# Design for Plateability Analysis for the Decorative Chromium Plating Process for a Fog Lamp Bezel Part

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**In this paper, design for plateability analysis for the decorative chromium plating process for a fog lamp bezel part is presented, comprising a computer simulation of the copper, nickel and chromium metal thickness distributions over the part. The analysis is based on a single part in a plating tank segment, and takes the tank dimensions and distance to the neighboring parts into account. Based on these simulations, different process parameters can be investigated and optimized, including maximum possible rack load, the necessity for additional tooling on the rack in order to meet specifications and the total imposed current and plating time required for each plating step. For companies involved in decorative plating of plastics or metals, like OEMs and dedicated plating companies, design for plateability analysis provides vital insight in managing profitability, cost and quality. Furthermore, it will be demonstrated that well-engineered and optimized tooling significantly affects process performance, avoiding product underperformance and related warranty issues.**

***Keywords:*** *Copper-nickel-chromium, decorative plating, computer simulation, plate distribution, design for plateability*

## Introduction

Elsyca has developed new technology and capabilities which enable the accurate prediction of the electrodeposited metal thickness distribution about any complex geometry. On a project basis, we have exploited this unique capability to design and optimize electroplating processes, tooling and racking. As only the computer-assisted design (CAD) of the component is required, not the physical part, this considerably shrinks the lead time and reduces technical and financial risks.

Design for plateability analysis is a methodology that has been developed in order to return key information quickly without building a completely detailed model, thus reducing cost and considerably speeding up the process. The approach is based on a single part in a plating tank segment, and accounts for tank dimensions and distance to the neighboring parts.

Design for plateability analysis for a decorative chromium plating-on-plastics process consists of an investigation of the copper, nickel and chromium layer thickness distribution over a part by means of computer simulation, in order to get a first idea as to whether the part can be plated to specifications without additional tooling, such as current robbers, conforming (auxiliary) anodes and insulating shields. If layer thickness specifications are not met, several problems might occur, including:

- Nickel "show-through," *i.e.*, spots without chromium coverage (typically exhibiting a yellowish color) and
- Failure during the CASS salt spray tests due to insufficient thickness of semi-bright, bright and microporous nickel layer thickness values.

The simulations are based on bath characteristics from some common acid copper, nickel and chromic acid baths as distributed by the main plating suppliers, or, if the data were available, based on the exact bath characteristics from the plating line used to plate the parts. The total applied current was based on a recommended value for the average current density over the plateable area. By multiplying the total plateable surface area per part, the total applied current was obtained. In this design for plateability, the effect of the different copper plating steps (*i.e.*, copper strike

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and acid copper) and the different nickel plating steps (semi-bright, high sulfur, bright, micro-porous) could be bundled into a single "virtual" plating step, in order to reduce computational and personnel effort.

## CAD model

Before any computer simulation can be performed on a part, the CAD model for this part should be "repaired" and simplified. Different repair operations are generally required and involve:

- Trimming of surfaces (edges not perfectly joined);
- Combining surfaces and
- Deleting small details (in order to reduce required computational resources).

Figure 1 shows the fog lamp bezel part that is the subject of investigation in this paper.

## Surface categories and layer thickness specifications

In most cases, not all surfaces of a part need plating. For automotive parts, a possible classification is as follows. Type A surfaces are exposed frontal view surfaces. Type B surfaces have only exposure by side view (not present on the fog lamp bezel) and Type C surfaces are not visible when mounted on the car or truck (such as the entire back side of the parts). In Fig. 1, the frontal surfaces in dark blue are Type A, while the surfaces in light grey are Type C.

Commonly used layer thickness specifications for Type A surfaces on ABS parts are 15 $\mu$m Cu, 20 $\mu$m Ni and 0.25 $\mu$m Cr. The copper layer consists of both the copper strike and acid copper plating layers, and the specification can be roughly subdivided as 2.0 $\mu$m for the copper strike plating step and 13 $\mu$m for the acid copper step. The nickel layer receives contributions from all four nickel plating processes. Taking into account the respective plating times and applied currents for the nickel plating steps, this translates to about 12 $\mu$m for the semi-bright nickel layer and 8.0 $\mu$m for the total high sulfur / bright / micro-porous nickel layer (or 5 $\mu$m for the single bright nickel step).

## Process conditions

The process conditions as applied for the computer simulations of the fog lamp bezel part are listed in Table 1. For this example, the copper and nickel steps have not been bundled into single "virtual" plating steps.

## Layer thickness distribution results

### *Acid copper*

Figure 2 depicts the copper layer thickness distribution over the fog lamp bezel part, obtained with no additional tooling (shields, current robbers or conforming anodes).

For the acid copper plating step, a validation of the computer simulation results compared to experimentally obtained data was also performed. The definition of the sample points is given in Fig. 3, and a comparison between measured and simulated layer thickness values is made in Fig. 4.

### *Semi-bright nickel*

Figure 5 shows the semi-bright nickel layer thickness distribution over the fog lamp bezel part obtained with no additional tooling, while Fig. 6 shows the impact of dedicated tooling (a combination of shields, current robbers and conforming anodes).

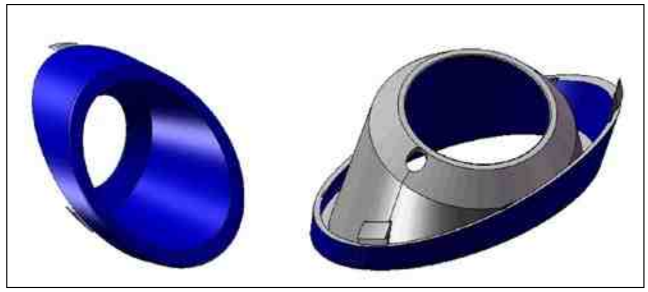


**Figure 1**—*CAD description of a GM fog lamp bezel part.*

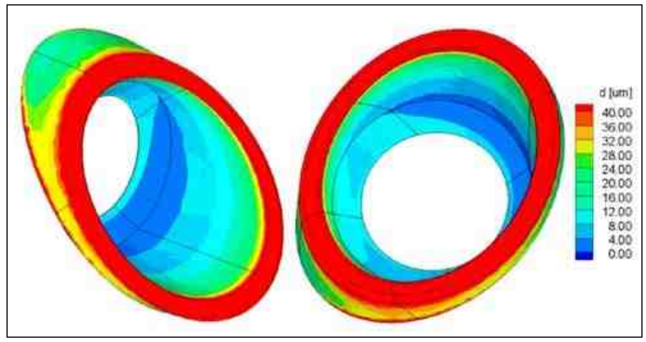



**Figure 2**—*Acid copper layer thickness distribution.*

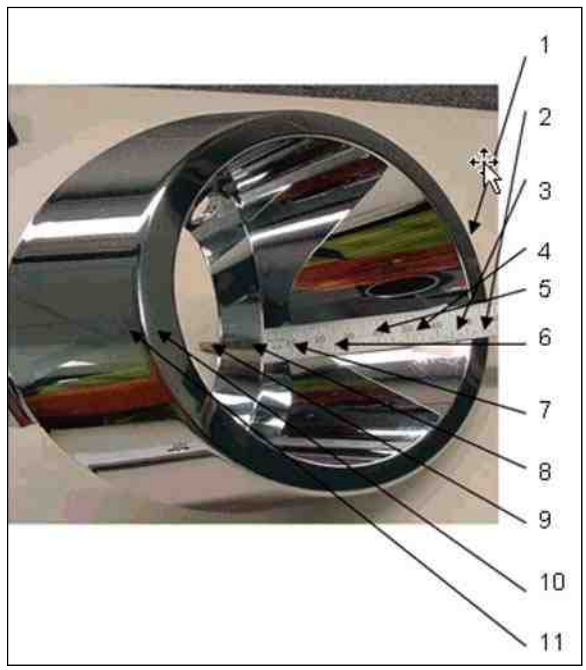



**Figure 3**—*Definition of sample points.*

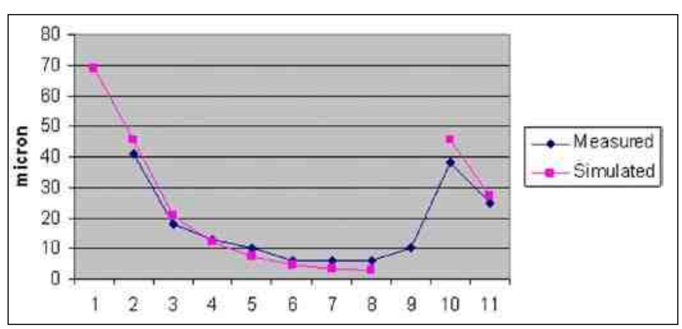



**Figure 4**—*Acid copper layer thickness values on sample points.*

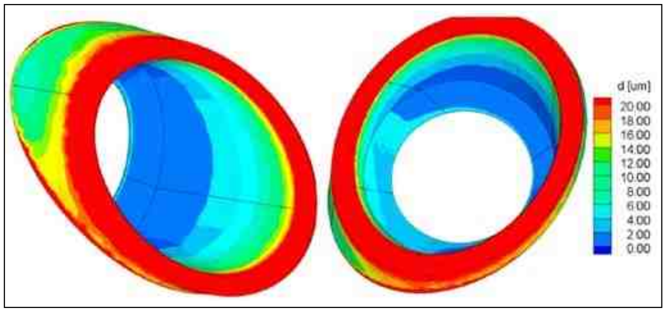



**Figure 5**—*Semi-bright nickel layer thickness distribution - no tooling.*

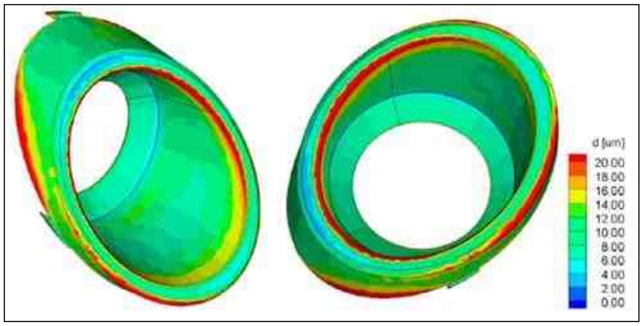



**Figure 6**—*Semi-bright nickel layer thickness distribution - with tooling.*

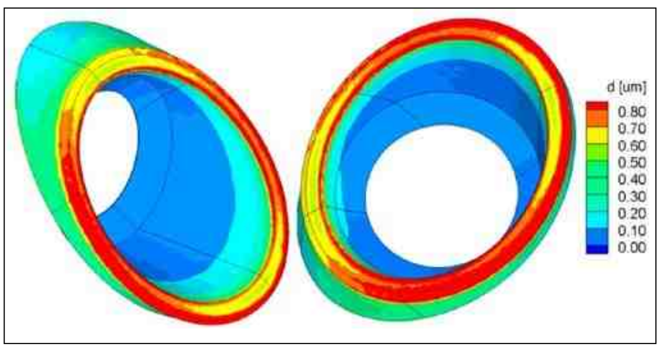



**Figure 7**—*Chromium layer thickness distribution.*

### *Hexavalent chromium*

Figure 7 shows the chromium layer thickness distribution over the fog lamp bezel part obtained with no additional tooling.

## Conclusions

It has been demonstrated that the simulated layer thickness values are in very good agreement with reality, thereby proving the validity and reliability of the computer simulated results. The fog lamp bezel part is largely overplated around the circular edge, while the recessed surface areas of the fog bezel opening receive very low copper and nickel layer thicknesses, with the chromium layer completely absent over a large surface area in the fog bezel opening (*i.e.*, nickel show-through). Hence it can be concluded that this part can not be plated up to specification without the use of a conforming anode structure.

**Table 1**
**Plating process conditions**

| | Acid copper | Semi-bright nickel | Chromium |
|---|---|---|---|
| Plating time | 22 min | 16 min | 3 min |
| Average current density | 4.0 $A/dm^2$ | 4.0 $A/dm^2$ | 14.4 $A/dm^2$ |
| Current per part | 15.6 A | 15.6 A | 54.8 A |
| Plated metal | 6.8 g | 3.5 g | 0.05 g |

This fog bezel part has a relatively simple geometry, and the judgment on design for plateability can also be made simply based on experience, by any plating operator with a sufficient track record in the decorative chromium plating business. However, design for plateability analysis can predict the actual plating thickness and clearly quantifies any issues. If carried out as part of a quoting process, this provides a clear and auditable trail with respect to quality, thereby reducing commercial and technical risks.

Design for plateability methodology also works easily for parts such as grilles, wheels and fender vents, all parts of more complex geometry where such an analysis can not be made confidently when solely based on operator experience.

Given the extensive empirical trial-and-error phase used in actual daily practice, it has clearly been demonstrated that a design for plateability analysis based on computer modeling is of high value for all players active in this field. For OEMs, design for plateability can be used in the design and engineering cycle in order to evaluate the design for manufacturability and plateability, and it can be used for supplier selection and development. For dedicated plating companies, this tool is a key factor in the quoting process to manage competitiveness while avoiding underperformance and consequential warranty claims. Finally, design for plateability analysis is also the starting point for further engineering and optimization of plating processes, enabling one to meet customer specifications while enabling profitability and a competitive edge.

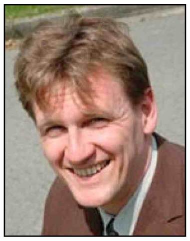
Several scenarios for engineering the tooling can be tested upfront with the advantage of having the proper tooling made when the first parts hit the factory floor. For a typical rack plating process, this involves the load, position and orientation of the parts on the rack, along with the development of dedicated tooling solutions like shields, conforming anodes and current robbers.

A major OEM reports that insufficient metal coverage is a continual challenge and risk to quality from plating companies using conventional judgment on plateability. Consideration is being taken to require all fog lamps be plated using auxiliary anodes and plating analysis.

For the fog bezel part, it has been demonstrated that conforming anodes, possibly combined with shielding and current robbing structures are required in order to get the copper, nickel and chromium layer thickness distributions within specifications. An "anode" is however not "an anode," meaning that a well-designed and engineered anode still makes a huge difference in plating time and plating results, enabling one to manage profitability and quality.

*For additional information on this technology as applied to printed circuit boards, please see the article on Elsyca's SmartPlate® technology on Pages 59-60 of this issue.- Ed.*

## About the authors



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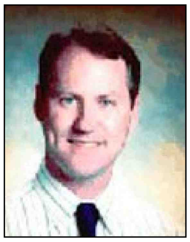

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