Uses & Properties of Multilayer Nickel Systems & Alternative Finishes in the Aluminum Wheel Market

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Plating of aluminum wheels for the automotive industry today requires that two to four layers of nickel be deposited to achieve the corrosion protection to meet OEM specifications. We will discuss the different layers and their function as to the overall finish. We will also discuss the alternative topcoats for these layers, including black nickel and trivalent chromium.

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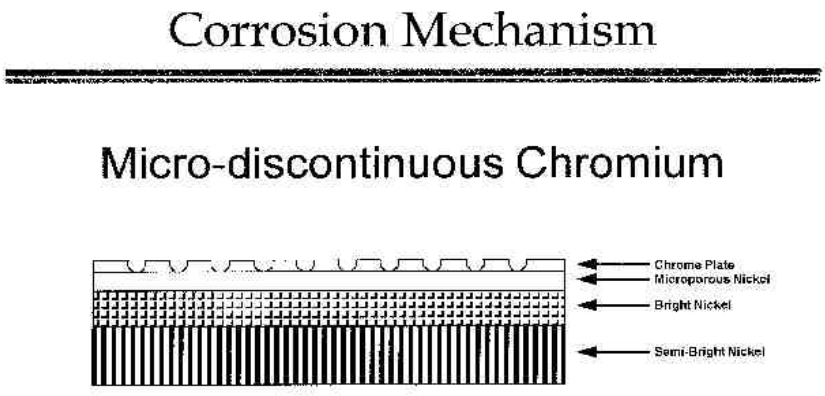
In today's marketplace, customers are demanding higher and higher quality at a lower cost. High quality nickel plating is a demanding finish and when you couple that with aluminum wheel castings, you end up with a very difficult part to plate. The aluminum wheel market is like many other markets that deal with aluminum such as motorcycle parts, bumpers and other automotive type applications. The ever-increasing corrosion specifications required by the market has prompted the use of multilayer nickel systems to pass the rigorous requirements.

In the aluminum wheel industry, there are OEM platers and aftermarket platers. The majority of the aftermarket wheel platers do not have any type of corrosion spec. They use mil spec "b"- make it look bright. These platers use only acid copper, bright nickel and chrome and the wheels look acceptable.

The OEM wheel market generally requires three layers of nickel, semi-bright, bright and micro-porous. The OEM's are requiring 48-96 hours of CASS, certain ductility requirements, step, pore count and exceptional adhesion. The multilayer nickel systems are designed to exceed these requirements. The corrosion performance of the wheel seems to be the most controversial when it comes to interpretation of results. Specs are written and supposedly followed, but essentially, they want no visible corrosion after their CASS tests are done. It is very important to understand the evaluation criteria of the customer, as this will determine if a part passes or fails. Every OEM has different interpretations and the evaluation tends to be subjective.

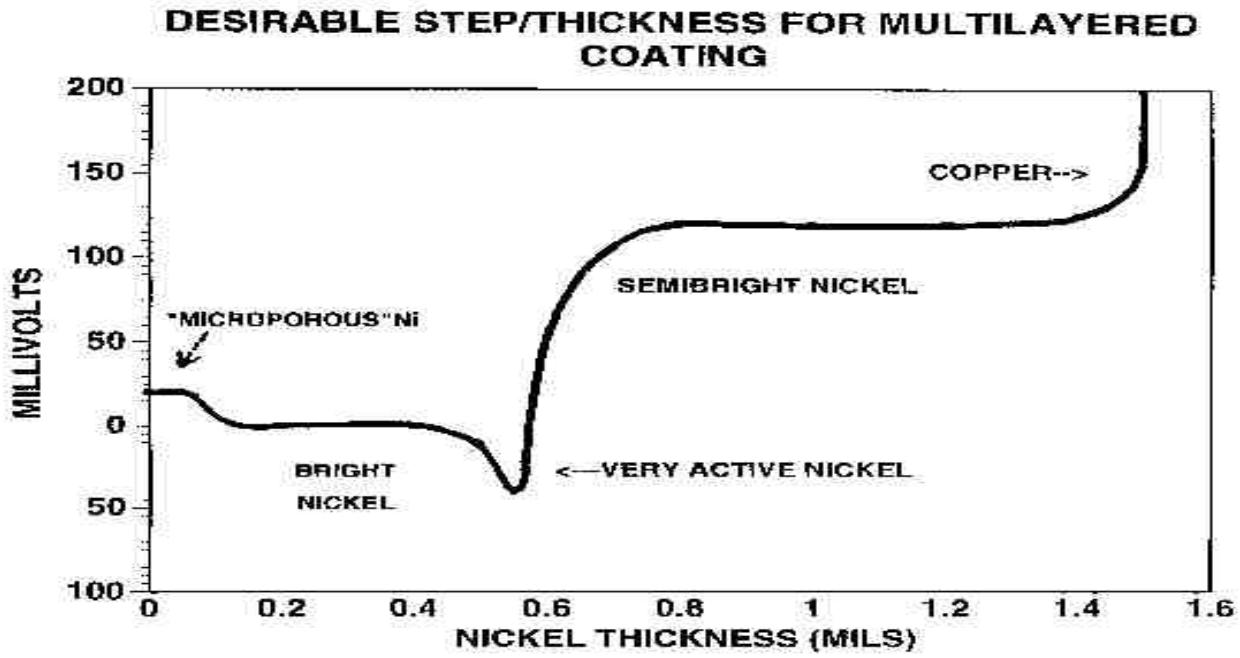
The current cycle for OEM aluminum wheels is generally the same. The wheels are polished after casting and machining. Pretreatment starts with a soak cleaner, etch, desmut and double zincate. Either a Watts, sulfamate, or electroless nickel strike or cyanide copper strike is applied. A deposit of acid copper follows this. The parts are then buffed, cleaned and activated prior to the nickel plating. Semi bright nickel is first followed by a high sulfur nickel strike (not often applied), bright nickel, micro porous nickel and then hexavalent chrome (fig 1). Each of these nickels provides specific properties that allow the wheel to pass the rigorous tests.

Figure 1



The semi bright or sulfur free nickel provides a leveled semi bright finish. The nickel is deposited as a columnar structure. The bright nickel is a highly leveled, very bright deposit that is deposited as a laminar structure. When properly done, there is a milivolt potential difference, or "step" between these two layers that protects the subsequent layer from corroding. The micro porous layer is a thin deposit where galvanic energy is dispersed to many small sites that spread the corrosion. This action creates many "pits", not just one. There is a potential difference between the bright nickel and the micro porous nickel layers also. Figure 2 below shows the desirable step/thickness for a multi layered nickel coating.

Figure 2.



All of these layers of nickel and chrome work synergistically to provide an extremely bright, functional decorative finish that the wheel customers have come to expect. The thicknesses of the nickel and chrome layers have a considerable influence on appearance and functionality. To get proper required thickness of nickel and chrome, auxiliary anodes are used to deposit more material in the low current density areas of the wheels. These are generally platinized titanium conforming anodes or iridium coated titanium conforming anodes. These anodes provide thickness in the window and lughole areas of the wheels without having to plate longer than needed to meet minimum thickness requirements. The OEM's have found that if minimum thickness is not achieved, premature corrosion failure can occur. The corrosion starts

where there is some kind of a hole in the topcoat. The chrome is purposely discontinuous because it spreads out the corrosion. The corrosion goes through the chrome and gets to the micro porous layer and starts to spread laterally. This appears as a hazy deposit over the surface of the wheel. Once the corrosion has made it's way to the bright nickel, it spreads laterally due to the laminar deposit of the bright nickel. It slowly works its way down through the bright nickel and hits the semi bright nickel layer. This layer is designed to have the corrosion go straight down and not spread. This allows the corrosion to get to the copper, nickel strike and eventually, the base aluminum. In order for us to see the base metal corrosion, the corroded aluminum slurry must work its way back through all of the layers and expose itself to the surface. We see this as "white" corrosion. The thicker the nickel layers, the slower this event takes place. Generally failures are in the LCD areas. We try to overcome this problem through the use of the auxiallry anodes.

When we talk about aftermarket wheels, the situation changes. Most are using bright nickel only with chrome on top. They also generally do not use auxiliary anodes in the nickels. This gives the chance for corrosion to happen much faster because it has a thinner layer of bright nickel only to pass through. Some of the aftermarket wheel platers do a semi bright and bright nickel and a few do plate to OEM specifications, but sell into the aftermarket wheel marketplace. These wheels will generally hold up in the field longer than a bright nickel only wheel.

We did not address the substrate, but it is a major consideration in the performance of a nickel chrome plated wheel. Pits, porosity and other surface defects greatly affect the performance characteristics of the wheels. The multilayer nickel systems are designed to minimize the effects of these surface imperfections.

Recently, some of the wheel platers have worked on using trivalent chrome and black nickel. The trivalent chrome provides a more environmentally friendlier alternative to the standard hexavalent chrome finish. The technology today provides a blue colored trivalent chrome that most could not distinguish from hexavalent chrome. The advantage is two fold for the use of trivalent chrome. One, it is much more environmentally friendly and two, it provides up to 95% coverage as compared with 60-70% with hexavalent chrome. The costs of the two systems are comparable when all factors are included like waste treatment and make-up costs. The corrosion performance of the trivalent chrome is not quite as good as standard hexavalent chrome, but it is close. The major objections from the OEM's on trivalent chrome were chrome thickness and color. Both of these issues are being addressed by suppliers and should be viable within a couple of years. With all of the regulations that are coming out for the automotive industry with regards to hexavalent chrome, alternatives will have to be addressed. The wheels have chrome metal on them not hexavalent chrome, but the platers who do the work have very large quantities of this carcinogen in their plants and worker safety is a major concern for the owners.

The black nickel is a tin-nickel strike bath after bright nickel and before trivalent chrome. This finish gives a very bright black finish to the wheel. It is a special market, but nonetheless, it provides opportunities for wheel platers to distinguish themselves from the many wheel platers throughout the world. Satin nickel and other chrome alternatives are also being looked at.

Conclusions:

The wheel market is demanding improved performance at a lower cost. This can be achieved by using multilayer nickel systems. A properly operated system can achieve well over 100 hours of CASS with little or no degradation in the surface appearance. The market is looking at safer alternatives to current finishes and they are also looking for different colors. Consumers customize their vehicles to make them reflect their personalities. Wheels will always be a big part of that customization.

References:
Figures 1+2- Technical presentation, “Corrosion”
Bob Tremmel (1999)