Some Production Plating Problems & How They Were Solved—Part 2

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Updated by Dr. James H. Lindsay, AESF Fellow

The following article is based on material compiled and contributed by Dr. Samuel Heiman, as part of the "Plating Topics" series that ran in this journal. This one deals with everyday production plating problems, many of which are still encountered in the opening years of the 21st Century. Much has changed ... but not that much. The reader may benefit both from the information here and the historical perspective as well. In some cases here, words were altered for context.

Chromate Conversion Coating On Cadmium Plate: Mottled Or Irregular Coating

The customer complained that his 80 gallons of chromate solution would work perfectly satisfactorily for a period of 24 hours, at which time cadmium-plated parts submerged in the chromate solution would not develop an overall uniform chromate film. When the bath was dumped and a new bath made up, normal coatings were obtained.

The chromate treating solution was checked for pH and hexavalent chromium and found to be well within the ranges prescribed. The cadmium plate was examined, and when treated in a fresh chromate solution, received a perfectly normal coating. No satisfactory reason for the limited useful life of the chromate bath could be found until, looking back at the surface of the solution while the sun shone on it through a window, it was observed that a light oil slick had accumulated. When this had been skimmed off the solution surface, the solution coated perfectly satisfactorily. It was then found that the oil came from a pump supplying air agitation to the bottom of the tank. The oil collected in just sufficient quantity so that it took 24 hours for an oil film to cover the top of the solution. This then coated the work, and when the plated piece was immersed, was sufficient to inhibit the formation of the chromate film. Eliminating the air agitation that caused the oil accumulation solved the problem.

Contributed by C. W. Ostrander,
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Pitting in Nickel Plating ... Revisited

This is how it was originally written.—Ed.

8:00 AM
Ring-Ring ... Hello, Laboratory. Yes, John. Nickel pitting? Tank 12. OK. Let me check our records on that tank (1)*. Hold the phone.

8:02 AM
Our records show that the solution had a full carbon treatment only last month. The anti-pit concentration as determined by the stalagmometer is OK. Considering how well we control your tanks you really didn't expect to find the trouble here, did you? Don't worry. I'll be right down.

8:10 AM
Let's look at the work. Black and pitted on the under side of horizontal surfaces, obviously caused by finely divided air in the plating bath. Let's take a look at the tank. Just look at the foam on the top of the solution (2). We had better check the heat exchanger and the filter discharge lines (3).

Well, John, we won't get anywhere here. The foam is too heavy. I can't tell which one is discharging the air. One glance at the sight glasses (4) should tell me which one is the culprit. I remember last year there was a loose joint on the discharge side after the sight glass that was sucking air. Naturally that air didn't show in the sight glass. Good. Just look at the air in that filter sight glass!

The heat exchanger sight glass looks crystal clear. Now we know that the suction side of the filter is sucking in air. John, I guess you had better tighten that packing gland on the filter pump (5). Oh, you did repack this gland last week, and you tightened it twice since then. It does look normal. The water is dripping slowly from the gland with 15 psi pressure. Thanks, John, I guess we had better look elsewhere.

I remember several years ago, we had a bad diaphragm in our valve that almost closed the suction line (6). Boy, did we get into "air pitting" then. John, would you please turn the filter off and check the diaphragm in this valve. It will only take a few minutes. What! No luck? The stem and dia-

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*Numbers in parentheses indicate the sequence to follow to find the cause.

phragm are intact and the diaphragm looks good. Well, something else is causing our trouble.

Let's check all these joints on the suction side of our filter pump (7). The joints all seem to be tight and we still haven't stopped sucking air. There is only one thing left to do, John. You had better tear down and inspect the entire suction side of the line. Look for any kind of restriction in the line (8) and call me when you find it or when the lines are all apart.

10:00 AM
Ring. Ring. Hello, Laboratory. Oh, hello, John. A glove, you say. In the primer tank, eh! Two anode bags also!! You don't say. Thanks, John. Oh, John, please make screens for the inlets to the heat exchanger and filter.

Note: Whenever the suction side of the line on a pumping system is blocked, a strong vacuum is created in the line between the pump and the blockage. In practice, air will be sucked in through the pipe joints, pump glands and other places where under normal conditions these joints do not leak. In the case in point, it is most likely that the air was entering through the pump gland. The numbers in the above story give a logical sequence of points to check when looking for the cause of pitting in a nickel deposit, particularly pitting from finely divided air bubbles in the solution.

Passivation of 400 Series Stainless Steel—Producing a Discolored or Etched Surface

Type 416 stainless steel parts hardened in a Vapocarb furnace were discolored after fabrication. The fabricator attributed the condition to the passivation procedure in the plating shop. The fabricator had installed a Vapocarb furnace for hardening type 416 parts supplied to the Armed Services. The furnace had been certified as satisfactory for the application. The parts had been machined, then heat treated for 20 minutes at 980°C (1800°F) and finally quenched in oil. This is a good heat treating cycle. A light heat tint was removed by vapor blasting, using a rust inhibitor and an anti-settling agent with the abrasive medium.

The parts were sent to an outside plating shop for passivation. The plater gave them an alkaline clean, cold water rinse and then passivated them in a 20% nitric acid / 2% sodium bichromate solution at 46°C (115°F) for 20 minutes. The solution was changed frequently. From 5 to 30% of the parts turned dark, whether the solution was new or old. This darkening occurred all over on some of the parts and at only the contacting surfaces on others.

The parts were examined metallographically before and after heat treatment. This showed a typically normal martensitic structure before heat treatment, but a carburized surface thereafter. The parts had been carburized during the heat treat process because of improper control of the heat treating atmosphere. The atmosphere in this furnace may be controlled to produce a carburizing, neutral or decarburizing atmosphere. For this particular heat treating process a neutral atmosphere should have been used. Instead, a carburizing atmosphere was used. In the carburizing process, the percentage of carbon on the surface of the steel is increased. This carbon combines with some of the chromium on the surface to form chromium carbides. Consequently, the effective chromium content on the surface is drastically reduced and the metal behaves more and more like iron instead of stainless steel. In other words, it becomes prone to attack by the passivating solution.

One cannot tell by looking at a 400 series stainless steel part whether or not it has been carburized. This can only be done by metallographic examination. On the other hand, after the part has been discolored or etched by the passivating solution, the carburized surface may have been disturbed or removed and, therefore, may not be revealed by metallographic examination. While the passivator did indeed spoil these 400 series stainless parts, the real culprit was the heat treater who used the incorrect atmosphere in the heat treat furnace.

Good passivating practice should include observing the part for the first few minutes during the passivating treatment to detect any unusual discoloration or gassing that accompanies chemical attack on improperly heat treated parts. The dark discoloration associated with a carburized surface should not be confused with the silvery grey "flash attack," which is essentially superficial, that occurs on the free machining hardenable grades (types 416 or 430) of stainless steel during passivation. "Flash attack" is generally associated with these grades containing more than 0.5% manganese.

Chromate Conversion Coating on Zinc Plating

A customer using a chromate conversion treatment complained that he was unable to meet his production requirements, or in fact, turn out any satisfactory work because the chromate conversion treatment stripped off the zinc-plated coating of 12.7 μm (0.5 mil) within 5 to 10 sec of immersion in the chromate bath.

Upon examining the situation, it was found that a zinc plate of 2.54 to 3.76 μm (0.10 to 0.15 mil) was being produced rather than 12.7 μm (0.5 mil). The customer had made an error in using the chemical drop test method for determining zinc plate thickness but had done this on a small area that already had a protective or inhibited chromate film and which, of course, would not give true results. Secondly, the rinse prior to the chromate treatment was found to be operating at a temperature of 93°C (200°F). The heavy metal part, which was in the rinse tank for a minute or more, had absorbed sufficient heat so that when the part was immersed in the chromate solution, the thin zinc deposit was removed almost instantaneously.

The customer was advised that he could determine zinc thickness only with a chemical drop test method on an untreated zinc surface and that the rinse preceding the chromate treatment should not be operated at a temperature in excess of that of the chromate solution itself, which should be in the range of 21 to 32°C (70 to 90°F).

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Premature Breakdown to Red Rust Of Chromated Zinc Surfaces

The customer complained that zinc-plated parts that had been chromate treated and then placed in storage showed pinpoint red rust spots within one week after processing. In checking with the customer, it was found that the final hot water rinse was recirculated boiler water and at times contained boiler cleaning compound, the residue of which, when retained on the chromated surface, penetrated through the chromate and the electrodeposited zinc and resulted in pinpoint red rust. When the water supply for the final hot water rinse was changed to fresh water, no further difficulty was encountered.

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Cadmium Plating: Dull Streaks

The final solution to this problem was actually the very first suggestion offered by the plater but rejected by the Engineering Department because it was concerned about its own problem and did not want to effect changes in manufacturing procedures that might cause costly die wear. The parts were blanked on a roll feed press from cold rolled steel in coils. Engineering recommended the use of a pigmented draw compound mixed with oil.

Parts were degreased before assembly and then put through a conventional cadmium still plate cycle that used a reverse current cleaner. The plater pointed out that a solid soil could not be totally removed by a degreasing cycle of hot solvent spray and suggested the use of an unpigmented draw compound. Engineering overruled his suggestion on the assumption that the compound being used was the best to be had and any solid soil left on the part should be removed by the reverse current cleaner. The plater tried to point out that if this solid film were a non-conductor, it might block passage of the current and prevent complete removal of the soil in the time the part was left in the cleaner. Production requirements prevented a longer cleaning cycle. Further, space was limited, so additional cleaning facilities could not be installed.

An attempt was finally made to obtain a new draw compound. After several trials, one was found to be acceptable to both the tool engineer and to the plater because bright cadmium was obtained without dull streaks.

The moral of this story is that many problems are not the concern of any one factor. The plater's troubles were rejects; the tool engineer's concern was die wear. Both were equally important and the opinion of one should not override that of the other. An intelligent discussion and acceptance of opinions from both factions was necessary before a satisfactory solution was arrived at.

Aluminum Anodizing: Titanium Anodizing Racks

In recent years many anodizing plants have changed from anodizing racks constructed of various aluminum alloys to racks of titanium. This has resulted in substantial savings in both labor and materials, because the need for stripping racks after each cycle is obviated and their life is greatly extended. The changeover has not been without problems, however, the most prominent of which are described below.

Difficulty has been experienced in producing satisfactory coatings where long anodizing periods are required, such as for parts to be colored black. This is particularly troublesome where the area of the part is large compared to the area of contact with the rack tip. The difficulty is that the aluminum part-titanium rack tip interface offers a much greater resistance to current flow than an aluminum part-aluminum rack tip interface. During the initial current surge, and before any anodic coating has formed on the aluminum, burning occurs at the interface contact area and an increase in resistance results. The rate of anodizing decreases during the processing cycle and at times the anodizing may stop entirely. This thin anodic coating will be shown by thickness measurements or by the light color if the coating is dyed. The problem can be overcome by raising the voltage very slowly during the initial 30 sec or so of the cycle, thus allowing a thin anodic film to form on the titanium which will, in turn, keep the current density reasonable as the voltage is gradually increased to its ultimate value. The conductivity of rack tips that have been burned may be restored by a short immersion in hydrofluoric acid or by abrading the point of contact.

Corrosion pitting may occur on anodized aluminum when it is in the dye solution, particularly where chlorides are present either in the makeup water or in the dye powder itself. This galvanic corrosion is a result of the formation of a titanium-aluminum cell and predominates on the copper-bearing alloys (such as 2024) which apparently suffer from microscopic discontinuities in the anodic film. It manifests itself as a dark spot of insoluble matter. The pit itself may go unnoticed unless the surface is examined under a microscope. In order to prevent this corrosion pitting, the exposed area of titanium (which is the cathode in the galvanic cell) should be kept to a minimum by coating the racks with a non-conducting material. If the condition still persists, the insertion of a sacrificial anode of bare aluminum on the rack during its immersion in the dye solution may be helpful. As a last resort the parts may be removed from the rack and dyed in a basket of non-conducting material.

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