Plating Systems & Technologies

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Impact Media for Mechanical Plating and Mechanical Galvanizing

Mechanical plating and mechanical galvanizing utilize the energy in glass beads to "cold-weld" the plating metal to the surface of the part to be plated. The selection of the impact media has an important effect on the quality of the plating obtained.

Mechanical plating was developed by Erith Clayton of The Tainton Co., Baltimore, Maryland, in the late 1940's and early 1950's. The Tainton Co. was involved in producing flaked metals from metal powders. In this process, metal powders were tumbled with steel balls to produce a powder comprised of thin, shiny particles. Clayton noticed that the steel balls used in the process did not rust, and hypothesized that this was the result of some of the metal powders being plated on the steel balls. Clayton felt that modifications of the chemistry could provide a process for depositing metal on metal without the use of electricity.

Clayton started a new corporation, Peen Plate, to develop the chemistry required to deposit commercial thicknesses of plating metals. After numerous experiments, a process was developed in which parts were tumbled with steel shot and zinc dust, along with chemicals that Clayton had developed. The tumbling process generally took at least several hours, and often over 8 hours to achieve the thicknesses required. The steel shot required acid stripping after each run.

Peen Plate, lacking the resources to achieve commercial development of the process, licensed the mechanical plating process to 3M of St. Paul, Minnesota. 3M made significant improvements in the process, reducing the cycle time to approximately 90 minutes per run. One of the most important improvements made by 3M was the John Cutcliffe's development of the use of glass beads as the impact media in place of steel shot, an invention which is at the foundation of mechanical plating today. This was a useful concatenation of 3M's position in mechanical plating and their position as a leading developer of retroreflective glass beads for safety purposes (Scotchlite signs and Centerlite 'Road Mix'). Glass beads offer the advantages of:

- *Chemical Inertness*
- *Low Cost*
- *Readily Available in a Variety of Sizes*
- *Non-Toxic*
- *Low Coefficient of Friction*
- *High Crush Resistance*
- *Non-absorbent Vitreous Surface*
- *Low Abrasive Wear*

For mechanical plating, the usual "rule of thumb" is that for each cubic foot (by volume) of live load of parts, the plater uses one cubic foot of media (approximately 115 pounds). For cross recess screws, the ratio of media to parts is often reduced, and the water level raised. For mechanical galvanizing (thicknesses over 0.001") the general rule is to use 2 cubic feet of media to one cubic foot of parts to provide additional cushioning to prevent chipping during the plating process. If the part type is difficult, the ratio of beads to parts may be increased even more.

Media Mixes for Mechanical Plating and Mechanical Galvanizing

The media mix most commonly recommended is as follows:

- *4 volumes (50%) 4 mm (4 - 6 mesh) or 5 mm (3 - 4 mesh)*
- *2 volumes (25%) 8 - 10 mesh or 10 - 12 mesh beads*
- *1 volume (12½%) 16 - 25 mesh beads*
- *1 volume (12½%) mush beads - usually 50 mesh beads*

This mixture is sometimes called a "4-ball" mix. A "3-ball" mix is similar to the above but with one intermediate size removed. A "2-ball" mix is usually large beads (3 - 5 mm) and mush beads.

On some machines, the preferred four component media mix cannot be used. The most common example is the old 3M "Metal Plating Centers" which (usually) have 3/16" perforated holes in the separator unit which would trap the media with the parts. For these machines, we recommend: 6 parts 8 - 10 mesh beads; 2 parts 18 - 25 mesh beads; and 1 part 50 - 70 mesh beads.

On some part types, such as cross-recess screws, one media size will lodge in the cross recess. Generally, this is media in the 10 to 25 mesh range. If any media size is capable of lodging it will lodge. Therefore, the plater must select a media mix that contains no sizes that will lodge.

There is a simple test for lodging. Take the media that is being contemplated as the plating medium and a few of the parts. Place them in a pint plastic bottle with water and shake vigorously by hand for two or three minutes. If the media can lodge in the parts, it will be evident.

It is impossible to completely separate media in such a way that 100% of the lodging size is eliminated; media in the sump, in cracks or crevices in the barrel, in the piping - all these contribute to the problem. For platers to whom this represents a significant risk, often the best solution is to set up an isolated system that only uses non-lodging media sizes.

For some part types the only alternative is to use straight "mush" media, which is 50 mesh - 100 mesh (i.e., 50 - 70 mesh [PS5070], 60 - 80 mesh [PS6080] or 70 - 100 mesh [PS7000]) with no larger media. This media mix has poor flow characteristics and typically plates at a lower efficiency than other media mixes. However, if the parts themselves act similarly to the media, this will work acceptably.

Another media mix that is worth evaluation is a mixture of only large beads and fine media (as described above, a "2-ball" mix). Typical mixtures are 50% to 70% large beads (3 to 8 mm) and 30% to 50% fine beads (50 to 100 mesh). The large beads are typically 3, 4, or 5mm beads but they can be even larger - such as 6mm, 7mm, or 8mm beads (available on special order from PS&T). The larger beads are typically made by a molding process, and are therefore both durable and expensive. A media mix like this will offer both the impact energy associated with the use of large beads and the "throw" associated with fine media.

For some part types, platers have developed their own media formulations. A great deal of flexibility is possible in mechanical plating. The only plating formula PS&T does not recommend (unless absolutely necessary) is the use of formulations that do not include a fine mesh impact media. Without the fine media, the deposit is rough, the efficiency is low, and the throw into recesses suffers. The mechanical plating process relies on the action of the fine beads to break up agglomerates of zinc that form in the (acidic) plating process. Without the fine beads, the agglomerates remain undispersed, resulting in a coarse deposit or an 'orange peel' effect.

During the plating process (including, in particular, the separation and media return) the fine media is typically lost from the system due to dragout. The finer the fine beads, the more of these losses are encountered (i.e., 100 mesh is worse than 70 mesh and 70 mesh is worse than 50 mesh). This must then be periodically replaced. Alert operators can tell when their plating system is low in fine media by seeing how the process cleans in recessed areas such as thread roots and how well the process plates in these areas.

Media should not contain an appreciable amount of broken media. Typical specifications are under 5%. Running heavy parts at too high a speed will break down the media. The 'crush resistance' of glass beads is about 31,000 to 36,000 psi. This is significantly in excess of the force needed to plastically deform the small (3 - 7 micron) zinc particles so as to 'cold weld' the particles to the substrate. Thus, broken media is generally evidence of excessive mechanical energy being applied during the mechanical deposition process.

Sampling

Sampling of the media to determine the relative amounts of each of the various sizes may be performed. The actual separation of the various sizes of media is performed by vibrating a stack of U. S. Standard Sieves (available from many lab supply houses and from Gilson, who specializes in particle testing). The most common difficulty is obtaining a uniform sample of the media since the media tends to stratify with the larger beads rising to the surface. Dry media mixtures may be sampled with a tube or with a 'spinning riffler.' Damp or wet media may be sampled with a sampling probe such as those used to sample grain per ASTM C183. Either dry or damp media may be sampled by putting it in a pile and sectioning it (sometimes called 'quartering' it). Slurries may be tested with sample cups designed with a long 'cutter' engineered to cut through the slurry and provide a uniform sample. Another sampling procedure is to take small samples continuously from the batch of impact media as it is returned to the plating barrel; in this way, even if the media is stratified, a representative sample is obtained. Additional information and assistance on sampling and testing is available from PS&T Technical Service Department.

Reference Materials

MIL-G-9954A "Glass Beads: For Cleaning and Peening" This is the Military Specification for glass beads. Many glass beads, even though not intended for military use, are sold by the MIL-SPEC sizing system.

ASTM E11 "Standard Specification for Wire Cloth and Sieves for Testing Purposes" The standard reference for particle sizes.

ASTM STP447B "Manual on Test Sieving Methods" More detailed information on types of sieves, sampling techniques for particulate materials, and test sieving for a variety of industrial products with some useful technical background.

ASTM D1214 "Standard Test Method for Sieve Analysis of Glass Spheres" How to sieve glass beads and get accurate reproducible results.

ASTM D1155 (Reapproved 1994) "Standard Test Method for Roundness of Glass Spheres" In this test method, the glass beads are mechanically separated into true spheres and irregular particles on a glass plate fixed at a predetermined slope.

"Particle Sizing and Sampling" (Catalog). Gilson Co., Inc. P.O. Box 677, Worthington OH 43085-0677; 800-444-1508 or 614-548-7298; Fax: 800-255-5314 or 614-548-5314. This company specializes in products for testing particulate materials - sample splitters, spinning rifflers, testing screens, sieves, shakers, riddles, etc.

McNichols Master Catalog - from McNichols Co., 5505 W. Gray Street, Tampa FL 33609-1017; 1-800-237-3820. McNichols is a source of perforated metal, wire cloth, test sieves, and similar products.

Physical and Chemical Properties of Glass Beads

Glass is one of the oldest industrial materials, dating back to about 2500 BC. Soda-lime glass (from which glass beads are made) is an amorphous (i.e., non-crystalline) material produced from sand (Silicon Dioxide, SiO_2), Limestone (Calcium Carbonate, $CaCO_3$) and Soda Ash (Sodium Carbonate, Na_2CO_3).

Typically glass will have the following physical characteristics:

- *Specific Gravity 2.50*
- *Crush Strength 31,000 - 36,000 psi*
- *Moh's Hardness 5.5*
- *Clear, colorless or slightly blue*
- *No Free Silica*
- *Smooth, vitreous, non-absorbent surface*