CHAPTER 38

EVALUATION OF THE INDUSTRIAL APPLICATIONS OF GALVANIZED COATING

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Introduction

Thin layers of metal are called metal coatings, and they are usually placed to the surface of another material for functional, ornamental, or protective reasons. They are employed in many different sectors, including electronics, medical devices, aerospace, and automobiles. Applying a thin layer of metal on the surface of another material is known as metal coating. This can be done for a number of purposes, including giving the underlying material a cosmetic surface, improving its electrical conductivity, or shielding it from corrosion.

A metallic coating is made up of a layer of corrosion-resistant protection that, by altering the surface characteristics of the material, can shield it from harsh external elements. Applications of metallic coatings on a surface include a variety of techniques.

Coatings made of a metallic element or metal alloy that are sprayed to surfaces chemically, electrochemically, or mechanically using a sprayer are referred to as protective metallic coatings. Such coatings are frequently used on equipment that has to be protected against sunlight, oxidation, and corrosion while yet having a glossy or shining look. Depending on the material being coated and the required qualities of the coating, different metal coating techniques will be employed for different applications.

The damage that metals sustain from chemical or electrochemical reactions with their surroundings is known as corrosion. The bulk of the material is lost as a result of metal corrosion. The physical and mechanical qualities of the material deteriorate as a result. Coating procedures offer financial advantages while safeguarding the chemical and physical characteristics of materials. Because iron and steel make up the majority of materials used in modern industry, the words corrosion and coating are crucial for steel. Corrosion is a key subject in these metals since iron and steel make up around 90% of the metallic materials utilized in industry today. The technique of applying zinc coating to iron and steel components derived from iron is known as galvanized coating. It is a part of industrial metal coating processes. Other than paint, it is the protective coating that is applied to ferrous metals the most. It is vital to decrease the coating's thickness in order to enhance its quality. As a result, expenses will go down.

A successful hot dip galvanizing process depends on a number of variables, including the angle at which the materials are immersed and removed from the zinc bath, the speed at which they are removed, the impact of using chemical solutions to clean the surfaces (acid-flux baths), and whether the materials are dried or wet after the flux bath. The zinc pool's temperature, the materials' surface

roughness, and the duration of the materials' immersion in the zinc pool. The process variables influencing hot dip galvanized coating were reviewed in this review research using data from the literature.

Metallic Coatings

Structure metals are kept apart from corrosive environments by applying metal coatings. One can categorize these metal coatings. Coatings made of metals like copper, nickel, and chromium are classified as more noble than the substrate. Since these coatings divide into two groups at holes those that are more noble and active than the base metal the protection provided by them is totally dependent on their continuity. Zinc, aluminum, and, to a lesser extent, cadmium coatings are among the first group of materials that protect steel. The metal is provided with cathodic protection by these coatings, which function as sacrificial anodes at discontinuities. Because accelerated corrosion of the base metal typically occurs at gaps in such coatings, the protection provided by them depends solely on their continuity. Despite the hazards, these coatings are utilized in numerous applications because they give unique qualities as hardness, shine, and electrical conductivity (J. Yahalom, 2001).

Steel surfaces can be coated with metal using one of four popular techniques. These include sherardizing, electroplating, thermal spraying, and hot-dip galvanizing. The last two procedures are utilized for fittings, fasteners, and other tiny components but not for substantial steelwork The level of corrosion protection provided by metallic coatings is mostly determined by the kind and thickness of the coated metal, with application technique having minimal effect.

The two other processes, hot dip galvanization and electro galvanization, are the most significant (Demirel T., 2023).

Hot-dip Galvanizing Method

Pickling and fluxing the steel component to be coated are steps in the hot-dip galvanizing process. The steel component is then submerged in a bath of molten zinc (at around 450°C) and removed. Bolt samples with a zinc plating, Figure 1 (neicorporation.com). Zinc alloy and zinc layers that adhere to the substrate by metallurgical bonding are evenly applied to the submerged surfaces. When applied to tiny damaged regions where the steel substrate is visible, the resultant coating offers cathodic (sacrificial) protection and is robust, long-lasting, and abrasion-resistant. A crystalline metallic luster known as "spagling" is typically observed when the zinc solidifies.

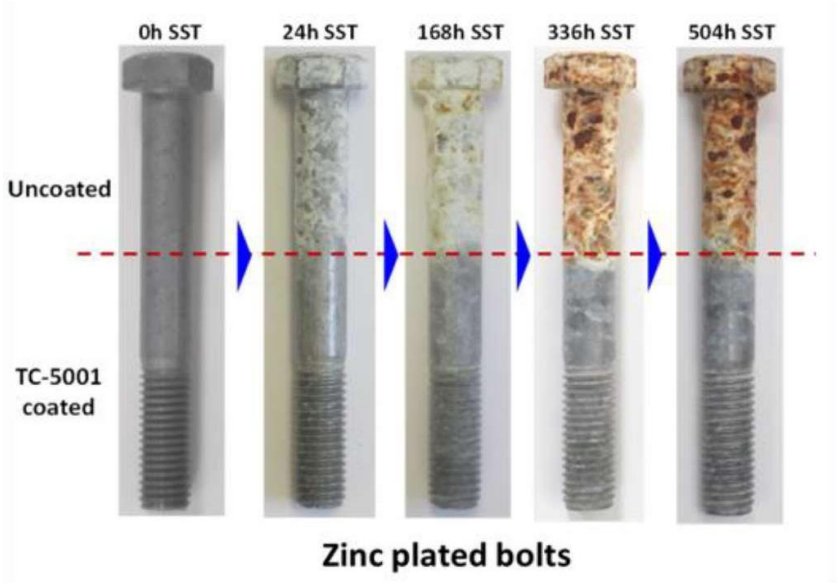


Figure 1. Zinc plated bolt samples, (neicorporation.com).

The size, thickness, and chemical makeup of the steel workpiece, as well as the way the steel surface is prepared, all have an impact on the thickness of the galvanized coating. For structural steelwork, 85 µm is the usual minimum average coating thickness. Coatings up to 140 µm in thickness are often produced by thick steel components and steels that have undergone abrasive blast cleaning. Naturally, there are size restrictions on the components that may be galvanized because hot-dip galvanizing involves dipping. When the workpiece's length or breadth is more than the bath's capacity, "double-dipping" is frequently an effective technique. With a maximum double-dip size of 28 meters and a maximum lift weight of 16 tonnes, the longest tank in use today is 21 meters.

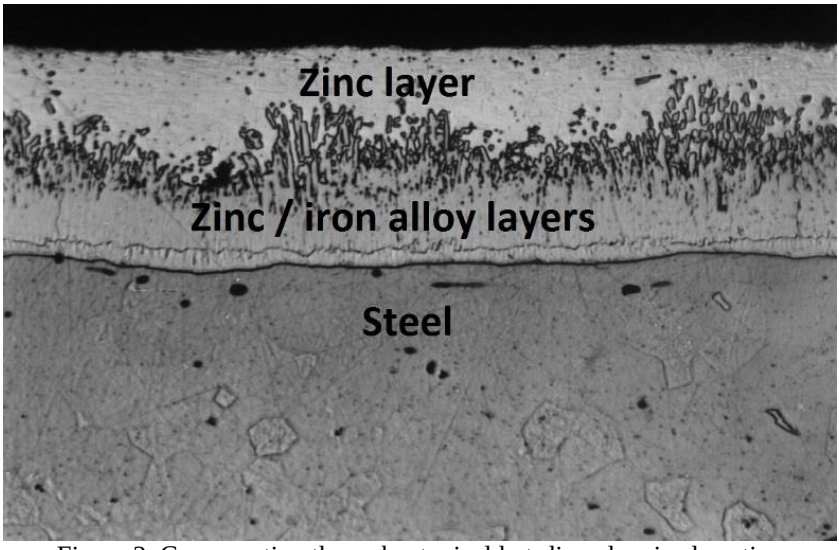


Figure 2. Cross-section through a typical hot-dip galvanized coating (steelconstruction.info).

The ease of filling, venting, and draining as well as the possibility of deformation are some of the characteristics of the design of structural steel components that require consideration related to the galvanizing process. Enough holes must be made in the hollow to let the molten zinc flow through, release hot gasses, and then drain the zinc in order to get an acceptable coating. BS EN ISO 14713-1 offers more specifications for the design of items intended for hot-dip galvanization.

Consideration should also be given to whether steels are suitable for hot-dip galvanizing. The material standards should be used to specify the precise possibilities for structural steel that is to be hot-dip galvanized (Manual of Contract Documents, 2014). Steel is totally submerged in a bath (kettle) of molten zinc during the process' "galvanizing" phase.

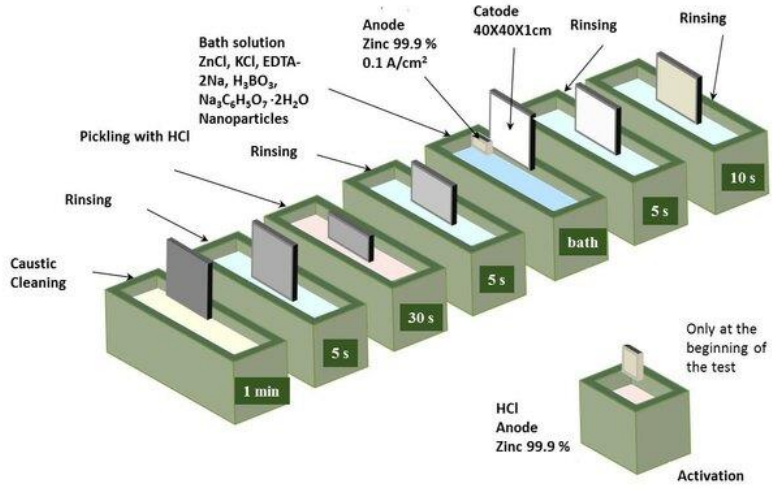


Figure 3. Method of electrogalvanizing used to create composite coatings using nanoparticles (J. A. Cabral-Miramontes, et al., 2019).

A minimum of 98% pure zinc and a temperature of around 840 F (449 oC) are required for the bath chemistry, per the specification. Crane hoists are used to lower the steel at an angle. In addition to allowing the molten zinc to displace the air, this also lets air to escape from any pockets or tubular forms that may be included in the design of a produced object. Zinc and iron in the steel combine in the kettle to create a sequence of layers of zinc-iron intermetallic alloy. The items are carefully taken out of the galvanizing bath after the manufactured item has reached bath temperature, marking the end of the coating growth process. Draining, vibrating, and/or centrifuging are methods used to remove excess zinc. As long as the item stays close to bath temperature after being removed from the water, the metallurgical reaction will continue. Items can be cooled by being submerged in water or a passivation solution, or they can be kept outside (steelconstruction.info). Hot-dip galvanizing is often utilized in applications without further protection. Paint coats are used, however, to add further durability or when

aesthetics is required. The term "duplex" coating is typically used to describe paint coats combined with metal. To guarantee effective adherence, certain surface preparation procedures must be done before painting galvanized coatings. These include using specialized etch primers or "T" wash, which is an acidified solution, to roughen the surface and create a mechanical key.



Figure 4. Some examples of galvanized parts, (lzhuiding.en.made-inchina.com).

Electrogalvanizing Method

Applying an electroplating layer of zinc to steel is known as electrolytic galvanization. The steel, which serves as the cathode, and an inert anode are immersed in an aqueous solution that has dissolved zinc salts in it to undergo this process.

A zinc metal coating is applied to a steel surface using the electroplating method known as electrogalvanizing. To create an electrochemical reaction on top of the steel, a steel component is submerged in a solution containing zinc salts and then electricity is applied. Electrogalvanizing offers a thinner layer and a more aesthetically pleasing finish than hot dip galvanization. Due to iron's oxidation upon exposure to oxygen, bare steel surfaces are vulnerable to corrosion.

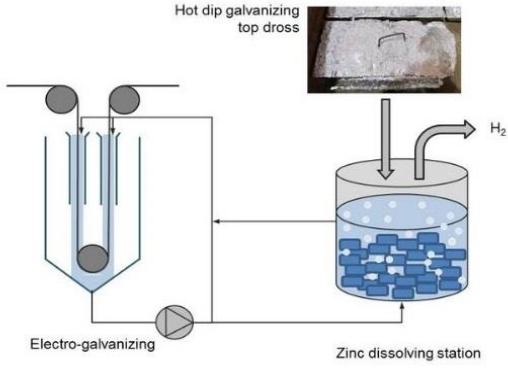


Figure 5. Application of the electrogalvanization method, (waykenrm.com).

Electroplating is the process known as electro galvanizing. Using this method, you may coat steel items with a coating of zinc that acts as protection. It is required that you use a solution that contains zinc solution. Electric power should be applied to the zinc solution while the steel items are submerged in it.A reaction occurs in the zinc solution when electricity flows through it. We refer to the process as electrochemical.During theelectrochemical process and deposit as a layer on the steel surface. Experts typically draw comparisons between the hot-dip and electrogalvanization processes. A thin, consistent layer of zinc is applied to the surface of the steel components using electro galvanization. The coating formed during the hot-dip procedure is thick yet uneven. Consider for the electro galvanization procedure over the hot-dip approach

if you want the layer to have the highest level of aesthetic quality. In fact, the lifespan of electro-galvanizing is rather short, lasting anything from a few months until a few years. Nevertheless, the typical lifespan of galvanized steel is 20 to 50 years. On the other hand, electro galvanization results in a superior finish. However, the finish of the galvanized steel is disagreeable and drab (linkedin.com/pulse/galvanized).

Electrogalvanizing Applications: A Versatile Coating for Diverse Needs

An extensive range of products and industries use electrogalvanizing because of the delicate, silky, and corrosion-resistant zinc coating. Listed below are a few well-known instances: The Automobile Industry Car bodies are protected from rust and have a longer lifespan because to zinc's resistance to corrosion in body panels. Fasteners: Electrogalvanizing provides wear and tear resistance for screws, nuts, and other tiny components. Parts related to brakes: An electrogalvanized coating gives brake callipers and other important components increased toughness and resistance to corrosion. Engineering Industry: Steel Frames: Electrogalvanized steel frames' ability to avoid corrosion enhances a building's structural stability. Fencing: Electrogalvanized fences look better for longer and can survive severe weather. Roofing: Watertightness and corrosion resistance are guaranteed by electrogalvanized steel roofing sheets. Washing machines are among the household appliances where electrogalvanizing protects internal parts like tubs and drums against corrosion and water damage. Dishwashers: The sturdy electrogalvanized coating on racks and other elements is unaffected by the rigorous cleaning conditions inside dishwashers. Refrigerators: The anti-corrosion qualities of electrogalvanizing protect cabinets, cooler drawers, and other refrigerator components.

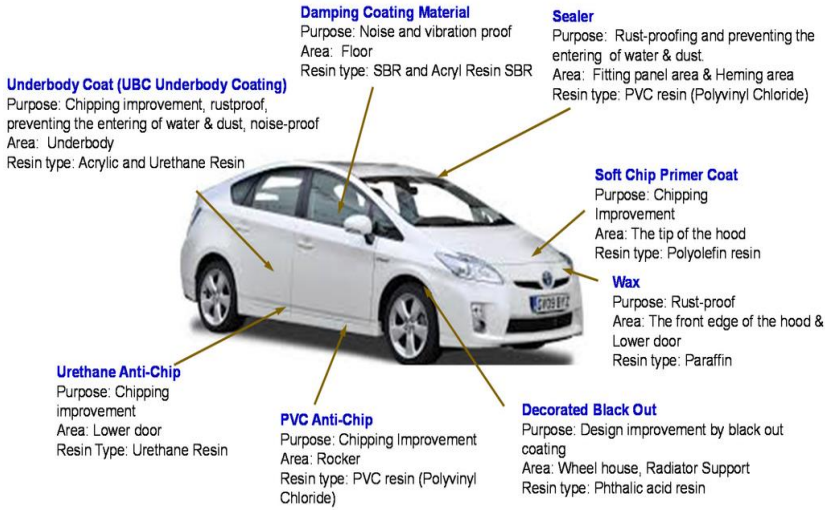


Figure 6. Application of the electrogalvanization method to automobiles (Akafuah NK., et al., 2016).

Electrical Parts: These are Wires and Cables: The plating of zinc prevents corrosion on electrical wires and cables, guaranteeing a secure and effective electrical flow. Electrical conduits are protected against corrosion and environmental damage by the electrogalvanizing coating.

The uses of electrogalvanizing go beyond these and include a number of different industries, such as: Upholstery: An electrogalvanized finish provides long-lasting protection for furniture with metal frames and parts. Equipment for Agriculture: The resistant to corrosion of electrogalvanizing protects farm machinery and implements from the weather. nautical hardware is protected from seawater corrosion by an electrogalvanized coating on boat fittings and other nautical components. According to (D.Deacon et al. (2012), electrogalvanizing is a vital tool that is applicable to a wide range of sectors. It imparts protection and lifespan to several items that we come into contact with on a daily basis.

Conclusion

In summary, there are many uses for metal coating, making it a useful industrial process. The intended qualities and application will determine the coating method and material to use. The performance and utility of metals may be enhanced via the development of novel materials and processes, which makes metal coatings a significant subject for research and development. Enhancing the characteristics of metals for a range of uses is known as metal coating, a diverse and crucial industrial procedure. A metal's resistance to corrosion, wear,

conductivity, appearance, and other qualities can all be enhanced by it. Many methods exist for coating metal, and each has benefits and drawbacks of its own. The substrate material, coating material, intended qualities, and other variables all influence the process selection. There are several industrial uses for metal coatings. Among the most popular applications are: Preventing metals from coming into touch with the environment is one way that metal coatings may be utilized to protect metals against corrosion. For instance, steel is frequently coated with zinc to stop it from rusting. Enhancing electrical conductivity: A substrate's electrical conductivity can be increased by applying metal coatings. To increase the conductivity of printed circuit boards, for instance, copper is frequently used. Giving a decorative finish: A substrate can be given a beautiful finish by the application of metal coatings. To give jewelry an opulent appearance, for instance, gold is frequently applied to it.

In summary, there are many uses for metal coating, making it an adaptable process. Numerous current technologies depend on metal coatings, which have a vast array of industrial uses.

Acknowledge

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