Electroplating of Plastics

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Summary

Background

Use of Plastics

Since the end of the Second World War the use of plastics has increased remarkably due to a systematic exploitation of their principal advantages, i.e. lightness, flexibility and toughness, ease of fabrication of complex components, and excellent surface quality as fabricated. This has led, in a very wide range of applications, to the replacement of metals with plastics as materials of construction.

Advantage of Metals in the Automotive Industry

One property of metal articles that cannot be matched by plastics is the inherent ability to be polished to a bright, reflective metallic finish. This proved to be a disadvantage when, in the early 1960s, the motor industry was looking to replace metal with plastics for the manufacture of exterior and interior bright trim. At that time, trim components were normally finished in bright electroplated nickel/chromium generally known, both then and now, as chrome plating, which provided the required high quality lustrous finish. If plastics were to be used as a replacement, some method was therefore required of providing a similar surface appearance.

Alternatives to Chrome Plating

A number of alternative ways of providing this type of finish were investigated. However, it was soon established that only electroplated nickel/chromium would give the necessary quality that was related not only to aesthetic appeal but also to other properties of this particular coating system - good resistance to corrosion, good resistance to abrasion, and ease of cleaning. The surface coatings industry was faced with the problem of producing this durable, attractive metallic coating on plastics components, thereby combining the advantageous properties of the substrate with those of the coating system.

Electroplating of Plastics

The Problem

The basic problem in attempting to electroplate onto plastics substrates is, of course, that they are electrically non-conductive and cannot be immersed in a plating solution and coated in the way that metal objects can. Some method was therefore needed whereby a conductive film could be deposited onto the plastics surface to provide the

basis for subsequent electrodeposition. It was, of course, vital that this surface layer, in addition to being electrically conductive, should adhere well to the substrate if the final coating system was to show good adhesion.

Substrate Etching

Early processes, using conductive paint or chemically reduced silver on surfaces roughened either mechanically or by solvent attack, did not provide adequate adhesion. In the mid 1960s, etching solutions based on chromic acid were developed which could successfully be used with acrylonitrile butadiene styrene (ABS) copolymer. Use of these solutions resulted in selective removal of the butadiene phase from the resin to give a micro-etched surface providing bonding to the subsequent conductive layer.

Electroless Plating

This development came at a time when great improvements were also being made in the technology of electroless nickel and electroless copper deposition. These advances in electroless plating combined with the development of the etching technique gave rise to a system that provided a highly conductive coating exhibiting satisfactory adhesion to the plastics surface.

The Plating Process

Current plating-on-plastics processes still employ the basic technology developed at that time, although inevitably many refinements and improvements have been. The basic steps are as follows:

• Etch in chromic acid based solution to promote adhesion

• Neutralise excess chromic acid

• Activate the plastics surface with a solution containing tin and palladium salts. This deposits nuclei of palladium metal on the plastics that catalyse nickel or copper growth from the subsequent electroless processes.

• Coat the surface with either nickel or copper (nickel is now generally the preferred commercial process) from an electroless plating solution.

Once the plastics component has been coated with this electrically conductive and

adherent surface layer it can subsequently be electroplated using conventional technology.

The electrodeposited coating system used on plastics substrates always consists of an initial thick copper layer. This has been found to be necessary to compensate for the difference in thermal expansion between the metal coating and the plastics substrate.

In the early days copper was normally followed by a relatively thin bright nickel layer with conventional chromium topcoat. At that time it was considered that only thin nickel deposits were required since the plastics substrate would not be subject to corrosion in the way that metals are. However, it was subsequently shown that the thickness of nickel required on plastics substrates is similar to that necessary on metallic ones to prevent corrosion of the thick copper undercoat.

Developments in Electroplating of Plastics

In addition to this, there have also been two very significant developments in nickel/chromium electroplating technology that have ultimately greatly improved the quality of electroplated plastics.

• Double layer nickel systems consisting of a semi-bright under layer with bright nickel topcoat - have been developed which give much improved corrosion resistance compared to single layer bright nickel coatings of the same total thickness.

• It has also become widely accepted that microdiscontinuous chromium systems, where the chromium layer exhibits either an extensive microcracked structure or is microporous, further increase corrosion resistance of nickel/chromium deposits.

Modern specifications for electroplated plastics that are to be employed in severe environments (e.g. external automotive applications) all call for the use of double layer nickel together with microdiscontinuous chromium.

Resins For Electroplating

Although a wide range of plastics resins can be electroplated the market has always been dominated by acrylonitrile butadiene styrene (ABS). This has been estimated to account for 90% of the material currently used in this application worldwide. Polypropylene has been used, mainly for applications where its low water absorption is important, but has generally proved more difficult than ABS to electroplate reliably and

its consumption has not grown significantly.

The plastics industry has recently introduced a range of new materials consisting of blends of ABS with polycarbonate.

Typically these contain 40-60% ABS with 60-40% polycarbonate, although a wider range of compositions can be used depending on the application. These blends not only have a higher inherent mechanical strength than unmodified ABS, but also show superior ductility in the as-plated condition. This is a most important property, particularly for the automotive industry, since it can provide a degree of recovery from impact. This may allow use of plated plastics for vehicle bumpers bars.

Other resins used for plating include nylon, modified polyesters, polysulphones, polyimides and polyetherimides, although the quantities are small compared to ABS. Particular interest is currently being shown in resins which are capable of being heated to higher temperatures than ABS in the as-plated state, such as rubber modified maleic anhydride copolymers. These would allow coloured, abrasion resistant lacquer finishes which require high curing temperatures to be applied on top of bright nickel as an alternative to chromium, thereby increasing the appearance options.

Applications of Electroplated Plastics

The Automotive Industry

The initial motivation for the development of processes for electroplating on to plastics came from the automotive industry and this market sector has consistently been by far the largest user of the product.

Once a successful process had been developed it rapidly became accepted by the industry, and by the early 1970s large areas of nickel/chromium plated plastics trim were appearing on vehicles. A whole range of components were produced in plated plastics, including radiator grilles, window trim, name badges, front/rear lamp units, mirror housings, interior trim, and auxiliary lamp units. This trend was particularly evident with vehicles manufactured in North America, where bright trim has always been more popular than in Europe.

The use of plated plastics in the car industry reached a peak in the late 1970s and early 1980s. After that time the use of all types of bright trim declined as the design of cars changed in order to achieve a more aerodynamic profile to improve fuel consumption.

This was particularly evident with European cars where nickel/chromium exterior trim was almost completely eliminated except on luxury models.

This eventually produced a generation of cars that were very similar in appearance. So by the early 1990s designers were seeking ways of creating a degree of visual individuality and of restoring marque identity. It is perhaps ironic that one of the most effective ways in which this has been achieved has been by restoring bright trim, albeit within the constraints of good aerodynamic shape. This has been used particularly in high profile areas of the vehicle such as the radiator grille.

This resurgence of application in the motor industry has produced a remarkable expansion of the plating on plastics industry over the last three to four years. It is estimated that in Europe as a whole the industry has grown by 50% since 1993, whilst in the UK in particular the increase has been even more dramatic, producing a doubling of capacity over that period.

Domestic Fittings

After the automotive market, the next most important application for plated plastics is for domestic fittings where the hygienic qualities of the finish and ease with which it can be kept clean are important factors. Items commonly produced in plated plastics include bath and wash basin taps, sink wastes, shower fittings, bathroom accessories, and kitchen accessories.

Other significant uses include knobs and buttons for the electronics and white goods industry. In France in particular the production of high quality perfume bottle caps in very large numbers represents a very important sector of the market. A new application appearing recently in the UK is for bar fittings and drinks dispenser units.

Summary

The plating-on-plastics industry in both the European and North American markets has been expanding, primarily due to a resurgence of interest in this finish in the automotive industry. Other mainstream applications of the process have retained a firm hold on their market sector and a number of significant new uses have appeared.

Reflecting the current optimism in the industry, recent symposia devoted to decorative electroplating of plastics have attracted enthusiastic support. The recent high rate of growth of plating on plastics is predicted to continue due to an ongoing commitment by

the automotive industry and assisted by further promotional activity.

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