Controlling Thickness Distribution To Improve Quality—Part I

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This is the fourth in a series of reviews looking back on past practical articles. About 25 years ago, Dr. Donald Swalheim (now deceased) began a series of articles entitled "AES Update." Much of this material has been lost over the years. It seems like anything before 1990 is so deeply buried that only a miracle brings it back to light. What follows are excerpts of this material, occasionally punctuated with my own words or revisions in brackets [ ]. Although my over-riding intent is to remain faithful to the original article, I have omitted some material that is much less relevant today.

In the first of the AES Update series, in November, 1976, Dr. Swalheim stressed the importance of thickness distribution and its relation to part quality. Much of this deals with racking as well as part design. Back then, as today, there was always a critical need for communication between the designer and the plater. Often this wasn't satisfied. Sharp radii and deep recesses, on which the designer would never compromise, continually presented difficult, expensive, and perhaps impossible challenges to the plating rack designer. Here, the intent was to bridge that gap of understanding.

This article will be covered in two parts, the first covering basic factors in determining plating thickness and distribution. The second will be covered next month, when techniques for improving metal distribution will be discussed.

"Failure to acknowledge factors affecting the thickness distribution on plated parts is a major contributor in production of poor quality work. In many cases, abnormally long plating cycles are called for in order to meet thickness requirements on recessed areas. This not only adds to the cost, but wastes metals. After discussing the more important factors influencing plate distribution, methods and steps which can be taken to improve the distribution will be presented.

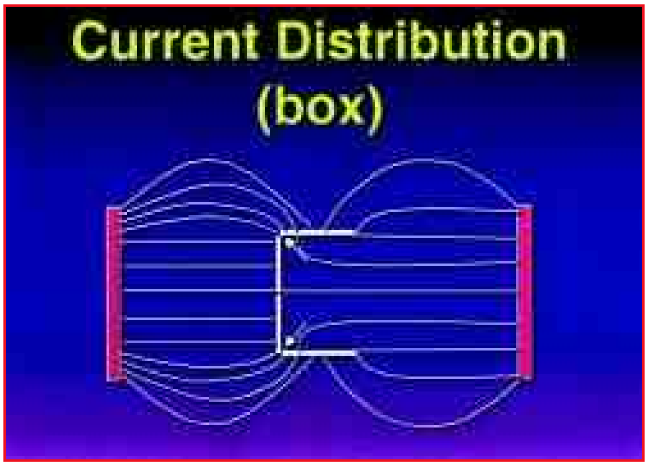


Fig. 1

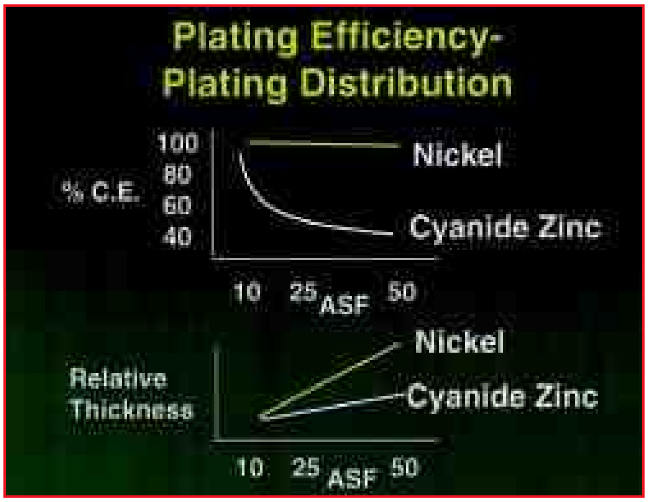


Fig. 2

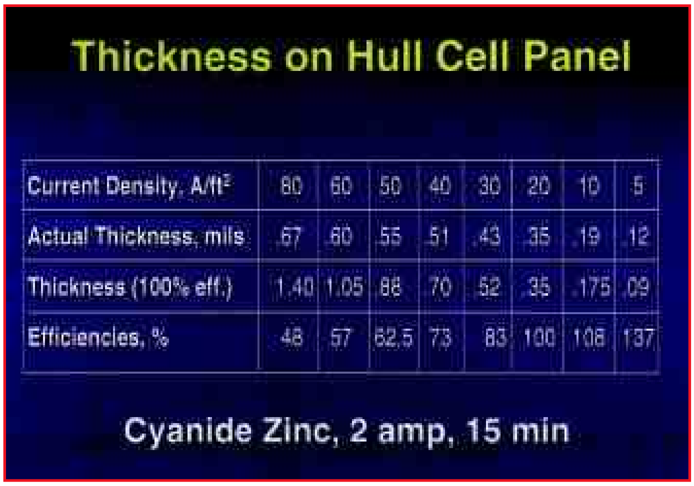
Basic Factors

"First let us examine the potential lines in plating a recessed part, such as a box, [shown in Fig. 1.]

"Note that the potential lines are closer together near the edges of the box shown on the right and at the corners shown on the left. In plating a part of this configuration with nickel, the thickness of metal will be essentially proportional to the potentials. The thickness on the right edges and left corners will be very high and the thickness in the corners [inside the box] as represented by the arrows will be very low. The differences in thickness are attributed to the poor throwing power of nickel baths.

"The deposit thickness distribution is quite different when the box is plated with cyanide zinc; it becomes much more uniform. The factor to be considered here is the change in plating efficiency with current density.

[Let us examine the lower curve, representing a cyanide zinc bath. Assume that the current density, for example, on the right edges of the box in Fig. 1 is 50 A/ft^2 (5.4 A/dm^2) and



Current Density, A/ft²	80	60	50	40	30	20	10	5
Actual Thickness, mils	.67	.60	.55	.51	.43	.35	.19	.12
Thickness (100% eff.)	1.40	1.05	.88	.70	.52	.35	.175	.09
Efficiencies, %	48	57	62.5	73	83	100	108	137

Fig. 3

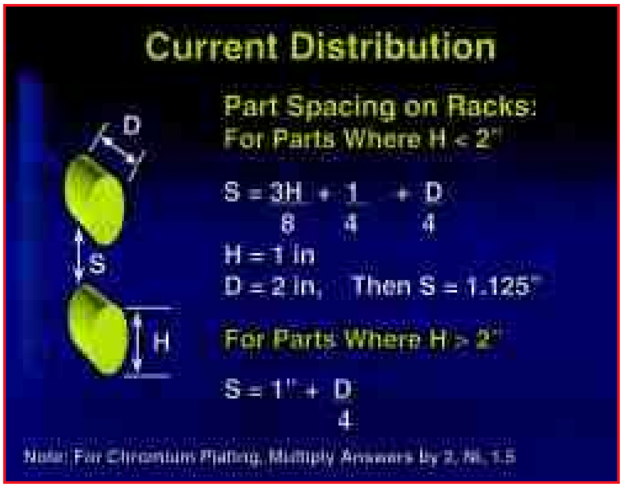


Fig. 4

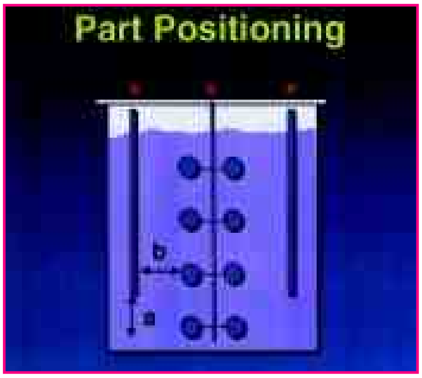


Fig. 4

the current density in the recessed area is 10 A/ft² (1 A/dm²). At 50 A/ft² (5.4 A/dm²), the current efficiency is about 40 percent. The efficiency at 10 A/ft² (1 A/dm²) or in the recessed area is about 80 percent. Therefore, the rate of deposition in the recessed area is closer to that on the edges of the box, when compared to nickel. This is evident in the lower part of the figure, where relative thicknesses are shown. The efficiency factor partially accounts for the good throwing power of cyanide zinc. There is also one other important factor which we shall discuss by referring to Fig. 3.]

"The first line represents the current densities as recorded in the Hull Cell scales, which would exist if polarization did not play an important role. Actual thickness measurements were made on the panel at various locations as recorded in the second line. The theoretical thicknesses which would be expected at 100-percent plating efficiency are recorded on the third line. The clue to the answer of the second factor contributing to the good throwing power of cyanide zinc is given in the last line of data. We know that the plating efficiency cannot exceed 100 percent, based on Faraday's Law. Yet, the efficiency at 5 A/ft² (0.55 A/dm²) is shown as 137 percent. This simply means that the actual current density of 5 A/ft² (0.55 A/dm²) on the Hull Cell scale is misleading. Polarization has shifted the values and the potential lines have been altered. The polarization at the higher current densities offers resistance, and the current is driven into the lower current density range. This factor and the higher plating efficiency at lower current densities accounts for the good throwing power of cyanide zinc.

"Now let's consider the relationship of the position of the rack of parts with respect to the anode, assuming that the parts are being plated with nickel.

"It should be noted that the bottom of the anode is positioned above the lowest part on the rack. This is important in order to reduce overplating on the lower parts. The [vertical] distance [between the bottom of the anode and the bottom of the lowest part] (a) should be about 6-8 in. [15-20 cm]. The distance [between the anode surface and the part surface] (b) is also important. If the distance is too small, the thickness of the deposit on the edges of the box will be greater and there will be less deposit in the recesses. In plated recessed parts, the distance (b) should be about 8 in. [20 cm]. If the parts are very small, the distance (b) can be maintained at less than 8 in. [20 cm]. It is recognized in plating a variety of parts on different racks that the distances (a) and (b) cannot always be maintained at the values given, and the suggested values are merely guidelines.

"The next factor to be considered is spacing between different types of parts.

"The size of the area facing the anodes and the depth of the sides of the article facing the anodes require consideration in proper spacing of the articles on the rack. Spacing will vary with the size and configuration of the parts. The first equation applies to small parts [where the part diameter (H) is smaller than two in.]. Note that parts having a diameter (H) of one in. and a depth (D) of two in. require a minimum spacing between parts of 1-1/8 in. As the diameter (H) of the part increases (as illustrated by the second expression) [where (H) is larger than two in.], a somewhat greater spacing must be allowed.

"The spacing will vary with the type of plating bath. A greater spacing for poor throwing power baths, such as bright nickel and chromium, must be allowed. The spacings given in Fig. 5 are adequate for baths having good throwing power, such as cyanide zinc."

To be continued. P&SF