Hot Dip galvanization

Prepared by

Jabar Othman Aziz

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Index

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Introduction

Huge economic challenges in the 21st century have brought great needs to utilize available limited resources in the most efficient and effective ways. The impacts of globalization, currency devaluation, inflation, environmental concerns as well as massive natural disasters are changing governance at all levels.

Technological advances have enabled new ways of deploying services in timely and cost effective means. It has become very clear that governance must be very strategic and the capacity to adopt technologies that would save cost especially in the long term is vital. Innovative technological applications drive efficiency, productivity and aid to enhance the quality of lives of citizens.

This technology should be durable, environmentally friendly as well as cost competitive. Over the years, many governments have made decisions to build and expand their infrastructures in order to be competitive in tourism, transportation and other key areas of the economy. Regrettably, governments have been slow to implement techniques to protect these facilities from corrosion.

As governments continue to focus on expanding militaries and managing political systems, budgetary allocations for expanding national infrastructures like bridges, dams, airports are expected to decrease despite increased levels of operations. To ensure that these facilities operate at optimal levels since building new ones are not immediate, efforts should be geared to preserve them using the most efficient corrosion protection method.

Corrosion causes both economic and environmental problems and adequate techniques should be used to control it in facilities to ensure maximal service to the citizens. Adopting the right technological solution to the hazards of corrosion will arguably extend the usefulness of these facilities as well as help the state to save money in the long run.

Presently, commonly used public corrosion protection techniques are painting and plating. These techniques though partially effective are not state of the art. They fail to deliver long-term benefits, which taxpayers expect from their taxes. As an engineering student that has studied the effects of corrosion and how to minimize their impacts, I wish to suggest hot-dip galvanizing corrosion protection method as a technique of choice.

This method of corrosion protection is a method where a metal is used to "bath" the one that is being protected to form a bonded structure that prevents rust. It is a form of "chemical mechanical bathing" of the metal that enables the formation of metallic oxides that prevent corrosion. This corrosion protection technique has been proven to be reliable, cheap, and durable with less harm to the environment. The process of galvanizing (bathing a metal with metal to form oxides resistant to corrosion) from which hot dip galvanizing is made has existed for more than 250 years and has been a mainstay of the industry since the early 20th century. It is used in different manufacturing processes to produce steel with unmatched *protection from the ravages of corrosion. From roofing nails to highway guardrail, to Brooklyn Bridges suspension and to NASA's launch pad sound suppression systems, galvanizing has provided means to protect materials from corrosion successfully.*

What is Corrosion and how to stop it?

Most people have seen the end results of corrosion on a number of appliances, vehicles, and other items that included metal components. But what is corrosion and how does it develop? Here are the basics of how corrosion begins and what can be done to prevent corrosion from ruining valuable items.

Corrosion is a process that takes place when essential properties within a given material begin to deteriorate, after exposure to elements that recur within the environment. Most often, this deterioration is noticed in metals and referred to as rust. What happens in this case is the chemical reactions that are set up by an exposure of the electrons in the metal to the presence of water and oxygen. As an example, a tin roof is exposed to the wind and the rain.

Over time, the basic workings of that exposure will allow the creation of acids that begin to alter the surface of the tin. The top layer becomes encrusted with corrosion in the form of a red-brown substance that lacks the cohesive nature of the tin. Continued development of the corrosion will eventually weaken the entire roof and the tin will eventually become so weak that it will no longer provide adequate protection as a roof material.

As a specially coated type of steel, galvanized metal enjoys a great reputation as being an ideal building product to use for any type of structure that is expected to stand for many years. Here are some basics about how galvanized steel is created, as well as how it can be used in various building projects.

Galvanized metal is simply steel in some form that has received a thin coating of zinc oxide. The purpose of the zinc is to protect the steel from elements that normally would lead to oxidation, corrosion and the eventual weakening of the steel. In this sense, the zinc coating *acts as what is called a sacrificial anode. In other words, the zinc will protect the steel from corrosion by acting as a barrier between the steel and the corrosive agent, at least until the zinc coating has been completely oxidized. Galvanized metal can be made into supports, girders and even into sheets of metal that can be used in all sorts of construction and building projects.*

Galvanized metal is often used in the construction of warships, such as carriers and submarines. The water and salt repellent qualities of the galvanized steel with its solid zinc coating make it the ideal material to use for hulls. When combined with customized paint formulas that are meant to be used with galvanized metal, the end result is a hull that will hold up to a lot of wear and tear.

Galvanized steel has gone through a chemical process to keep it from corroding. The steel gets coated in layers of zinc because rust won't attack this protective metal. For countless outdoor, marine, or industrial applications, galvanized steel is an essential fabrication component.

The principal method of making steel resist corrosion is by alloying it with another metal, zinc. When steel is submerged in melted zinc, the chemical reaction permanently bonds the zinc to the steel through galvanizing. Therefore, the zinc isn't exactly a sealer, like paint, because it doesn't just coat the steel; it actually permanently becomes a part of it.

The zinc goes through a reaction with the iron molecules within the steel to form galvanized steel. The most external layer is all zinc, but successive layers are a mixture of zinc and iron, with an interior of pure steel. These multiple layers are responsible for the amazing property of the metal to withstand corrosion-inducing circumstances, such as saltwater or moisture.

Zinc also protects the steel by acting as a "sacrificial layer." If, for some reason, rust does take hold on the surface of galvanized steel, the zinc will get corroded first. This allows the zinc that is spread over the breach or scratch to prevent rust from reaching the steel

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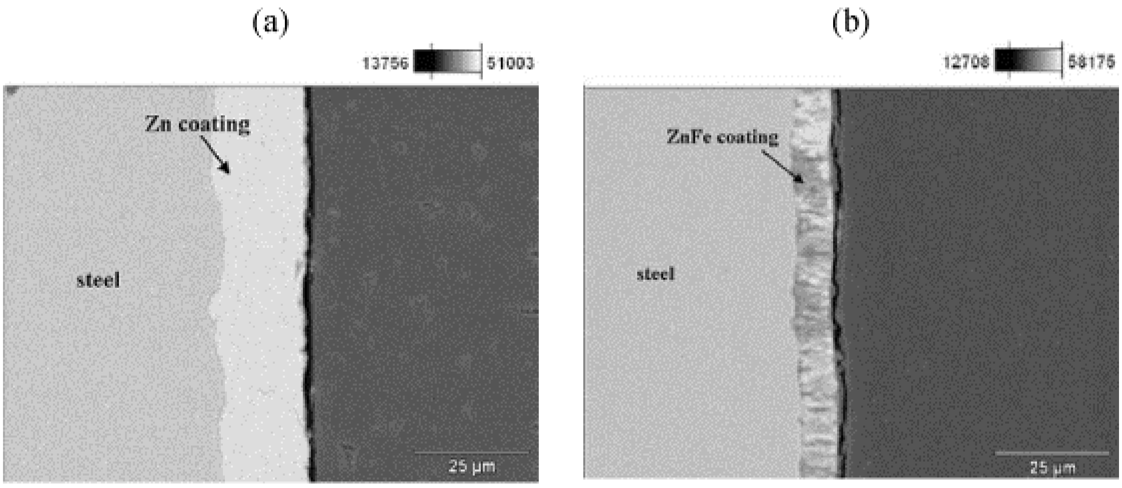
How does galvanizing protect steel from corrosion?

Zinc metal used in the galvanizing process provides an impervious barrier between the steel substrate and corrosive elements in the atmosphere. It does not allow moisture and corrosive chlorides and sulphides to attack the steel. Zinc is more importantly anodic to steel - meaning it will corrode before the steel, until the zinc is entirely consumed.



The galvanizing process not only prevents corrosion of various "soft" metals, but adds to the strength of the original, uncoated metal. Obviously, galvanized metal is thicker than uncoated metal, thus fittings and fastenings are generally measured with the additional galvanizing mil specs in mind. Various American Society for Testing and Materials (ASTM) specifications provide guidelines and continuity for the thickness of galvanized metals.

Galvanization of nails and screws is the most common method of preventing the unsightly staining seen on many types of house siding. Non-galvanized steel nails and screws, when used outdoors, will "bleed" when they corrode, causing dark stains on the siding. This staining is only eliminated by re-painting the siding. Staining on a building façade due to corroded nails, screws or other types of fasteners, is not only ugly, but also indicates that, because they're not galvanized, the metal fasteners are deteriorating and must be replaced.

The hot dip procedure to galvanize metals is essentially a bath of molten zinc. The zinc is kept liquefied at a temperature of about 860 degrees F (460 C) and the metals to be coated are dipped into, or, in some cases, fed through this zinc bath. Prior to dipping, metals are cleaned and prepped for the hot dip by pickling in a light acid solution. The zinc coating is ordinarily distinguishable from shiny bare steel or iron in that it is a dull, medium gray. Magnesium is put into the hot dip solution when galvanized metals are to be used in a marine environment.

Zinc

Zinc is a metallic chemical element found in reasonable abundance around the world. It is classified in the transition metals, along with nickel and mercury, among others. The metal is used in a variety of alloys and compounds which have a range of uses, from sunscreen to fine art. Living organisms also rely on zinc as a valuable nutritional trace element; many foods are excellent sources of zinc, including seeds and whole grains.

Pure zinc is a bluish white, lustrous metal. It is extremely brittle at average room temperature, although when it is heated it becomes soft, malleable, and easily worked. When zinc is burned, it yields a bright blue to green flame, and the metal is reactive, combining readily with an assortment of other elements. On the periodic table of elements, zinc is identified with the symbol Zn, and the metal has an atomic number of 30.

Humans have been using zinc for thousands of years; the element was used extensively in India in particular. Around the 1500s, zinc began to be imported into Europe, where it was a costly and unusual metal. Allegedly, zinc was named by Paracelsus, after the German zinke, "jagged," to describe the way it behaved in a furnace. By the 1700s, several European scientists had managed to isolate the element; there is some dispute over who did it first, although many people give the credit to Andreas Marggraf.

In addition, the main component of galvanizing, zinc is readily available- about 25th in the order of abundance from the earth crust. This component is a mineral that is essential for growth and development of nearly all life- both plant and animal. About 1.4 - 2.3 grams are found in average adult with a recommended intake of 15 grams advised by the World Health Organization (WHO). In different forms, zinc is beneficial to life and in the form of zinc oxide is used as a nutritional supplement. It is not harmful to the environment and does not pose any threat to human.

Besides, it is 100% recyclable with less energy required to process it for use in corrosion protection. It could serve as the ultimate material to protect our state's structures in the parks, waterways, airports, etc.

Hot-Dip Galvanizing HDG

History

In 1742, French chemist Paul Jacques Malouin described a method of coating iron by dipping it in molten zinc in a presentation to the French Royal Academy. In 1836, French chemist Stanislas Sorel obtained a patent for a method of coating iron with zinc, after first cleaning it with 9% sulfuric acid (H_2SO_4) and fluxing it with ammonium chloride (NH_4Cl).

***Hot-dip galvanizing** is a form of galvanization. It is the process of coating iron, steel, or aluminum with a thin zinc layer, by passing the metal through a molten bath of zinc at a temperature of around 860 °F (460 °C). When exposed to the atmosphere, the pure zinc (Zn) reacts with oxygen (O_2) to form zinc oxide (ZnO), which further reacts with carbon dioxide (CO_2) to form zinc carbonate ($ZnCO_3$), a usually dull grey, fairly strong material that stops further corrosion in many circumstances, protecting the steel below from the elements. **Galvanized steel** is widely used in applications where rust resistance is needed, and can be identified by the crystallization patterning on the surface (often called a "spangle").*

A process by which zinc is coated over corrosive metals is known as galvanizing. The galvanizing process is actually a method of coating corrosive metals, such as steel and iron, with a non-corrosive metal. Zinc is melted and applied, usually via what's known as a hot dip, to the metal, providing a coating of corrosion protection from one mil to just over four mils thick. When cured, the zinc, through reaction with the coated metal, becomes zinc carbonate.

Advantages of Hot Dip Galvanizing:

The following are few advantages of the hot dip galvanizing over other methods of protection from corrosion:

** Hot dip galvanizing enjoys a low initial cost advantage over many other corrosion protection techniques. In addition, it is less labour intensive compared with other corrosion protection methods.*

** In rare cases where hot dip galvanizing has a higher initial cost than other corrosion protection techniques, it is more cost effective in the long term since it is durable with less maintenance needs. Because the protected materials are metallurgically bonded to the metal it protects, it offers superior resistance to abrasion and water and general mechanical damage in transport, erection and service.*

** Hot dip galvanizing coatings enjoy a high life expectancy of up to 45 years even in severe coastal and urban environments. In addition, this life expectancy and performance of the protected metal are easily predictable.*

** Hot dip galvanizing process is simple, straightforward and closely controllable. The coating thicknesses are regular, predictable and easily specifiable. This enables precision during usage and design resulting to quality results.*

** Implementation of corrosive protection is readily faster with hot dip galvanizing thereby providing a way to reduce project time and government money. A fully galvanized protective coating can be applied in few hours compared to a proper four-coat painting that requires up to one week. Hot dip galvanizing does not require any further site preparation, painting or inspection. Once erected, cladding can begin immediately, thus accelerating the construction program.*

** Inspection of hot dip galvanized coatings are assessed readily by eye, and simple non-destructive thickness testing methods can be used without the complexity usually used in other protection techniques. This could save money for government as well as provide an easy means for contingency planning.*

** The protection offered by hot dip galvanizing is complete since all parts of the materials are protected, including recesses, sharp corners and inaccessible areas. This is because the material when dipped in molten zinc is completely covered - inside and out - including awkward corners and narrow gaps. No coating applied to a structure or fabrication after completion can provide the same protection as hot dip galvanizing.*

In summary, hot dip galvanizing offers public utilizes across the globe a more strategic option to protect the state's infrastructures. Compared with other corrosion protection techniques, which are presently being combined with it to protect the state's facilities, it is less laborious both in implementation, maintenance and inspection. In the long run, it would offer better returns on investments through its long-term cost competitiveness and durability. Hot dip galvanized materials are harmless to both human and environment and should be the method of choice over paints, which contain dangerous chemical components, in corrosion protection in our parks and public places. Adoption of this state of the art corrosion *protection technique would be for the best interest of taxpayers because it would provide far better value than any other technique.*

What are the steps in the galvanizing process?

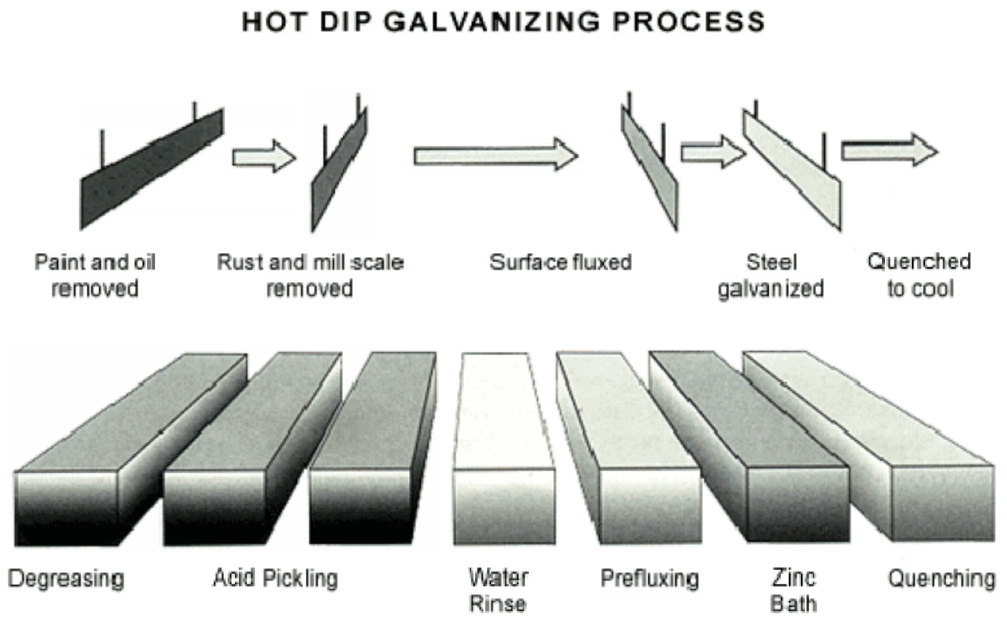
There are four steps:

1. Pre-inspection - where the fabricated structural steel is viewed to ensure it has, if necessary, the proper venting and draining holes, bracing, and overall design characteristics necessary to yield a quality galvanized coating

2. Cleaning - steel is immersed in a caustic solution to remove organic material such as grease and dirt, followed by dipping in an acid bath (hydrochloric or sulfuric) to remove mill scale and rust, and finally lowered into a bath of flux that promotes zinc & steel reaction and retards further oxidation of the steel... (steel will not react with zinc unless it is perfectly clean

3. Galvanizing - the clean steel is lowered into a kettle containing 850 F molten zinc where the steel and zinc metallurgically react to form three zinc-iron inter metallic layers and one pure zinc layer

4. Final inspection - the newly galvanized steel is sight-inspected (if it looks good, it is), followed up by measurement of coating thickness with a magnetic thickness gauge



Electro-galvanizing is an electrolytic process of galvanizing, where a thinner, tighter-bonding coat of zinc is applied to a metal via electroplating. In this process, an electric current is passed through a zinc compound, positively charging the zinc ions to adhere more securely to the conductive primary metal. Electro-galvanizing provides a somewhat stronger tensile strength to the coated metal by virtually impregnating the metal with zinc. This process is most commonly employed with galvanizing iron or steel beams, angle-irons, etc. that are to be used in building construction. Hot dip and electro-galvanizing are the most common of several methods of galvanizing metal.

The main differences is clear in the advantages of the HDG while the HDG is classified as friendly environmental.

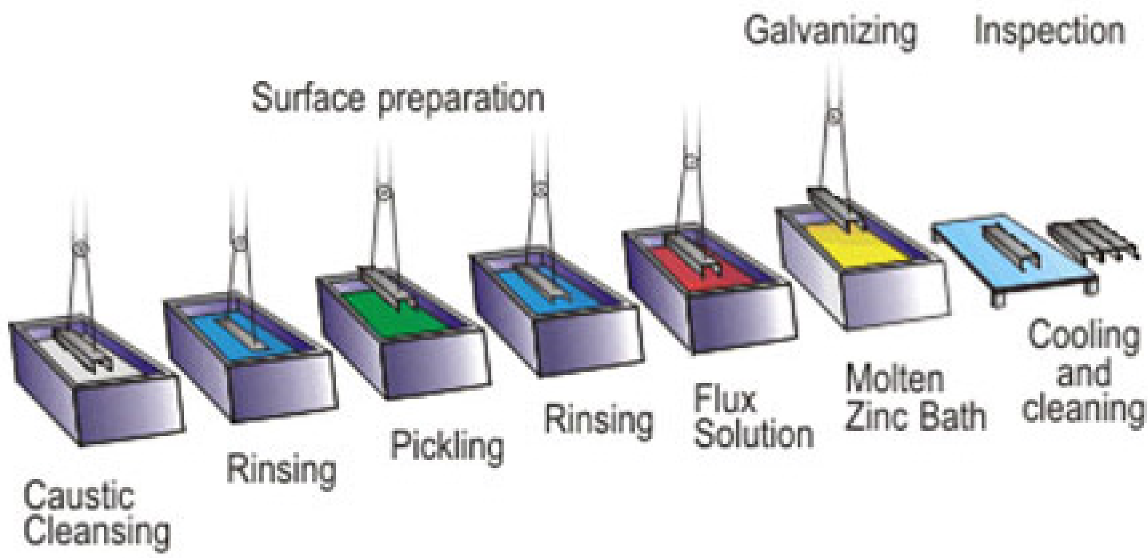
Process

The process of hot-dip galvanizing results in a metallurgical bond between zinc and steel with a series of distinct iron-zinc alloys. The resulting coated steel can be used in much the same way as uncoated. Galvanized steel can be welded; however, one must exercise caution around the resulting zinc fumes. Galvanized steel is suitable for high-temperature applications of up to 392°F (200°C). The use of galvanized steel at temperatures above this will result in peeling of the zinc at the intermetallic layer. Electrogalvanized sheet steel is often used in automotive manufacturing to enhance the corrosion performance of exterior body panels, this is however a completely different process.

Lead is often added to the molten zinc bath to improve the fluidity of the bath (thus limiting excess zinc on the dipped product by improved drainage properties), helps prevent floating dross, makes dross recycling easier and protects the kettle from uneven heat distribution from the burners.[1] Lead is either added to primary Z1 Grade Zinc or already contained in used secondary zinc. A third, declining method is to use low Z5 Grade Zinc.[2]

Steel strip can be hot-dip galvanized in a continuous line. Hot-dip galvanized steel strip (also sometimes loosely referred to as galvanized iron) is extensively used for applications requiring the strength of steel combined with the resistance to corrosion of zinc. Applications include: roofing and walling, safety barriers, handrails, consumer appliances and automotive body parts. One common use is in metal pails. Galvanised steel is also used in most heating and cooling duct systems in buildings

Individual metal articles, such as steel girders or wrought iron gates, can be hot-dip galvanized by a process called batch galvanizing. Other modern techniques have largely replaced hot-dip for these sorts of roles. This includes electrogalvanizing, which deposits the layer of zinc from an aqueous electrolyte by electroplating, forming a thinner and much stronger bond.



Metal Pickling

Pickling (Chemical Descaling)

Pickling or chemical descalling is but one of several pre-treatment steps available for preparing an article for further processing such as passivation and electropolishing, or to perform a superior cleaning operation of welded structures.

Prior to pickling, the heavy surface soils such as oil, grease, buffing compounds, drawing compounds, some scale, heavy rust, dye and paint markings, tape, adhesive residue and other foreign substances must be removed. This step may be accomplished by the use of alkaline cleaners, solvent cleaning, vapour degreasing, ultrasonic cleaning, steam cleaning, water-jetting, or other mechanical cleaning. Pre-cleaning is not required if oxide or scale is the only soil on the surface.

Pickling is typically performed to remove tightly adherent oxide films resulting from hot-forming, heat treating, welding and other high temperature operations. Welding or heat treatment often produces complex oxides that can vary in colour. All these oxides are generally referred to as "scale" and must be removed. Where applicable, alternative mechanical methods such as blasting, shot, tumbling, and wheel abrading may also be performed. Abrasives containing iron should not be used. In many cases, pickling of stainless steels is performed in two steps, one for softening the scale and one for final scale removal. Over-pickling, under-pickling and pitting usually are the direct results of lack of control over process variables including acid concentrations, solution temperature and contact time.

End