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Plating Magnesium

Dear Advice & Counsel,

We are a job shop electroplating facility, and one of our clients has asked us to plate magnesium alloy parts. We presently plate onto aluminum and steel, but I have to admit that we have never plated magnesium. I have read numerous articles and they all mention a zincate dip, but they don't provide a formulation. Is this the same zincate as we are using on aluminum? Please provide me with some guidance. Thank you.

Signed, Maggie

Dear Maggie,

To answer your question, I needed to go back more than 40 years. In a paper presented at the 48th Annual Convention of the American Electroplaters Society (we were known as AES back then), H.K. DeLong of the Technical Service and Development Laboratory, Dow Metal Products Co. detailed the preparation of magnesium for plating. The following is a summary from Mr. Delong's paper:

There are three methods of obtaining electroplated deposits on magnesium alloys:

1. Electroplating over an immersion zinc coating.
2. Direct electroplating with nickel.
3. Plating with electroless nickel.

Of these methods, plating over a zinc immersion pretreatment offers the best corrosion resistance. In any of the methods used for electroplating magnesium, clean parts are essential, and appropriate methods of removing the soils present must be employed.

1. Electroplating Over an Immersion Zinc Coating

The zinc immersion method of preplate treatment consists of the following steps:

- Surface conditioning.
- Activation.
- Zinc immersion.
- Copper strike.

Surface Conditioning

These include the ferric nitrate pickle, which consists of dipping the parts in a solution of chromic acid (24 oz/gal), ferric nitrate (85 oz/gal) and potassium fluoride (15 oz/gal); the phosphoric acid pickle, which consists of dipping the parts in a 90 percent solution of phosphoric acid (85 percent); and the acetic nitrate pickle, which consists of pickling the parts in a solution of glacial acetic acid (25.5 fl. oz/gal) and sodium nitrate (6.67 oz/gal). In cases where little dimensional change is permissible, an aqueous solution of chromic acid (24 oz/gal) can be used.

Activation

For activating the magnesium parts before immersion zinc is applied, Mr. DeLong recommended a water solution containing 10 percent ammonium acid fluoride and 20 percent phosphoric acid, operated at room temperature. Parts should be immersed for 15 seconds to 2 minutes.

Zinc Immersion

The zinc coating process consists of chemical reduction from a pyrophosphate bath, dissolving surface oxides, and depositing a thin, adherent zinc coating.

Copper Strike

Immediately after rinsing the immersion-zinc-coated parts, copper striking for six minutes minimum is required before further plating. Periodic reverse is helpful at this stage, because it helps to produce bright, smooth deposits and good adhesion.

2. Direct Plating Magnesium

Mr. DeLong also described a process for plating nickel over magnesium, without a zincate. The magnesium was activated in a chromic-nitric acid dip followed by a rinse, hydrofluoric acid etch, rinse, and immediate transfer to the nickel plating tank. Mr. Delong indicated that the corrosion resistance of this plated part would be inferior to one treated with a zincate and copper strike.

3. Plating Magnesium with Electroless Nickel

Mr. DeLong did not detail the procedure used, but we can assume the same preparation method as described for nickel electroplating would work here as well.

By now you are probably saying, "Here we go again!" Mr. DeLong did not provide a formulation for the zincate used on magnesium. Fortunately, my good friend, Dr. Jack Dini wrote a paper titled "Plating on Some Difficult to Plate Metals and Alloys" for an AES Symposium held in October of 1980. In his paper, he discusses how use of an acid pickle ahead of zincate improves adhesion and he provides a zincate formulation. Jack compared adhesive strength of three preparation cycles:

1. Clean, zincate, copper strike, nickel plate.
2. Clean, immerse in 100 g/L ethylenediamine tetra/methylphosphonic acid at pH 6.0–7.3, zincate, copper strike, nickel plate.
3. Clean, immerse in 5% nitric acid, zincate, copper strike, nickel plate.

Processes 2 and 3 yielded similar adhesive strength (20,700 psi vs 21,000 psi, ring shear) while process 1 was significantly lower (16,400 psi).

The zincate Jack used was:

5.5 oz/gal Zinc Pyrophosphate ($Zn_2P_2O_7 \cdot 7H_2O$) + 27 oz/gal sodium pyrophosphate ($Na_4P_2O_7 \cdot 10H_2O$) + 2 oz/gal potassium fluoride ($KF \cdot 2H_2O$)

Immersion time was 2 minutes. The temperature of the zincate was 160°F and the pH was controlled to 10.0. Jack recommended that the copper strike be 2–5 microns (0.00008-0.0002") thick.

Thanks to Dr. Dini and Mr. DeLong, you should be able to develop a process for your own application. ***P&SF***