Advancement in the Control and Prediction of CASS Test Performance

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The demand for improved corrosion performance from automotive decorative chromium components has evolved over the last twenty years. This has generally been characterized by the extended CASS test requirement in automotive standards. It is well known that CASS test performance is strongly linked to microporosity, among other deposit attributes. Only recently, one automotive manufacturer adopted a new method for assessing active micropores using the Fuhrmann test instead of the Dubpernell test. The advantage of the new procedure is the direct correlation of the pore count before CASS test to the active sites after CASS exposure. Consequently the Fuhrmann test is effective for predicting corrosion results, assuming all other deposit characteristics such as thickness and STEP comply with the specification. The acceptance of the Fuhrmann test by other OEM's is anticipated due to its improved reliability.

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Introduction

Electrodeposition of metal layers is used primarily to give surface improvement and decorative enhancement to metallic and plastic components. Naturally the attractive appearance should ideally last for the functional life of the component. Today electroplated metallic and plastic components are used extensively in some of the most severe corrosive environments, such as the exterior trim of motor cars. This type of application necessitates a performance level with a stain and defect free appearance, and exceptional corrosion resistance.

Automotive designers having rediscovered the aesthetic benefits of decorative chromium and are demanding greater durability combined with consistent high quality. The ability to quickly verify the corrosion performance of the surface finish presents an advantage to both the production plating plant and to the end user.

The combination of a controlled microporous nickel chromium process, the STEP test, and a porosity test procedure known as the Fuhrmann test, provide the key elements for a reliable decorative system.

Decorative Chromium Plating

Bright chromium plating has always been the favoured decorative plated finish for both metallic and plastic components. Metallic chromium is completely tarnish resistant, hard, and wear resistant and most of all has an elegant blue metallic appearance. Bright chromium is not just a single chromium layer but invariable has an under layer or layers of electroplated nickel ranging from 5 to 50 micrometres. The visible top layer is a thin chromium coating typically with a thickness of 0.4 micrometres.

For components used indoor such as office furniture, office equipment and domestic appliances, a single layer of bright nickel is adequate to afford the necessary surface improvement. This combined with the chromium layer provide sufficient product durability. At the other end of the environment spectrum, exterior automotive trim presents much greater demand on the metallic layers in terms of corrosion resistance, and subsequently, it requires a more complex system.

Research[1] going back over thirty years or more has shown that very significant improvements in corrosion resistance can be achieved with two or more different nickel layers and special microdiscontinous chromium top coating or strike layer. Today multi-layer nickel and microporus chromium are the preferred choice to resist even the most severe environments.

Corrosion attack on nickel chromium systems occur at discontinuities in the chromium layer. A corrosion cell is set up with the chromium as the cathode and the nickel as the anode. When there are a few defects in the chromium layer, the surface area of the cathodic chromium is greater than the surface area of the anodic nickel.

A corrosion cell is formed and nickel is dissolved rapidly, resulting in visible corrosion.

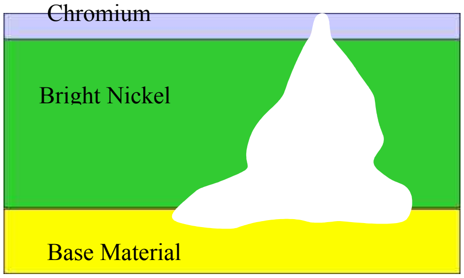


Figure 1. Rapid corrosion penetration to substrate.

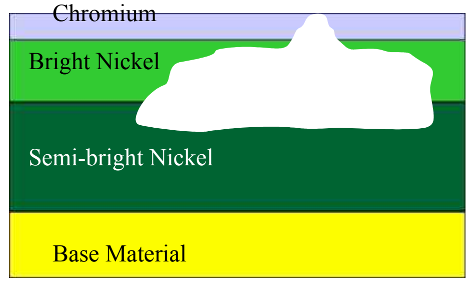


Figure 2. Delayed corrosion due to duplex layers.

Microporous Chromium

Simple chromium layers have random discontinuities such as cracks or pores. In practice these defects are difficult or impossible to eliminate, so corrosion occurs at these points described earlier. The solution to this, practised for many years, is to produce many discontinuities in the form of cracks or pores in the chromium layer.

A microdiscontinous chromium layer over duplex nickel layers provided a major improvement in corrosion resistance and met end user requirements[2] from the 1970's until the mid-1990's. During this period, extensive accelerated testing and service life evaluations demonstrated that microporous chromium was the preferred method of producing microdiscontinuous chromium. In recent years, microporous chromium has been recognized by European automotive manufacturers[3], where microcrack chromium was more widely accepted.

The revival of decorative chromium for automotive trim in the mid-1990's pushed demand to new heights stimulating development and refinement of techniques and processes. Research focused on the critical areas of consistency, control and rapid evaluation of production quality.

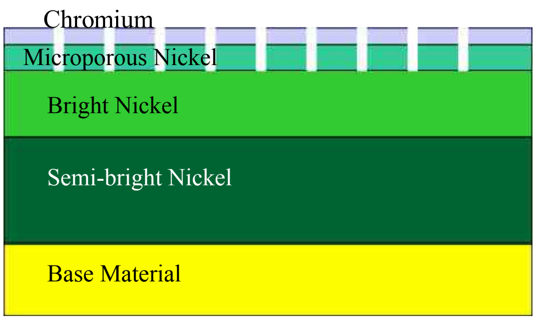


Figure 3. Delayed onset of small corrosion sites with microporous nickel.

In order to produce microporous chromium, a special diphase bright nickel layer must be deposited directly before the chromium. This special nickel process contains very small inert particles co-deposited with the bright nickel. Particle selection is based on an optimum range in size or diameter. The particles protrude from the nickel layer and interrupt the deposition of chromium layer.

Consequently particle distribution, particle size, and corrosion activity of the pores are heavily dependant on the co-deposition mechanism of the inert particles. A uniform particle distribution over the surface of complex shaped components is necessary for corrosion protection on the entire part.

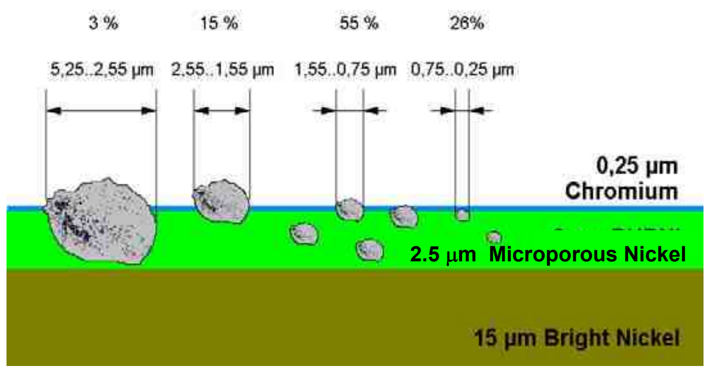


Figure 4. Pore distribution

Duplex Nickel

In order to control corrosion and provide optimum base material protection, different types of nickel plating processes are used to produce the multi-nickel layers. Semi-bright nickel is plated first, followed by the bright nickel.

Semi-bright nickel is a purer layer with a different structure from bright nickel. The purity is characterised by the low sulphur content in the layer. Semi-bright nickel must have less than 0.005%, compared to bright nickel, which typically contains 0.04% sulphur.

The significance of the sulphur is directly related to the corrosion of the layers. In a corrosion cell, the semi-bright nickel is cathodic to the bright nickel, so attack or dissolution is confined to the bright nickel layer. The semi-bright nickel layer remains intact and provides protection for the substrate.
The activity of the layers is controlled by solution additives and by the purity of the electrolyte. Proper maintenance of the nickel electrolytes is one of the key factors in optimising the corrosion resistance of the system.

The STEP test (Simultaneous Thickness and Electrochemical Potential) is a test method[4] developed at the Chrysler Corporation for measuring the thickness and the dissolution potential of nickel layers.

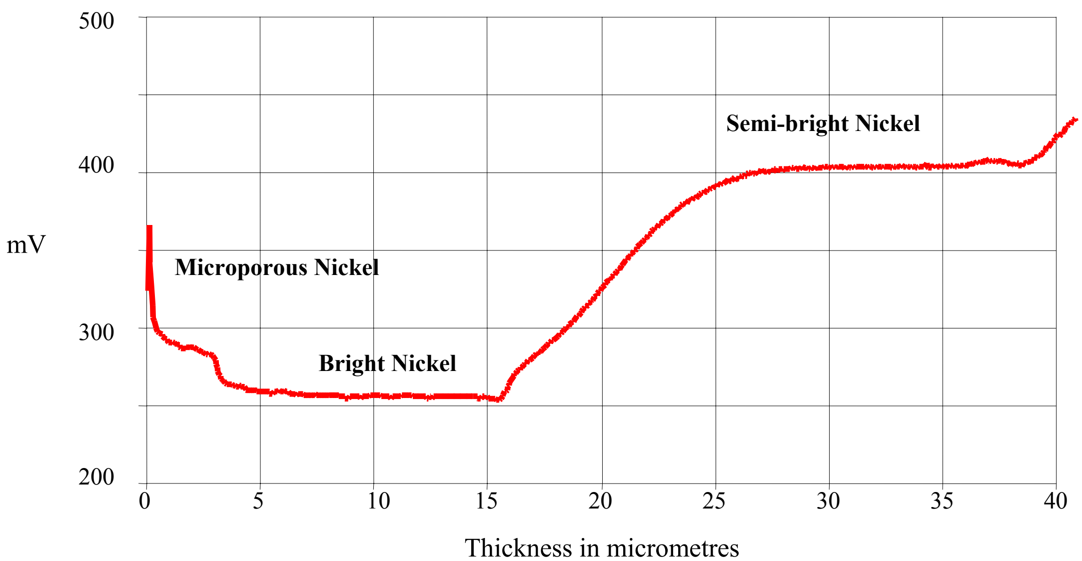


Figure 5. STEP test curve.

The above graph illustrates the dissolution of the nickel layers and simultaneous thickness measurements of the deposit. Also the microporous layer is more noble, or inactive, than the bright nickel. This is an advantageous in a corrosion cell since the bright nickel corrodes preferentially, thus maintaining the chromium and microporous nickel layer intact. The component remains untouched even after prolonged exposure to the most severe environment. Likewise the semi-bright nickel is considerably more noble the bright nickel and corrodes preferentially and sacrificially, thus protecting the substrate.

Extensive observation of service performance has shown that there is a clear correlation between an appropriate potential difference or correct STEP and exceptional durability.[5] The STEP test is now incorporated into most automotive specifications, such as DaimlerChrysler, General Motors, and Ford Motor.[6]

Quality Control

A dilemma faced by every quality manager is ensuring that the product coming off the plating line meets the desired quality standards. This is more critical today as components can be assembled and dispatched within a few hours of processing. Most quality control methods for electroplated parts involve lengthy corrosion testing, such as the CASS test (Copper Accelerated Acetic Acid Salt Spray). At times, up to 100 hours may be required. The STEP test is the exception requiring only a few minutes although alone it is insufficient to indicate the corrosion resistance of the system.

An equally critical factor is the number of active pores in the microporous chromium since this has a major influence on maintaining the surface appearance after corrosion. A well established rapid method, the Dubpernell test, has been used for many years. This method utilises the deposition of copper on the plated component. Since copper does not deposit on the chromium, only the exposed nickel is plated with copper, which is an indication of microporosity.

When the typical automotive specification only required 16 to 24 hours of CASS testing, the Dubpernell test was adequate to indicate subsequent performance in the accelerated corrosion test. However, as quality requirements were extended to 48 hours CASS and above, it became clear that the pores indicated by the Dubpernell test were not always active after exposure to the CASS test. It was not uncommon to find failures on components, which appeared to have the correct number of pores based on the Dubpernell test.

Comparison of Dubpernell Test Results and Corresponding Active Sites After CASS test

Figure 6. Dubpernell pore count

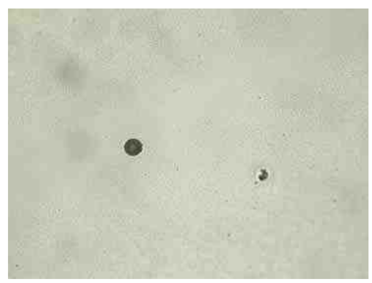


Figure 7. Active sites after 48 hours CASS test

Recent research has produced an improved pore count test known as the Fuhrman test.
This method is based on the Dubpernell method but the deposition of the copper is carried out at a prescribed voltage setting on a defined surface area. Variations in current, common to the Dubpernell test are eliminated. Only pores capable of creating corrosion cells or active sites are visualised. Consequently there is a direct correlation between the Fuhrmann test pore count and the number of active sites after CASS testing. Both DaimlerChrysler and Volkswagen have or will included the Fuhrmann test in their specifications.[7]

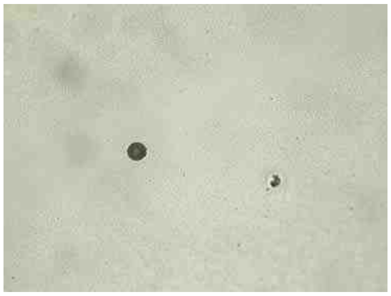


Figure   Active sites after 48 hours CASS test

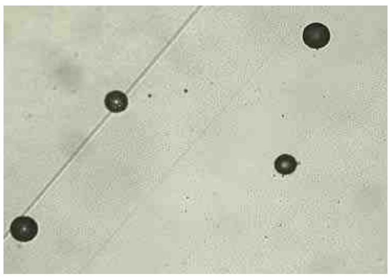
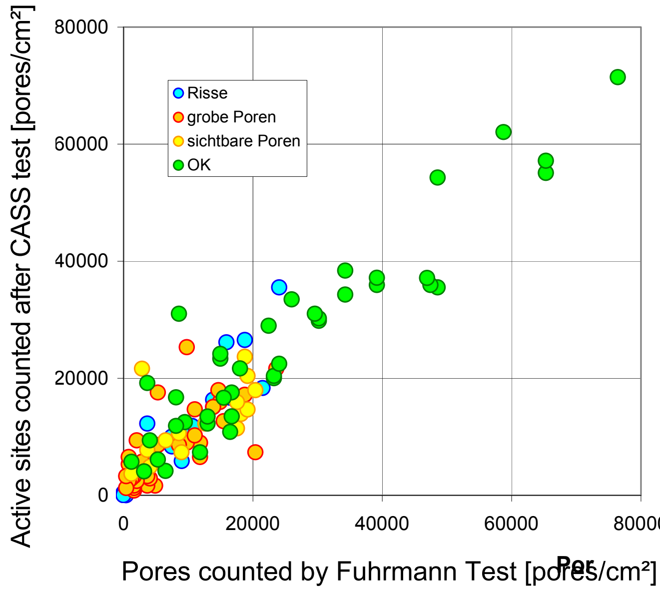


Figure   Fuhrmann pore count



Comparison of Fuhrmann Test Results and Corresponding Active Sites After CASS Test

Summary

Clearly the aesthetic appeal of decorative chromium trim has contributed to its popularity on motor cars for over thirty years. But besides its bright appearance, consistent reliable corrosion performance will ensure its continued use in the future. The combination of a controlled microporous nickel chromium system, the established STEP test, plus the new Fuhrmann test provides the plating suppliers a practical means to verify and predict CASS test corrosion results. The advantage is rapid feedback on the integrity of the finished product to meet the automotive manufacturers' standards.

Acknowledgment

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