Advice & Counsel

Frank Altmayer, MSF, AESF Fellow
AESF Technical Director
Scientific Control Labs, Inc.
3158 Kolin Ave.
Chicago, IL 60623-4889
E-mail: faltmayer@sclweb.com

Falling In STEP

Dear Advice & Counsel,

I need some help with a corrosion issue. It seems that one of our competitors is able to deposit nickel and chromium over their parts and get a significantly higher level of corrosion resistance compared to the finish we are applying. We had a sample of our competitors' part tested by a laboratory. We were told that the competitors' part has much more nickel than ours. I have an uneasy feeling that the added thickness is not the whole story. Can you give me a second opinion?

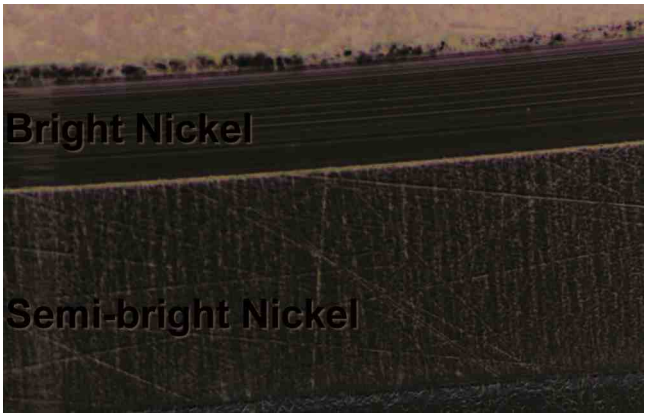
Signed,
Doubting Thomas

Dear Mr. Thomas,

The part you sent me does have a significantly higher level of plating thickness. And you are right. That is not the whole story. It seems that the laboratory you used did not etch the cross section of the part to reveal the layers of plating. For a nickel-chromium plated part, a typical etchant we like to use is 2/3 acetic acid and 1/3 nitric acid. About three to five seconds in this acid will reveal the layers of nickel. Dull or semi-bright nickel typically will have an amorphous structure, while bright nickel will have a laminar appearance. Under the metallograph, each layer of nickel can then be measured. This is important because nickel is not a sacrificial coating for steel substrates. To obtain a significant amount of corrosion protection, the nickel deposit must be relatively thick (to eliminate or minimize the presence of microscopic porosity). Further, for higher levels of corrosion protection, multiple layers of nickel are used.

Duplex Nickel

The most common multiple nickel layer system employed on decorative parts is often called "Duplex Nickel." This is a layer of semi-bright nickel followed by bright nickel. An excellent specification for nickel-chromium electrodeposits is ASTM B456. This specification classifies these coatings into SC-1 through 5, with 5 being the highest level of corrosion protection. As an example for SC-5 the total nickel thickness should be 1.4 mils minimum and the semi-bright nickel should be at least 75% of this total thickness (almost 1 mil).



Your competitor is applying about 0.3 mils of semi-bright and 0.6 mils of bright. Your parts are plated with 0.2 mils of semi-bright and 0.3 mils of bright, which explain some of the difference in salt spray performance.

STEP Value

Next we need to discuss the STEP value. Duplex nickel should be applied from solutions with additive packages that are formulated to produce a voltage step between the bright and semi-bright layer, when tested with an instrument called a "STEP tester" (STEP stands for Simultaneous Thickness and Electrochemical Potential). The additive package produces semi-bright nickel that is free of sulfur (<0.005%), while the bright nickel contains at least 0.04% sulfur. With this combination, the bright nickel will behave as a sacrificial metal to the semi-bright nickel, causing corrosion to drift sideways instead of down towards the basis metal. Therefore, it prolongs the time to base metal corrosion. ASTM does not mandate a specific STEP voltage, but they do indicate that it is generally agreed that between 100 and 200 mV should be generated between the semi-bright and bright nickel layers for best corrosion performance.

To make this discussion more general, there are platers applying more than two layers of nickel. For those applying semi-bright followed by high sulfur followed by bright nickel, the STEP between the high sulfur and the bright nickel should be 15–35mV, with the high sulfur nickel more active than the bright nickel. For those plating Duplex nickel followed by particle nickel prior to chromium, the STEP between the bright nickel and the particle nickel may be 0-35 mV, with the bright nickel more active than the particle nickel.

When we tested your competitors' part, it had a STEP of 150 mV, while the deposits you are applying have a STEP of only 10mV.

This means that your competitor has two advantages over your product; more thickness and the correct electrochemical potential. The added thickness is relatively easy to correct for, but you will need to contact your supplier of additives for your nickel plating solution to discuss means of correcting the faulty STEP results.

I recommend you consider obtaining a STEP testing instrument so that you can monitor the electrochemical potential of the Duplex nickel you are applying.