# Shop Talk

## Plating & Surface Finishing Retrospective

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Based on an original article from the early "Finishers Think Tank" series [Plating & Surface Finishing, **68**, 24 (October 1981) and **68**, 16 (November 1981)]

#### Zinc or manganese?

**Q:** In our receiving/inspection department, I run tests and examine finishes on parts processed by outside job shops. When it comes to testing phosphate coatings, I can't tell whether I'm getting zinc or manganese. Do you have a spot test that will identify manganese phosphate coatings?

**A:** A test used by a large manufacturer of farm equipment to identify manganese phosphate coatings is as follows:

- Thoroughly degrease part to remove all oil, grease and other organic coatings.
- 2. Immerse a small portion of the phosphated part in 10 to 15 mL of concentrated nitric acid at 50 to 60°C (120 to 140°F) for 10 to 15 sec.
- 3. Dilute the nitric acid to 50 to 60 mL with distilled water.
- 4. Carefully add 6 mL of concentrated sulfuric acid.
- 5. Boil for a few minutes.
- 6. Add 0.5 g of potassium periodate.
- 7. If manganese is present, a red color will develop.

It is important to use concentrated nitric acid in step 2. If dilute nitric acid is used, some steel will dissolve and allow manganese from the steel to enter the solution and give a false indication. Also, do not rinse the concentrated nitric acid off the test piece into the beaker. The rinse water will dilute the nitric, destroying the passivity of the steel and allowing it to be attacked by the acid. Before using this test on production parts, try it on other articles known to be phosphated with zinc and manganese.

#### Silver on nickel

**Q:** Do you have any information on methods for plating silver over nickel without developing the adhesion problems associated with immersion plating? I hope to find some past work that might help my research into this problem.

A: I assume that your concern is plating adherent deposits of silver on a nickel strike over a basis metal such as copper, alloy steel or stainless steel. The problem of nonadherent silver deposits has been solved for many years. For quite awhile, platers relied on a "quicking" solution or dip prior to silver plating to achieve any degree of adhesion on copper, brass or German silver basis metals. The dip formed a thin immersion deposit of mercury, which forms an amalgam with the basis metal and the subsequent silver deposit. The mercury dip technique was used for many years in industry and apparently provided adequate adhesion. When silver-plated basis metals, especially steel, were subjected to greater physical stress and extreme temperatures and environments, the mercury dip gave way to more reliable strike solutions or processes. (*Today, environmental and health issues would rule out the mercury dip test entirely – Ed.*)

It was not until Mathers and Gilbertson explored the possibility of depositing silver several hundredths of an inch thick on steel with the idea of producing silver-lined bearings by electrodeposition that a great deal of effort and research was conducted to produce adherent silver deposits that could withstand severe service conditions. It was shown that very adherent silver plate could be electrodeposited on steel using a preliminary silver strike. If three general conditions were met, the silver strike resulted in excellent adherence of the silver plate. These conditions were as follows:

- 1. The cathode must be connected to the current source before immersion in the strike bath.
- 2. The current density of the strike must be high enough to provide vigorous gassing at the cathode during the strike.
- 3. The time of the strike must be so regulated with regard to the current density and bath composition as to assure complete coverage of the cathode without appreciable "treeing" of the strike coat.

This work indicated that the strike is essential to good adherence of the plate. While some improvement of adhesion was attributed to silver deposition into cracks in the etched steel surface, many adherent plates were produced on highly polished steel surfaces with little opportunity for mechanical attachment. The strike produces strong crystal nuclei at the edges of ferrite and these nuclei result in the growth of columnar structures, which, when they approach each other, result



Fig. 1-Current distribution.

in the formation of twinned crystals. The function of the strike is one of deposition of silver within the sphere of influence of the basis-metal atoms. By virtue of this orientation, a continuation of the crystalline structure is formed through the interface without reproducing the physical appearance of the basis metal.

A series of articles published in *The Monthly Review* in 1946 detailed the production procedures for the heavy silver plating of aircraft-engine bearings. Although the plating procedures varied somewhat from one manufacturer to another, all emphasized the importance of the silver-strike composition and operating conditions to prevent immersion silver deposits and promote perfect adhesion. Further improvements to the procedures for silver plating aircraft-engine parts were proposed by the Battelle Memorial Institute in 1953.

Procedures used today by many large aircraft companies are similar in the major steps but differ in detail as to bath composition and operating conditions. The essential steps for alloy steel or stainless-type alloys are:

- 1. Alkaline clean.
- 2. Acid activate (anodic or cathodic).
- 3. Nickel strike (Watts, Woods or sulfamate).
- 4. Silver strike.
- 5. Silver plate.
- 6. Bake at high temperature in an inert atmosphere.

A typical detailed procedure may consist of:

- 1. Vapor degrease.
- 2. Grit blast if scale is present.
- 3. Masking.
- Anodic alkaline clean at 5.0 A/dm<sup>2</sup> (50 A/ft<sup>2</sup>) for 3 to 5 min at 90°C (194°F).
- 5. Warm rinse.
- Cathodic activation at 8.0 A/dm<sup>2</sup> (75 A/ft<sup>2</sup>) in 50 vol% (20°Be') hydrochloric acid for 4 to 6 min.
- 7. Rinse.
- 8. Woods nickel strike at 8.0 A/dm<sup>2</sup> (75 A/ft<sup>2</sup>) for 1 to 2 min.
- 9. Rinse.
- 10. Silver strike at 1.6 to 3.2 A/dm<sup>2</sup> (15 to 30 A/ft<sup>2</sup>) for 30 sec in 2 to 4 g/L (0.25 to 0.50 troy oz/gal) of silver and 70 to 80 g/L (9 to 11 oz/gal) of free potassium cyanide. Note: Make electrical contact prior to entering the strike.



Fig. 2-Desirable current flow.

- 11. Silver plate at 1.1 to 2.2 A/dm<sup>2</sup> (10 to 20 A/ft<sup>2</sup>) to the desired thickness in the following solution: 30 to 33 g/L.(3.5 to 4.0 troy oz/gal) of silver; 90 to 115 g/L (12 to 15 oz/gal) of free potassium cyanide; 15 to 45 g/L (2 to 6 oz/gal) of potassium carbonate and brightener per the vendor's recommendation. Plate for approximately 360 A-min/ft<sup>2</sup> per 25.4  $\mu$ m (0.001 in.) deposit.
- 12. Rinse.
- 13. Hot rinse, dry and unmask.
- 14. Bake at 502 to 518°C (935 to 965°F) for 20 to 60 min in an inert atmosphere.
- 15. Inspect for blisters and indications of a poor bond.

#### Tin plate appearance problem

**Q:** Enclosed are some samples of small steel chassis that I am having trouble plating with bright acid tin. The parts are being rejected because of non-uniformity of appearance. They're dull, especially around the small holes. I'm plating 30 racks at a time (five pieces to a rack) in a 300-gal tank with two cathode bars. There are three anode bars, one along each side of the tank and one between the two cathode bars. Each load is run for about 20 min at approximately 1.0 V and 120 A with slow cathode-bar agitation. The thickness requirement is 2.5 to 7.5  $\mu$ m (0.10 to 0.30 mil). Samples of the solution have been sent out to the supplier for analysis twice in the last month. They have said the bath is within range chemically and that I should be getting good work out of it; but I'm not.

A: I checked the thickness on several of the samples and most of them average about 6.4  $\mu$ m (0.25 mil) on one side and only 3.0  $\mu$ m (0.12 mil) on the other. The side with the thicker deposit appears to be satisfactory, whereas the side with the thin deposit looks semibright with a very definite dull pattern around each of the numerous small holes in the panel. The source of your problem seems to be one of both uneven current distribution and too low a current density.

The surface area of each chassis is approximately  $1.5 \text{ dm}^2 (0.16 \text{ ft}^2)$ . Since there are five chassis per rack and 30 racks per tank load, the total area being plated at one time is  $2.2 \text{ m}^2 (24 \text{ ft}^2)$  – and more if the rack contacts are included. If the 120-A reading is accurate, you are plating at an average of  $0.5 \text{ A/dm}^2 (5.0 \text{ A/ft}^2)$ , which is on the low end of the plating range for bright acid tin.

Because the thickness is twice as much on one side as it is on

the other, the current density also would have to be double. To be able to deposit 6.4  $\mu$ m (0.25 mil) in 20 min would require a current density of about 0.65 A/dm<sup>2</sup> (6.0 A/ft<sup>2</sup>) or 120 A-min/ft<sup>2</sup>. The other side, with just half the thickness in 20 min must be plating at only 0.32 A/dm<sup>2</sup> (3.0 A/ft<sup>2</sup>) or 60 A-min/ft<sup>2</sup>.

Although I cannot be certain, I would guess that the reason for the obvious difference in current density is due to the double cathode bar and the third anode bar between them. While this is a common arrangement used by many platers, it often results in the uneven plating similar to your situation. In order to plate uniformly, the center anode bar must carry twice as much current because it must supply current to two cathode bars, whereas each side anode bar supplies current to only one anode bar. The example that follows will illustrate this point.

In your situation, you are drawing 120 A of total current, or 60 A per cathode bar. The current flow in the anode circuit is probably 40 A per anode bar. Figure 1 shows the current distribution for this case. The work on the left cathode bar draws 40 A from the anodes on the left and 20 A from the center anodes. The cathode on the right draws 40 A from the anode in the center. The problem here is the work surfaces that "see" the center anodes are drawing only half the current as are the surfaces facing the outside anodes. The result is uneven plating.

Figure 2 shows the desirable current flow to achieve a uniform current distribution. The center anodes now carry twice the current as either of the outside anodes. Each cathode now draws 30 A from the outside anodes and the inside anodes, resulting in uniform current density. Work surfaces facing either inside or outside anodes will "see" the same amount of current.

Check out the current distribution of both your anode and cathode bars by using a wrap-around tong meter. A tong meter is an

essential tool for the plater and no shop should be without it. It is vital for troubleshooting plating problems and establishing proper current distribution on a rack-to-rack basis.

To get more current going to the center anodes, you can do one of several things:

- 1. Add more anodes to the center bar.
- 2. Move the cathode bar closer to the center anode bar and further from the outside anode bar.
- 3. Add rheostats to the anode circuit to control and adjust the current going to each anode bar.

However, the simplest thing you can do is to turn the workpieces 180° halfway through the plating cycle so that all surfaces are subject to the same current conditions.

One last comment is in order for your particular problem. Raise the overall average current density to about 1.2 A/dm<sup>2</sup> (12 A/ft<sup>2</sup>) to get into the bright range of your bath. If you start to get gassing in the high current density area, back off to a lower current until visible gassing ceases. This should allow you to cut back on your time considerably. p&sF

Editor's Note: The edited preceding article is based on material compiled and contributed by John Laurilliard, as part of the "Finishers Think Tank" series, which began its long run in this journal 25 years ago. It dealt with everyday production plating problems, many of which are still encountered in the opening years of the 21st century. As we have often said, much has changed ... but not that much. The reader may benefit both from the information here and the historical perspective as well. For many, it is fascinating to see the analysis required to troubleshoot problems that might be second nature today. In some cases here, words were altered for context.

