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Applications of thin coatings in automotive industry

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Materials

ABSTRACT

Purpose: Use of thin coatings in automotive industry give economic and ecological savings. This is evoke by reducing of weight of used construction elements and currently by increasing of their service life and with that connected elevating of nanomaterials manufacture qualities.
Design/methodology/approach: In the paper was disscussed the possibility of applications of thin coating in automotive industry.
Findings: The paper shows the examples of thin coatings application in automotive industry.
Practical implications: Through the assimilation, improvement, and generation of new technologies, the coating community, as a major supplier to the very large automotive industry, will continue to thrive, grow, and maintain its environmental stewardship in the global marketplace.
Originality/value: Applications of thin coatings in automotive industry is and with nanotechnology together will be in centre of interest of automotive industry in near future.
Keywords: Metallic alloys; Coatings; Surface properties; Application; Manufacturing

1. Introduction

Automotive industry is divided between the tier one and tier two suppliers. The first tier suppliers provide sub-assemblies to auto manufacturers. Their work is associated with product innovation from research and development and product design. Auto manufacturers often involve first tier suppliers in the initial phases of vehicle development and design. The second tier component firms supply first tier firms with components for their sub-assemblies and provide auto manufacturers with unassembled components.

New performance attributes will be greatly enhanced by sustaining improvements in the structural, electrical, thermal, optical, magnetic and catalytic properties of materials, and their biocompatibility.

Product range in automotive industry covers technologies for the entire spectrum of decorative and functional surface treatment for various materials including steel, aluminum and plating on plastics and all possible applications from engine and power train to electrical devices.

To be successful in a global market, products have to meet the most stringent local rules and regulations with respect to product properties and environmental concerns. This is why the automotive industry belongs to the most demanding customers in the world.

2. Coatings

2.1. Pretreatment

Fundamental to all metal finishing applications is the right substrate surface preparation. With weight savings being an important automotive priority, well proven plating on aluminum/magnesium pretreatments provide the capability to process these light metals with superior decorative and functional finishes.

Whatever the final finish, cleaning is an integral and fundamental start to the success of any Metal Finishing application.

As economical and environmentally friendly technologies for the pretreatment and cleaning of surfaces we can used:

- Al Pretreatment Systems
- Soak Cleaners
- Electrocleaners
- Auto Controllable Liquid Cleaners
- Spray Cleaners
- Long Life and Low Temperature Cleaners
- Phosphating

2.2. Using of coatings

Decorative Coatings

Product range of decorative coatings covers technologies for the entire spectrum of decorative and functional surface treatment for various materials including steel, aluminium and even plastics.

Quality and dependability of brilliant finishes, corrosion-free protection and durability are required – from parts for the automotive, sanitary or electronics industries to jewellery.

At the present time are applications plastics as well as metal, from car wheels to bumpers and door handles to radiator grills.

Decorative coatings can be made from:

- Plating on Plastics
- Copper
- Nickel
- Chrome
- Precious Metals

Plastic and plastic composite materials continue to be popular because of the way they combine the advantages of both worlds. Plastics are light, corrosion-free and can be formed to virtually any shape. Even complex components can be costeffectively produced in volume. A metal surface gives plastics a high quality, decorative appearance. This is why the advantages of plating on plastics are being appreciated in more and more industries.

Non-chrome alternatives for the decorative top-coat application include bright, high speed electroless nickel, electrolytic nickel-tin, cobalt-tin, and white bronze.

Rotogravure (or engraving) is a well-established high quality printing process for constant reproductions of a large number of copies with superb colours and gloss. Rotogravure is the transfer of a design onto the printing image carrier - a copper plated chrome finished steel or aluminum base cylinder. The thin chromium layer is needed to achieve the necessary hardness and resistance to wear for printing. Different sizes of cells with various shape and depth are either chemically etched or more commonly electronically engraved into the surface.

Silver electrolytes has a wide range of applications, suiting both rack and barrel plating, as well as post-treatment processes for excellent anti-tarnish on silver and silver-plated items.

Gold has the unique visual attraction and durability that makes it ideal for a wide range of applications. As gold is also an excellent conductor and almost totally resistant to corrosion and wear, it makes a reliable coating for technical and industrial purposes such as those in the electrical and electronics industry.

Palladium and palladium-nickel coatings are ideal for decorative and technical applications. Palladium coatings have many of the properties of gold coatings but come at a fraction of the price. Pure palladium coatings are used as a diffusion barrier and in cases where a nickel-free coating is required.

The anthracite-colored, highly transparent visual approach of ruthenium creates an outstanding visual effect. Especially in combination with gold or palladium coating, the decorative effects that can be achieved with ruthenium are unsurpassed and offer excellent wear resistance.

The most popular type of decorative copper plating processes is Acid Copper. The high ductility of the acid coppers minimizes thermal expansion and flexing problems. Acid Copper is suitable for applications on zinc, brass, aluminium, bronze, steel, various other metal alloys, ABS, ABS/PC, or most other commonly plated substrates. The ductility of Acid Copper makes it ideal for use on plated plastics to form the layer that absorbs the thermal expansion differential between the plastic and nickel layers. The copper deposit is easily buffed as is often required for intricate cast aluminium parts such as aluminium wheels. Acid Copper is versatile and very easy to operate. It is extremely bright, even in low current density areas, to make finding problems easier. In high current density areas the system is very resistant to burning.

Functional Coatings - Corrosion Resistant

As functional coatings corrosion protection coatings for a global industry with high environmental demands are used.

Corrosion protection coatings concerned:

- Zinc and Zinc Alloy
- Conversion Coatings
- Sealers

Due to the increasing expectations of consumers, the international automotive industry is required to extend vehicle warranties. Thus improvements in corrosion protection are becoming increasingly important. From bright acid zinc baths through environmentally safe cyanide-free alkaline zinc electrolytes to high performance zinc alloy electrolytes and mechanical plating solutions. E.g. zinc-iron and zinc-nickel processes provide superior corrosion resistance even for complex shaped parts through uniform thickness distribution, and these highly bendable layers also allow machining.

Zinc coatings enhance performance and extend component service life through improved corrosion resistance. They enable the bulk properties of construction materials such as steel, to be combined with their beneficial surface properties. Processes for the application of zinc must be commercially viable whilst being environmentally responsible. Improvements in corrosion protection are an important consideration for many of today's industrial applications, where the use of traditional zinc coatings are not possible because of its limited performance capabilities. Zinc alloys provide increased corrosion protection over zinc. The use of alloys has developed because of the need to extend component service life through enhanced coating properties.

In a subsequent treatment, the coatings are chromated or passivated, which protects the zinc from 'white rust' corrosion. In order to stabilise the conversion coating, a sealer is applied as a supplementary treatment.

Conversion coatings are produced onto surfaces by immersion. Traditional chromates based upon hexavalent chromium are available in a variety of colours. Different chromate colours indicate changes in the thickness and composition of the film, which influence the level of corrosion protection that will be achieved.

Clear blue films are generally preferred where a chromium-like finish is desired. Yellow and olive green films are chosen for their superior corrosion protection. Black films are often used to achieve an attractive decorative finish combined with good corrosion protection.

Passivates based upon trivalent chromium are used as an alternative to chromates. The thin film blue passivates offer a pleasing chromiumlike colour with good levels of corrosion protection. The thicker film iridescent passivates produce a thickness similar to yellow chromates and offer higher levels of corrosion protection, particularly after heattreatment.

Fig. 1. Applications examples of thin coatings in automotive industry [5]

Functional Coatings - Wear Resistant

Next application of functional surfaces are applications for superior wear resistance and friction reduction

Automobile components exist in demanding environments where long life requires maximum wear resistance. Hard chromium and electroless nickel coatings to wear performance for automotive applications are delivered.

Wear resistant functional coatings can by made by:

- Hard Chrome
- Electroless Nickel

High efficiency hard chromium process gives piston rings, engine valves and suspension parts excellent wear performance due to its high hardness characteristics and low coefficient of friction. Hard chrome process offers extreme wear resistance, high level of corrosion protection, and the lowest possible chromium coefficient of friction. The required surface properties can be varied over a wide range by controlled changes in electrolytic and deposition parameters.

Scientific tests and commercial experience have demonstrated the superior performance of this process for dry friction, lubricated sliding wear applications as well as suspension system corrosion prevention.

In general hard chrome layers exhibit a high micro-hardness. Matt or satin finish chrome coatings, e.g. hot chrome, typically have micro-hardness values at the lower end of the range. Good resistance against many acidic and alkaline media. This is the basis for the convincing corrosion resistance of the layers and channel systems. The presence of microcracks in hard chrome coatings provide a maximum level of corrosion protection. The network of microcracks also provides other positive surface properties, for example with an improved oil adhesion on hydraulic components.

Electroless nickel plating systems provides ideal wear performance for a variety of applications such as brakes, fuel systems, planetary gears, valve stems and steering components. These processes offer a high level of flexibility to deliver just the right hardness and affinity to lubricants to reduce the wearing of highly mobile parts and to perform optimally as part of the total system of components.

Electroless nickel coatings are resistant to oxidation, chemically insensitive and in certain instances can be made non-magnetic and solderable. These products are not only used to produce wear resistant surfaces for a variety of auto-motive parts, they are also used to enhance tool life and overall quality for automotive manufacturing, especially in processing and stamping plants.

Electroless nickel coatings are highly resistant to corrosion, hard and resistant to wear, resistant to oxidation, chemically insensitive, non-magnetic and solderable.

Functional Electronics Coatings

Production systems and processes of functional electronic coatings are impressed with the specific requirements of automotive electronics. In today's automobiles, trucks and motorcycles electronic components are essential to control its movements and the entire range of chemical, mechanical, and electrical processes involved. These electronic systems ensure safety, provide communication and are imperative for the on-board entertainment. Automotive applications like systems for driver assistance, occupant protection and transmission control are key growth areas in this market. A strong increase of the electronic components' contribution to the total manufacturing expense is forecasted.

Functional coatings meet the specific needs of the automotive industry for high-tech electronics. The whole range includes products and processes for precious and non-precious metal plating as well as for pre-and post-treatment. These do not only comply with the most stringent quality standards, but are also in accordance with modern environmental regulations.

With the growing number of electronically supported functions, vehicles are becoming far more complex. Ensuring the functional reliability of electronic components has always been the major challenge for vehicle developers. From the manufacturing side, the challenge is quality and yield. Meeting the tough requirements of automotive applications in terms of temperature, humidity, endurance (life-cycle) and mechanical shocks calls for highly advanced electronic components.

Because of its thermal and dimensional stability, ceramic substrates are ideally suited for various automotive applications.

Functional electronic coatings concerned:

- High Speed Cu / Ni Plating
- Sn and Sn/Pb Alloys
- Ag and Pd/Ni Alloys
- Au and Au Alloys

3. Application

In an average vehicle, more than 3000 parts are treated with protective and decorative finishes. Many coatings have been around for a long time and still continue to have use and function in the automotive marketplace. To possible places with applications of thin coating in automotive industry belongs brake calipers, fluid delivery tubes, fasteners, tie rod ends, antivibration components, shocks rods, piston rings, engine valves, car door handles, emblems, front grills, plated aluminum wheels, fuel injection housing and other.

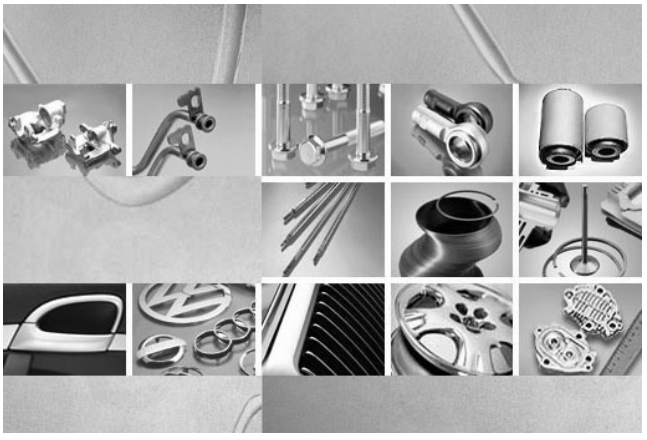


Fig. 2. Applications examples of thin coatings in automotive industry [4]

Brake Calipers

Cast iron brake calipers are a important component within modern braking systems. For improved corrosion protection and enhanced appearance they are electrolytically zinc plated.

Sealers can be used to further increase corrosion protection. For brake fluid compatibility it is necessary to use inorganic based sealers that don't contain any organic lacquers.

Other cast iron applications include steering knuckles, which can be electroplated for enhanced corrosion protection.

Fluid Delivery Tubes

Fluid delivery tubing for automobiles like power steering, air conditioning as well as brake and fuel lines are usually made of low carbon steel and therefore require a corrosion resistant coating.

For productivity reasons, many fluid delivery tubes are processed in straight conditions and are submitted to a post forming process. Therefore a highly ductile coating is needed which preserves its corrosion protective properties even after bending.

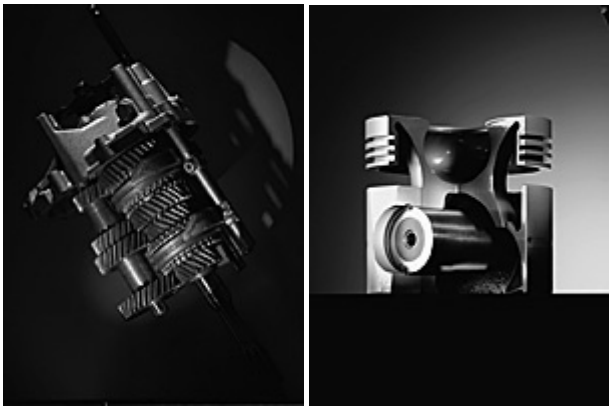
Processing of Fuel Injection Rails (FIR) does not involve the post-bending requirement, but highest standards for absence of particles. To achieve best inner tube corrosion resistance without any risk of particle formation even with alcoholic fuels, the parts can be electroless nickel and followed by alkaline ZnNi plated.

Fasteners

Fasteners - nuts, bolts, screws, washers, etc. this is the stuff that hold things together. The finish of a fastener is critical to its function. Most fasteners are coated to protect against corrosion and to achieve special properties such as controlling the amount of torque required to tighten a threaded fastener.

The automotive industry is the single largest fastener consumer of any industry, using 26 billion parts annually out of the 200 billion produced, or approximately 42% of the industry. This consumption makes the automotive industry a powerful player and trendsetter in the fastener industry. Because fasteners are used on all parts of vehicles, each part requires different tolerances. The auto industry's requirement to fulfill government regulations impacts the mix of products available to fastener manufacturers and finishers. However, the auto makers still demand the same, or greater quality standards to be achieved in part performance, challenging finish makers to come up with better alternatives.

With increasing demands for higher corrosion protection the use of ZnNi on fasteners is steadily increasing.



Figs. 3, 4. Applications examples of thin coatings in automotive industry [5]

Tie Rod Ends

Tie rod ends are typically plated after the rubber coating was applied. Thus the temperature in the plating process has to be limited to 80 °C.

Antivibration Components

A large number of antivibration components such as suspension bushes or engines mounts are used within a vehicle. Different surface finishes are applied depending on type and requirements.

Antivibration components are coated by:

- Phosphating
- Plating before/after Vulcanization

Traditionally those parts receive a zinc phosphate coating for corrosion protection and good rubber-to-steel bonding.

With the growing requirements towards corrosion protection an increasing share of antivibration components is being plated with zinc-nickel. The main challenge of this application is to plate on parts that consist of rubber and steel.

Two methods exist:

- Plating before Vulcanization - companies decide for plating before vulcanization to avoid contamination of the plating bath and full coverage of crevice area around the rubber, no sealer can be used, as the heat treatment for vulcanization would destroy it, proper adhesion of the rubber on the plated layer is critical.
- Plating after Vulcanization - the plating of already vulcanized parts allows the use of a sealer for improved corrosion protection, temperatures in the plating process are kept below 80 °C to avoid attack to the rubber.

Shocks Rods

Piston Rods used for shock absorbers, strut rods and gas springs need a hard chromium plated surface to provide excellent wear and corrosion resistance as well as a low coefficient of friction. Without this coating the service life for these components would be very short. The components are placed on vehicles at locations where they are subject to considerable environmental impacts such as corrosive salt-water solutions from de-icing of road surfaces and from stones hitting against them from the road.

Piston Rings

Piston rings provide a seal between the engine piston and the cylinder wall. Since the advent of hard chromium plating on these components the service life of the rings has been dramatically improved. Hard chromium provides excellent wear resistance and low coefficient of friction that is especially important in engine applications.

Engine Valves

Engine valve systems are hard chromium plated to provide excellent wear and a low coefficient of friction. The need to replace these components has been greatly reduced since the advent of this kind of surface coating.

Car Door Handles

The automotive industry demands ever reduced weight and resulting fuel savings, which is an important aspect in car manufacturing. By combining comparably low weight and production expenses of plastic parts with perfect metallic appearance, plating on plastics (POP) is the ideal solution. Most of modern car door handles are made of plated plastic today.

Emblems

Today, nearly all OEM emblems are made of plated ABS or ABS/PC blends. To apply a corrosion resistant and decorative metallic coating onto the piece of plastic, several steps are necessary.

Front Grills

Most of modern car front grills today are made of plated plastic, mostly ABS polymers. To convert this piece of plastic into a functional and decorative grill, several steps are necessary.

Plated Aluminum Wheels

Worldwide, almost 50% of new cars are fitted with cast aluminum wheels. While the standard finish is likely to be paint or powder coating, there is an increasing demand for the bright nickel/chromium plated finish.

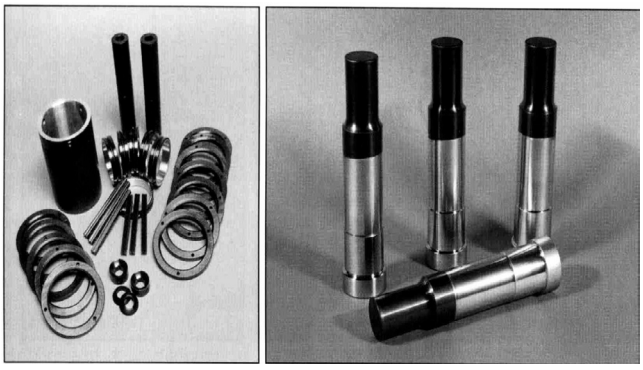


Fig. 5. Applications examples of thin coatings in automotive industry [2]

Fuel Injection Housing

Injection pumps used in diesel engines are mostly made of cast aluminum plated with an electroless nickel coating. The pumps are driven indirectly by gears or chains from the crankshaft and operate at very high pressures. Electroless nickel coatings are used when you need a excellent corrosion and wear protection. In addition, electroless nickel deposits a uniform thickness over the entire part without the need for expensive anode fixturing.

Diesel cylinder liners are hard chromium plated to provide excellent wear resistance and a low coefficient of friction. The need to replace these components has been greatly reduced since the advent of this surface coating.

4. Conclusions

Applications of thin coatings is perspective branch, while automotive industry is always hungry for new observations.

These areas will be in centre of interest of automotive industry in near future.

Through the assimilation, improvement, and generation of new technologies, the coating community, as a major supplier to the very large automotive industry, will continue to thrive, grow, and maintain its environmental stewardship in the global marketplace.

Acknowledgements

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