# Improving Performance Of Decorative Chromium Plating Baths<sup>\*</sup>

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"The operator of a shop performing decorative chromium plating should be concerned with improvements in productivity, plating reliability and plating of complex parts. At the same time, he should decrease his costs, both for plating and waste treatment, employ lessconcentrated baths and minimize energy consumption. This article offers tips to the goaloriented operator on operating factors such as anode-to-cathode ratio, scaled anodes, voltage, tank bars and racking. Improving the nickel deposit [and] activation are also detailed.

"Improvements in the performance of decorative chromium plating baths usually involve covering power, throwing power, activation, burn-free deposits, plating speed and color. These subjects for improvement will be discussed more than once with the concepts presented in this article.

# **Operating Factors**

"The specific performance expected from a decorative chromium bath depends on the solution make-up. Performance from proprietary baths is usually superior to that from conventional sulfate-type baths.

"There are relatively few

improvements a plater can make in the type of chromium plating bath he has chosen, but there are many important operational variables that he can control: anodes, voltage, racking, current density, temperature, condition of the nickel surface and activation rinsing, which are discussed below.

#### Anodes

"There are many facets of the anode that can be monitored to improve plating performance [see illustration on anode maintenance]. Sometimes its importance is ignored, perhaps because of the plater's understanding that it is insoluble.

"The decorative chromium bath should have approximately 1.5 to 2 times as much effective anode area as cathode area normally plated. This ratio usually keeps the trivalent chromium concentration at less than 1%. This ratio only applies, however, when all the useful anode area being

\*Based on an original article from "AES Update" Series [*Plating*, **66**, 18 (September 1979)] The preceding article is based on a portion of the original piece written by Joseph P. Branciaroli for the "AES Update" series that ran in this journal in the late 1970s and early 1980s. The series, begun and coordinated by the late Dr. Donald Swalheim and carried on by many others, brought practical information to the metal finisher. In some cases, words were altered [in brackets] for context.

# Anode Maintenance

- Operate anodes at 100-175 A/tri-
- Use tong meter
- Verify amp rating on anode trooks.
- 1 1/2" round ≈ 150 amps
- Check frequency for lead peroxide
- Remove during idle periods
  - 27 (ound = 250 umps)

considered is in an active state. Occasions when the anode will not be fully active are:

- When anodes are placed on the ends of the anode bar while all racks are plated at the center of the bar.
- When the anode length is considerably below the normal bottom of the rack.
- When the back sides of flat-type anodes or round anodes are inactive due to close spacing between the anodes.

"The ratio of anode-to-cathode area is meaningless, however, when a variable such as the condition of the anode surface is disregarded.

#### Voltage

"A number of factors can create a need for higherthan-normal voltage. Whether a localized condition or a general one, the causes of this higher voltage may indirectly cause plating problems. Some factors to consider are:

# Tank Bars

"Tank bars which become oxidized or soiled have a higher resistance than clean ones and may create a need for abnormally high voltages. The necessary voltage for proper plating may exceed the limit of the power source and, consequently, the current may be insufficient and result in expected loss of performance - poor covering power, low plating speed and discolorations at low current-density areas.

"A tank bar fed electrically from one end provides decreasing voltage along its length as the plater moves away from the contact points. Racks plated at the opposite end of the contacts have cur-

# Shop Talk: Practical Information for Finishers

# **Poor Racking Practice**

- Improper parts positioning.
- Non-uniform garts contact
- Presence of the sectors
- Poor current distribution.
- Overloading parts per rack
- Breaks in the rack coating

rent lower than desired, and poor covering power, plating speed, etc. will result. On the other end, performance may suffer from too high a current density near the contact.

"Undersized bars create voltage problems and result in the non-uniformity of current density. They may not be able to carry the weight of the anodes and become badly bowed.

#### Rack Hooks

"Oxidized or soiled rack hooks have a higher resistance than clean hooks. If there is a large variation in hook resistance, some racks will receive too much current while others will have too little. Problems can be created with either condition. The size of the rack hooks should also be identical if the racks are to carry the same amount of current.

#### **Badly Scaled Anodes**

"The badly scaled anode can be a source of problems for [many] reasons:

- Such an anode causes a high electrical resistance and contributes to non-uniform current distribution of general low current density.
- The scaled anode puts out more current at the ends and results in burning on the tops and bottoms of racks.
- Poor current distribution from the center of scaled anodes can produce a loss of covering power at the center of racks being plated.
- Lack of current at centers of racks results in inadequate deposit thickness. This may be a matter of concern when corrosion-resistance requirements must be met.
- Poor deposit color may be encountered - iridescence or brown colors at low-current-density areas and hazy or blotchy white colors at high-current-density sites.
- Scaled anodes generate heat during plating which leads to problems associated with high temperature, including loss of covering power, decreased plating rate

and iridescent deposits at lowcurrent-density areas.

## Part Contacts

"Metal build-up on contact surfaces increases the resistance of current to the parts. The resultant loss of current causes poor coverage and thin deposits on the parts concerned.

"Contact pressure should be sufficient to provide adequate voltage and current density.

Proper contact pressure prevents movement of the parts on the rack which can create intermittent contact resulting in gray deposits.

"In addition, an ample number of contacts should be used to prevent overloading at any one point so that rack burns do not occur. Parts with thin cross sections or those made of a highly resistant material can be best processed when a satisfactory number of contacts is provided to assure good current distribution.

# Solution Conductivity

"Solution conductivity influences the voltage required for plating. Generally, low conductivity creates problems with coverage in low-current-density areas. Other problems usually are associated with the inability to get the required current density because of high voltage requirements.

"The plater is often unaware of changes in solution conductivity and therefore does not take corrective measures. Solution conductivity is impaired by the following:

- Low chromic acid concentration— Plating performance is generally poor when using solutions in which the chromic acid level has become significantly lower than normal. Routine use of a hydrometer should prevent this problem. Generally speaking, most platers want to operate with the lowest concentration possible to save on pollution problems. However, to achieve this, they must have all other factors effecting voltage at their optimum.
- Excessive concentration of trivalent chromium—When trivalent chromium exceeds 2% the bath tends to cause discoloration at low-current-density areas.
- Contamination with metallic impurities—This causes loss of plating performance and leads to discolored deposits at very low-current-density areas. Metallic

impurities can be removed only by ion-exchange techniques, which can be quite costly. The plater has the alternative of replacing a portion or all of the bath.

Recycling waste solution-Whenever waste solutions are concentrated and returned to the plating tank without first undergoing purification, there is a build-up of metallic impurities as well as trivalent chromium. Ultimately, problems develop and force replacement of the contaminated bath. The plater should allow some dragout from the bath to be discarded continuously to maintain performance. Such dragout should be treated in accordance with existing anti-pollution regulations. The plater using total recycling with purification to salvage his dragout solutions may be able to operate high-concentration chromium baths without economic worries.

# Racking

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"There are six important aspects of racking that the plater should be aware of [see illustration on poor racking practice]:

- Improper positioning of parts on the rack—When possible, the lowcurrent-density area should be positioned in such a way that it receives adequate current. Since the parts are usually on the same rack for nickel plating, proper placement provides a better nickel surface condition that is more readily covered with chromium. Generally, an area with a hole should be positioned downward to facilitate coverage around it.
- Lack of uniform contact for parts—This problem is usually due to inadequate rack maintenance. Poor contact pressure provides insufficient current to the effected part. Metal build-up on the contacts decreases current available for the part because of the higher resistance factor or because of a thieving action.
- Lack of suitable connectors—This involves undersized parts in the rack [construction] as well as contact condition. As discussed previously, oxidized rack hooks have a higher resistance factor and deprive the rack of its proper share of current, especially when more than one rack is in the tank.
  Lack of a sufficient quantity of current provided to each

part—Racks which are excessively overloaded cause problems of improper current distribution, not only in the chromium bath but also in the nickel bath.

Insulation or racking coating is not intact—Breaks in the rack coating permit the metal underneath to become plated. This often causes a thieving action which affects parts around the damaged area.

## **Influence of Nickel Deposit**

"The condition of the nickel surface has an important influence on the performance of the chromium plating bath, as previously stated. While this influence is generally recognized, little effort is actually expended for improving the nickel surface solely for the ensuing improvements in chromium plating.

"All too often the chromium bath must be adjusted to overcome the inferior condition of the nickel surface. Usually, passive nickel deposits at lowcurrent-density areas are not covered easily with chromium. The plater often raises the chromic acid concentration of the bath to gain better covering power, but this practice creates costly operating expenses in terms of chemical usage and waste treatment.

"At high-current-density areas, the plater often encounters blotchy white patches in the chromium deposit as a result of using high brightener levels while nickel plating. He overcomes this problem by raising the sulfate or catalyst level in the chromium bath, but, as a result, covering power is decreased and the plater has another problem.

#### **Benefits from Improving Nickel**

"There are three economically-related benefits which the plater can realize with respect to improving nickel deposits:

- A much lower concentration of chromic acid provides equivalent chromium plating performance as formerly was obtained by plating with a higher-concentration bath on nickel surfaces of inferior quality.
- As a direct result of using a lower-strength bath, waste treatment costs are lower.
- A nickel deposit of equal or better quality can be obtained at the same time that the consumption of nickel brightener is decreased.

# **Current Density**

"The quality of the nickel deposit in low-current-density areas can be improved by the following [see illustration on enhanced nickel quality for chromium overlayers]:

- More frequent electrolytic purification of the nickel bath to remove metallic impurities.
- ٠ Use of carbon treatment as required to keep organic impurities in the nickel bath at a minimum.
- Use of high-pH treatment for nickel bath purification.
- Elimination of brightener overload which causes nickel skip-plating.
- Use of the highest, practical average current density while nickel plating.
- Use of a nickel activation treatment.

"A better quality nickel deposit in high-current-density areas can be attained by the following:

- Eliminate use of excessive concentration of nickel brighteners in the bath due to poor addition practices.
- Hold the nickel brightener levels to the lowest values that will provide the required nickel finish and color.
- Use a nickel activation treatment.

## Nickel Activation

"Most production deposits are not at the optimum condition for chromium plating immediately after nickel plating. An activation step after nickel plating usually improves the nickel surface condition and permits the chromium plating bath to perform better. Usually, activation allows use of lower-concentration chromium baths.

"Some deficiencies of the nickel deposit can be eliminated or made less severe by using one of the following.

#### Acid Activation Plus Rinsing

"After the rinsing following nickel plating, the parts should be immersed in a suitable solution, [e.g., 30-50 vol. % solution of HCl for 30-60 sec]. Some surface conditions may require use of an electrolytic activator, [e.g., cathodic treatment at 4-6V in a 5 vol. % solution of H<sub>2</sub>SO<sub>4</sub> for 15 sec]. To be effective, the activating solution should be kept up to strength. Replacement of the solution on a periodic basis is important for most effective performance. Thorough rinsing should follow use of the activator.

# Enhanced Nickel Quality for Chromium Overlayers

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   Uper stacked activation

# Acid Activation without Rinsing

"Some plating lines do not have a sufficient number of tanks to accommodate the required rinsing following the use of an acid activator. Hand-line or hoistline operators may object to the extra handling time needed to use an acid activator and the required rinsing steps. In such cases, a chromic-acid type activator may be used without rinsing. The solution should contain 2 to 4 g/L (0.25 to 0.50 oz/gal) of chromic acid, which should be kept up to strength by daily additions to replace dragout losses. Sufficient volume of the chromium plating bath from the dragout tank may be used to make up the activator solution. [However,] activation should never be done in the dragout tank after chromium plating because this relatively concentrated solution tends to passivate the nickel. The activator should be replaced on a periodic basis since it loses its effectiveness after becoming contaminated with nickel bath components.

# Activation without Acid Solution

"In the event an acid activating step cannot be used, some activation can be accomplished by warm rinsing. [This should only be considered as a last resort.] A final rinse in water at 38 -49°C (100 - 120°F) is quite effective for activating some nickel deposits. This step helps to prevent problems in highcurrent-density areas, but is less effective for activating low-current-density surfaces. If drying of the parts occurs before chromium plating, the temperature of the warm rinse should be decreased.

#### Improved Rinsing

"If extremely poor rinsing is done after nickel plating, improving the rinsing technique will minimize chromium plating problems in high-current-density areas." PessF