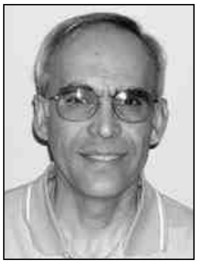
Stephen F. Rudy, CEF
Hubbard-Hall Inc.
563 South Leonard Street
Waterbury, CT 06708
E-mail: sfrudy@optonline.net



Aluminum Finishing: Zincating Facts

Last month's article reviewed the surface preparation of various candidate aluminum substrates for plating. These can be any of the typical alloys, extrusions and stampings. Since aluminum is highly electropositive, plating on to its surface cannot be achieved. Instead, the cycle step prior to plating is to zincate, by which a zinc-rich coating is bonded onto the surface, and on which subsequent plating occurs. Excellent adhesion of the zincate to the aluminum surface is required, as is also initial plating adhesion to the zincate surface. This critical, final surface preparation step is very important. Yet, its success is closely related to the surface preparation steps we reviewed last month: soak clean, etch and desmut. A wide variety of aluminum parts are thus plated. Industries served include consumer, automotive (especially after market), electrical, aerospace, medical, construction, machinery and military, to name a few.

Besides zinc, zincates may contain additional metals that contribute to modifying the structure formation. First-generation zincates consisted of zinc oxide and sodium hydroxide (caustic soda) in a balanced concentrate. These commercial blends were introduced in powder form, dissolved to achieve a high operating concentration. The excess heat liberated during bath make-up required perhaps 24 hours of sufficient solution cooling before the bath could be used. In basic operation caustic soda dissolves the surface layer of aluminum oxide, permitting the galvanic deposition of zinc onto the active aluminum surface. This zinc coating prevents formation of an oxide and becomes itself an excellent base to accept subsequent plated deposits.

Over the years, concerted research was conducted to improve the zincate action on a wide range of alloys and castings. It was found that incorporating metals, specifically copper and iron, were of most benefit. This work lead to a second generation of zincates, now referred to as alloy zincates, by adding iron to the concentrate. Commercial formulations were available in powder and liquid concentrates. The latter significantly reduced the time required for solution cooling, thereby improving production schedules. A third generation of zincates, also of the alloy type, significantly improved characteristics of the zinc deposit. These newer alloy zincates, composed of three additional metals: copper, iron and nickel, provided significant benefits. The alloy zincate formed was thinner, with a denser barrier film. This major development significantly improved resistance to lateral corrosion, compared to the earlier formulations. Modifications to grain structure and limiting deposit thickness helped to achieve these benefits. Another improvement was the incorporation into a formula concentrate of much lower viscosity. This improved solution penetration into deep grooves and recesses, forming an overall uniform, highly adherent surface. Lower solution viscosity also reduced solution drag-out and facilitated post rinsing. The four metal alloy zincates are commercially available in cyanide and non-cyanide formulations. It was initially necessary to incorporate a small quantity of cyanide to maintain solubility of the metals, with subsequent improvements to offer cyanide-free versions as well.

Operating parameters

Powder zincates:
1 - 2 lb/gal (454 - 908 g/L),
65 - 85°F (18 - 30°C),
20 - 120 sec.

Liquid zincates:
Full strength - 50 vol%,
65 - 85°F (18 - 30°C),
20 - 120 sec.

The operating temperature is important to control development of the zincate film to an effective, desired thickness. Overheating the working solution promotes thicker, spongy like (less dense) deposits. Some of the liquid concentrate zincates should be stored above 50°F (14°C) to prevent freezing and precipitation of formula constituents.

Immersion in the zincate should produce a uniform film covering the entire aluminum surface. Patchy films or pull-off by tape test may indicate under or overcleaning.

Dip time may vary according to alloy composition. Normally, about a two-minute zincate immersion is required for commercially pure aluminum and silicon, copper-containing alloys. Other alloys, such as those containing magnesium, require shorter zincating times.

In some applications, a double zincate dip is preferred. This would refer to cast alloys, wrought alloys containing little or no magnesium and unknown alloys. In this modification, the first zincate film is deliberately stripped in either 50% nitric acid or in a commercial, nitric acid-free dip. What actually occurs is the zincate is stripped, but just down to the surface, where it is directly bonded to aluminum. This very thin layer acts as a "seed or anchor" to which a second, subsequent zincate film deposits. The effect is the formation of a tightly adherent, thin zincate film, with a greater tendency for adhesion in the plating cycle. In labor intensive process cycles, rejects can easily increase the handling and reprocessing cost by three to five times. Therefore application of a single or double zincate is very important.

Continued on page 29.

Conclusions

The application of adherent brush plated coatings onto titanium alloys Ti-6Al-4V and Ti-6Al-6V-2Sn was demonstrated using a special brush plating technique. The surface pretreatments of mechanical finishing, followed by anodic etching, cathodic activation, and plating a thin layer of nickel effectively prepared the surface. The surface was kept under potential control at all times during the electrochemical pretreatments. The anodic etch microroughened the surface which increased surface area. Cathodic activation reduced oxides formed during the anodic cycle. The etch and activation were performed in the same acid chloride electrolyte.

Future work

Future research work should look for the underlying principles for the good adhesion to the titanium alloys and improve it. The work should use this knowledge to identify a process to deposit coatings with improved adhesion on Grade 2 titanium. Deposition of other materials which have improved tribological performance onto the nickel-coated titanium 6Al-4V should also be investigated.

References

1. A. Zhecheva, *et al.*, *Surf. Coat. Technol.*, **200** (7) 2192 (2005).
2. L.L. Shreir, *Corrosion*, Vol. 1, 2nd Ed., Butterworth, Inc., Woburn, MA; p. 5:36.
3. A. Bloyce, P.H. Morton & T. Bell, "Surface Engineering of Titanium and Titanium Alloys," in *ASM Handbook, Vol. 5 - Surface Engineering*, ASM International, Materials Park, OH, 1994; p. 835.
4. L.J. Jennings, *Proc. 12th Annual Airlines Symposium*, NASF, Washington, DC, 1976; p. 5.

About the authors

Darrin Radatz is a Senior Research Technician at SIFCO Applied Surface Concepts. He has over 25 years of experience in electroplating including the last 17 years with SIFCO ASC which included ten years managing the Contract Manufacturing Department. He received his technical degree in computer/electronics repair from Hickok Technical Institute in 1988.

Dr. Sid Clouser is Manager of Research and Development for SIFCO Applied Surface Concepts in Independence, Ohio. He received a Ph.D. in electrochemistry from Case Western Reserve University in 1981. He has 28 years of experience in industrial electrochemical research.

Finishers' Think Tank

Continued on page 17.

Analysis

Most commercial zincate baths can be analyzed by the titration method. Usually the alkalinity is determined in one titration and metals (based on zinc) in a second titration. Replenishment is based on the analysis results. In standard operations, drag-out losses, coupled with vendor advice on bath depletion per surface area zincated, can fine-tune replenishment additions.

Testing for quality adhesion

Post-plate baking at 450°F (232°C) for one hour is followed by a cold water quench. Edge grind and peel back. Saw grind. Standard aluminum Q panels are processed in the cycle as a control.

Problems and corrections

Problem	Cause	Correction
Streaked, uneven zincate	A. Additives out of balance	Analyze, make adds
With poor adhesion	B. Bath temp. out of range	Adjust
A & B not effective	C. Surface preparation	Evaluate each step
Parts gas in zincate	Insufficient desmutting	Adjust or replace desmut
Spongy, poor adhesion	Excess zincate dip time	Adjust

The structure of the zincate film is detrimentally affected by drag-in of excessive aluminum, chromium, lead and fluoride.

Some tips for good operation and preventive maintenance

- Make chemical adds to each process bath, as established, on a regular basis.
- Do not exceed the optimum service life of the surface preparation baths.
- Where possible, know the alloy designations of aluminum processed.