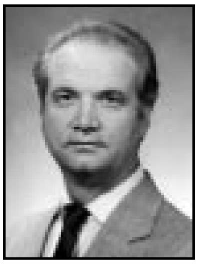

Advice & Counsel

Frank Altmayer, CEF
AESF Technical Director
Scientific Control Laboratories, Inc.
3158 Kolin Avenue
Chicago, IL 60623-4889
e-mail: mfconsultant@msn.com

10 Questions on Electroforming

Dear Advice & Counsel,
Our company recently purchased the AESF CD, "Electroplating for Beginners," which we found very useful. However, we have an electroforming operation utilizing a sulfamate nickel plating solution that, frankly, I know very little about. Could you answer some remaining "beginner" questions and help us out?

Signed,
Earl Engraver

Dear Earl,
You should consider taking the AESF course on Electroforming, developed jointly with the Nickel Development Institute (NiDI). Most of the following information was gleaned from this course. I'll go over each of your questions, one at a time.

1. How do you set current density, and what are the typical amperes per ft^2?

Current density is typically set by increasing the voltage until the ammeter indicates the correct number of amperes, for the total area of parts in the tank. Electroforming operations using sulfamate nickel plating solutions operate at current density ranges of 5–300 amperes per ft^2, depending upon the level of agitation, solution composition and complexity of mandrel to be plated. The higher the current density, the shorter the plating time required to produce a given thickness of deposit. Having the current density too high can cause excessive nodules and/or burning of the mandrel (burning is a powdery deposit). Having the current density too low increases plating time and tends to plate-out metallic impurities along with the nickel. Current density also has an impact on stress, which will be discussed shortly. To recommend a current density for your specific application, more information about your operation would be needed, including the size of mandrel, complexity (dimensions), and material of construction.

2. How do you compute surface area of complex mandrels? Is it just orthographic projected area?

The surface area of the mandrel includes all surfaces that will be conductive during the plating process. It is not the projected area. A simple method we have used to measure the area of a complex shape is to press aluminum foil over the part to be measured and press it into all crevices, until it conforms to the shape of the surface. The foil is then weighed on a four-place analytical balance. A one-in. square of the aluminum foil is also weighed. The weight of the pressed foil is then divided by the weight of the one-in. foil to obtain the area in square inches. For more accurate measurements, a laser instrument for making area measurements is available. One was exhibited recently at SUR/FIN® '98 in Minneapolis.

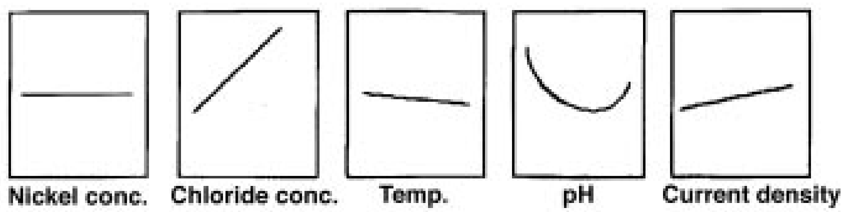

Fig. 1—Effect of common operating variables on stress.

3. How should stress be controlled?

Stress is controlled through control of the solution composition, purity, current density, pH and temperature. Ideally, the stress should be zero, but this is a stress level that is almost impossible to control to. Some electroformers aim for a slight tensile stress, while others aim for a slightly compressive stress (± 1,000–2,000 psi). The graphs in Fig. 1 were developed by NiDI, and are intended to show the effect of common operating variables on stress.

Chloride concentration, pH and current density have the greatest impact, as shown in Fig. 1. Careful control of pH is necessary to maintain proper stress levels. pH should be monitored twice per day and adjusted downward with sulfamic acid. To determine how much sulfamic acid is required, place 100 mL of the nickel solution under a pH meter and add a 100 g/L solution of sulfamic acid drop-wise from a calibrated burst until the correct pH is obtained. Each milliliter required to lower the pH to 4.0 represents an addition of 1 g/L (0.13 oz/gal)) to the plating tank. The effect of the tensile stress inducing operational parameters can be somewhat mitigated by the addition of a stress reducer, such as saccharin. The effect of saccharin on stress vs.

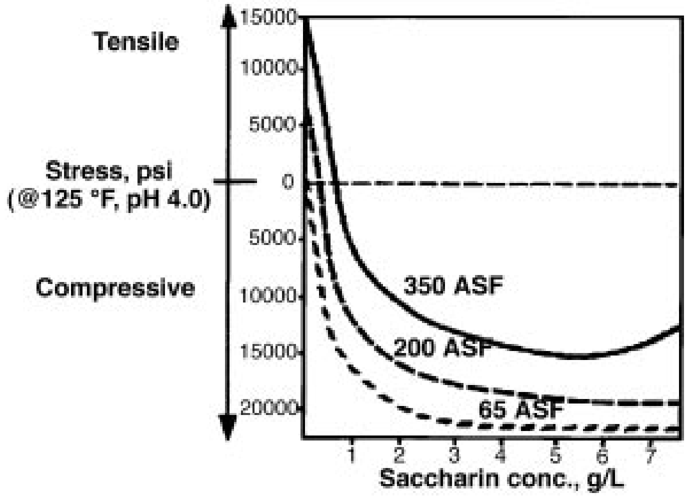

Fig. 2—Effect of saccharin on stress vs. current density.

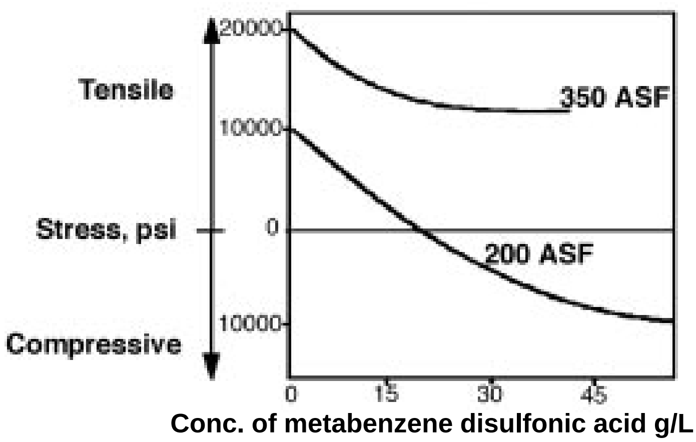

Fig. 3—Stress vs. concentration of metabenzene disulfonic acid.

current density is shown in Fig. 2 (also developed by NiDI).

Other stress reducers are available commercially, and may have a lesser impact on stress (requiring less critical control over concentration). One alternate stress reducer is metabenzene disulfonic acid. A graph of stress vs. concentration for this compound is shown in Fig. 3 (also from NiDI).

Solution purity is also important to stress. Following is a list of commonly encountered impurities, and the concentration required to impact stress by 1,000 psi:

- Chromium 1 mg/L
- Lead 10 mg/L
- Magnesium 100 mg/L
- Copper 100 mg/L
- Iron 150 mg/L
- Zinc 150 mg/L
- Sulfate 1,000 mg/L

4. Should stress be measured in or out of the plating tank?

Your stress measurement should be made under conditions that most closely simulate the plating of your mandrels, which means "in the tank."

5. How important are Hull cell tests?

A daily Hull cell test will provide a history of the plating tank, if the panels are cataloged and stored for future reference. Hull cell panels can indicate excessive contamination of the solution (through dark deposits at low current densities) and provide a qualitative indication of brittleness/stress (bend the corner at the high-current-density end).

6. What are tank cleaning and leaching requirements?

A new tank should be leached with a 10-percent sulfamic acid solution for 8–24 hr before use. Following the leach, the tank should be rinsed and put into service.

7. What are the effects of plating cobalt along with nickel in an electroforming operation?

Cobalt increases the hardness, tensile strength and tensile stress of the deposit. The addition of cobalt has no marked effect on brightness, pitting, porosity, leveling, color or luster. If hardness is an important property of your molds, it would make some sense to consider plating a nickel-cobalt alloy. The complexity of the process increases dramatically when plating an alloy vs. a single metal, so you should plate nickel-cobalt only if necessary.

8. How should boric acid additions be made to the tank?

The most common method we have used is to place the boric acid powder in ananode bag and hang it in the solution over the side of the tank.

9. Should addition agents be made based on ampere-hours of operation?

Stress reducers are typically consumed by ampere-hours of operation. A feed system, based on an ampere-hour meter, makes sense in operations that utilize the tank continuously. The solution should be analyzed on a daily basis, and adjustments should be made in any constituent that is off by more than 5–10 percent from the control point.

10. Should we use nickel chloride in the solution?

Most electroformers have found that nickel chloride, in low concentrations, will improve anode corrosion. If anode efficiency drops below 100 percent, an organic contaminant (azo-disulfonate) will form at the anodes, increasing stress and yielding brittle plating. Chloride is also important to solution conductivity and throwing power.

Between one and two oz/gal of nickel chloride is beneficial, without excessive effect on stress, in most applications. Alternates are magnesium chloride and nickel bromide, which have been reported to have a lower impact on tensile stess than nickel chloride. In our experience, nickel chloride in the solution will work fine. P&SF