be deposited (*e.g.*, zinc) rapidly covers the copper film with active sites of zinc that will readily accept additional layers of the metal deposit (4–7 min).
6. Deposition Build-up. Based on the thickness requirement, several aliquots of the very fine metal powder may be added. Approx 2-4 min between additions of metal powder. This promotes uniformity of metal thickness on parts with accompanying smoothness across the entire barrel load.
7. Rinse.
8. Retrieve. Parts are separated from media and collected for post-plate finishing.
9. Post Finish. Chromate (*e.g.*, clear, blue, yellow). Silicate seal or lacquer.
10. Dry.

Shopping List

The operating cycle incorporates the use of a fresh make-up solution for each step, eliminating the carryover or re-use of contaminated solution. Segregating parts in the same barrel eliminates loss of parts, because they aren't transferred out until the cycle is complete. Solution temperature for steps 2–6 is about the same, with 65–85°F (18–29°C) preferred. Some process development is required to determine the optimum conditions for surface conditioning, promoter, flash coat, and deposit build-up. Metal powder requirements for deposit thickness are measured on the basis of metal powder weight/deposit thickness/surface area of parts. Critical areas include:

- Parts loading,
- Ratio of parts to impact media,
- Volume of water,
- Barrel rotation speed and angle, and
- Desired deposit thickness.

The vast majority of finishing cycles offer approximate cycle parameters that usually require some minimal fine tuning. Because the solutions are acidic, stainless-steel barrels, rubber or appropriate plastic-lined barrels are preferred. Barrels vary greatly in handling volume, from 1–50 ft^3. Glass impact media size and ratio to parts is very critical. The requirements for media include: cushioning the load, preventing scratching or abrasion, and the ability to reach into tight geometric recesses and threaded areas. Optimum conditions permit the media to efficiently transfer mechanical energy from the rotating barrel to peen metal dust particles on the substrate, and build thickness over previously bonded metal layers. Size and diameter of media must also be considered to prevent it from being lodged and trapped in parts. Media diameter may range from <0.001 in. to >0.25 in. Experienced operators develop reference points that offer good confirmation to preferred load performance (*e.g.*, color of foam or solution, color of parts, appearance).

Bragging Rights

Listed are some features and benefits of the mechanical plating process.

- Eliminates hydrogen embrittlement
- Post-plate baking is not required
- Deposit uniformity of thickness is consistent throughout the part
- "Dog bone" effect of thickness distribution is eliminated
- Adhesion is excellent
- Up to 1 mil deposit thickness without harmful stress
- Flat parts are compatible (no sticking, nesting, or masking)
- Readily plates hardened steels, powdered metals, fasteners, nuts, bolts, washers, clips, and screws
- Excellent chromatability of plated parts

More Benefits

Compared to conventional electroplating, the mechanical plating cycle is much simpler. Most of the steps are completed in the same barrel, so tanks and space are greatly reduced in the mechanical process. Being non-electrolytic, rectifiers are not required. Water usage is predominantly a factor of sufficiently charging the barrel, unlike a much larger in-place tank. Rinsing uses sufficient fresh water for each step. Drag-in of solution from a previous step should not occur. The plating solution requires zero maintenance after a run, because it's always replaced. There are no polypropylene plating barrels that require more frequent repair and service. As previously stated, each process solution is replaced with a respective new one after a cycle run.

By determining the proper additions of metal powders and related operating parameters discussed previously, deposition efficiencies greater than 95 percent are achievable.

The effluent does not present any special burden for the waste treatment system. Mechanical plating uses non-complexing and non-chelating chemistries. Being acidic, cyanides are not present. Under proper operating conditions, discharged effluents are low in metals and do not contain any chemicals that hinder or complicate most common waste treatment systems. Because chromating is accomplished in a separate tank, chrome-containing waters can be appropriately segregated and treated. Aside from the powder metal additives, surface conditioners and promoters are primarily liquid concentrates. As such, they are typically low in solids, only minimally contributing to any sludging during bulk neutralization of the spent solutions.

Related Costs

Every process retains specific expenses relative to the individual capabilities and requirements. Based on the described equipment for mechanical plating, the cost savings when compared to traditional electroplating may range from 65–75 percent. Processing of parts also reveals some additional economic benefits:

- Handling from step-to-step involves less manual labor
- A complete cycle may be completed within 60 min
- Each cycle step (after cleaning) does not require maintained heating
- Solution chilling is not a factor
- Filtration, other purification equipment, and methods are not factors
- Buildup times for metal deposits are not proportional to desired thicknesses
- No anodes (consumable or inert)
- The post-plate baking step is eliminated

These acknowledged cost savings are built into total process economics. If aesthetic brightness is desired (depth and leveling), mechanical plating does not match proprietary electroplated systems. At best, the mechanical finish develops by some contributory burnishing, a low-level brightness. As the mechanical thickness requirement gets lower, the relative cost versus equivalent electroplating thickness gets closer.

Corrosion Protection

Unlike the electroplating application, up to 1 mil or 0.001 in. thickness (ex. zinc) is routinely accomplished. Depending on the finishing requirements or specifications, any thickness and most post-finishes can be obtained. An example of the related corrosion protection is tabulated below:

ASTM B-117 Salt Spray Data
Mechanical Zinc Plating
With Blue & Yellow Chromates

Zinc

Zn thickness, in.	Blue, hr	Yellow, hr
0.0003	90-95	150-175
0.0005	100-125	200-225
0.001	200-225	285-310
0.002	295-310	390-410

The thickness of the zinc deposit and its properties (adhesion, ductility, uniformity, etc.), provides a base of strong support for the overall corrosion protection. Application of a chromate and post-seal (*e.g.*, lacquer, wax, polymer, organic), can yield more than 1,000 hr of salt spray protection.

Mechanical Zinc in Application

The major automotive corporations worldwide have included mechanical zinc for many years in their particular finishing specifications. ASTM and MIL specs describe cycles and finishing parameters. State and federal highway and transportation agencies also specify mechanical zinc finishes. On an industrial scale, many finishes call for mechanical zinc, or specify it to meet coating requirements or corrosion protection.

Mechanical plating is an important contributor to quality finishing. This process is in position to help meet and exceed future requirements as the industry continues to improve its efforts to fight corrosion. *P&SF*