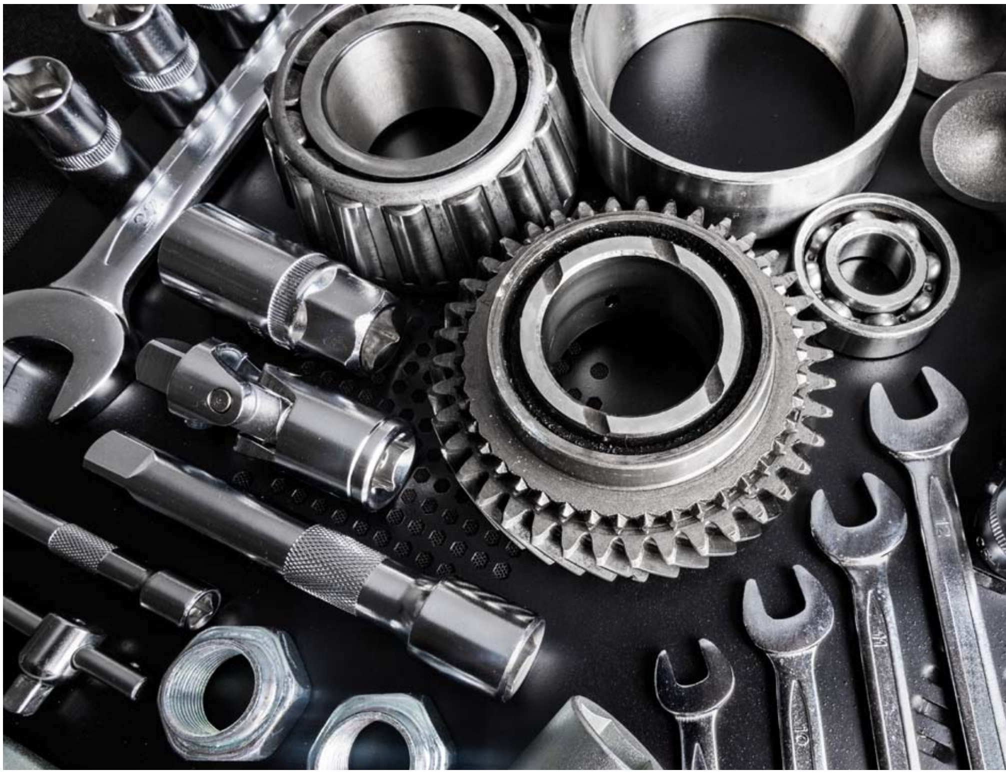
When I started in the fastener industry thirty years ago, our automotive customers were significantly divided in how they approached the platings and coatings used on fasteners. The spectrum ranged on one end from OEMs that had only a handful of choices to the other end of the spectrum where it seemed there was an option for every engineer that had been convinced by a plating chemical supplier that they had the best mousetrap. In the intervening years this has mostly changed, so that today, even though each automotive OEM still has their own set of standards and preferred finishes, the selection has tightened up considerably so that all the OEMS are now doing relatively similar things.

To understand how we have arrived at the place we are today, one has to understand a number of trends and occurrences that have either helped or forced the industry to go in a particular direction. Most of the rest of this article will focus on these discrete events to assist us in understanding the landscape today.



Automotive Platings and Coatings

by Laurence Claus

Cadmium Elimination and Replacement

With respect to automotive this is the oldest occurrence to impact current direction, but still one of the most important. Cadmium, as a plating option, has been around for many years. Cadmium plating has many positive attributes which has made it a favorite among users. Amongst these positive performance attributes is cadmium's lubricity. This advantageous property provides cadmium plated fasteners a natural torque-tension consistency when compared with other platings. It was, therefore, especially favored with an application of wax in automotive thread forming applications.

Unfortunately, its positive attributes were determined to be outweighed by its lurking dangers as a heavy metal that can potentially cause health problems with those who have prolonged exposure. For the most part, the danger lies not in the plated parts but rather from exposure to fumes during the plating process or dust released when tumbled with other parts during assembly or during post plating manufacturing operations. In any case, the automotive community assessed the potential risks as too high and cadmium plated fasteners were banned from U.S. automobiles roughly thirty years ago.

The impact of this decision had several consequences:

1. By eliminating the option of cadmium plating, automotive companies effectively shrank the number of electroplated options considerably.

2. Because of the natural lubrication advantage, the elimination forced the surface finishing industry to find new ways to obtain the same consistency and torque-tension behavior for replacements that they formerly achieved with cadmium. This likely lead to advancement in both integrated and supplemental lubricants benefiting the industry today.

3. It helped accelerate the search for new technology or replacements, such as zinc-nickel or zinc-iron. These finishes very likely would have found a niche regardless of the cadmium situation, but often get picked as the best replacement alternative, so that the elimination of cadmium has accelerated their use and acceptance.

4. It has helped pave the way for other industries that have become motivated to also eliminate cadmium plated parts further reducing the industry capacity and leading to accelerating the growth of alternatives.

Elimination of Hexavalent Chromium

In 1997 the European Union passed a Directive (their form of a law) on End of Life Vehicles. This was a set of regulations dealing with what happens to a car at the end of its life. In other words, how that car can be recycled. This Directive basically says that a vehicle cannot be recycled properly if there are hazardous components that make up part of the automobile. It, therefore, mandated that such hazardous constituents be removed within a certain sunset period.

One of the constituents on the list of "bad actors" is a material known as hexavalent chromium. If one goes back to their early chemistry lessons, they may recall studying atoms and mapping out how atoms might lose or gain electrons to form what the scientists call ions. One may further recall that many elements can take several different forms of ions. This is the case with chromium. It can form either a Cr6+, hexavalent chromium, or a Cr3+, trivalent chromium, ion. Although there is currently debate whether either of these ion states is environmentally acceptable, it is universally agreed that, for sure, the hexavalent chromium state is not. Therefore, to meet the mandate of this directive it would be necessary to eliminate hexavalent chromium from any part or assembly that included it.

This was very bad news to the surface finishing industry and, by default, all upstream industries that utilized surface finishing, because hexavalent chromium was used everywhere. This would be especially difficult to electroplaters who depended on the post electroplating process of chromating to improve corrosion resistance. Although the electroplaters were in a bind because almost all, if not all, electroplated parts were chromated after plating, many other coatings and paints also depended on hexavalent chromium.

Although this was a Directive of the European Union, so in theory only applicable to EU countries, in reality it impacted the entire world, as no one wanted to lose the opportunity to supply the lucrative European automobile industry with cars or parts. Therefore, starting in about 2000 and effectively ending in 2007, a wholesale and global effort to remove hexavalent chromium containing compounds from automobiles was undertaken.

In a striking example of cooperation and necessity the surface finishing and automotive industry effectively succeeded in accomplishing what they started. However, it was not without significant consequences. To eliminate the hexavalent chromium, the chemical companies that develop these plating and coating systems had to either completely eliminate all chromium containing compounds or replace hexavalent chromium with lesser performing trivalent chromium compounds. Hexavalent chromium is a high performer, so that taking it out or replacing it with a lesser performing substitute resulted in a drop in performance. This lead to all sorts of initial complications, several of which the surface finish industry is still trying to fully resolve.

The impact this has made has resulted in the following consequences:

1. Passivation using chromium containing compounds is performed to improve corrosion protection. Trivalent Chromium does not do this as effectively as Hexavalent Chromium. Therefore, to compensate, electroplated parts now have thicker base metal deposits and the passivation process using trivalent chromates is almost always now followed with an application of an organic or inorganic sealer.

2. The hexavalent chromium systems provide a variety of natural color options, including clear (silver or sometimes called blue), yellow, gold, brown, olive drab, and black. Generally speaking, however, trivalent chromium systems do not provide the same variety of options. In fact, in many cases, to achieve some of the legacy colors, dyes have to be used. These generally do not provide the same richness, hue, and durability as those naturally developed by the hexavalent chromium processes.

3. With respect to coatings that do not rely on a chromate conversion for improved performance, it has forced the industry to develop chrome-free options. Most such dip-spin applied, sacrificial or barrier, metal flake coatings are today entirely chrome free.

Increase in Performance

During the same period of time that changes were being made regarding hexavalent chromium, the automotive industry was pushing for better performance. In this case, better performance was defined as increasing corrosion protection and providing better torque-tension consistency. This was fueled by needs in the automotive industry for improved vehicle durability and longevity. However, the elimination of hexavalent chromium set these initiatives backwards and introduced new hurdles and challenges for the surface finishing industry and the user community.

These trends have contributed to a number of changes:

1. On electroplated parts it has resulted in a couple of trends; **a.** Plating systems have changed to include thicker metal base coats, trivalent chromates, and sealer topcoats. The thicker base coat and sealer are the effective constituents to increase the corrosion protection. **b.** The trend to replace simple zinc electroplating with the better performing zinc alloy platings, particularly zinc nickel.

2. This has also driven more significant use of the metal flake, dip-spin applied coatings. These coatings are highly customizable and can be applied to provide moderate to exemplary corrosion protection, improved torque-tension behavior, and overall better appearance.

These three happenings have shaped the automotive fastener industry as it is today. As mentioned at the outset of this article, when I started in the industry a little over thirty years ago, each automotive OEM had a long list of finishes they relied on. Often times, the choice was driven by a release engineer who had worked with a chemical supplier or applicator, and not given much thought to whether the choice fit an integrated company strategy or not. It also often failed to place checks and balances on options that were not readily available or lacking in sufficient industry capacity. Today, the automotive OEMS have all but eliminated these practices and platings and coatings can only be chosen off an approved list. As such, the number of platings and coatings utilized has consolidated to a narrow list of zinc electroplating, zinc alloy electroplating, zinc flake dip-spin coatings, and zinc phosphate. Naturally there are other options that get used on a specialized basis, such as manganese phosphate, aluminum ceramic, tin electroplating, and electroless nickel to name a few, but these are more the exception than the rule.

This shorter list of finishes is expected to perform better than the platings and coatings from years past. They are expected to possess exemplary corrosion resistance, torque-tension consistency, adhesion, and appearance. They are expected to be delivered at fair prices and processed in a manner that reduces certain fastener specific risks such as hydrogen embrittlement, recess fill, and thread gaugablity.

In summary, plating and coatings for fasteners has made significant advancements in the last thirty years. They have gotten better and more dependable and the list of options has consolidated down enough to make supply easier, faster, and relatively interchangeable between automotive OEMs. All of these are positive trends because they improve the quality and durability of the end product. ■