High Corrosion Resistant Plating Process for Magnesium Substrates

NASF Technical Conference
Cleveland, Ohio USA

Eric J. Olander CEF
President
EPi
17000 W. Lincoln Ave
New Berlin, WI 53151
USA
www.epi.com

Magnesium substrates are being evaluated by the automotive, defense, motorcycle, bicycle and other industries as the new metal for their products because of the many technical advantages magnesium castings have over zinc, carbon fiber and aluminum castings. These advantages will be discussed after we go over the history of magnesium metal.

HISTORY OF MAGNESIUM

When I was approached by Bill Giebel on developing a plating process for magnesium, all I could think of was “mag wheels”. In the late 70’s if you had a fast car, such a Firebird or Camaro, you had mag wheels on it. While I never can claim that I had such wheels on my vehicle, Mark Karner from ABQC in Milwaukee, WI told me his story about the mag wheels on his 1969 Chevelle . Per Mark Karner, he would polish the mag wheels with Mothers polishing compound and then he would wax the wheels. This would be done twice a month. The polishing compound would remove the oxidization and the dirt on the wheels, then the coat of wax would protect the wheels. The mag wheels would turn grey and pit if you did not perform this maintenance on regular basis. During the winter, he would put on a thick coat of beeswax and keep them in the basement.

Today, if you see polished automotive wheels that are shiny like chrome you will find that those wheels are made out of cast aluminum, not magnesium. You can find magnesium wheels, but they are usually in race cars because of the light weight and also the performance of the magnesium casting is far superior to other substrates.

WHY MAGNESIUM?

The stable cost of the substrate, the performance characteristics, and the weight of magnesium are all reasons that magnesium castings are being considered today.

In the 1930’s the price of magnesium used to be $0.30-0.40 per pound then it increased to $1.60-$1.80 per pound in the 1980’s and has come back down to $1.20-$1.40 per pound. 80% of the world’s magnesium comes from brine or salt water so there is a large raw material resource, but more facilities are needed to process the magnesium.

The second reason why magnesium castings are being considered today is the fact the magnesium castings are stronger than zinc and aluminum castings. In fact you can cast a stronger thinner wall casting in magnesium that is 0.08 inches thick than you can in either zinc or aluminum. What does this mean? To achieve the strength that engineers require more aluminum must be used to achieve the same strength properties as magnesium.

Magnesium casting dies last 2-3 times longer than the ones for aluminum castings and the magnesium casting process cools quicker than aluminum castings. One pound of magnesium needs 1800 BTUs while one pound of aluminum needs 2500 BTUs, thus using magnesium saves the caster energy costs. Lower shot pressures are necessary for magnesium versus aluminum. The machinability of magnesium is 500, while aluminum is 300 and B1112 steel is 100. In fact the tooling life of magnesium is extended and costs about 70 % less than aluminum.

MAGNESIUM casting vs. ZINC castings
One pound of magnesium costs $1.21. To cast the same area of magnesium, you would need 3.6 pounds of zinc at a cost of $0.495/pound. Your total zinc material costs are $1.78. The magnesium would generate a 32% savings.

The main driving force today in castings is the weight of magnesium. It weighs 67% of the weight of aluminum. The search is on for all industries to make vehicles lighter, as we chase that ever elusive goal it of increasing the mileage per gallon (MPG) of vehicles. While plastic bumpers have already replaced our chrome bumpers, the automotive industry is still looking for another substrate that has more strength than plastics. One draw back to using magnesium is finishing it. The resulting salt spray corrosion numbers and adhesion challenges upon baking the plated part are not the same as on zinc die cast and on aluminum castings. Presently, there are two processes used for plating on magnesium substrates: cyanide copper process and electroless nickel process.

CYANIDE COPPER PROCESS

1. Soak Clean
2. Rinse
3. Acid Activation
4. Rinse
5. Zincate
6. Rinse
7. Cyanide Copper Strike
8. Cyanide Copper Plate
9. Rinse
10. Acid Copper
11. Nickel Processes
12. Chrome

Cyanide copper processes do work, but they present two challenges. The first is the corrosion protection you can achieve with the cyanide processes. The second is that eventually cyanide will be the next plating process to be eliminated. In China, the federal government has mandated that electroplaters gradually stop using cyanide copper and other types of cyanide plating. In fact, as this paper is being written, we are having some success in China with alkaline non cyanide copper on zinc castings and on aluminum wheels. One of the concerns about using cyanide is the potential terrorists' threat of cyanide being used on the general population. Therefore, long term use of cyanide is not something a metal finisher should be committed to at this point. Recently Homeland Security established a new threshold for sodium cyanide or potassium cyanide (Appendix A) on a site at 2000 pounds. If your company has 2000 pounds or more on site, you will be classified into a special Tier for your site security plan.

ELECTROLESS NICKEL PROCESS

1. Soak Clean
2. Rinse
3. Acid Activation
4. Rinse
5. Zincate
6. Rinse
7. Electroless Nickel Process
8. Rinse
9. Acid Copper
10. Nickel Process
11. Chrome

Electroless nickel processes are some of the most costly processes to plate any substrates. The advantage is that it plates uniformly across the parts and on other substrates. High phos electroless nickel offers superior corrosion resistance. The defense industry is looking for an electroless nickel process that will produce high salt spray hours on magnesium substrates and later in this paper we will show how you can achieve this process. The other factor is the cost of nickel metal. It is currently at an all time high cost which makes it difficult for the end user to absorb the additional expense, especially when the performance is not there.

The solution for the magnesium end user is to switch to a new specially formulated alkaline non cyanide copper process that differs from other alkaline non cyanide copper processes with proprietary additives that promote adhesion and high corrosion protection. This new alkaline non cyanide copper hits the sweet spot with its performance.

The past paradigms of cyanide copper vs. alkaline non cyanide copper was that on performance cyanide always won. Now there is a case for the alkaline non cyanide copper process because it offers two advantages: (1) it is a tightly adherent deposit that provides a denser deposit on magnesium as it is a fine grain structure and (2) the pH of the working solution. Typically the non cyanide copper is a pH of 9.4-9.8, while the pH of the cyanide copper is 10.3-11.5. The lower pH means less OH ions on the zincated surface. In fact the pH of the zincate solution is 10.3-10.4. Most traditional zincates for aluminum contain a high amount of caustic (sodium hydroxide) and do not work on magnesium.

ALKALINE NON CYANIDE COPPER PROCEDURE

1. Soak Clean
2. Rinse
3. Acid Activation
4. Rinse
5. Zincate
6. Rinse
7. Alkaline non cyanide copper

8. Rinse
9. Acid Copper
10. Buff Acid copper
11. Complete copper-nickel-chrome finish

Soak Cleaning- Initial thought is to use a traditional aluminum cleaner that contains silicates and will not etch the magnesium. A high caustic cleaner will not etch magnesium. Why? The magnesium does not dissolve in caustic. Therefore, either cleaner will work.

Rinse

Acid Activation- Proprietary chemistry that removes oxides and prepares the magnesium for the zincate process.

Rinse

Zincate- Not your traditional zincate for aluminum as the process is run at a lower pH 10.0-10.8. Temperature very high 150-170 F. The sludge that is dissolved has to be filtered out to extend bath life. Longer immersion time 5-10 minutes.

Rinse

Alkaline non cyanide copper process. Plate a minimum of 0.5 mils of copper thickness. Higher thickness of one mil can help with corrosion protection and when the baking the part at 350 F for one hour. Acid copper plating of two mils and polishing will help with casting defects.

Challenges

Casting quality of magnesium parts need to be improved to the level of aluminum casting so that we can achieve appearances that are similar to the appearances achieved on the aluminum castings. We have seen magnesium parts that when polished appropriately using a polishing compound for magnesium come out great. Aluminum buffing compounds do not work on magnesium. The cleaning of the buffing compound is another consideration that needs more investigation. Initial studies used a contaminated aluminum buffing compound alkaline spray washer that resulted in poor appearance. Vapor degreasing worked better on the surfaces leaving a nice clean surface.

The biggest challenge to date is the magnesium cast surfaces that are not polished, such as deep recesses and or the back side of a part that has not been polished. After plating the deep recesses have an Swiss cheese appearance. The polished area next to the deep recessed area looks great. Polishing deep recesses can be a challenge. Polishing the back side of the part is usually not economical and depending on the part design can be difficult to do.

If the surface of the magnesium casting could be improved then an excellent cosmetic finish would be possible and the gates would swing wide open for the OEM's to switch more parts over to magnesium.

What is next?

A partnership of the OEM, magnesium casters, metal finishers, and the chemical suppliers needs to be formed so that the features of this exciting substrate can be capitalized on.

To learn more about magnesium go to www.magnesium.com. I would like to thank Bill Geibel of Line Tec in Wausau, WI for being the catalyst in making this project happen. All of the technical information on the properties of magnesium is from www.magnesium.com.