Proper Design is Essential For a Quality Finish

The focus of this month's *P&SF* is "design for finishing." Designers have as much influence as the surface finisher on the quality attainable in the finish of a part. Often the finisher has to be creative and jump through hoops to achieve a good finish on a difficult-to-plate part. Good design—with the finish in mind at the beginning—doesn't always happen. Where can finishers and designers go for help?

One source is the Metal Finishing Suppliers' Association (MFSA), which has published eight *Quality Metal Finishing Guides** that contain a wealth of practical information on the many different aspects of surface finishing. All of MFSA's *Guides* that pertain to surface finishing present similar information on design, tailored to each specific finish. Subjects of the eight *Guides* include:

- Decorative Copper/Nickel/Chromium
- Zinc and Cadmium Coatings
- Mass Finishing
- Tin and Tin Alloy Coatings
- Hard Chrome
- Electroless Nickel Plating
- Decorative Precious Metal Plating
- Chemical Surface Preparation for Electroplated and Metallic Coatings

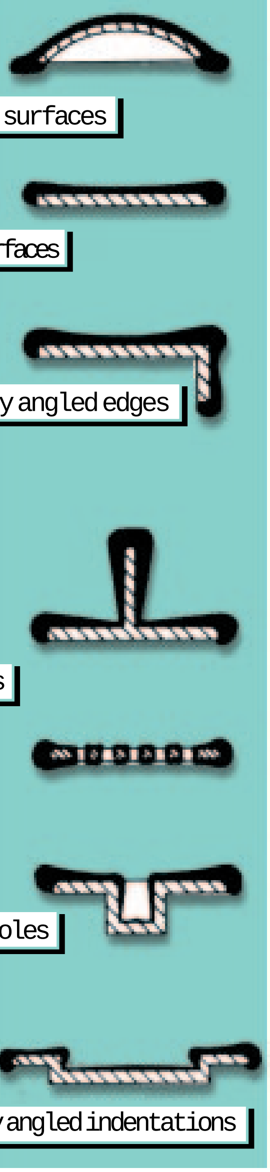
The following exerpts are from the *Quality Metal Finishing Guide for Decorative Copper/Nickel/Chromium:*

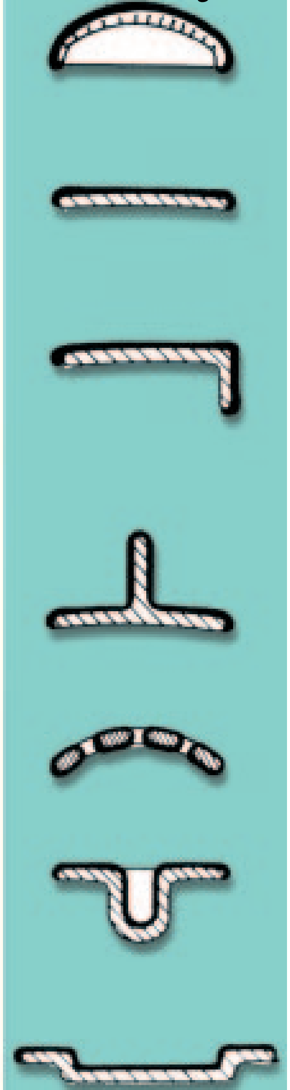
A program to improve and control the quality of a metal or plastic product should start at the desk of the designer. The metal finisher is restricted by certain basic principles of mechanical finishing and electroplating.

The designer should understand the limitations imposed by shape and size of components to facilitate quality finishing at an acceptable cost. The designer can exert as much influence on the quality attainable in finishing a part as can the electroplater himself. ASTM Standard B-507 can provide the designer with helpful information.

Influence of Design on Electroplatability

The distribution of electroplate is indicated in an exaggerated fashion.





Feature		Better Design
Convex surfaces	Ideal shape. Easy to plate uniformly, especially where edges are rounded.	
Flat surfaces	Not as desirable as crowned surfaces. Use a 0.4 mm/25.4 mm (1/64 in./in.) crown to hide undulations caused by uneven buffing.	
Sharply angled edges	Undesirable. Reduced thickness on center areas. Also requires increased plating time for depositing a minimum thickness of durable electroplate. All edges should be rounded. (Edges that will contact painted surfaces should have a minimum radius of 0.8 mm [1/32 in.]).	
Flanges	Large flanges with sharp inside angles should be avoided to minimize plating costs. Use a generous radius on inside angles and taper the abutment.	
Slots	Narrow, closely spaced slots and holes reduce electroplatability and cannot be properly plated with corrosion-protective nickel and chromium unless corners are rounded.	
Blind Holes	Must usually be exempted from minimum-thickness requirements. Where necessary, limit depth to 50-percent of width. Avoid diameters less than 6 mm (7/32 in.)	
Sharply angled indentations	Increase plating time and costs for a specified minimum thickness and reduce the durability of the plated part.	

Significant Surfaces

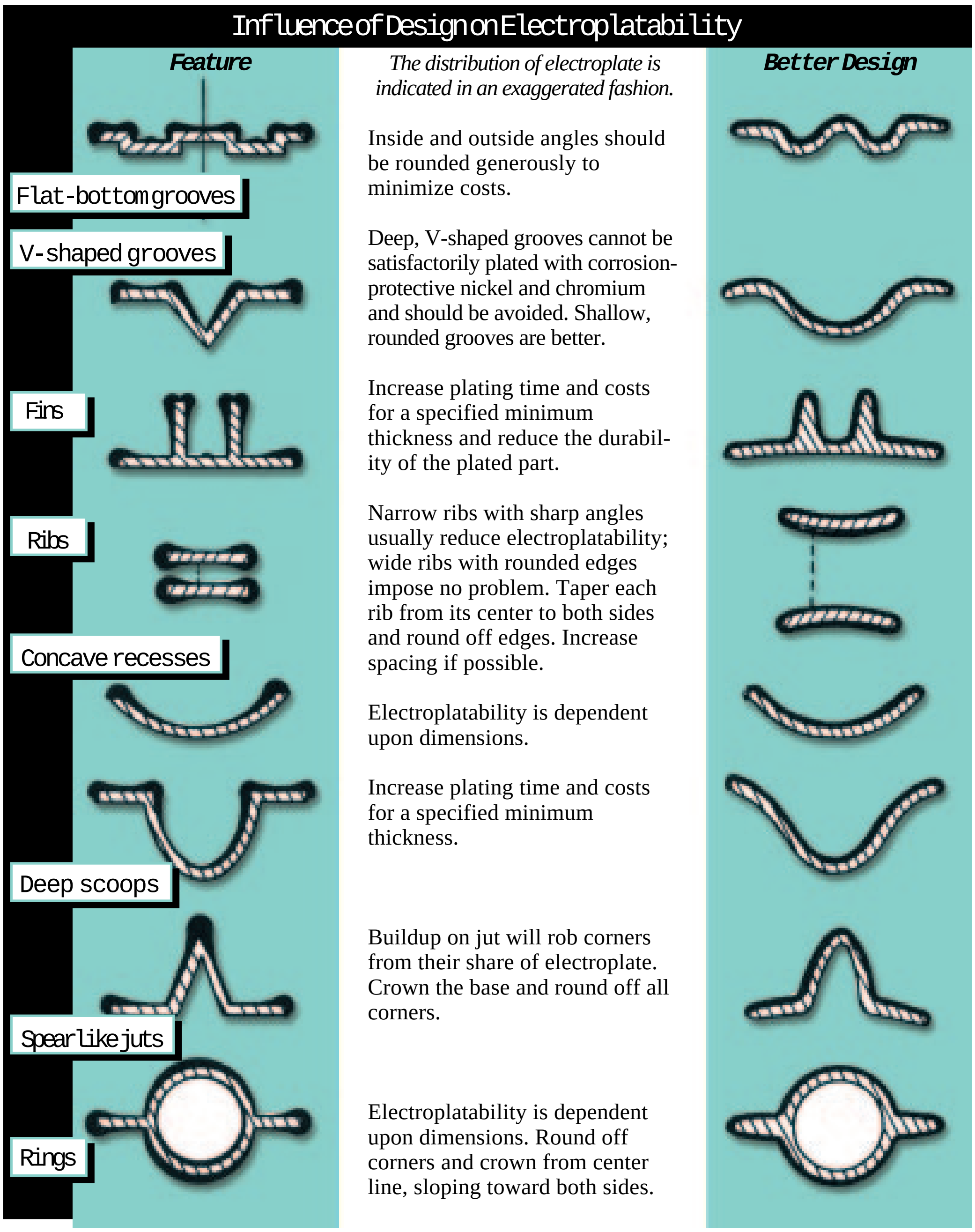
A very important term used in specifying metal finishing is "significant surfaces." In most products, the same standard of quality is not required over every square inch of the surface. Instead, the quality specifications apply and compliance is expected only for the so-called "significant surfaces" defined by mutual agreement between the producer and purchaser as follows:

Significant surfaces are defined as those normally visible (directly or by reflection), which are essential to the appearance or serviceability of the article when assembled in normal position; or, which can be the source of corrosion products that deface visible surfaces on the assembled article. When necessary, the significant surfaces shall be the subject of agreement between purchaser and manufacturer, and shall be indicated on the drawings of the parts, or by the provision of suitably marked samples.

Design for Mechanical Finishing

Metal products that are to be coated with copper/nickel/chromium or nickel/chromium finishes are typically subjected to abrasive polishing with belts or wheels in preparation for the plating operations. This is done to aid in securing an attractive, uniform, mirror-like or satin appearance on the finished part. Mechanical finishing is an expensive operation. To reduce costs and assist the metal finisher in improving the appearance and quality of the product, the designer should consider certain rules applicable for parts requiring mechanical finishing:

- Avoid blind holes, recesses and joint crevices that can retain polishing compounds and metal debris.
- Avoid intricate surface patterns that will be blurred by polishing.
- Significant surfaces should be exterior, reachable by ordinary polishing wheels or belts.
- Avoid sharp edges and protrusions that cause excessive consumption of wheels or belts.



For small parts that are to be processed in a barrel, these rules apply, in addition to a requirement that the parts be sturdy enough to withstand the multiple impacts of barrel rotation. Small, flat parts should be designed with ridges or dimples to prevent them from "nesting" together as they are processed.

Design for Racking, Draining & Entrapment

Most metal or plastic parts weighing more than a few ounces are not plated in bulk in barrels, but are mounted on racks for processing in cleaning and electroplating tanks.

Products that would occupy a large volume in processing tanks—large in proportion to surface area—should be designed to be plated in sections for assembly after coating.

Consult with the plater to make certain that parts can be held securely on a plating rack with good electrical contact, without masking a significant surface. Many difficult racking problems can be solved by design modification.

Provide for good drainage of processing solutions from racked parts. Certain shapes tend to trap solution. This causes contamination by carry-over, possible corrosion of the part and waste of materials. Carry-over increases waste disposal problems. When designing a part, avoid rolled edges, blind holes and spot-welded joints. Drain holes are especially important in irregular shapes and tubular parts.

Avoid shapes that can trap air on entry into processing tanks, if the air could block access of solution to areas requiring treatment. Whenever air can be trapped, hydrogen or oxygen gas may also accumulate during a cleaning or plating step.

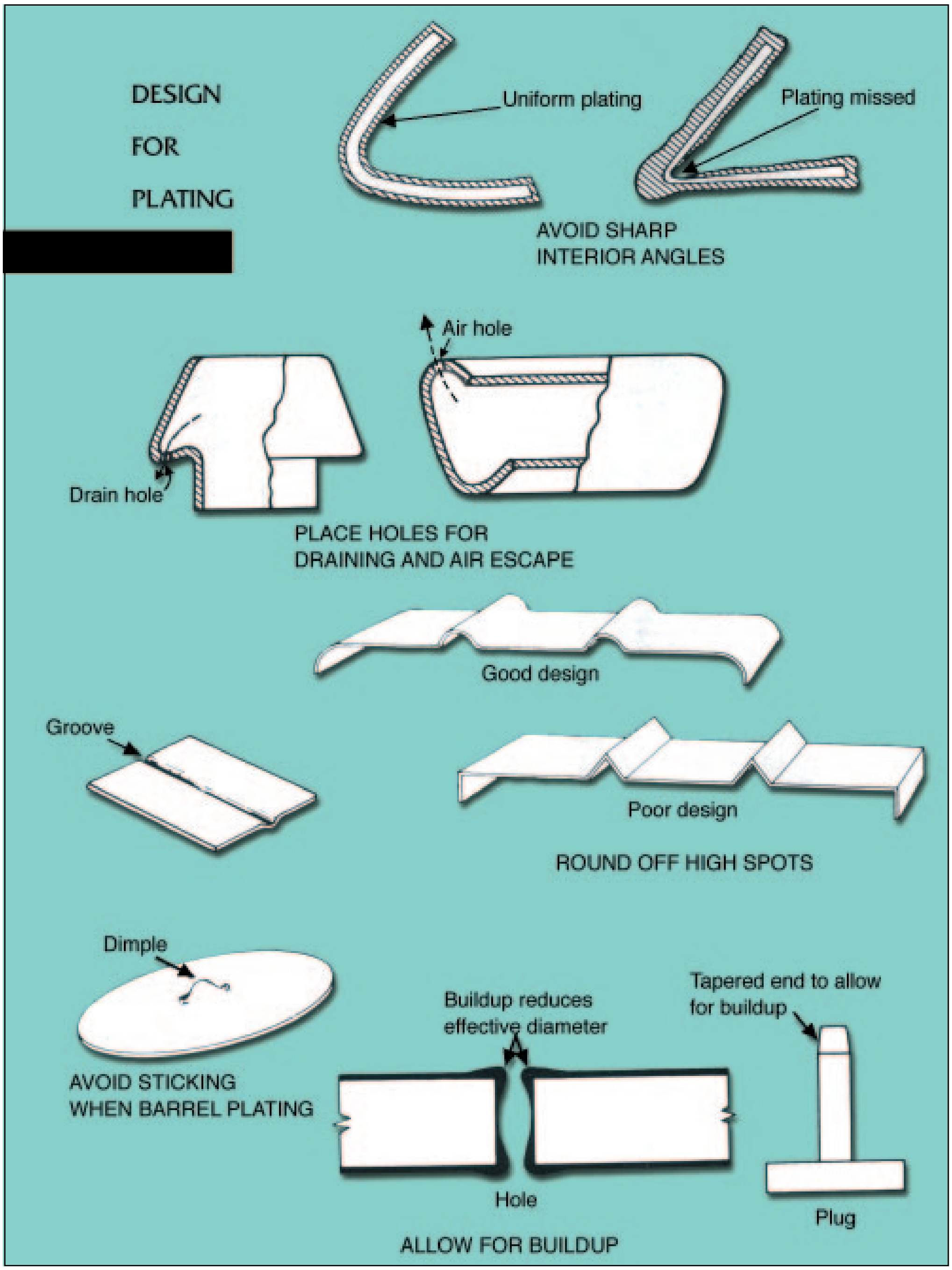
Design for Good Distribution of Electrodeposit

Experience and cost accounting show that simple shapes are always finished more uniformly and more economically than complex shapes. This is rule number one for the designer.

One of the most important factors determining the quality of a coating is its thickness on significant surfaces. Fundamental laws of electrochemistry operate to prevent a perfectly uniform deposition of an electrodeposited coating on a cathode of any practical shape and size. Portions of the work nearest the anodes tend to receive a heavier deposit. Sharp edges or protrusions at all current densities tend to steal a disproportionate share of the current. The goal of the designer and the plater is to make thickness variations as small as possible. At the same time, uneconomical waste of metal by excessive build-up on both non-significant and significant areas must be avoided.

It is possible to estimate metal distribution ratios from models or mock-ups, but there are also empirical rules. These can guide the designer to improved uniformity of thickness, resulting in improved quality with greater economy. These general principles illustrate what has been learned from practical experience.

- Avoid concave or perfectly flat significant surfaces. Convex or crowned areas receive more uniform coatings. Use a 0.4 mm per 25.4 mm (0.015 in. per in.) crown minimum.
- Edges should be rounded to a radius of at least 0.4 mm (1/64 in.); preferably 0.8 mm (1/32 in.).
- Re-entrant angles or corners should be filleted with a generous radius, making the radius as large as possible.
- Avoid concave recesses, grooves or slots with width less than one-half the depth.
- Minimize the number of blind holes, because these typically must be



exempted from minimum thickness requirements. Where necessary, limit their depth to 50 percent of their width. Avoid diameters less than 6 mm (7/32 in.).
- Countersink threaded holes to minimize electroplate thickness at the peripheries and to facilitate insertion of fasteners after plating.
- If fins or ribs are required, reduce their height and specify a generous radius—1.6 mm (1/16 in.)—at each base. Round off tips with radii of at least 1.6 mm (1/16 in.). Multiple parallel fins should have spacing between centers equal to four times the width of the fin. Broad, hollow ribs are preferred over slender, solid ones.
- Adopt recessed in preference to raised letters and insignia, but round off edges and provide gentle contours.
- Integrated studs for fasteners should be shortened as much as possible and inside angles at each base should be rounded generously. Tips should be similarly rounded.
- Studs or bosses with hollow centers should be shortened as much as possible and angled 90 degrees from the major plane of the part. All bosses should face the same direction.
- Assist the plater by clearly marking significant surfaces in part drawings.
- Avoid use of a variety of basis metals in any one part to be plated. The contact of dissimilar metals may interfere by galvanic action with covering power or with adhesion of the deposit. Cleaning may also be complicated because of unequal reactions with the different metals.

Design Features That Influence Electroplatability

The effect of the basic design of a product or component upon the effectiveness or durability of the plating used has been the subject of much study and research. Many failures for which the plater has been blamed can be attributed to the original design.

A major contribution to the plating industry was made by the Zinc Institute, Inc., when it sponsored a design study by Battelle Memorial Institute, which has resulted in the establishment of basic design principles to be applied to zinc die castings. These principles can be applied to other substrates.

The various shapes illustrated in this article are examples of design configurations and their relationship to electroplating quality. (Courtesy of the Zinc Institute, Inc.) P&SF

*All *Quality Metal Finishing Guides* are available through MFSA for $15 each ($100 for full set). The member price is $12 each ($75 full set). Order through the National Association of Metal Finishers (NAMF), 209 Elden St., Suite 202, Herndon, VA 20170-4815 (Phone 703/709-8299; FAX: 703/709-1036).